Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Alpine Nature 2030

Creating [ecological] connectivity for generations to come

Cover picture

Lech Valley in Tyrol, Austria (August 2016) provides an excellent example of an intact landscape supporting ecological connectivity. The Lech valley straddles the countries of Austria (Bundesländer of Voralberg and Tyrol) and Germany (the Allgäu, Bavaria) representing one of the last natural riverine systems of the Alps. The three environmental 'milieus' (terrestrial, aquatic and aerial habitats) are all represented within this landscape. Connectivity is required in each of these spaces if wild life and biodiversity are to be safeguarded, and our generation has a responsibility to protect this precious resource for those generations to come.

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Edited by
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Editors and main authors
Dr. Guido Plassmann, Dr. Yann Kohler, Dipl. Ing. Marianne Badura, Prof. Dr. Chris Walzer

Final Editing
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Mapping
Dr. Dominik Cremer-Schulte

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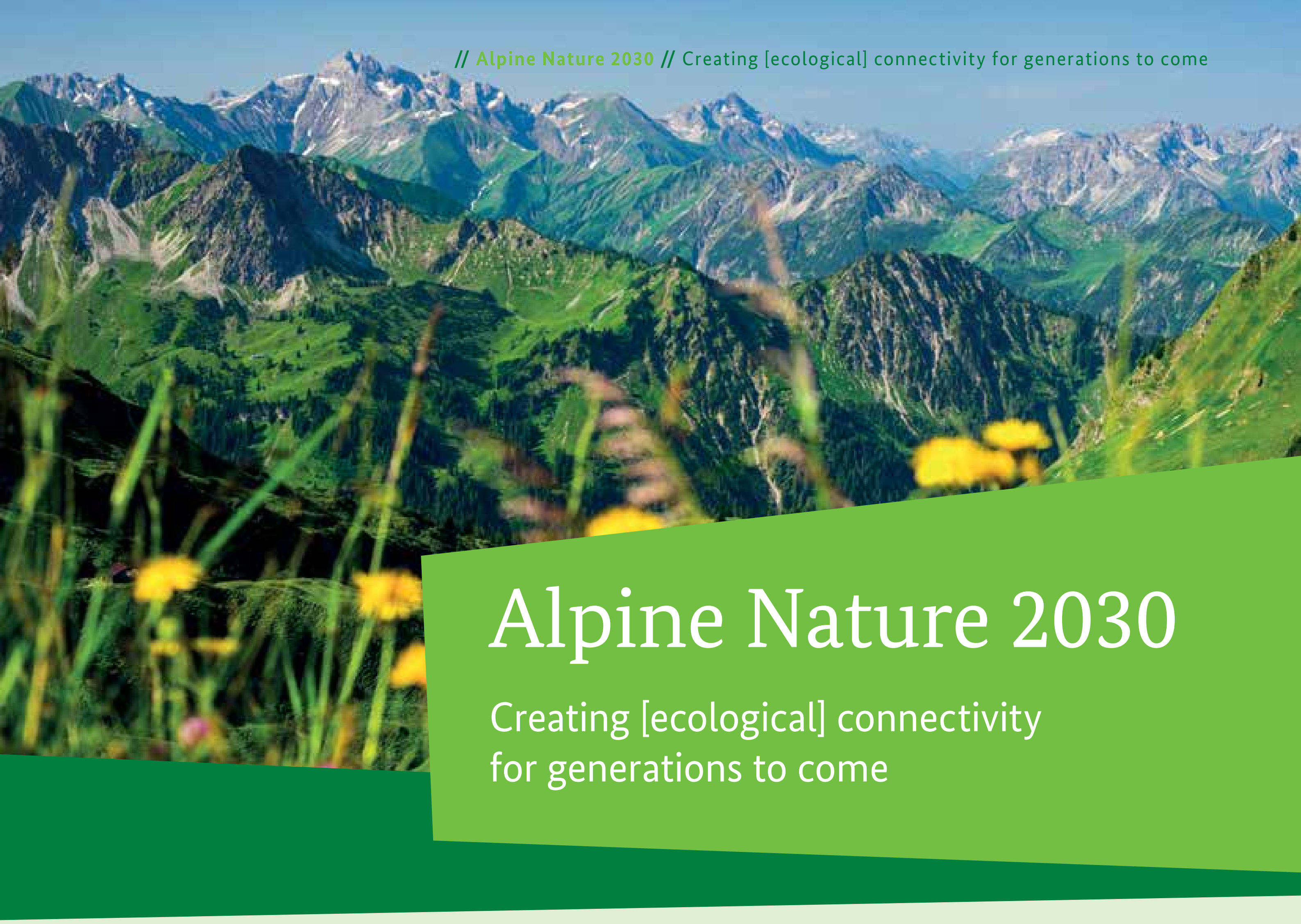

Alpine Nature 2030

Creating [ecological] connectivity for generations to come

Connecting Alpine habitats – helping preserve global biodiversity

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety considers the creation of an ecological network in Europe to be crucial for achieving a global network of protected areas as envisaged in the Convention on Biological Diversity (CBD). In this context, the spatial connectivity of protected areas and transboundary protected areas plays an important role in the implementation of the Alpine Convention. Article 12 of the Nature Protection and Landscape Conservation Protocol of the Alpine Convention envisages the creation of an ecological network.

The Alps are still home to a wealth of different habitats and species, and we want to keep it that way. Thus, together with France, the Federal Environment Ministry has been supporting the creation of an ecological network under the Alpine Convention since 2003. The Alpine Network of Protected Areas (ALPARC) is a key partner in this. For many years, this international organisation has been coordinating and monitoring over 1,000 Alpine Protected Areas across all the Alpine countries and supporting them in international projects.

The Ministry has provided support for the project based work of ALPARC, the Platform Ecological Network of the Alpine Convention, relevant EU (European Union) projects under the Alpine Space Programme and the development of expert tools and methods for connectivity by means of research projects from the Federal Environment Ministry's departmental research plan. The result of these activities was the establishment of comprehensive, technical, political and strategic principles for implementing the Nature Protection and Landscape Conservation Protocol and, in particular, for creating the Ecological Network as envisaged in Article 12 of the Protocol. These principles can be applied beyond the Alpine region, for instance, in other mountainous regions such as the Carpathians. This publication highlights the results of this long-term and successful cooperation and its contribution to biodiversity conservation in Europe.

Content

Foreword: Ecological networks

// Mario BROGGI //

Former President of CIPRA International;
Former Director of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Liechtenstein

The German writer Peter Maiwald once wrote, somewhat sarcastically, "A national park is where we keep everything that is in danger of dying out." How comforting the idea is, nonetheless. If it were really possible for parks to work like this for the species that are facing extinction because of us, we could soothe our collective conscience.

Obviously, this is not how national parks work. The European Environment Agency's 2015 state of the environment report tells us that 60 percent of protected species are still endangered, and the conservation status of 77 percent of protected habitat types is still considered unfavourable. We are reaching a point where things we now think of as ordinary, such as a field of colourful flowers, are becoming rare. Why?

This is largely caused by direct habitat loss, but extensive areas are also affected by increasing airborne over-fertilisation. This comes from combustion processes, but also first and foremost from agricultural activity. We are talking about a literal "nitrogen bomb" that is raining down on fields and forests. In Central Europe, this "rain" is equivalent annually to full agricultural fertilisation as it was applied after the Second World War. Pesticide use comes in addition to this. Along with these more subtle phenomena, this publication is primarily concerned with the increase in habitat fragmentation, which stands in the way of ecological networks. To address these issues, we need ecologically sound land use in place for 100 percent of the land area.

The European Environment Agency also reports that 21 percent of Europe's terrestrial land mass, including inland waters, has protected status. The European Union, for its part, registers almost 28,000 Natura 2000 sites. These are impressive figures. In the Alps, seven percent of the region has been designated as a national park or nature reserve to date. This directly serves nature conservation goals. We are promoting protected areas everywhere. Whether these areas receive targeted, graduated maintenance interventions or not, we take heartfelt action on their behalf. Our day-to-day work in nature conservation has expanded to include social and political issues along with species and habitat protection. This demands great sensitivity from us, not to mention natural science expertise. Managers of protected areas today should have at least as much social competence as they do knowledge of the natural sciences. These professionals have to cultivate contact with local people using inclusive participation processes.

As for protected areas, they are like islands in our landscapes. The Nature Conservation Protocol of the Alpine Convention stipulates that existing protected areas be preserved in keeping with their protective function and that they be managed and expanded where needed. Impairing or even destroying protected areas is to be avoided.

In the meantime, we have learned that preserving biodiversity requires a large, adequately interconnected ecological network – going above and beyond the protection of particularly sensitive "islands." Plants and animals, in all their biological diversity, must be protected and kept safe. To do this, we have to situate them in a well-connected and, if need be, managed network of protected areas. The space between these protected "islands", therefore, has come into the focus of our concerns.

The question becomes, then, "How can we establish a network?" Each of us has likely had personal experience with this question. For my part, I recall three key experiences. My first encounter with this problem came in the form of an alarming number of frogs and toads dying on the roads in early spring. We thought and thought about how these amphibians could cross roads in safety and how we could gain acceptance for such safety measures from both the animals and people in the area. My next encounter with this issue involved larger, hoofed game animals. It was in Switzerland, at a national level. I learned that, according to assessments in north-western Switzerland, only one functional wild animal corridor was then in existence between the Jura Mountains and the Swiss Plateau. Moreover, this corridor was potentially at risk of being built over. According to new studies, drastic barrier effects caused by motorway construction lead to measurable genetic divergence even after just decades of isolation for roe deer populations. To prevent this, wild animal overpasses, modelled on initial projects in France, were built over the roads at many places. Third and finally, I was able to participate in biological and geographical investigations in Austria and Switzerland in the context of studies related to the problem of hydro power generation in residual water courses. We found catastrophic losses of benthic fauna below the sampling courses. These losses were increased by the surge and drop in water levels (hydropeaking) caused by energy generator operation. This is how we came to understand the life blood, the circulatory system, of running waters. Functioning ecological links in water courses, like arteries in the human body, can demonstrate something very significant about questions of interconnectedness. These questions follow on the heels of ongoing revitalisation projects dealing with existing ecological barriers.

Hundreds of amphibians were killed by traffic every year during the migration season near the nature reserve Grand-Lemps in France. The building of several underpasses has considerably improved the situation, and the populations of newt and true toad have recovered.

The managers of protected areas, in particular, are only responsible for their own special "islands", not for the areas between, the corridors that connect one to another. Every day we learn about new necessities for the management of protected areas. We know that nature reserves are not rigid constructs. They have to be developed or we deliberately allow some processes of ecological succession to take place. Acceptance for such measures on the part of local inhabitants is crucial. There is talk already about third or fourth-generation parks. There is tentative movement in the direction of new forms of protected areas that would allow sustainable development. The UNESCO Biosphere Reserves are an example of this.

We now need careful thought and action extending over the borders of our "own" protected areas. Initial knowledge about stepping across the boundaries of protected areas has already been gained in the area of transnational parks. In these cases, we have learned that cultural borders also have to be overcome. We can learn from each other. Now the degree of complexity is growing exponentially as the importance of connectivity becomes clear. Connections between protected areas also create new links to additional stakeholders, for example regional planners. Ideally, we can gain experience by taking case studies as models.

We have to learn by doing. In the Alpine region, we are learning by studying examples from all four corners of the globe. We are thinking about how we can connect mountain ranges, with the example of the Alps and the Carpathians. The apex predators such as bears, lynxes and wolves and their migration into the Alps are currently making us very aware of the necessity of free wildlife movement. Of the 80 wolves that were known to live in Switzerland, 19 died of unnatural causes. Six of these were run over by vehicles. These important predators are not just wildlife mascots. They can also live in cultivated and inhabited areas. Nonetheless, it would be best to secure less developed, unspoilt habitats for them. Identifying and securing what are called "white zones" could be an exciting area of work and new task for the Alpine Convention. Numerous projects like ECONNECT, but also national initiatives, give us puzzle pieces for putting together the knowledge that we need.

Extensive human activities contribute to the high diversity of species and habitats in the Alps. The meadows between 1,800 and 2,200 metres above sea level are part of the richest plant association of Europe with up to 80 different plant species per hundred square metres.

Conflicts with returning large carnivores like the lyxn could be reduced by providing them less developed, unspoilt habitats.

And already we are facing new challenges. It seems like the Iron Curtain, after its fall, had only just been repurposed as a part of the European Green Belt, when new fences began to be put up through the middle of Europe. These are meant to prevent human migration. But experience shows that fences do not solve any problems. At most, they show our weakness. Let us hope that they will soon be removed, that the fences, like the many barriers affecting ecological networks, will ultimately be made passable again.

Innovative, communicative individuals have already taken their chances crossing borders in the area of connectivity. In the Eastern Alps, in particular, we have many examples. This publication reports on these experiences, and, in this way, ALPARC is kindly passing on its knowledge.

We are facing a herculean task in the field of nature conservation. Connectivity presents us with a massive challenge. I hope that this publication will find interested, open-minded readers and that the constructive suggestions the authors propose will be taken up. Thanks are due to the authors for their thoughts – for the thinking they did before and after their projects, but especially for the thinking they did “outside of the box” – which is so important to our difficult mission: making a liveable world where people, animals and plants can coexist.

1

Alpine nature protection: A global historic context and the conception of "ecological networks"

Introduction

"Ecological connectivity has become a cornerstone of conservation science and practice." – this sentence from the last part of this chapter holds true for the European Alps, following the establishment by the Alpine Convention of the Platform "Ecological Connectivity" in 2007. Since then, numerous transnational projects, exchanges and education activities have been carried out on which this chapter gives an overview. Moreover, it provides an insight into the historic development and global framework for nature and biodiversity conservation, linking activities in the Alps to other mountain areas in Europe and to global biodiversity goals. The authors explain the motivations for potential beneficiaries to join forces for an ecological continuum in the Alps. And, it further opens the dialogue on future scenarios for an Alpine biodiversity and nature conservation policy together with the population and important stakeholder groups.

1.1 The global framework for nature protection

// Karin SVADLENAK-GOMEZ //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Biology and Evolution, University of Veterinary Medicine, Vienna, Austria

The history of the conservation of natural areas and species has been influenced by changing motivations, perceptions and priorities. Certain types of conservation, such as forest management or the setting-aside of sacred sites or hunting reserves, date back several hundred years in some parts of the world. Most of these were pragmatic measures, responding to a need to conserve natural resources for human use. A view of nature as a good in itself, worthy of preservation, emerged later, in the second half of the nineteenth century, at a time when large-scale destruction of the natural environment through industrial processes was becoming a source of concern. The romantic Henry David Thoreau famously said *"I wish to speak a word for Nature, for absolute freedom and wildness, as contrasted with a freedom and culture merely civil – to regard man as an inhabitant, or a part and parcel of Nature, rather than a member of society"* (Thoreau, 1862). Thoreau influenced several late nineteenth and early twentieth century initiators of the American conservation movement, including John Muir, who played a key role in the establishment of the Yosemite State Park as the first National Park in 1890.

In Europe, particularly in the Alps, conservation of forests and afforestation began seriously in the second half of the 19th century. However, this was not focused on conservation of nature for its own sake but primarily to take advantage of forests´ protective function, as there had been repeated devastating flood events. Additionally, there arose a desire to form landscapes that symbolised, in the minds of national rulers, a distinctive identity (Joanaz de Melo, 2011). National forestation laws were issued in the different Alpine countries from the 1860s onwards over a span of a quarter century. Although the purpose was purely anthropocentric, the forest management mandated by these laws also impacted the region´s biodiversity significantly. At the same time, with industrialisation, romantic notions of natural landscapes began to emerge mainly among an urban elite (Krämer, 2011).

1.1.1 International conservation agreements

One of the first international conservation agreements was the Paris Convention for the protection of birds useful to agriculture of 1902, which focused only on individual bird species and not at all on landscapes (Bätzing, 2015).

The Alps, in particular, became popular with early proponents of nature protection around 1900 (Mathieu, 2010). Several later global and regional Conventions, such as the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) (Ramsar Convention Secretariat, 1971), the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) (CE, 1979), and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) (UNEP/CMS, 1979) are still valid and of relevance in the Alpine region, even though they were later supplemented by newer and even more comprehensive global legal frameworks. As of 2014, about a quarter of the Alpine region has come under some kind of protection (ALPARC, 2016).

Sills, like these seen here in the river Johnsbach in the National Park Gesäuse (Austria), can be important barriers to several aquatic species.

Concerns about environmental pollution and the escalating loss of species and natural areas mounted from the 1970s onwards, and in 1987 the World Commission on Environment and Development, also known as the Brundtland Commission, which had been convened by the United Nations General Assembly, published the seminal report, Our Common Future (WCED, 1987). This document defined the meaning of the term "Sustainable Development" and laid down the path towards the major global environmental conference held in Rio de Janeiro in 1992, that became popularly known as the Earth Summit (UN-DESA, 2016).

The outcomes of this summit, officially the United Nations Conference on Environment and Development (UNCED), laid the foundation for today´s global and European biodiversity conservation goals. It brought together 172 governments and 108 heads of State, who agreed on a framework for tackling a broad range of social and environmental concerns, from deforestation, managing fragile ecosystems, conserving biological diversity, protecting water resources, dealing with all kinds of wastes, and protecting the earth´s atmosphere and climate, to combating poverty through sustainable development. All this was written into a non-binding policy statement called Agenda 21 (U.N. GAOR, 1992), which was adopted at UNCED along with the Biodiversity Convention, the Rio Declaration, the UN Framework Convention on Climate Change, and the Statement of Forest Principles. Agenda 21 outlines principles and objectives relating to implementation of actions in support of sustainable development at a national level. The Biodiversity Convention advocates an ecosystem-based approach to the conservation of biological diversity. It defines biodiversity broadly, as the *"variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (CBD, 2015a).

In the year of the Earth Summit, the European Union also issued Directive 92/43 on the conservation of natural habitats and of wild fauna and flora, the "Habitats Directive", which supplemented the earlier Directive 79/409 on the conservation of wild birds ("Birds Directive") (EC, 1992; EC, 2010). This was to become a very valuable major binding instrument for the protection of entire ecosystems, not just individual species. It is particularly important as, in contrast to the Biodiversity Convention and other global Conventions, there is an enforcement mechanism attached to it. A considerable time after the land-based conservation Directives, the European Council passed the Water Framework Directive (EC, 2000), which is also highly relevant to ecological connectivity, as it is concerned with achieving "good ecological status" in water bodies – a requirement that cannot be achieved without preserving aquatic connectivity and that also contributes to both land-based and aquatic ecological connectivity.

At an Alpine scale, the multilateral framework treaty of the Alpine Convention, signed in 1991 and ratified by all Alpine States in addition to the European Union, aims for sustainable development of the Alpine region to enhance quality of life for Alpine residents (Alpine Convention, 2011; Alpine Convention, 2015). The Alpine Convention´s eight protocols focus more specifically on the various environmental, economic, and social aspects of this goal. The Protocol on Conservation of Nature and the Countryside is of special relevance for the conservation and restoration of ecological connectivity in the Alps. Its stated goal is to *"protect, care for and, to the extent necessary, restore nature and the countryside, in such a way as to ensure the lasting and widespread functional efficiency of the ecosystems, the conservation of countryside elements and wild animal and plant species together with their habitat, the regenerative ability and lasting productivity of natural resources, and also the diversity, specificity and beauty of the natural and rural landscape"* (Alpine Convention, 1991a).

Article 12 of this Protocol *requires the establishment of an ecological network in the Alps. Other Protocols, such as the Protocol on Spatial Planning and Sustainable Development, also contain important instructions concerning the maintenance of landscapes and species habitats (Alpine Convention, 1991b).*

It should be noted that, although the European Union ratified the Alpine Convention, it did not follow this up with any mountain-specific legislation, nor is there much mountain-specific environment legislation in Alpine countries (Krämer, 2011), and not all Alpine countries have ratified all of the Alpine Convention Protocols. For example, neither Switzerland nor the European Union ratified the Protocol on Conservation of Nature and the Countryside.

1.1.2 Ground-level implementation efforts

The principal implementation instrument that countries have employed to protect biodiversity is the establishment of protected areas. Specifically linked to the implementation of the Habitats Directive is the establishment of the Natura 2000 network of protected areas (EC, 2016). For non-EU countries, there is an equivalent, the Emerald Network of Areas of Special Conservation Interest (CE, 2014; EU/CE, 2015). It was launched by the Council of Europe as part of its work under the Bern Convention in 1989. Overall, there are now 209,429 officially designated protected areas in this network globally, corresponding to an area larger than Africa or 14 percent of the earth´s land surface (15.4 percent without Antarctica) and 3.41 percent of the marine area (Deguignet *et al.*, 2014).

The total protected area network has grown more than two and a half-fold in area since the year of the Earth Summit 1992, but there are some significant regional differences. While, in terms of numbers of sites, 65 percent are located in Europe, these only cover 12 percent of the total global protected area. Europe thus has a large number of relatively small sites, often with more than one designation of protection. These range from strictly protected to various degrees of lesser protection (for example National Park, Special Protection Area, Nature Reserve, protected landscape, and more) (IUCN, 2015). Only about one percent of Europe´s land area corresponds to a wilderness zone as defined in the IUCN criteria for protected areas. In the Alps, when defined strictly as IUCN category Ib only (unmodified or only slightly modified areas), wilderness areas cover only 0.06 per cent of their territory. Defined a bit more loosely to include category Ia (strictly protected, with very limited and controlled human impact) as well, 0.32 per cent of the Alps can be considered protected wilderness areas. Looking at numbers rather than land area, there are currently 457 category I protected areas (of about 6700 protected areas overall) (IUCN, 2016).

A global gap analysis in 2004 assessed the effectiveness of protected areas in representing different species (in this study, only terrestrial vertebrates, the best studied species group, were considered) (Rodrigues *et al.*, 2004). The study found that there was only a partial correspondence of the location of protected sites to the distribution of several threatened species. Well managed protected areas can be effective tools for biodiversity conservation, and many are successful despite resource constraints (Leverington *et al.*, 2010). Nevertheless, even the best managed "islands of conservation" are unable to ensure long-term species conservation or ecosystem function, as adaptation to climate change requires a network of physically connected natural areas, combined with compatible land use practices, to allow species and populations to move between areas as needed (Hannah, 2011; Hannah, 2007).

The concepts of ecological networks or ecological connectivity have by now found their way into global, regional, and national strategies, guidelines, and other policy documents. At a global level, most recently the Strategic Plan for Biodiversity 2011 to 2020 was adopted at the 10th meeting of the Conference of the Parties to the Biodiversity Convention, and it includes the Aichi Biodiversity Targets (CBD, 2015b), where Target 11 aims to improve global protected area coverage and effectiveness *"By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and* ***well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes"*** (emphasis added). At the European Union level these targets were translated into the EU Biodiversity Strategy to 2020 and adopted by the European Parliament in 2012 (EP, 2012).

In the early 19th century, due to hunting, the Alpine ibex (*Capra ibex*) only survived in the Gran Paradiso area. The establishment of the Royal Hunting Reserve of the Gran Paradiso (1856) and later the Gran Paradiso National Park (1922) contributed to the protection of this species in the Alps.

The Grossglockner (3,798 metres), the highest mountain of Austria, is located in the Hohe Tauern National Park.

Looking at it from an institutional point of view, there are now many inter-governmental organisations that address biodiversity conservation concerns, either as their primary mandate or as part of a broader mission, including several United Nations and European Union agencies, as well as non-governmental organisations. Their work, and that of national and local government agencies, has led to a sizeable number of additional legal instruments, policies, guidelines, and strategy documents. However, many of these instruments are of a voluntary nature and as such lack the "teeth" that would be needed to compete with conflicting land use interests (Svadlenak-Gomez *et al.*, 2014b).

At an Alpine level, challenges regarding coordinated conservation efforts among different institutions, particularly across federal state borders within nation states and between the various countries remain. The history of collaborative conservation efforts is more recent. Transboundary collaboration is facilitated through some European Union programmes, such as the Alpine Space Programme of the European Regional Development Fund, and there are some examples of successful cross-border collaboration for the establishment of ecological networks, as is described in other chapters of this publication. Even though such collaboration has faced unique challenges – associated with national legal and structural particularities that have arisen over centuries – the 21st century´s common global and European nature conservation goals encourage trans-sectoral and trans-border alliances, holding out an aspirational promise of success in conserving the Alps´ outstanding natural and cultural heritage.

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1.2 Nature protection in the Alps – Which motivation?

*// **Guido PLASSMANN** //*
Alpine Network of Protected Areas ALPARC, Chambéry, France

Nature protection is something relatively young in the Alps. First expressions of the need to protect the landscape coincide with the creation of the first national park in the United States – Yellowstone National Park (1872). Before this time, the concept of protection was exclusively linked to the protection of human inhabitants of the Alpine regions, who were often exposed to natural disaster, and to the protection of their cultures.

Until the late 19th century, it was inconceivable to traditional agricultural societies that nature might need protection from human activities rather than vice versa. The idea of nature protection was in fact an urban concept arising in the second half of the 18th century and reaching the Alps from the outside during the industrialisation of the Alpine valleys (Bätzing, 2015).

As the Alps represent more of a cultural landscape than a natural one, nature protection in the Alps early in the 20th century employed primarily an island protection approach based on sites known for their high value of biodiversity (especially diversity of flora: plant area protection) or for the aesthetic aspects of their landscapes. The first national parks of the Alps were established between 1914 and 1935, and one of the most important objectives was to protect the sites for touristic or technical use, including construction. Several national parks benefited from an historic special status of property (such state owned territories as the Gran Paradiso and Berchtesgaden national parks, which have been hunting reserves of the respective monarchies).

So the central component of the "classical" nature protection in the Alps is essentially an "island" protection approach – at least for the strictly protected parts of the territory. Another feature is the high average altitude of these strictly protected areas. Indeed more than two-thirds of the surface of the national parks in the Alps is located at an altitude greater than 2,000 metres above sea level.

If the Alps are more a cultural landscape than a natural one, if the protection of the most valuable sections– at least from an aesthetic point of view – is already insured, and if there appear to be enough protected areas globally, then why is the subject of nature protection still so topical?

According to the perimeter of the Alpine Convention, the Alps have more than 1,000 protected areas (Map 1) with around 28 percent (Table 2) of their territory "equipped" with a special status which one could call "protected".

Nevertheless, just a small percentage of this total protected surface area actually conforms to international nature protection standards such as the IUCN categories I, II and IV (Table 3) and those of some more strictly protected nature parks especially in Italy.

These strictly protected areas are, as already mentioned, very often at high altitudes, where conflicts of use are not as critical, and where valued components may not be as plentiful. However, the highest biodiversity lies in the lower areas.

In light of these figures, the questions that may arise are those dealing with the motivation of nature protection in the Alps:

- → Why protection?
- → Protection from what or whom?
- → Protection for what or whom?

To respond to these three questions may seem easier than it is. Indeed, if the answer to the first question remains that it is a very "precious" territory in view of Europe's nature and functioning eco-systems that are important for many species, then the answers to the other questions are even more complex.

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1.2.1 Protection of Alpine nature in some of Europe's largest eco-systems

Reasons for nature protection can be seen mainly in three categories: the value of natural richness based on scientific knowledge; the aesthetic value of the landscapes; and the intrinsic evidence supporting the wisdom of protecting nature – a central element of our living environment.

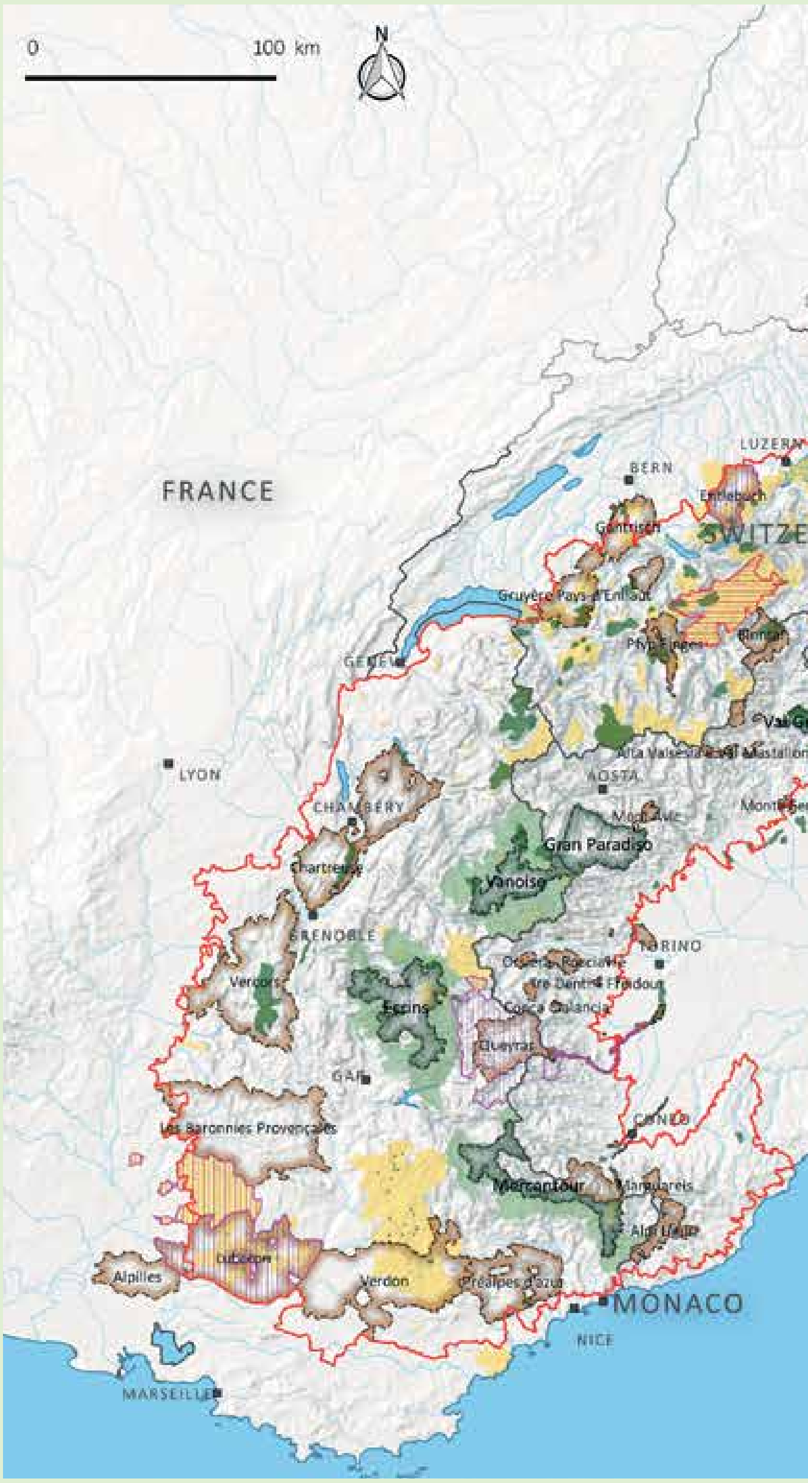
The Alps are one of the largest mountain eco-systems of Europe representing very precious eco-systems characterised by a mosaic of different natural spaces influenced by centuries of human activities and formed by different climate, geological and vegetal conditions. The diversity of contrasting geographical and ecological situations in the Alps also creates an enormous richness of species and an assortment of small or middle-sized habitats, many of which are unique to Europe[1] (WWF European Alpine Programme, 2004). IUCN classified the Alpine area as one of the last large territories in Europe where species diversity is still exorbitant and widely untouched areas remain (Bätzing, 2003).

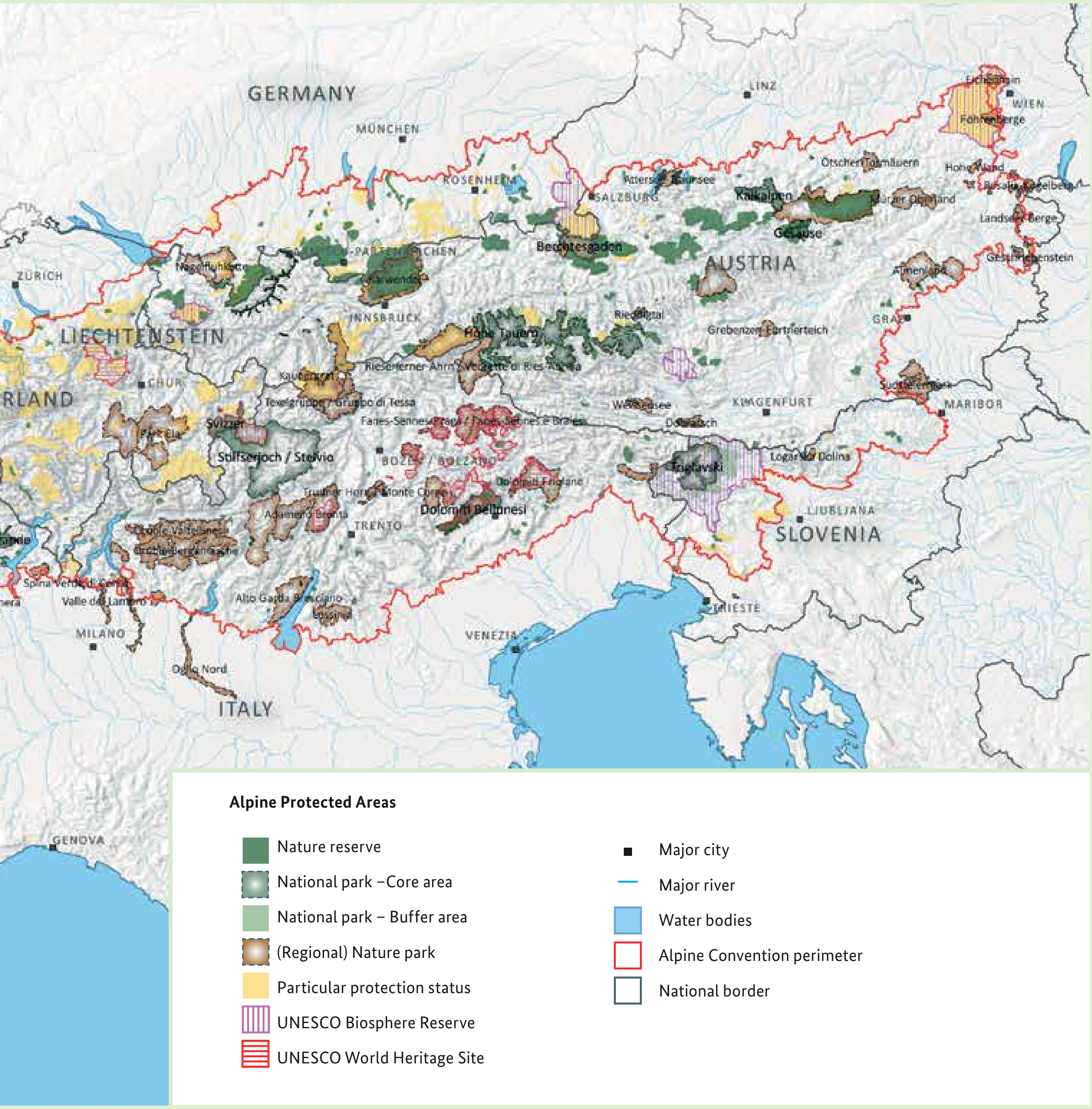
The Alps are, for the European continent, a very young high mountain range with a high potential for natural dynamics, often called "nature disaster". This dynamic effect is, nevertheless, a normal feature of young mountain ranges of this altitude. Additionally this dynamic is enhanced nowadays by the phenomena of climate change (reduction of the permafrost areas and linked movements of soil and rocks) and an intensive human use of the Alps (intensive tourism and infrastructure, energy production, waterproofing of important surfaces).

The fact that the Alps are the only high mountain range in the heart of Europe with this high nature dynamic combined with the long-standing tradition of human use of the Alpine natural space makes the Alpine area an extraordinary and valuable territory even on a global scale.

To protect this natural heritage and to guarantee its preservation for the next generations is a central issue of the Alpine Convention and other international or EU legislations as well as of the protected areas of the Alps. However, protection provided by international conventions and the respective protected areas does not necessarily integrate biodiversity 'hotspots' and

// **Map 1:** Protected areas of the Alps





Source: Data: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © EuroGeographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes and localities; European Environmental Agency/SRTM for the digital elevation model; ©EuroGeographics for the administrative boundaries. **Note**: This map makes no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

// Table 1: Number of Alpine Protected Areas*

Country								
Type	**AT**	**CH**	**DE**	**FR**	**IT**	**LI**	**SI**	**Total**
Nature reserve	128	55	37	27	83	1	15	346
National park	3	1	1	3	4	–	1	13
Regional park	32	9	1	9	45	–	2	98
Particular protection	57	453	76	54	12	–	20	672
Biosphere Reserve (UNESCO)	5	2	1	3	1	–	1	13
World Heritage Site (UNESCO)	–	3	–	–	1	–	–	4
Total	**225**	**523**	**116**	**96**	**146**	**1**	**39**	**1146**

*Protected areas in the perimeter of the Alpine Convention or outside but member of ALPARC

Source: ALPARC Alpine Protected Areas database, January 2016. ALPARC makes no claim of exhaustivity.

// Table 2: Coverage of Alpine Protected Areas

Type	Alpine Protected Areas (km²)	Alpine Convention (km²)	Share (%)
Alpine Protected Areas* > 100 ha	53,820	190,268	**28,3**

*Protected areas in the perimeter of the Alpine Convention or outside but member of ALPARC

Source: ALPARC Alpine Protected Areas database, January 2016. ALPARC makes no claim of exhaustivity.

// Table 3: Coverage of areas with strict protection status

Type	surface (km²)	% of surface of the Alpine Convention perimeter
1. National parks (Core area)	7,083.3	3.72
2. Nature reserves	5,318.5	2.80
3. Nature parks (Italy)	6,053.9	3.20
Total (without overlapping)	**18,193.9**	**9.60**

Source: ALPARC Alpine Protected Areas database, January 2016. ALPARC makes no claim of exhaustivity.

may sometimes prove inadequate. The development of a modern nature protection policy based on the principle of non-fragmented spaces would be an adequate answer to potential deficits in existing approaches.

1.2.2 Protection from many and diffuse threats

What are actually the most important threats to the natural environment of the Alps?

That depends on whether one considers the Alps as purely a natural environment or a natural environment strongly influenced by cultural features and history. The Alps today are, at least up to an altitude of 1,800 – 2,000 metres, more a culturally shaped than natural space, and they are a far cry from a "wilderness" stage, even if this was initially suggested by some stakeholders.

Wilderness, in its primary sense, is defined as an area in an original stage not influenced by humans or by any human activity. In reality, today wilderness also means parts of the landscape that are no longer used by humans but which have been exposed to a certain degree of human use in the past. This interaction has often created a particular biodiversity (that is agriculture pastoralism).

So, the Alpine wilderness concept is probably based on an already transformed natural space but one in which ecological processes currently occur without, or almost entirely without anthropological influence.

For this reason, the definition of threats may vary according to which concept of natural environment we are employing. We consider both definitions and evaluate each. The first concept is that the Alps represent a natural or almost natural space, even if the wilderness concept in its narrow definition (pristine landscapes) cannot be applied. The second suggests that they represent human shaped environments. In both scenarios these are ecosystems with a high potential for natural characteristics and offering the basis for a rich biodiversity and precious habitats.

In the first case, considering the Alps as a natural space, the main threats may occur either at high altitude or in areas with a special status (protected area, humid site, special habitats) that can be qualified as "ecologically rich". Examples of such threats include: an intensification in touristic infrastructure (ski resorts, new sports and equipment like mountain board, summer activities) and probably a reorientation of leisure activities due to climate change. These reoriented leisure activities will not necessarily be any less harmful for the balance of the eco-systems and habitats. Other threats may arise from an inadequately managed settlement policy of Alpine states or regions and especially of communities.

The fact that the protected areas were defined through historical coincidence rather than through dedicated and considered selection means that these areas do not represent habitats at all altitudinal levels and do not always reflect the most precious natural spaces. In this sense they are not covering in a satisfactory way the natural "milieus" of the Alps that are insufficiently protected today – neither in their status, their geographical distribution nor in their representation of the large variety of Alpine habitats and eco-systems.

In the second case of the culturally influenced landscape and semi-natural spaces, threats are more diffuse and include not only a wide variety of possible impacts by economic activities but also by special fields like infrastructures, settlements, transports, agriculture and mono-cultures, energy production and industrial and mining activities. The issue is not to reduce or to forbid such activities but rather to better organise them and to give space to nature at the same time. The main challenge today consists in avoiding the fragmentation of natural spaces by human presence and activity in the Alps, as human population becomes ever more concentrated in the most important Alpine valleys.

Generally, the intensification of human activities is fuelling an ever-increasing fragmentation and urbanisation of the Alpine landscape, particularly in the valleys. The increasing development of sparsely populated or unpopulated areas, new infrastructures, changes in land use and the growing pressure of urbanisation cause habitats to shrink, to fragment into smaller, isolated areas, or to disappear.

If a habitat becomes too small, or if its connections to other areas are cut off, the survival chances of many species decrease rapidly, since small, isolated populations adapt less effectively to extreme environmental conditions such as those triggered by climate change. This can lead to the disappearance of individual populations (Scheurer *et al.*, 2009).

This fragmentation threat is due to the Alpine biodiversity conservation policy of the last 100 years, which has been driven by an almost exclusively "protected area approach", aiming at establishing a number of isolated reserves, which are not always representative of all Alpine habitats and are separated from the rest of the Alpine space. However, in today's increasingly human-dominated Alpine landscapes and in the face of global climate change, this approach must be revised: new and innovative solutions need to be identified and implemented to preserve the overall dynamic potential of the Alps. To this purpose, conservation efforts must aim at preserving and restoring a permeable landscape matrix (spaces where movement of flora and fauna is not hampered by barriers) through the implementation of ecological networks across the entire Alpine region (Walzer *et al.*, 2011).

1.2.3 Who are the beneficiaries of a new protection policy?

Nature protection is, of course, an objective "per se" due to the high intrinsic value of the protected object: nature, the basis for life. By definition, a holistic policy of Alpine and environmental protection is inclusive: protecting the biodiversity, ecosystems and habitats of the Alps as well as the economic, social and cultural environment of the whole mountain range and if possible its surroundings.

Economic stakeholders are beneficiaries:

As the economic space is very often based on the richness of the Alpine nature and landscape (tourism, attractive locations for enterprises, energy production, and more), the economy and all people living from diverse activities directly linked to the Alpine nature and landscape are the primary beneficiaries of a sustainable Alpine conservation policy.

Alpine landscapes and species are beneficiaries:

The Alpine landscape is indeed a mosaic of different biotopes. Meadows, water courses and open prairie, but also farming infrastructure such as pastures, ditches, terraces and hedges create varied spaces for a great diversity of species. These species are the primary beneficiaries of intact habitats and ecosystems.

However, the protection of these habitats in itself is unlikely to be enough to ensure a long term and global nature protection.

Habitats need to be connected to ensure genetic exchange and a long-term protection of species and biodiversity. Small populations distributed along connecting elements, such as corridors, see their survival chances improve. However, the effects of reduction and fragmentation of habitats cannot be balanced through the creation of individual connecting elements alone. A properly planned overarching approach is needed and must be adapted to local situations and include the local stakeholders. Such a concept must safeguard the connection of precious habitats and the accessibility of individual parts of the landscape for various species. This is a task of networking, in its proper sense, for local societies and regional governments (Ecological Continuum Initiative, 2013).

People are beneficiaries:

In this regard, connected habitats and biotope networks are not only of benefit to plants and animals, but also to people. A liveable surrounding area with a varied landscape, suitable for local recreation and high species diversity, increases not only the quality of life of the population, but also the attractiveness of a region in terms of tourism and location for enterprises especially from the service sector.

This means that networking measures for ecological connectivity, as a main element of a modern nature protection policy in the Alps, make life better for fauna and flora but also benefit people. For example, the renaturing of watercourses can transform jogging or a weekend hiking into an exciting nature experience; sustainably managed and interconnected forests provide effective protection against avalanches for the local population; and ecological corridors act as "green lungs" in heavily settled Alpine valleys.

Regions are beneficiaries:

Finally, a well-structured landscape can define the character of an entire region, as is the case for terraced vineyards or hedgerow landscapes. They are an unmistakable part of the local identity and play an important role in tourism (ALPARC 2013).

There are numerous beneficiaries according to the scale of the implementation of a sustainable and modern nature protection policy in the Alps applying the concept of ecological connectivity – not just the protection of fauna, flora and habitats in an isolated manner.

1.2.4 Conclusions: Nature protection with the people and for the people

Nature protection including a governance concept and a sustainable management system of the Alpine space as a foundation of a modern approach to nature protection is future orientated. EU Strategies like the EU2020 biodiversity strategy are potentially aligned with the needs of the Alpine space in terms of sustainable and inclusive growth. Nevertheless these large scale strategies need more regional and local involvement. Targets like the maintenance and enhancement of ecosystems and their services, with special commitments to establish green infrastructure and to restore 15 percent of degraded ecosystems (target 2 of the EU Biodiversity Strategy 2007 to 2013), are logical on a European scale but absolutely must be translated to the territorial level and should include concrete processes in cooperation with local stakeholders.

The Alpine nature protection is, of course, part of EU policies and has its own framework convention: The Alpine Convention [*www.alpconv.org*] with its protocol on Conservation of Nature and the Countryside. However, this means that funds must be available to implement the binding directives of the Alpine Convention as much as those of national laws. Legal obligations have to be fulfilled, even if they encounter resistance from diverse stakeholder groups.

Today the most important barriers to a successful implementation of nature protection are very often social and cultural ones. The endless pitting of economic interests against nature protection doesn't generate solutions. All too often, this exchange promotes polemic debate and projects inaccurate impressions of EU nature protection policies. Political courage is required to implement some of the most urgent nature protection goals and to convince local stakeholders of their value.

The preservation of one of the largest connected natural areas in Europe and its diversity is the central goal of the Alpine Convention. The needs of inhabitants and the meaning of the Alps as an economic space are also primary considerations. Therefore, different protocols

Landscape of the Pfyn-Finges Nature Park in Switzerland. The numerous small landscape structures (hedges, forest patches, meadows) offer good movement opportunities to many species.

Environmental education is a key mission of the Alpine Protected Areas as seen here in the Swiss National Park. Nature protection challenges need to be explained to the larger public but also to the local populations.

have been developed taking into account both the ecological aspects and the economic, social and cultural framework of the Alps.

Key economic sectors (agriculture, forestry, fisheries, energy, transport, construction and tourism) may often have conflicting goals and therefore be unable to coordinate adequate measures to respond to biodiversity targets and long term environmental planning. A trans-sectoral approach is the most important issue and a key element to success of any long-term strategy for environmental and ecological improvements for the Alps. Numerous potential synergies between biodiversity conservation, spatial planning, tourism and agriculture are currently under-utilised (Svadlenak-Gomez *et al.*, 2014b).

We must be wary of exclusion, bias, and lopsided argumentation. Networking is certainly part of nature protection. However it should not exist only between environmentalists, but should rather extend in a larger sense. Candid and progressive discussions between all involved parties are essential to success in Alpine nature protection.

Some points to be noted:

- Nature protection cannot be achieved through protected areas alone
- Alpine nature is, on some level, a product of centuries of cultural efforts – this makes nature protection complex and important
- Local stakeholders and populations need to participate in any approach to Alpine nature protection in order for it to be successful
- EU policies and international conventions are useful but must be coupled with local involvement and concrete actions
- Trans-sectoral approaches are essential to success.

1.3 Alpine Protected Areas: The long road to modern conservation policies in the centre of Europe

// *Guido PLASSMANN* //
Alpine Network of Protected Areas ALPARC, Chambéry, France

Opinion is divided among local residents, but town dwellers are appreciative: the Alpine Protected Areas have to tackle many different, contradictory and often emotive issues. The concept of Alpine parks and reserves only dates back to the early 20th century, with the first Alpine national park created just 40 years after the idea initially emerged on the international scene with Yellowstone National Park (1872) in the United States. Local residents and visitors often have different views of the protected areas and their usage. Nevertheless, protected areas in the Alps are here to stay, and have been a key economic factor in the development of small Alpine regions for several decades now. Perceptions of the areas vary from one country to another and from one era to another. Their objectives are constantly evolving, both in terms of preserving the unique cultural and natural heritage, and also as a reflection of changing social needs. The Alpine Convention, created in 1991, demands greater cooperation between the Alpine Protected Areas in order to create a genuine trans-Alpine strategy for nature conservation and sustainable development. National and regional parks, as well as nature and biosphere reserves increasingly form the cornerstones of environmental and economic policy in the Alps, but are also a reason for such policies. One very recent development is the realisation of an Alpine ecological continuum: creating links between territories with high nature value and functioning ecosystems using specifically managed protected areas as core areas with stepping stones such as nature reserves and Natura 2000 sites as elements to achieve this important challenge of this still new century.

1.3.1 Short history of Alpine Protected Areas

There are many different approaches to protecting natural environments in the Alps, and they have developed over time (see map 2). It all began in 1914 with the creation of the first Alpine national park in Switzerland, which is still the only national park in that country today. The park was the first self-contained reserve to be established in Europe and the first Alpine national park. The impetus was provided by the Swiss research society (*Société Suisse de Recherche*) and the Swiss Association for Nature Conservation (*Association Suisse de Protection de la Nature*). Other pioneering Alpine projects included the creation of the "Königssee plant protection reserve" (which went on to become the core of Berchtesgaden National Park) in 1910, and la Bérarde Park, established in 1913, which marked the starting point for France and later became the central zone of the Ecrins National Park. The Gran Paradiso National Park was created in Italy in 1922 and built upon the hunting reserve established in 1856 under Vittorio Emanuele II to protect the last ibex in the Alps, whilst the Stelvio National Park was created in 1935 under Mussolini's regime to protect a vast area owned by South Tyrol and Lombardy. Stelvio is still the largest Italian national park, although it has struggled to gain acceptance and has been hampered by complicated legislation that has generated conflicts regarding land use (ski resorts, hunting and agriculture). Nevertheless, these large national parks, created prior to World War II, were characterised by the concept of conserving islands of more or less intact nature, and land use conflicts were locally limited.

Most Alpine national parks were created decades later in the 1960s and 70's: Triglav (Slovenia) 1961; La Vanoise (France) 1963; the Ecrins (France) 1973; Berchtesgaden (Germany) 1978, and Mercantour (France) 1979. These more recently developed entities encountered greater conflicts regarding land use, as they became a regional or even national focus of economic competition particularly with winter sports activities. It is hardly surprising that, at the time, some parks were initially seen as a means of offsetting the burgeoning development of tourism, which placed a lot of pressure on the environment.

The following decade saw the establishment of the three sections of the Hohe Tauern National Park (Carinthia in 1981, Salzburg in 1984 and Tyrol in 1991). Unlike their predecessors, these new parks initially combined the notion of a cultural area with a less rigorous conservation focus. Some hunting was permitted, albeit subject to strict rules, and traditional

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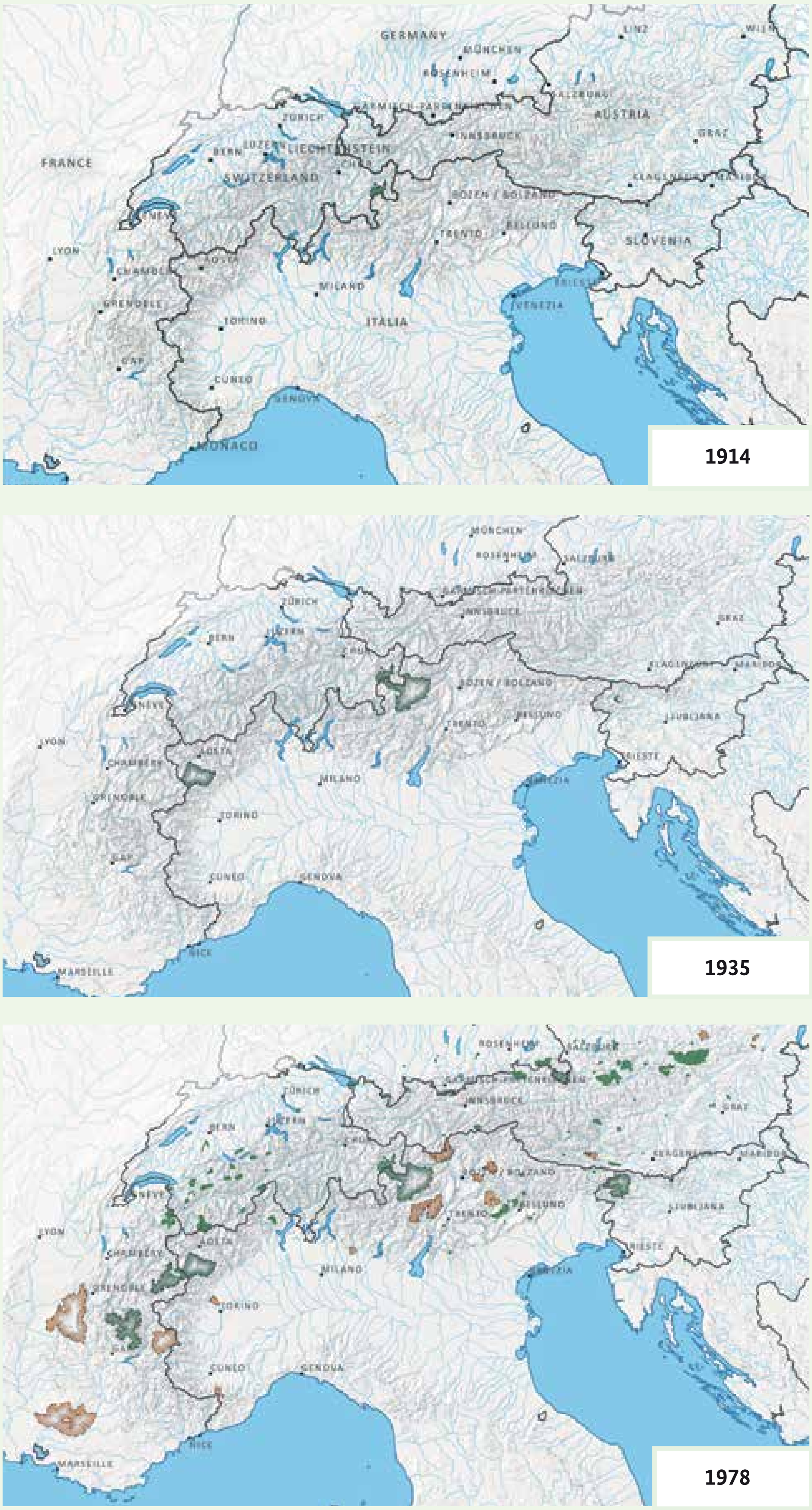
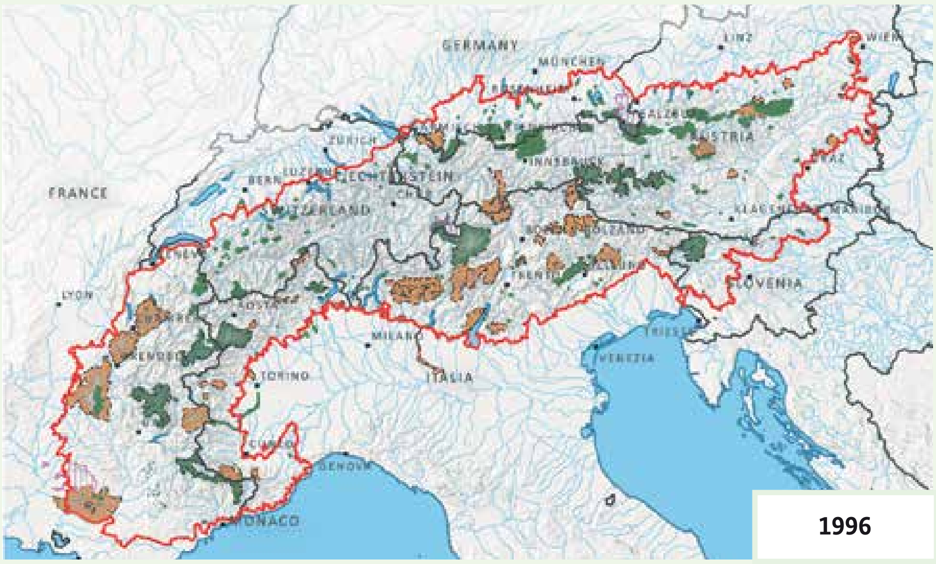
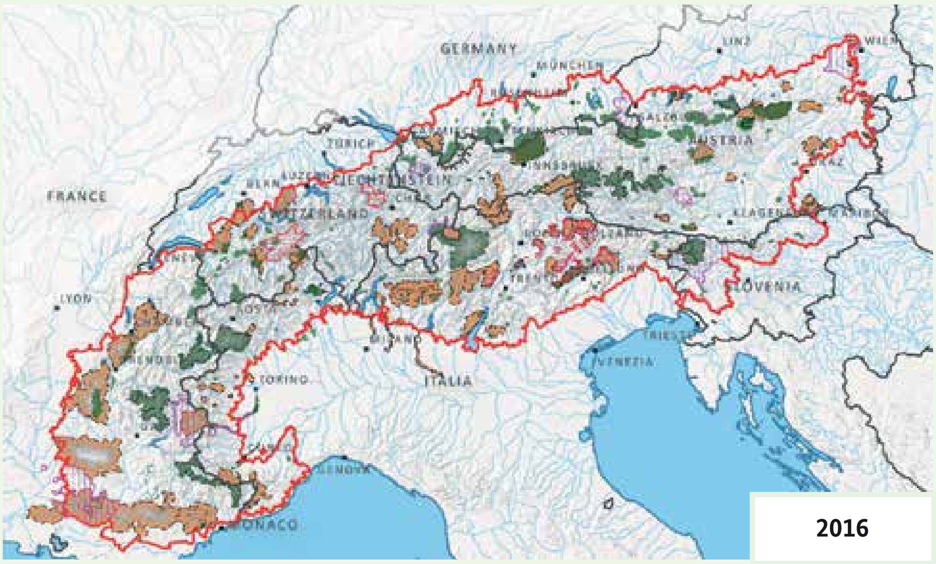
// **Map 2:** Historical evolution of Alpine Protected Areas







Alpine Protected Areas

- Nature reserve
- National park – Core area
- (Regional) Nature park
- UNESCO Biosphere Reserve
- UNESCO World Heritage Site
- Major city
- Major river
- Water bodies
- Alpine Convention perimeter
- National border

Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: These maps make no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

forestry practices continued. In Carinthia, the Nockberge National Park was created in 1987 in the wake of a local protest against the creation of a massive skiing area (in a referendum, 94 percent of citizens voted against the creation of the huge skiing area). Nevertheless, the national park's protected status was always relatively weak, and it was changed to a biosphere reserve in 2012 (*Biosphärenpark* is the official Austrian denomination).

The last wave of national park creations occurred in the 1990s: the Italian Dolomiti Bellunesi and Val Grande (in 1990 and 1992 respectively), and the Kalkalpen (1997) and Gesäuse (2003) in Austria. The most recent national parks in the Alps have returned to a strong conservation emphasis. The Val Grande National Park contains the first integral nature reserve[2] in the Alps (del Pedum, covering 973 hectare), established in 1967. Otherwise, only the Ecrins National Park has a similar integral nature reserve (Lauvitel, 700 hectare). The status of these integral nature reserves is matched only by the Swiss National Park, with visitors forbidden to leave the marked paths. At the end of the 20th century, after a period during which national parks were less strictly regulated, we saw a return to the original formula: the notion of wilderness referred to in the first Alpine national parks. This can also be seen in the international recognition awarded to the three sections of the Hohe Tauern National Park in September 2006 following the introduction of stricter rules within the protected area.

The improved complementarity between strict nature protection, zoning of the protected area and sustainable development models that has emerged between Alpine Protected Areas since the late 20th century has also facilitated a return to the roots of strict nature protection systems, which since the beginning of the 21st century have focused increasingly on terminologies like "wilderness" or "non-fragmented habitats".

There were no harmonised conservation instruments in Austria to match the French regional parks – a different type of protected area focusing more on local development – that have evolved considerably in France since the 1970s and marked a turning point in the history of land conservation in the Alps. In Austria the concept of the national park had to be adapted to a country that had not experienced a rural exodus and where the federal structure (regional government) precluded the creation of a centralised State model. As a consequence, an integrative process involving the communities and the inhabitants of the park area took place, but was initially unable to incorporate strict nature protection in the first Austrian national parks. These parks only gained the IUCN category II (see below) some years later, after having been classified in category V.

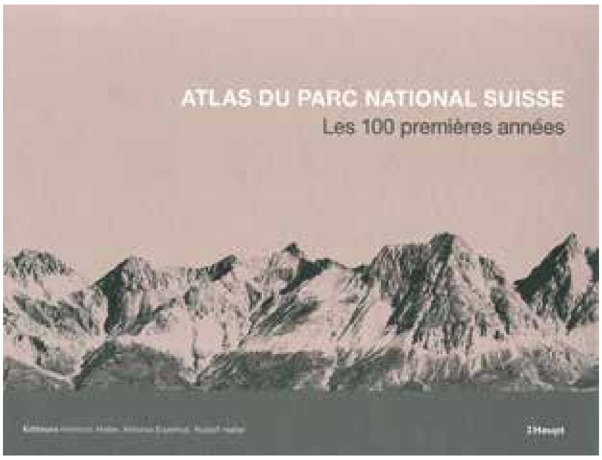
Since the late 1990s, a series of nature parks have been created in Austria based on the notion of sustainable development. At the same time, the national parks are striving for a stricter conservation status that will also allow them to be recognised as a national park by the World Conservation Union (IUCN category II) if the park complies with the criteria for hunting-free areas (for example Hohe Tauern).

Particularly since the early 1980s, the Italian Alpine regions have committed themselves to establishing a multitude of natural and regional parks. These parks have a stronger conservation status than all of their French and most of their Austrian counterparts, but management varies from region to region, and from one province (autonomous and otherwise) to the next. Nevertheless, the parks are an effective tool for conserving habitats and species. Many areas are involved in pioneering work such as the *Adamello Brenta*, where bears have been reintroduced, and the *Giuli Prealpi*, which promotes high quality local products. By the late 20th century there were around 45 regional nature parks in the Italian Alps alone.

> **There is now a wealth** *of protected areas in the Alps – more than 28 percent of the Alps (in 2016) is protected in one way or another or has a special status.*

The level of protection varies to reflect the objectives and the cultural contexts but is often considered fairly low (protected landscapes, regional nature parks, biosphere reserves, tranquil zones, nature and national parks, biotopes, nature reserves, integral reserves and more recently the so called "geoparks").

The vision and implementation in the different protected areas vary hugely from one country to another, and from one Alpine region to the next. Thus the Alps have a diverse and highly complementary range of protected areas that seem to be well adapted to their specific Alpine situation and socio-cultural contexts. Nevertheless some harmonisation of the management and the goals, especially in trans-border regions would make sense.



A hundred years ago the Swiss National Park elected to allow the free evolution of nature inside its boundaries and to observe these processes. The atlas of the Swiss National Park documents the evolutions taking place in this large nature reserve in the centre of the Alps on a cartographic basis.

Furthermore, the planning (management plans, conservation zones) and use of sophisticated management techniques in some of these areas are increasingly cited as the international benchmark (species monitoring, restoring natural sites, geographic information systems, databases, interpreting satellite images and aerial photographs). The management methods and long-term planning support the creation of large areas where the regulations stipulate “no intervention” (as in the case of integral reserves). In the space of exactly one century (1914 to 2015), land conservation management has become much more professional and diversified.

1.3.2 Protected areas with special status

The UNESCO Man and the Biosphere Programme formed the basis for the development of biosphere reserves in the Alps from the early 1980s onwards. These reserves combine the conservation of natural resources in a strictly regulated area together with sustainable development measures and the continuation of traditional activities in the remaining area. The reserves are often superimposed on other structures, such as nature parks or reserves, dividing the area into different zones. Monitoring is usually the responsibility of the management body.

UNESCO also classifies natural and cultural monuments as “World Heritage Sites”, a label that is highly sought after by many sites, including Alpine Protected Areas. At present, only five sites in the Alpine region have been classified an UNESCO Natural World Heritage Sites: Jungfrau-Aletsch-Bietschhorn in the Bernese Oberland, the Monte San Giorgio in Ticino, the Tectonic Arena Sardona in Glarus (all Switzerland); the Dolomites in five Italian provinces and the Škocjan caves in Slovenia (in the karst region at the border of the Slovenian Alps).

In 1992, the European Union ratified the Habitats Directive, which is designed to protect natural habitats, flora and fauna in Europe. The EU also helped to set up the Natura 2000 network, which brings together sites representing the continent's ecological diversity. Many Alpine Protected Areas have been designated as Natura 2000 sites in part or in full and thus contribute to strengthen the coherence of the European nature conservation network.

There is a wide range of other protection statuses internationally. One of these is the European diploma, which, in addition to conferring protected status, constitutes a guarantee of quality for existing protected areas and the RAMSAR sites, which provide protection for wetlands. The latter tend to be underrepresented in the Alps. It is probable that further statuses will be developed in an effort to gain international recognition such as different labels defining areas of “wilderness”. The aforementioned “geoparks” received an official UNESCO label (UNESCO Global Geoparks) in November 2015. Nevertheless the protection level conferred by these special labels mostly depends on the local or regional management, the political willingness and the legal framework.

1st August 2014, the 100th anniversary of the foundation of the Swiss National Park, was celebrated with a big festival in Zernez, location of the National Park Administration.

The Triglav National Park is the only Alpine national park in Slovenia but is a model for national protected areas policy.

1.3.3 Different styles in different countries

In France, protected areas cover more than 800,000 hectares: about one-fifth of the French Alps. The high average altitude combined with a pronounced abandonment of rural areas made it slightly easier to create the three national parks. Particularly in the 1970s, their creation was seen as a means of countering the widespread development of ski resorts in the Alps. The same is not true for the eight inhabited regional nature parks, which were founded under local development policies from the early 1970s on. With the exception of the Queyras and the more Mediterranean parks of Luberon, Verdon, Prealpes d'Azur, the regional nature parks are all in the Prealps (Bauges, Chartreuse, Vercors, Baronnies provençales). The regional park of Alpilles abuts the Alpine area. Often located close to large conurbations, the parks tend to be popular with town dwellers as recreational areas. At least two further regional nature parks are due to be created in the next two years to complete the range of regional parks in the southern French Alps.

In Bavaria, the Alpine Plan (*"Alpen-Plan"*) established in 1972 divided the land into different zones, including tranquil zones (*Ruhezone*) which make up 42 percent of the whole area.

Under the plan, 19 extensive nature reserves were created or expanded, and the only German Alpine national park was established: Berchtesgaden. Today this most successful concept of territorial planning in the Alps seems to be under pressure, as persistently low snowfall at ski resorts prompts decisions in favour of new cable transports linking neighbouring skiing areas even in the most protected part of the plan.

Switzerland has a long history of nature conservation, and the reserves are usually fairly small, forming a more or less continuous network of protected areas in each canton. The one national park has the strictest conservation rules in the Alps. The UNESCO Biosphere

Entlebuch has existed since 2008 (as Biosphere since 2001) and the UNESCO Biosphere Val Müstair since 2010. Since the law of 2007, initiating the creation of further protected areas, a few regional parks have been created, mainly in the Swiss Alps (Binntal, Diemtigtal, Ela, Gantrisch, Gruyère Pays-d'Enhaut – since 2012 and Beverin and Pfyn-Finges – since 2013).

Two further national park projects, namely Adula and Locarnese are in preparation and will be submitted to local votes. Furthermore two to three projects are under assessment (Netzwerk Schweizer Pärke, 2016).

The responsibility for the four national parks in the Italian Alps is shared between the central government and the relevant regions, with an exception made for the Stelvio National Park, which has been exclusively under regional governance of the three concerned regions since February 2016. The concept of a regional park only appeared in the late 1970s. The number of regional parks varies from one region to the next, as does their status and objectives. Sometimes parks enjoy levels of protection comparable to a national park (as in the case of the South Tyrol and Trentino nature parks). Nature reserves tend to focus on specific protection issues (certain habitats or species).

In Austria, the federal *Länder* are responsible for managing protected areas. Whilst the conservation measures in the central zones of the national parks have been increased (in combination with extensive measures for preserving the cultural landscape in the peripheral zones), the same is not true in other protected areas that were often intended to counteract extensive development in mountain areas (for example tranquil zones in Tyrol). The creation of a substantial number of nature parks is increasingly a key factor in the rural development in Austria, but often the parks are understaffed and so cannot really make their presence felt.

The Triglav is the only Alpine national park in Slovenia, but is a model for national protected areas policy. Three regional parks focus on combining stable economic development and preserving existing resources. One nature park was created as a private initiative in the Logarska Dolina valley and is now managed by local families. There are also a dozen nature reserves with high levels of protection.

The Principality of Liechtenstein has mostly small reserves to fit in with the landscape. The country is very active in protecting the natural environment. Although a project for a national park was abandoned in the 1990s.

Finally, the Principality of Monaco, another Alpine Convention signatory, does not have any protected land areas (although it does have several very important marine reserves), but it is involved in projects to conserve the natural and cultural heritage of the Alps through the Alpine Network of Protected Areas and exhibits strong interest in activities such as ecological networks.

1.3.4 Future developments within the Alpine Convention and the Alpine Macro-Regional approach

The Alpine Protected Areas fairly accurately reflect the natural and cultural diversity found in the Alps. However, most of the large protected areas – particularly national parks – are at high altitude (two thirds of their surface area is higher than 2000 metres above of sea level). This raises questions as to their actual contribution as a habitat and refuge for certain highly endangered species that live at lower altitudes. In view of this, one of the Alpine Convention protocols (Nature Protection and Landscape Conservation Protocol) provides for the creation of a cross-border network of protected areas: a genuine ecological continuum[3] in the Alps. A subsequent effort to realise this ambitious goal has been exerted by the Convention and different organisations on an international level, mainly by ALPARC and its partners for nearly the last 15 years.

Such a trans-regional and transnational ecological network coordinated between the Alpine states will allow a more effective and pertinent conservation policy of functioning ecosystems and habitats and consequently the protection of biodiversity. For this reason, the realisation of a high quality ecological network is one of the central issues of the Alpine Convention's and the Macro-Regional nature protection policy (Policy Area 3: Environment and Energy, Objective 3, Action 7 of the European Strategy for the Alpine Region (EUSALP) Action Plan: "To develop ecological connectivity in the whole EUSALP territory") and is also a clear mitigation strategy to the challenges of climate change allowing species migration to more adapted climatic situations.

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1.4 The conditions for success of nature protection in the Alps

// Guido PLASSMANN //
Alpine Network of Protected Areas ALPARC, Chambéry, France

The success of nature protection policies probably depends directly on their capacity for regional or local implementation and, at least in the long term, on participatory processes. To insure cohesion of nature conservation quality and of the type of measures applied for the whole Alpine arch, a minimum of coordination and harmonisation of approaches between the Alpine countries is needed.

1.4.1 Different political systems need to cooperate and exchange competences

Today the competences for nature protection are spread through numerous territorial levels, and systematic coordination is lacking. While nature protection may be a topic of national relevance in some countries (France, Italy and Slovenia), it is more of a decentralised issue for the federal states of the Alps (Austria and Germany) within the "Bundesländer". For Switzerland nature protection is, apart from the sites of national importance, a concrete competency of the Kantons. Different levels of legal competences do not always permit international coordination between essential decision makers and policies. European policies, by definition, are drafted in order to improve a given situation or maintain existing features. Most environmental policies are, however, not tailored to specific landscapes or regions, and they don't need to be, because they are defining general and logical principals that can be implemented in all sorts of regions with or without adaptations. Mountains, like other landscapes, have ecological, economic and sometimes social peculiarities. Thus, the way in which policies are implemented and adapted by involved partners, stakeholders and decision makers is essential and needs to be coordinated in order to be efficient in an Alps-wide context.

1.4.2 Different historical and cultural backgrounds and use of the Alpine space should not be a disincentive for future-orientated policies

The Alpine space was, is, and will in the future be subject to very different interests of use. These interests are partially linked to different historical and cultural backgrounds of the Alpine regions. Historically, the Alpine countries developed different strategies for economic growth in the Alps (more or less specific, planned at a central level or based on regional or local initiatives) and different opinions on the use of the Alpine space. As a result, we are nowadays confronted with a fragmented space and a lack of common understanding of "what we will do" with the Alps.

The Alps can be seen as an economic site, as a recreational area, as a nature and wilderness area, and finally as a living place for 14 million inhabitants. The Alps are all these things, and the use of this space varies significantly from one region to another. Some

In the early 20th century, the bearded vulture (*Gypaetus barbatus*) was extinct in the wild due to human persecution. From the 1970's onward, on the basis of enhanced protection, it was successfully reintroduced to the Alps.

Research, environmental education and leisure offers figure also among the tasks of Alpine Protected Areas. Specific programs are proposed to the young locals and visitors addressing different topics like biodiversity or landscape.

regions are exposed to rural exodus (isolated pastoralism area without supplementary activities), others to extreme concentrations of activities (multi-functional tourist resorts and areas, industrialised valleys, energy production and more), and some areas strive to create regional economic development that will retain local population (in some Alpine valleys with innovative approaches).

> **Perspectives on the use of the Alpine space** *may differ, but common goals are crucial for the 'borderless' topic of nature protection.*

Through its implementation protocols, the Alpine Convention has tried to give such a common vision to the protection and the sustainable development of the Alpine regions since the early 1990's. In this forum, different strategies and planning processes developed in the Alpine states find a sort of common legal framework, as it is an international treaty ratified in almost all Alpine states. This means that the convention reveals (at least theoretically) the limits of certain national strategies (for example "plan neige", France; highway Alemannia, Italy) or, on the other hand, tries to include national spatial planning concepts in its policy like the Bavarian "Alpine Plan" or the Swiss National Ecological Network (REN).

In this sense, the convention is a basis for cooperation between the Alpine states, and it fosters future-orientated policies, which should be shaped cooperatively. The most important issue remains, nevertheless, a common identification of the inhabitants with the central goals of biodiversity protection and sustainable and regional development. This goal is difficult to achieve and constitutes a long-term process that will involve more than one generation.

1.4.3 Nature protection needs to evolve from a static to a dynamic approach and policy

Protected areas could and should be the core areas of local, regional and Alps-wide ecological networks today, covering extended functions as facilitators, mediators and laboratories with the goal of involving stakeholders and organizing regional development together with economic players. "Protected area administrations are indeed starting points for the development of successful governance models of connectivity at a regional level due to their interdisciplinary competences and know-how" (Künzl *et al.*, 2011).

Protected areas nowadays fulfil several missions – from strong nature protection (national parks and nature reserves) to more or less "soft" protected areas acting primarily as platforms for regional development, to extensive land use and regulatory protection wherever it makes sense. They are often well accepted by local people through a more or less developed governance process. Natura 2000 sites are part of this last category.

The "platform" function of regional development particularly supports the role of protected areas within regional negotiating processes, as it generates a dialogue with the surrounding communities. The platforms can often demonstrate new approaches of management for a territory and discuss alternatives to existing approaches.

Nonetheless, it is clear that protected areas are all too often "only" an island of protection in the middle of heavily used Alpine spaces (for example Vanoise National Park, numerous nature reserves). The potential of a sensible and well-reflected policy of ecological links (corridors) and measures in-between protected areas is not yet fully utilised in the Alps. This means Alpine nature protection policy is currently a static policy. Ecological corridors would actually be only one element of an Alps-wide ecological continuum and should be accompanied by local sustainable land management measures and specific provisions for the various local stakeholders (contractual protection, agro-environmental measures, and more). Nature protection requires adaptation and flexibility.

Another important issue is the fact that strongly regulated protected areas are mainly at higher altitudes. This does not reflect the reality of biodiversity, which is mostly present in middle and even low altitudes, where all the conflicts of land use are at their highest potential. It will be crucial to adapt the links between protected areas in order to establish the ecological continuum at a local level based on an assessment of local potential at all altitudes.

Creating more, even smaller, strictly regulated protected areas at lower altitudes is another way to compensate for the lack of large protected areas at low altitude. Nevertheless, it is vital to link those protected areas and existing natural areas (for example by ecological corridors) in low level zones (small, well-preserved biotopes, large natural reserves, greenbelt areas) in order to develop migratory routes between them and eventually create larger protected areas in the longer term.

In terms of the ecological continuum, this movement could be boosted through zoning and through establishment of buffer zones around protected areas in order to reduce the impact of neighbouring towns and villages. Protected landscapes and transition zones in biosphere reserves should be used to reach this future-orientated goal.

The protected areas are now an undeniable part of regional structures in the Alps. They are spread throughout the Alps and play a role in conserving endangered species as well as in preservation of social and cultural life in the Alps, which is being threatened by economic globalisation and land management policies.

Certain species that have returned after being eradicated by humans in the early 20th century now use the protected areas as places of sanctuary and in their migrations. However, these areas are generally too small in surface area, and their greatest potential lies in connection to one another. Creating Alpine ecological corridors is one of the greatest challenges facing the protected areas and the Alpine Convention – equivalent to that of European policy and the Alpine Macro-Regional strategy in the coming years.

Alpine Protected Areas are currently highly complementary due to their various missions and provision of numerous eco-system services. They are the key element of every future-oriented nature protection policy in the Alps insuring the survival of numerous species. Nevertheless, they will definitely need connectivity and will benefit from a dynamic policy of adaptation to new situations and threats.

1.4.4 Ecological connectivity entails networking and persuasion

To be successful in creating ecological connectivity, a strong involvement of diverse stakeholders is crucial. To ground connectivity projects in local and regional reality, the involvement of local stakeholders is essential, and this must be coupled with political support from ministries and regional administrations. Even more important is a continued dialogue process. Beside the fact that connectivity needs to be planned with adapted tools and legal frameworks, the implementation of ecological connectivity as a pre-condition for long lasting functioning ecosystems should be considered as a process of continuous exchange between different policy levels and communities that are being asked to undertake certain activities.

In order to test, apply and improve governance processes and real implementation of ecological connectivity, so called Pilot Regions comprising protected areas have been created all over the Alps. These have been labelled by the Alpine Convention Minister Conference. Such areas are launching stakeholder participation processes, including pilot activities for ecological connectivity such as the creation of continua between protected areas via special stepping stones (biotopes) or other species or habitat orientated measures. Some of these Pilot Regions have started to include the topic of ecological connectivity in all landscape planning documents.

Crucial elements of this exchange or governance processes generally and especially in Pilot Regions are:

Discussions during stakeholder workshop in the Pilot Regions Berchtesgaden/Salzburg and Northern Limestone Alps.

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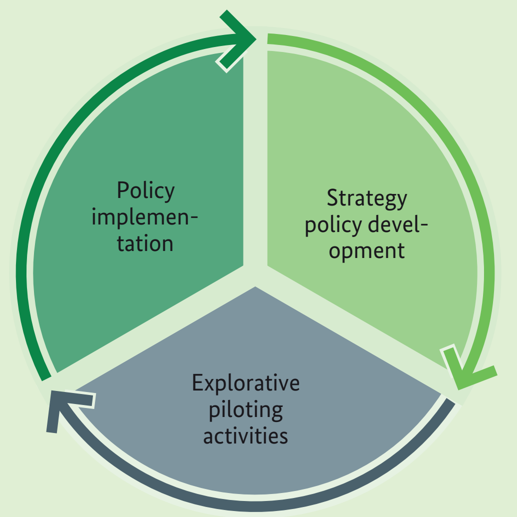
// Figure 1: Alpine Space Programme (ASP) Policy Cycle – Projects and policy making have to be linked



Source: Alpine Space Cooperation Programme 2014 to 2020

General awareness among stakeholders and the wider public about creating ecological connectivity

Most people are not rational, and don't make daily decisions based on logical scientific analysis. Instead they are motivated by a mixture of emotion, habits and social norms. It is how biodiversity makes them feel, not think, that leads them to act. Biodiversity is the world's most elaborate scientific concept, but also, potentially, its greatest story. For most people, a love of nature is about awe, wonder and joy, not habitats, ecosystem services or extinction (Svadlenak-Gomez *et al.*, 2014a).

Let's make people dream and act for biodiversity and life!

Support of protected areas as facilitators for nature conservation in extended regional contexts

Protected areas are a key element of ecological networks due to their spatial role in the network and their potentially catalytic function for the initiation and support of the process to maintain and restore ecological connectivity. For protected area administrations it has become obvious that the delimitation of Pilot Regions must thoroughly consider the territorial aspects of natural areas versus administrative boundaries, as well as the needs of participatory elements in the delimitation process and a clear distribution of competences and tasks within the group of involved persons and institutions (Künzl *et al.*, 2011).

Protected areas are more than just sites, they are animators and often initiators of new processes such as ecological connectivity!

Awareness of ecosystem services and sustainable use of Alpine resources delivered by well-established protected areas with high biodiversity

While society appears to appreciate the value of protected areas (for example sanctuary, recreation) and generally accepts the importance of biodiversity and the associated ecosystem services, there is little understanding of the dynamic needs of our environment. It appears prudent to raise awareness of the limitations of a static protected area approach to Alpine environmental protection in the face of rapid regime changes (Füreder *et al.*, 2011). Well-recognised protected areas can deliver a better understanding of the needs of connectivity linked to a sustainable use and protection of Alpine resources through their action and work in educational programmes for the wider public.

Protected areas are insuring a pedagogical mission through their numerous activities and their simple presence!

Cooperation between all sectors and improved links between the nature conservation scene and economic players

Pilot areas allow theory to be transformed into reality, and work in cohesive territories permits the involvement of relevant stakeholders and decision makers from different sectors. This dialogue process with the local population and stakeholders from different economic sectors helps to define goals and common actions in specific regions (Svadlenak-Gomez *et al.*, 2014a).

It is definitely necessary to overcome or better yet to break down the barriers between the nature protection orientated argumentation and convictions on one hand and the economic based argumentation and ambitions on the other hand!

This whole governance process should be managed as a natural developing process of exchange rather than exclusively according to rigid plans, goals, objectives, targets and schedules. Plans and objectives are important,

Laternser Tal, Vorarlberg, Austria

but they are not convincing without a strong involvement at the local level.

In the case of protected area regions, one opportunity is to integrate their management planning into the management of surrounding landscapes based on an ecosystem approach, which would lead to a more coherent integration of nature protection in the regional planning as a whole. Moreover, the private land uses, especially by agriculture and forestry, still need to be integrated in such approaches and planning concepts probably through participatory processes during the establishment of planning documents.

Parks and comparable structures may promote cooperation between different municipalities or across borders, but are in some cases faced with reluctance by municipal administrations to cooperate outside their own boundaries. Furthermore, cooperation may be hampered by unsupportive legal regimes, and the operational possibilities of park administrations are sometimes constrained by a lack of legal authority (Svadlenak-Gomez *et al.*, 2014a).

The success of improving biodiversity conservation depends not only on the work of different stakeholders and decision makers but also relies heavily on the support of the local population and various stakeholder groups. In order to gain their support (or at least strong approval) for complex issues of global importance such as ecological connectivity, this subject must be communicated in a tailored fashion.

Public awareness and education is therefore fundamental to persuading decision makers and the global public to take action on conservation. Biodiversity science may provide the foundations of understanding, and it is an essential basis for policy making. However, it rarely succeeds in inspiring public action on its own. Sound science is fundamental to understanding the consequences of biodiversity loss. It also has the potential to be a powerful incentive for conservation action, but only if the global population understands what science is saying, and only if people care about what it means (Svadlenak-Gomez *et al.*, 2014a).

The challenge consists in convincing people on the grounds of scientific knowledge to be part of the most important stakeholder group and to realise their ability to act and to influence the evolution of our source of life – to conserve biodiversity!

1.5 The science of connectivity measures

// Chris WALZER //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Ecology and Evolution, University of Veterinary Medicine, Vienna, Austria

In the final years of the 20th century the global number of protected areas had reached an impressive number of some 110,000 individual sites (UNEP-WCMC, 2016). These islands of protected land often resided in isolation within a patchwork of highly varied multi-use landscapes. During this period and in the first decade of the 21th century, the effects of anthropogenic global climate change also became clearly apparent. The various climate models and predictions delineated the ramifications of change on habitats and the species therein. This gave rise to a marked increase of interest in the resilience of landscapes to change.

It soon became clear to the scientific conservation community that biodiversity conservation would necessarily require large interconnected natural landscapes (Worboys, 2010). Within the International Union for the Conservation of Nature (IUCN), Andrew Bennett pointed out the importance of ecological connectivity: "… linkages have a role in countering climate change by interconnecting existing reserves and protected areas in order to maximise the resilience of the present conservation network." (Bennett, 2003).

In the Alps, the project ECONNECT reached a similar consensus for the patchwork of Alpine Protected Areas: "The project envisions an enduringly restored and maintained ecological continuum, consisting of interconnected landscapes, across the Alpine Arc region, where biodiversity will be conserved for future generations and the resilience of ecological processes will be enhanced" (Walzer *et al.*, 2011).

Initial reflections on connectivity date back at least to Aldo Leopold, who stated in his seminal conservation economics paper that:

> **"Conservation goals involving forestry,** *soils, game, and recreation require a minimum land area and connections across the landscape, something that public landownership alone cannot achieve" (Leopold, 1934).*

The scientific basis of connectivity or connectivity conservation dates back to the 1970s but remained a fringe and controversial approach until far more recently (Chester and Hilty, 2010). While formative contributions towards the field where made within the frame of the IUCN (Bennett, 2003; Bennett 2004), it was only in 2006, with the publication of a profusion of major texts, that the field clearly defined itself (Anderson and Jenkins, 2006; Bennett and Mulongoy 2006; Crooks and Sanjayan, 2006; Hilty *et al.*, 2006; Lindenmayer and Fischer, 2006).

Connectivity is broadly viewed as the spatial and temporal extent to which animals, plants (and/or their genes) and spatially widely distributed ecosystem functions such as soil and water processes can move between habitat patches. Various landscape structures such as: i) corridors, ii) greenbelts, and iii) stepping stones have been identified to facilitate connectivity (Chester and Hilty, 2010). Certainly the most controversial of these approaches is the corridor concept, which lacks a consensus definition and subsequently is defined along a functional gradient anywhere from "… any space, usually linear in shape that improves the ability of species to move between patches of habitat" to "large, regional connections that are meant to facilitate animal movements and other essential flows between different sections of the landscape" (reviewed in Chester and Hilty, 2010). Dobson *et al.*, (1999) characterised the scope at which connectivity can operate by defining the following increasing scales: i) connectivity between habitat patches, ii) connectivity at the landscape mosaic scale and iii) connectivity at large or regional (many countries) scale.

The theoretical basis for connectivity science was originally based on the island biogeography theory, which stated that the number of species on a marine island was directly related to the size of the island and its proximity to the mainland (MacArthur and Wilson, 1967). However, after difficulties became apparent when applying island biogeography to terrestrial habitat islands, biologists developed the theory of metapopulations – the study of connected and unconnected populations of individuals of the same species (Handski, 1998). With time, additional concepts from landscape ecology (i.e. matrix, patch and corridor) have been formally integrated into the study of connectivity (Forman, 1991).

Based on island biogeography, metapopulation theory and landscape ecology, Chester and Hilty (2010) have elegantly summarised the raison d'etre of connectivity in a single word: "movement". Moving through a landscape can be described from various angles, most notably in terms of structural connectivity and functional connectivity. The former is related to the physical distribution and form of structures and habitats in the landscape, while the latter denotes the behavioural response of individuals, species and ecological processes (Chester and Hilty, 2010). Functional connectivity has been subdivided into habitat connectivity – connectedness of species-specific habitat patches – and ecological connectivity – connectedness of ecological processes (Chester and Hilty, 2010; Crooks and Sanjayan, 2006; Lindenmayer and Fischer, 2006).

Since 2008, when ten papers were published, there has been a substantial increase in scientific studies and publications related to connectivity and conservation, with some 35 papers published in 2013. This significant increase was related to the novel approaches based on graph theory and circuit theory, and on new approaches to spatial conservation planning (Correa Ayram *et al.*, 2016). Interestingly, about half of the reviewed papers (n=162) identified and proposed connectivity measures, though validation and implementation studies were largely lacking (Correa Ayram *et al.*, 2016).

Due to its diverse background, varied theoretical core principles and the multidisciplinary approaches, connectivity science still struggles when framing goals and defining clear objectives. Arguably, a large number of studies have demonstrated species loss in isolated habitats and shown that even the largest protected areas in the world are often too small to maintain viable populations of far-ranging species (reviewed in Crooks and Sanjayan, 2006). Furthermore, individual studies have shown clear benefits of interconnected larger habitat patches, inter alia: urban avifauna (Evans *et al.*, 2009); amphibians (Parris, 2006), mammals (Magle *et al.*, 2009). However, implications of landscape connectivity are often viewed as "self-evident for conservation", while actual empirical evidence that connectivity measures benefit biodiversity conservation is, in many cases, still largely lacking (Correa Ayram *et al.*, 2016). That being said, there is today a strong consensus amongst biologists and conservationists that the potential benefits of connectivity measures far outweigh possible negative effects (for example Chester and Hilty, 2010). Certainly, some of the major challenges remaining in connectivity science today are validating the numerous published model approaches in planning connectivity and ground-proofing the actual effects of such approaches on biodiversity.

In this context it is essential to understand and embrace the notion that in the complex and dynamic realm of environmental sciences, validation of theoretical data is more often than not difficult and demanding on many levels. Consequently, the precautionary principle, a statutory requirement in European Union law, must apply in decision-making processes (Recuerda, 2006). This precautionary approach, in the face of lacking empirical evidence with respect to connectivity measures, has been argued previously to policy-makers by ECONNECT. The project consortium assumed that: i) larger tracts of interconnected and permeable landscapes in undisturbed and human-dominated landscapes maintain more biodiversity than fragmented landscapes, enabling regeneration and renewal to occur after ecological disruption. Following disruption, smaller less diverse ecosystems may suddenly shift from desired to less desired states, and their capacity to generate total economic value may decrease, ii) functioning ecological processes are the foundation for the adequate provision of ecosystem services. Subsequently, this implied that iii) active adaptive management and governance of resilience must not be limited to individual elements of an ecological network (corridors, core zones), but must necessarily be applied to the entire territory (matrix) and across all sectors of society, while enabling non-exclusive, multi-functional spaces for sustainable economic and recreational activities in Alpine communities, and iv) in the face of marked global anthropogenic change and applying the precautionary principle, policy makers are urged to initiate wide-reaching decision-making processes and implement any needed policy changes on a legal/institutional level to sustain desired ecosystem states and transform degraded ecosystems into fundamentally new and more desirable configurations.

1.6 Fostering cooperation globally – A memorandum of cooperation between the Convention on Biological Diversity, the Alpine Convention and the Carpathian Convention

// **Bettina HEDDEN-DUNKHORST** //
Federal Agency for Nature Conservation,Division of International Nature Conservation, Bonn, Germany

The Convention on Biological Diversity (CBD), which became effective in 1993, is the largest and most comprehensive international convention related to biodiversity. Its three major goals are: 1) the conservation of biodiversity, 2) the sustainable use of its components, and 3) a fair and equitable sharing of the benefits arising from the utilisation of genetic resources. At the 9th Conference of the Parties of the CBD held in Bonn in 2008, the Alpine Convention, the Carpathian Convention (Framework Convention Carpathians, 2003) and the CBD signed a Memorandum of Cooperation (MoC). This agreement aims to foster cooperation and to create synergies in terms of exchange of experiences and best practices, capacity development and project implementation related to biodiversity. Building on the CBD's Program of Work on Mountain Biological Diversity (CBD, 2004) and the experiences of the two European conventions, the MoC specifically stresses the importance of an ecological network as a means to facilitate continuity and connectivity of natural and semi-natural habitats at national, regional and global levels. Fostering regional cooperation and national implementation by member states are goals central to the CBD's mandate (CBD, 2010).

To date, joint activities among mountain regions in response to the MoC have focused primarily on Alpine and Carpathian initiatives. Yet, there is substantial scope for mutual exchange and learning including other mountains around the world. In the Alps, for instance, substantial competence on ecological connectivity has developed in terms of: stakeholder participation, capacity development, Geographical Information System (GIS)-based planning instruments and the establishment of Pilot Regions (Ulrich-Schneider *et al.*, 2009). These experiences could be useful for other mountain regions. Equally though, more holistic, non-sectoral, ecosystem oriented approaches towards sustainable development – that integrate land-use and climate change – as outlined in the CBD's Program of Work on Mountain Biological Diversity and pursued elsewhere, could be valuable approaches for European mountain regions. The recently adopted Sustainable Development Goals (United Nations, 2015) – especially target 6.6 and 15.1 – and Paris Climate agreement article 5.1 on adaptation provide added impetus for effective implementation and for achieving the Aichi Biodiversity Targets of the CBD's Strategic Plan for Biodiversity 2011 – 2020 and the Sustainable Development Goals in mountain ecosystems (United Nations Framework Convention on Climate Change, 2015). Furthermore, as part of the preparation of the 6th Report on the State of the Alps on greening the economy, an initiative to mainstream biodiversity conservation in the Alpine region into other sectors has begun a new project that aims to identify the contribution of multisectoral measures to foster ecological connectivity for greening the economy.

Signing ceremony of the Memorandum of Cooperation between the Convention on Biological Diversity, the Alpine Convention and the Carpathian Convention.

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1.7 Exchange and experience on ecological connectivity in the Carpathians

// Ján KADLEČÍK //
State Nature Conservancy of the Slovak Republic, Banskà Bystrica, Slovak Republic

The Carpathian Mountains extend across seven countries of central and south-eastern Europe (Czech Republic, Hungary, Poland, Romania, Serbia, Slovakia and Ukraine) and can be considered a relatively well preserved region with rich and unique natural and cultural diversity and connectivity of ecosystems. The rapid development of the region during the last few decades has increased landscape fragmentation, limiting dispersal and the genetic exchange of wildlife (Köck *et al.*, 2014).

Ensuring continuity and connectivity of habitats and species, cooperation of contracting parties in developing an ecological network in the Carpathian Mountains and protection of migration routes are among the key principles of the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention). These principles are transferred into relevant articles of the Convention and its thematic protocols, including the Protocol on Conservation and Sustainable Use of Biological and Landscape Diversity, or the Protocol on Sustainable Transport. The Carpathian Convention is a sister convention to the Alpine Convention, using its experience and expertise of institutions involved. Collaboration in the field of ecological connectivity is also

This green bridge across the Vienna-Bratislava motorway in Austria is one of the measures implemented within the framework of the "Alps-Carpathians Corridor" project to re-connect the eastern reaches of the Alps to the Western Carpathians.

included in the Memorandum of Understanding for the cooperation between the Alpine Convention and the Carpathian Convention signed between the Secretariats of both Conventions. For implementation of these principles several projects have been developed and implemented in particular during the last decade.

Important steps *towards maintenance and development of suitable landscape structures, building of green bridges and land use plans in the space between the Alps and the Carpathians were projects supporting the Alpine-Carpathian corridor (AKK) implemented between 2008 and 2013.*

The aim of the AKK projects was to safeguard the ecological connectivity between the Alps and the Carpathians within the CENTROPE region. The projects strengthened conservation management for the protected areas along the Alpine-Carpathian Corridor and neighbouring habitats. The strategy was to secure migration and genetic exchange among wildlife populations through the construction of several eco-ducts (green bridges) over motorways in Austria and Slovakia and through the creation of suitable habitat patches or stepping-stones for migrating animals and through increased public awareness.

A cross-border action plan with a comprehensive compilation of necessary actions to preserve and re-establish ecological networks has since been elaborated. It now creates the framework for joint implementation of proposed measures along the Alpine-Carpathian corridor up to 2022 in both countries. The Memorandum of Understanding was signed in January 2012 between the respective ministries, regional authorities and highway companies of Austria and Slovakia expressing strong political commitment towards safeguarding the corridor. By 2014, the project on extension of the Alpine-Carpathian Corridor following the original AKK Basic and CENTROPE projects was aimed at safeguarding the corridor and the connection to the core area of the Carpathians in the area where intensification of agriculture, increasing land use for settlements and commerce in combination with the highway in Slovakia were assessed as causes for lack of connectivity (Alpine-Carpathian Corridor Project, 2016).

"Integrated management of biological and landscape diversity for sustainable regional development and ecological connectivity in the Carpathians" (BioREGIO Carpathians) is another good example of useful exchange between the Alps and the Carpathians.

The project (implemented from 2011 to 2014) facilitated communication and discussion of experience of the Alpine countries through the project partner (EURAC Research) and several exchange workshops. In this project the analysis of connectivity in the Carpathians was carried out based on GIS model and completed by site visits in pilot areas (Köck *et al.*, 2014). The Habitat Suitability Model was used, applying the ArcGIS 10.0 tool *Corridor Designer*, allowing the assessment of habitat quality for selected species. This model serves as basic layer on which the most probable corridors (least-cost paths) for species migration were identified. Once the suitability model was created, those areas having the highest suitability and certain ecological characteristics were selected as core areas (best habitat patches with the highest probability of occurrence). Then the most probable paths for wildlife dispersal were identified using ArcGIS 10.0 tool *Linkage Mapper*. The tool identified adjacent core areas and created maps of least-cost corridors between them. The result of the application of these tools is a network of least-cost paths. The resulting value of each grid cell expresses the level of connectivity between core areas and indicates which routes encounter more or fewer features that facilitate or impede dispersal for the umbrella species in the study area. In the project the analysis was made for several species, including Eurasian lynx, grey wolf, brown bear, Eurasian otter, western capercaillie, chamois and European hare. Habitat suitability models were produced for all of these species. The basic approach underpinning this study was based on the assumption that, in contrast to the Alps, ecological connectivity still exists in the Carpathians, and the project had to identify the migratory paths, which ought be protected.

Besides the physical barriers, economic and social aspects –which also represent potentials and barriers – were analysed in the Carpathians based on rapid social and economic transformation processes in the last 20 years. For the analysis, an "on field" approach was chosen, combining interviews with researchers and professionals working in the Carpathians. The analysis highlighted the fact that various economic sectors affect ecological connectivity. As a result, it became obvious that development of plans for promotion of ecological connectivity and the prevention and avoidance of human wildlife conflicts are primary objectives in strategies to reduce social and economic barriers. These conflicts mostly result from a lack of coordination, planning and monitoring of the co-existence between human activities and wildlife. Four main objectives were identified to modulate economic and social activities:

1. Planning: The concept of ecological connectivity should already be considered in the planning phase – particularly for new transportation infrastructure or urban expansion, but also for the extension of agriculture or forestry activities. The availability of subsidies offers support for connectivity-friendly measures in these fields and could support a preventive approach to reduce conflicts between humans and wildlife.

2. Intervention: A quick and clear response in case of an emergency resulting from the interaction between human activities and wildlife can have a positive impact on the attitude of citizens towards ecological connectivity.

3. Awareness: It is crucial to raise the awareness among all relevant stakeholders, mainly of those involved in infrastructure planning, urban expansion and policy development at different levels.

Densely urbanised landscape in the region located between Vienna and Bratislava. As a part of the EU Strategy for the Danube Region (EUSDR), the Alps-Carpathian-Corridor is being restored to support ecological connectivity and the sustainable development of the whole region.

4. Monitoring: The analysis has shown the potential in strengthening data collection at the Carpathian level and in involving local population for the monitoring of wildlife presence, applying a simpler, clearly structured and efficient reporting system of damages.

Infrastructures should be well integrated into existing ecological structures like stepping stones and linear corridors. There is opportunity to redesign the roads

// Map 3: Species analysis: Habitat Suitability Model for different species in the Carpathians

Landscape suitability for wolf with least cost path options and core areas

Landscape suitability for otter (general)

Source: BioREGIO Carpathians WebGIS

to provide safe passage for all, to reduce the costs and to tailor each type of crossing to the specific species in each of the various landscape contexts. This implies a continuous monitoring of the wildlife species present in a certain area. The provision of crossing infrastructure at key points along transportation corridors should be coupled with a large campaign of environmental awareness to emphasise the fact that the best prevention system is always a correct driving behaviour.

Alpine experts were involved in consultation processes in the Carpathians and exchange of experience of the Alpine countries from projects on ecological networks helped to formulate measures for the Carpathian region. In order to continue cooperation and exchange, new proposals for follow up projects supporting implementation of measures concerning improvement of ecological connectivity in the Carpathian region and between the Alps and the Carpathians have been developed together with partners from Alpine countries. The aim of these projects is to address the increasing habitat fragmentation and biodiversity loss and to improve the restoration and management of mountain ecological corridors, including threatened wetland habitats of transnational relevance in the region.

There is still the necessity to identify critical mountain ecological corridors for flagship species in the Carpathians, to strengthen the knowledge base and to collect data and information with regard to green infrastructure development. To this end, an improved integration of ecological corridors and wetland habitats in spatial development processes and infrastructure planning needs to be realised. There are some examples of severe conflicts between transport infrastructure plans and nature conservation interests as well as EU directives in the Carpathian countries leading to lengthy delays for construction projects. Therefore, integrated transport planning is necessary. The Protocol on Sustainable Transport to the Carpathian Convention calls for guidance and action planning to secure its implementation. Building on significant experience and knowledge of previous and ongoing projects in the Alps and the Carpathians, cooperation can help in achieving a safer and biodiversity-friendly road and railroad network by improving planning frameworks and developing concrete solutions. An interdisciplinary approach involving planners, economists, engineers and landscape architects provides the necessary knowledge and inter-sectorial dialogue (WWF DCP, 2015).

Landscape suitability for capercaillie (general)

0 100

Landscape suitability for bears during summer months with least cost path options

bear(summer)-corareas
bear(summer)-least cost path

1.8 Ecological connectivity and large scale conservation – A planetary response to save nature

// *Gary M. TABOR* //
// *Meredith McCLURE* //
Center for Large Landscape Conservation, Bozeman, MT, USA

Ecological connectivity has become a cornerstone of conservation science and practice. Since the introduction of wildlife corridors as a game management strategy in the early 20th century, followed by the recognition of connectivity as a fundamental element of landscape structure in the 1990's, well over 1,000 scientific papers on corridors and connectivity have been published in the fields of biodiversity conservation and ecology. During this time, habitat loss and fragmentation have widely been agreed to constitute the single greatest threat to biodiversity worldwide, and climate change is expected to exacerbate these effects, as species' ranges must shift across fragmented landscapes to track suitable conditions. Although protected areas such as national parks have long been the primary focus of conservation, it is now widely understood that isolated reserves will not be sufficient to sustain some species and communities in the face of these combined threats. Land use modification around protected areas has reduced their ecological function via a range of mechanisms linking them to the degraded ecosystems that surround them, and specific climate envelopes for many species currently supported by reserves are expected to shift beyond reserve boundaries.

Corridors are intended to mitigate the effects of land use and climate change by facilitating movement of individuals among patchy resources and among populations, providing buffering effects from local extinction processes, supporting gene flow and thus genetic diversity, maintaining ecological processes such as migration, and enabling species and ecological community adaptation in response to climate change. Conservation strategies that maintain biodiversity in human-modified landscapes beyond protected area borders, particularly those aiming to maintain or restore connectivity between remaining habitat patches, are now considered critical in the face of future landscape change.

The conceptual underpinnings of corridors and connectivity have progressed tremendously over the past decades. In 1991, corridors were defined simply as linear landscape elements facilitating movement among habitat patches. Early corridor studies focused on monitoring wildlife use of de facto corridors such as fencerows, roadside vegetation, and linear remnants of logged forests. Early studies conceptualised corridors as discrete elements of the landscape connecting discrete patches of habitat embedded in a uniformly human dominated 'matrix', an approach that stemmed from their roots in island biogeography, and in metapopulation theory. As our understanding of connectivity science has become more refined, connectivity conservation is no longer a theoretical concept, but an essential ecological process that needs immediate conservation attention.

If Yellowstone National Park was a model of 19th century conservation and ecosystem-based management is the model of 20th century conservation, ecological connectivity has become the conservation approach of the 21st century. This approach is growing exponentially around the globe in response to large scale environmental change. From marine seascapes to terrestrial landscapes, ecological connectivity conservation is the preferred approach in supporting the ecological processes that sustain nature and people. In North America alone, there are over 300 self-identified large scale conservation efforts that embody ecological connectivity from the Canadian Boreal Forest to the Yellowstone to Yukon Conservation Initiative to New England's Wildlands and Woodlands effort. In other parts of the world, there are a comparatively similar number of large scale connectivity efforts from transfrontier conservation initiatives in Africa, the Coral Triangle in the South Pacific, the Great Eastern Ranges Initiative in Australia and ECONNECT in Europe. The reality of large scale conservation is that ecological connectivity conservation embodies multi-jurisdictional and multi-stakeholder collaboration; it utilises the best available science and local knowledge; and supports collaborative conservation practice.

If we are to have a global response to the myriad of impacts affecting the health of our planet, ecological connectivity conservation not only connects natures, it also connects people. We can save the planet by connecting this global community of conservation practice. We can save the planet by connecting one large landscape and seascape effort at a time.

// **Map 4:** The Yellowstone to Yukon conservation initiative along the western coast of the USA

Source: Ecology Center GIS, 2002

Box 1:

The hierarchical ecological networks – Ten years of experiments in Isère

// Guy BERTHOUD //
ECONAT-Concept, Yverdon-les-Bains, Switzerland

This text is issued from the ECONNECT Publication "Methodological guide of the hierarchical ecological networks" (Berthoud, 2010)

The ecosystemic approach to landscape is based on a number of principles developed by or applied in landscape ecology. The hierarchical ecological networks method is a new, more complex method for ecological network design, firmly founded on recognised scientific principles. The principles underlying the ecological networks approach have been described in detail in the final report of the Swiss National Ecological Network Project (Berthoud & al, 2004). Prior to that, the account of a partial practical application of the method was published in the context of the departmental ecological network of the Isère (ECONAT, 2001).

An account of a complete practical application of the "hierarchically organized ecological networks" method has not yet been published, but already exists in the form of technical charts drawn up for various partial applications. The ECONNECT project constitutes an opportunity to present the method as it was applied in its entirety and progressively calibrated over a period of ten years in projects focused on the French department of the Isère.

The approach was structured over two distinct stages:

- The cartography of the natural infrastructure of the landscape;
- The exploitation of available eco-geographical data according to a tri-factorial evaluation system weighted according to multiple criteria.

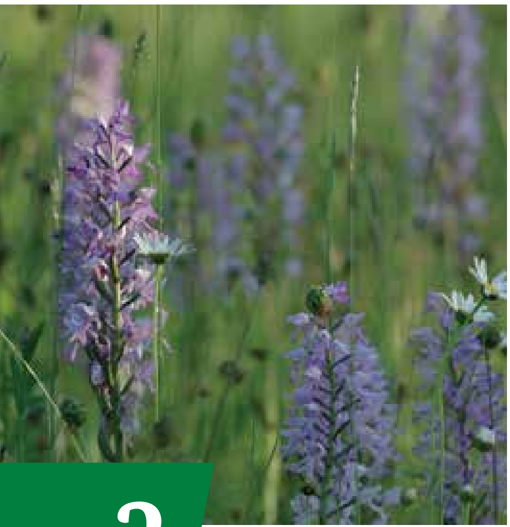
The analysis of landscape structure is based on the existence of a spatio-temporal entity termed a "continuum". A continuum defines a living space that is available in a landscape for a group of species sharing analogous ecological affinities. The variable frequentation of this theoretical living space is defined in terms of a graduated scale of frequentation intensity.

And this scale allows us to establish a differentiated standard zoning:

- A nodal or reservoir zone = Constant presence of populations;
- An extension zone = Regular frequent presence of populations;
- A continuum margin zone = Regular periodic presence of populations;
- Corridors = Episodic presence of populations.

The specific characteristics of each of these different zones are also related to different qualitative and functional criteria. This model of ecological spatialisation can be applied to a species guild, to a group of specialised species or to a single species according to the requirements of the analysis in question. A landscape territory always plays host to several characteristic species guilds. As a result, these species guilds necessarily occupy a number of favourable habitat continua. The aim of the hierarchically organised ecological network approach is to acquire a synthesising picture of the living spaces required for the development of specific chosen populations. The choice of the pertinent cartographical scale results based on a satisfactory compromise between the amount of necessary information about living spaces that needs to be collected and the level of scale that is pertinent and useful to the problems of planning in the territory under analysis. More often than not, the choice made is relevant to a relatively limited area, an area that allows the use of a mapping scale of 1:25,000. If the object were the entire Alpine region, however, the appropriate mapping scale would be 1:100,000, so as to obtain, for example, a synthesizing cartography to a scale of 1:300,000.

The analysis of the Pays Bièvre-Valloire region has been chosen to illustrate the complete methodology of the approach when applied at a scale of 1:25,000. Some of the examples described illustrate particular applications, such as the maintenance of the permeability of motorway networks to fauna or the restoration of biological corridors in highly urbanised zones. Finally an application at the communal scale describes the potential to better understand ecosystemic functioning at that scale. It is notably marked by the switch to a 1:5,000 mapping scale.



2

Current status of Alpine ecological networks

Introduction

Chapter 2 presents an overview of the Alpine activities concerning ecological connectivity that have been carried out in a coordinated manner over the last twelve years. Indeed, various actions have been taken in the Alpine context aimed at implementing a pan-Alpine ecological network as foreseen by the Alpine Convention, the international treaty signed by the countries of the Alpine Arc. Protected areas are given a specific role in this context, placing them as key players in a wider territorial context, the Pilot Region approach, and as such they are driving forces for the implementation of ecological connectivity. A central challenge of all pan-Alpine activities is to guarantee the coherence between the international actions and the various national, regional, provincial and local settings that differ significantly from one another. Nevertheless, a classification is proposed allowing a categorisation of Alpine areas according to their degree of vulnerability concerning ecological connectivity. Since the first steps in 2003, significant progress has been achieved, as the example of the project Netzwerk Naturwald in the Pilot Region Northern Limestone Alps illustrates concretely. The importance of the activities carried out in the Pilot Regions is highlighted by two local stakeholders giving a lively impression of concrete impacts on local and regional connectivity and the added-value of addressing this crucial topic at an additional Alpine international level.

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2.1 History and implementation of ecological networks in the Alps

// Yann KOHLER //
Alpine Network of Protected Areas ALPARC, Chambéry, France

2.1.1 Ecological connectivity in the Alps – 12 years of experience

The activities aimed at protecting and conserving the extraordinary Alpine biodiversity by insuring smoothly functioning ecosystems through ecological connectivity in the Alps are founded in the article 12 of the Nature Protection Protocol of the Alpine Convention: "Ecological network – The contracting parties shall pursue the measures appropriate for creating a national and cross-border network of protected areas, biotopes and other environmental assets protected or acknowledge as worthy of protection. They shall undertake to harmonise the objectives and measures with the cross-border protected areas."

Based on this article, the contracting parties of the Alpine Convention created the Alpine Network of Protected Areas ALPARC (see also article chapter 1) in 1995, gathering all large protected areas of every type of category in the Alpine Arc. For nearly ten years, the work of this network was limited to insuring thematic exchange and cooperation between its members. But in 2003 the protected areas identified the importance of the spatial dimension of the network of protected areas and started first activities with the objective of creating a territorial ecological network across the Alps, with the existing protected areas of the ALPARC network providing the core areas for this endeavour.

Inspired by the initiative of the Pan-European Ecological Network (Bonnin et al, 2007) and in the context of a general recognition of the importance of ecological networks for biodiversity conservation throughout the world, a first assessment of activities and initiatives in the Alps was completed in 2004 (Kohler, Plassmann 2004). Beyond giving an overview of the different methodologies and implementation activities employed at local, regional, national and international levels, this study also proposed first implementation recommendations and particularly a concept of the role of protected areas in such an Alpine ecological network: a model placing neighboring protected areas in a larger geographical context and proposing leverage of the Pilot Regions for ecological connectivity in the Alps (see Article 4.7).

The recommendations of the assessment were acknowledged by the Alpine Convention bodies and thereby obtained a political dimension culminating in the creation of a separate working group of the Alpine Convention on this topic in 2007: the Platform Ecological Network of the Alpine Convention (see article 2.6). This political body is important as it provides an official frame for the cooperation and acts as facilitator for the sharing, comparing and revising of crucial information on measures and methodologies between the different Alpine countries. Furthermore it provides a link between policy makers, the scientific community and the practitioners, fostering efficient cooperation with other sectors.

Meanwhile four large Alpine networks joined forces (CIPRA, ISCAR, ALPARC and WWF) in the Ecological Continuum Initiative (see box 5). This initiative developed an initial methodological approach for the implementation of a pan-Alpine ecological network (Ecological Continuum Project, 2009) and initiated communication efforts involving stakeholders, policy and also the broader public. Additionally, it inaugurated the cooperation between several Alpine Pilot Regions, which tested the methodology implementation on the ground, and it laid the groundwork for the first big international implementation projects.

At the international level activities fostering ecological connectivity in the Alps where carried out in successive large Alpine Space Projects like ECONNECT (2008 – 2012), recharge.green (2012 – 2015) and greenAlps (2013 – 2014). These projects significantly enlarged the community of actors involved in the efforts toward developing and implementing an Alpine "ecological continuum, consisting of interconnected landscapes, across the Alpine Arc region, where biodiversity will be conserved for future generations and the resilience of ecological processes will be enhanced" (Füreder et al 2011).

A coherent Alpine spatial approach for the evaluation of the potential of a given territory in terms of ecological connectivity is another prominent result of these projects: the GIS tool Jecami (see article 4.4) offers for the first time the potential for comparable analyses over the entire mountain range and consolidates the

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"Alpine" dimension of the activities in favour of ecological connectivity carried out by the Pilot Regions. This becomes even more important considering the accepted conclusion that efforts to restore and conserve ecological connectivity "cannot be limited to individual elements of an ecological network (corridors, core zones), but that active adaptive management and governance of resilience must necessarily be applied to the entire territory (matrix) and across all sectors of society, while enabling non-exclusive, multi-functional spaces for sustainable economic and recreational activities in Alpine communities" (Füreder et al 2011).

2.1.2 Working on different geographic levels, from the local to the European scale

One of the major forces of the process in the Alps is the vertical exchange between the different levels of intervention: close contact to local stakeholders via actions is vital in the Alpine Pilot Regions, but so too is the direct dialogue at the international policy level. Since 2004 with the first "political recommendations" (ALPARC 2004), specific messages were directed to Alpine and European policy makers on various occasions (Füreder et al 2011; Badura et al 2014), highlighting the particularity of the Alpine approach that enables protected area managers to play an active role in the local and regional ecological network by supporting and promoting the process and involving relevant stakeholders.

The feasibility of this approach has been proven in several Alpine Pilot Regions, such as the NetzwerkNaturwald Project supporting ecological connectivity in old growth forests in the Northern Limestone Area in Austria or the activities of the Foundation *Pro Terra Engadina* in the Swiss part of the Rhaetian Triangle Pilot Region.

The topics treated within the initiates and projects labeled "ecological connectivity" have evolved from strictly nature protection aspects to a broader range of themes: the aspect of climate change and the importance of ecological connectivity (for example the international conference "Ecological network in the Alps – a response to climate change that will conserve biodiversity?" in Berchtesgaden 2009), ecosystem services (for example the project recharge.green) and more recently the aspect of green economy (for example BfN project GreenConnect). This is also reflected in the involvement of additional stakeholder groups in the activities. Though most of these projects are still closely linked to the nature protection domain, the involvement of other sectors like tourism or hunting is increasing.

Working at the scale of an entire mountain range in a highly international context is a particularity of the Alpine approach that makes it interesting as an example of good practice for other regions in the world. Since 2008, the topic of ecological connectivity has also become a central aspect of the cooperation between the two mountain massifs of the Alps and the Carpathians, also explicitly mentioned in the Memorandum of Understanding signed between the Alpine and Carpathian Convention and the CBD the same year. This exchange has led to the development of similar initiatives in the Carpathians, for example the project BioREGIO.

The establishment of an ecological continuum across the Alps, although achievable only with huge collaborative effort, is just a first step in the realisation of a wider, pan-European network. A common vision for intact migration and dispersal spaces for all kinds of organisms is the foundation of a mountain network spanning across Europe from the Pyrenees over the Alps to the Carpathians. A trans-boundary approach towards ecological concerns is necessary along the mountain ranges crossing the continent. Already existing strategies at the European level, for example Natura 2000 network, Water Framework Directive, FFH-Directive, Birdlife Directive, need to incorporate the requirements for this pan-European mountain belt. At least 16 European countries with different languages and cultures have to work on a common topic as complex as nature conservation. In the Alps this exercise started in 2004.

The availability of interesting tools and results is only the first step toward a coherent Alpine approach for ecological connectivity. The second (and for the practitioners the most important) step is generating the political will in their regions to develop concepts and implement them with sufficient support from the different administrative levels. Closing the gap between the strategic administrative and policy level and the local and regional levels in all Alpine countries is an urgent requirement, which is constantly highlighted and addressed by the different Alpine initiatives. Projects, policy recommendations and working groups like the Platform Ecological Network can deliver valuable inputs, but cannot replace the motivation and means of national and regional governments. This is especially true in the field of nature and biodiversity conservation, where goals tend to be non-binding and are therefore ignored or postponed in favour of short-term economic gain (Svadlenak-Gomez et al 2014). But even given full political support, the realisation of the Alpine ecological network remains a multi-generation al challenge that may take decades to achieve.

2.2 Alpine Protected Areas and their contribution to the Alpine ecological network

// *Yann KOHLER* //
Alpine Network of Protected Areas ALPARC, Chambéry, France

Today the Alps are a largely protected area. Even allowing for the fact that protection of the natural environment is not the main vocation of a large number of these areas, the area of national parks and natural reserves that is specifically set aside for safeguarding biodiversity is considerable (seven percent of the Alpine Convention area). However, despite these efforts, biodiversity is continuing to decline. The main reasons in these mountain areas, as in the rest of Europe, are the destruction of natural habitats and the deterioration of cultural landscapes associated with the fragmentation of areas vital to fauna and flora (Jaeger *et al.*, 2005), phenomena that manifest themselves mainly outside the protected areas.

Maintenance of biodiversity depends, therefore, not only on the preservation of natural habitats (areas that support the largest number of animal and plant species) and traditional practices, but also on the interstitial areas that allow biological exchanges between these habitats. It is therefore important to respect the natural dynamics of the area as a whole (Burel, Baudry, 1999).

The traditional concept of an ecological network represents a system made up of core areas or zones – in general, protected areas – that guarantee the resources necessary for the survival of the species that it supports. In an ideal situation, these core areas are surrounded by buffer zones, creating a transitional area that limits the influence of neighbouring zones and minimises negative marginal effects. These different zones are connected with one another by linking elements such as ecological corridors or stepping stones that allow the movement of individual animals as well as genetic mixing within the network (Illustration of classic ecological network).

Since each species has different requirements with regard to the types of links it uses, it is not possible to define a single corridor as being a definitive migration path between different biotopes. Instead the needs of priority species and specific problems related to the local situation must be evaluated and addressed in an appropriate manner. This explains the dynamic character of these connecting structures, which implies a certain reversibility of spatial planning. It is not a question of creating other static conservation elements like the core areas of the network (classic protection areas such as parks or reserves) but more of providing solutions adapted to local problems (Bennet, 1999). This is even more important considering the fact that the major drivers of biodiversity decline are in fact situated outside protected areas.

In the context of ecological networks, this means that it is important not to simply concentrate environmental measures along the borders of fields or hedges, or on fallow land, but rather to encourage working practices that are sustainable and respectful of the environment over the area as a whole. To ensure that ecological interconnections function correctly, the concept of ecological networks thus provides for the conservation of core areas of substantial size, stepping stones with similar characteristics to the core areas, and corridors, combined with a more thoughtful use of the area. Discussions and measures undertaken around the theme of ecological connectivity give rise to a completely new perception of practices to protect the natural environment: the place and role of protected areas within their region are being redefined, placing them in a wider territorial context.

2.2.1 Alpine Protected Areas as key elements

Based on these findings, the role of protected areas has been defined in an Alpine context placing them in the heart of Pilot Regions. In concert these areas should bolster the Alpine Ecological Network.

These Pilot Regions are composed of several protected areas and other zones situated between and around these areas. This constellation represents a major challenge for these protected areas, because they find themselves confronted with unknown situations, forcing them to "take an interest in" areas situated beyond their administrative boundaries and to work together with new partners, in other words to change from a static approach to one based on dynamic exchanges. Among these new partners are the different actors

The implementation of habitat improvement measures for the Capercaillie (Tetrao urogallus) in the Hoher Tauern National Park demonstrates the possibilities of inter-disciplinary co-operation between forestry, agriculture, hunting and nature conservation.

of the region concerned, such as farmers, hunters, planners and developers, to name but a few.

Protected areas thus take on a new role within their region: they are no longer seen as and no longer act as "nature islands", but are instead integrated into a more global approach. The 2006 law concerning national, regional and marine parks in France is evidence of this, in that it introduces the notion of "ecological solidarity" between the heart of the parks and their surrounding areas. Until now, the effects of protected areas on their neighbouring region have been perceived primarily in economic terms, with the emphasis on financial spin-offs and the added value generated by the presence of a protected area in the region (for example Jungmeier et al 2006; Job 2003). The "Alpine Pilot Region approach" provides these areas with a new constructive role in a programme for planning and organising the region. This approach also endows the protected areas with a new role at an Alps wide scale based on the vision of an Alpine ecological network.

The role of protected areas is therefore twofold: First, the extensive protected areas form indispensable core areas within the ecological networks (Kohler and Plassmann 2004), and, secondly these areas provide possibilities for "testing" and acquiring experience on setting up ecological networks in the Alps. Among the personnel of protected areas are geographers, biologists and other experienced naturalists with a very good knowledge of the terrain, the species and the special issues in the area. They also possess important communication skills. In addition, the protected areas administrations are partners known to and recognised by the local actors and therefore provide the ideal link in transmitting, discussing and developing such projects in their region. Finally, according to several international and European agreements and guidelines, they are obliged to ensure the spatial and functional integration of the protected area into its surroundings (for example Natura 2000).

Nevertheless, these roles have limits, and it is often very difficult for protected area managers to initiate and support a planning and implementation process in territories beyond the protected area itself. It is evident that protected area managers have no direct decision competence for areas outside the protected areas' official boundaries, even though, as core zones, protected areas constitute a fundamental element of the ecological network of a certain region. The park manager needs political support and official legitimisation to participate actively and as an initiating organisation within the process. Such legitimisation is particularly important for protected areas featuring a Pilot Region for connectivity in the Alps. Legitimisation has to be conferred by the competent administrative organ in accordance with the political systems of the individual Alpine countries (federal or centralised systems).

Currently legal competence for the landscape between protected areas is situated mainly within local, regional or national agencies and not with the protected area management authorities. Financial and human resources should be strengthened within these authorities to ensure the realisation of an ecological continuum over the long term. Park borders are generally too constrained to allow for fully functional ecosystems at a scale large enough to conserve biodiversity.

The importance of protected areas in discussions on these questions is undeniable. This can be seen in France, for example, where regional natural parks (PNR) were at the heart of a working group on the implementation of the national Green and Blue Infrastructure from its inception. The objective of the group is not only to reflect on the notions of ecological connectivity and their importance in a park area, but also to set up scientific pilot projects. It was in this way that the regional natural parks, in a document prepared in 2007 for their 40th anniversary, undertook to "contribute to the national and European ecological network based on common reflection to determine a hierarchy of natural areas, their functions within the ecological network (corridors, buffer zones, core zones) and the heritage species" (translation). To do this, the "Parks define, together with other administrative levels, structured and coherent territorial strategies to protect the natural environment. They then try out these notions in landscape and spatial management protection and planning tools" (translation) (Fédération des Parcs Naturels Régionaux de France, 2007). The study and commitment in favour of ecological connectivity were thus written into the objectives of the charters of certain regional natural parks (the PNR Chartreuse, for example). This has also been done by Queyras Regional Nature Park, which has placed this question at the centre of the discussion for the newly created transnational UNESCO biosphere reserve around Mount Viso, consisting of several parks and neighbouring protected areas also in Italy.

It is not only the natural parks, however, that are concerned by these questions by virtue of their objectives and special missions. Discussions on connectivity aspects are also ongoing in other types of protected areas, such as the Berchtesgaden National Park in Germany (in the framework of the ETC projects ECONNECT, greenAlps or Recharge Green), the Swiss National Park (closely involved in local initiatives of ecological connectivity improvement with the foundation Pro Terra Engadina) and the Kalkalpen National Park (local Project on Connectivity of forest areas NetzwerkNaturwald) to name just a few.

2.2.2 Beyond borders

Transboundary protected areas play an important role as dynamic elements in the landscape of protected areas. The examples of thematic cooperation in all type of thematic fields (knowledge exchange, communication, and more) are numerous but also concern the direct day-to-day work with common monitoring procedures, shared databases, joint management plans and other activities (staff exchange or research projects). The international cooperation receives an additional significance when it is, as is the case for the French National Park Mercantour and the Italian Nature Park Alpi Marittime, formalised in an official cooperation convention. The protected areas contribute through their transboundary activities to the emergence and consolidation of a transboundary region.

> **Transboundary cooperation** *between protected areas offers linking spots for the Alpine ecological network.*

Besides enhancing the exchange specific to the protected areas themselves, these spots offer the possibility to study synergies between the different national, regional and local approaches for ecological connectivity conservation.

Sometimes this can be the starting point for large transboundary initiatives, as in the transboundary region Berchtesgaden-Salzburg where the local analysis of transboundary connectivity has been extended to the entire border region between Austria and Germany in cooperation with the regional administrations (Rapp and Haller 2015).

National borders are a challenge for cooperation, but regional and even municipality borders can also represent important political barriers capable of impact as important as the physical barriers. The project Netzwerk Naturwald in the Northern Limestone Alps region provides a first step in overcoming such internal barriers offering a platform for cooperation around a nature protection topic moderated by protected areas (National Park Kalkalpen as project leader), which is progressing successfully (Nitsch *et al.,* 2015).

2.2.3 A homogenous representation over the Alpine arch

The map of the protected areas offers a good representation of protected sites all over the Alpine arch (see map 1), many of them with their own administrations. This illustrates the high potential for partners on the ground. Even considering their unequal altitudinal distribution (see chapter 1), protected areas play an important role in biodiversity conservation, as illustrated by the fact that the priority conservation areas identified in 2002 (WWF 2002) match nearly exactly with existing protected areas.

In some areas of the Alps several protected areas are located close to one another forming larger patches of protected lands, as is the case in the eastern Alps with the Hohe Tauern National Park and the neighbouring Nature Parks in Tyrol and South Tyrol as well as the Nockberge Biosphere Park. Actions led by them in unison as a consortium, as is the fundamental spirit of the Pilot Region approach, have an impact on a large parts of the Alps.

The protected areas of the Alps, especially the inhabited areas such as the regional nature parks or biosphere reserves, are often considered as test and/or model areas (Laslaz 2010), and models for new approaches to stakeholder cooperation in the field of biodiversity protection. Recognizing all positive examples, some of which are covered in this article, it is important to note that the cooperation among different sectors in this field is still the exception rather than the rule. Furthermore, although the number of actors and groups involved in the initiatives is constantly growing, most cooperative efforts still originate from the “green” sector. Nonetheless, improvement of this situation is at the heart of all Alpine nature conservation efforts.

2.3 Alpine national strategies and visions for ecological networks

// **Karin SVADLENAK-GOMEZ** //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Biology and Evolution, University of Veterinary Medicine, Vienna, Austria

All Alpine states are party to the Alpine Convention, and all but Switzerland are members of the European Union. Therefore, they are bound to implement Directives and, at least morally, obliged to attempt to adhere to the various protocols, strategies, and guiding policies that demand the preservation or restoration of ecological networks in the Alpine region. The degree to which such regional policies are translated at a national level differs from one country to another. Political structures and historically grown institutions influence the particularities of ground-level implementation. This section provides a very brief overview of the status of integration of connectivity into policies and implementation in different countries by way of examples. It makes no claim of completeness, bearing in mind that the establishment of networks is a continuing process.

All Alpine countries have national biodiversity strategies (some have gone through several updates already), and most of these make direct reference to the preservation or restoration of ecological connectivity. Slovenia is currently updating its biodiversity strategy, and it is likely that the new version will also contain some connectivity-related goals. In some countries, such as France and Germany, there are also corresponding provincial strategies.

Wide forests characterise the area of the Northern Limestone Alps in Austria. The project Netzwerk Naturwald aims at creating stepping stones consisting of natural forests to connect the remaining natural forest habitats of the three large protected areas of this region.

The status of implementation of ecological networks at provincial or regional level presents a mixed picture. Italy, for example, has anchored the establishment of such networks in provincial laws and has initiated the establishment of networks in all Alpine provinces. In the French Alpine provinces work on regional ecological networks is also well advanced. In Germany, the Bavarian Berchtesgaden region presents an outstanding example of advanced implementation, while in Austria there are a number of concrete implementation examples in the early stages of design. Switzerland has created a solid national foundation for a regional ecological network and has intentions to construct "green infrastructure" beyond protected areas. The national strategy is translated into on-the-ground actions to varying degrees in the different cantons.

2.3.1 Austria

There is no uniform Austrian environmental law. Instead, there is a legal framework of environmental protection that is determined by a variety of laws. Numerous legal areas have a more or less direct or indirect impact on biodiversity, both at national and at provincial levels. These include nature and forestry legislation, but also laws from areas such as land use planning, hunting laws, air quality regulations, and more.

An integration of ecological connectivity measures (wildlife crossing points) into traffic infrastructure planning for new roads was mandated in 2006 through instructions by the Austrian Ministry for Transport, Innovation and Technology (BMVIT) to the Austrian state-owned company ASFINAG, which plans, finances and builds the entire primary road network in the country (BMVIT 2016).

In December 2014 Austria´s Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) published the Austrian Biodiversity Strategy 2020+ (Biodiversitäts-Strategie Österreich 2020+)

(BMLFUW 2014). It is scheduled to be reviewed following an assessment in 2020. Most of the five goals ("fields of action" – "Handlungsfelder") have some bearing on ecological connectivity, but the one of most direct relevance is number 4 – conserving and developing biodiversity. Its targets include Target 10: "Species and habitats are conserved", and Target 11: "Biodiversity and ecosystem services are taken into account in spatial planning and transport/mobility". Several concrete sub-targets specifically refer to ecosystem function and connectivity. Many specific measures to achieve these targets are listed, among them better coordinated spatial planning that incorporates biodiversity aspects and ecological functions at all levels of planning; an action plan to reduce soil consumption; safeguarding of wildlife corridors; identification of areas with need for green infrastructure; harmonised ecosystem services mapping across Europe; consideration of functional connectivity and the habitat network when establishing compensation areas; and development of nationwide strategies (for habitat connectivity for a complete list of all recommended measures please refer to the strategy document). Legally and administratively the Biodiversity Strategy Austria 2020+ is implemented by territorial authorities and by the other actors and stakeholders involved in the field of biodiversity that are indicated in the strategy.

There are other connectivity-relevant strategy documents in effect in Austria, including those from non-governmental or private institutions. For example, in the Austrian National Park Strategy of 2010, the regional protection of biodiversity and the ecological connectivity with areas surrounding the National Parks is one of the expressed goals (BMLFUW 2010). The indicators of success for this goal are formal agreements on ecological networks between National Parks with adjacent protected areas.

According to governmental figures, 27 percent per cent of Austria´s surface area is subject to some kind of nature conservation legislation, of which 16 percent are Natura 2000 areas, National Parks or strictly protected "Nature Protection" areas, while about 11 percent are under less strict forms of protection, such as landscape protection (Landschaftsschutz) (BMLFUW 2014). Austria has four Alpine National Parks (Hohe Tauern, Limestone Alps, Gesäuse, and Nock Mountains). At the same time, some 80 percent of the land area is used for agriculture and forestry, which points to the paramount importance of sustainable practices in this sector if biodiversity is to be safeguarded. Compared to other countries, Austria has a rather high proportion of extensive agriculture (56 percent) (BMLFUW 2014), which is more favourable to ecological connectivity than intensive agriculture. Austria is also a leader in organic agriculture within the EU in terms of share of arable land under organic vis-à-vis conventional farming systems.

There has been some limited progress in establishing ecological networks to date. One good example is the "Netzwerk Naturwald", which builds on the Alpine Space project ECONNECT, and which has succeeded in negotiating the set-aside of a tract of forest belonging to the Styrian Provincial Forests (Steiermärkische Landesforste) as a stepping-stone between two National Parks (see also interview with DI Andre Holzinger in chapter 2).

> **The Austrian Federal Forests** *(ÖBf), which are official partners of the Kalkalpen National Park (ÖBf 2015), offer another example of progress in the establishment of ecological networks.*

They have also elaborated a concept for ecological networks that complements the work of the Network Natural Forests project.

Recently, in March 2016, the Austrian Ministry of Agriculture, Environment, and Water (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft), brought online a web portal on natural habitat networks in Austria, (*www.lebensraumvernetzung.at*), which lists the different international, national and provincial projects of ecological networks that have so far been implemented in Austria, with corresponding maps. The province of Carinthia ("Carinthia´s green backbone – das Grüne Rückgrat Kärntens"), various provincial wildlife and green corridor maps, the Upper Austria province´s habitat connectivity map, and the Alpine Carpathian Corridor offer some of the examples of planning for ecological connectivity. These are, however, mostly still at the planning stage and not fully implemented (Leitner *et al.* 2015).

2.3.2 France

In France, the protection of habitats essential to the survival of some animal and plant species, is provided by prefectural decrees. The earliest of these was a decree promulgated to implement measures related to species protection in 1977. The provisions of this decree are codified in the Environment Code (MEDDE 2012). The protection of habitats needed by species living in aquatic environments was later added, and more recently France has legally protected ecosystems and ecological connectivity in a series of national laws (DREAL PACA 2014). In the French Alps, there are three National Parks (Écrins, Vanoise, and Mercantour), in addition to other protected areas.

Apart from the Ministry of Environment, decision-making bodies at the national level include the Grenelle Environment Forum National Sustainable Development Committee (CNDDGE), a consultative body associated with the development, monitoring and evaluation of the Biodiversity Strategy. In compliance with the Grenelle I Act (article 25), the Government established a National Biodiversity Observatory (ONB), which is responsible for monitoring all activities at the interface of biodiversity and society (MEDDTL 2011). In accordance with the Environment Code, the framework document "National Guidelines for the Preservation and Restoration of Ecological Connectivity" was developed under the aegis of the "green and blue network" (trame verte et bleue) and was adopted by a Council of State decree in 2014 (MEDDE 2014).

France published a new National Biodiversity Strategy for 2011 – 2020 (La Stratégie nationale pour la biodiversité) in 2011, in line with the EU Biodiversity Strategy to 2020 as well as the National Sustainable Development Strategy (SNDD) (MEDDTL 2011). The Strategy is divided into six interacting strategic goals and twenty targets. Most important in this context is Target 5: “Build a green infrastructure including a coherent network of protected areas”. This target addresses the need for species to be able to move and, therefore, the need to define, preserve, and restore a coherent network of “green and blue infrastructure” on all territorial levels. At the same time, Target 6 (“Preserve and restore ecosystems and their functioning”) is relevant, as it concerns the preservation of ecosystems and the restoration of those that have become fragmented or otherwise damaged as a matter of priority. Also quite important, because this is a challenge in all countries, is Target 14 (“Ensure consistency between public policies on all scales”), referring in particular to consistency in spatial planning documents at the territorial level, and to coordination between the different scales of organisation in implementing the Strategy and developing or reviewing regional and local biodiversity strategies. (For further details refer to the National Biodiversity Strategy document.)

The corridor contract for the area of the ecological corridor linking the Nature Park Massiv des Bauges and the Nature Park Chartreuse foresees various measures pertaining to existing water courses, like here the building of an underpath at a bridge crossing the Coisetan river.

For clarification purposes it is worth noting the use of a slightly different terminology here than in Austria. The Grenelle law identifies the regional level as a particularly relevant intervention level at which to preserve biodiversity and includes the development of regional and local strategies. Unlike in Austria and Germany, where the federal structure divides the countries into provinces (federal states or “Länder”), in France the largest administrative unit after national state is the region (région). The National Strategy is meant not only as a commitment of the National Government, but also to guide local authorities´ actions, including regional strategies, action plans and projects. Therefore, the French Alpine regions of concern here have developed their own matching regional biodiversity strategies.

In terms of implementation of connectivity measures, France has developed a “Regional Scheme of Ecological Coherence” (Schéma Régional de Cohérence Ecologique – SRCE), which blends biodiversity conservation and land management (Région Rhône-Alpes not dated). This in turn is a component of the above-mentioned national “green and blue network” concept. The state and the regional environment directorates (directions régionales de l’environnement, de l’aménagement et du logement – DREAL) jointly develop the SRCE.

Both the Rhône-Alpes region and the PACA region have prepared their own biodiversity strategies in line with the national strategy in 2014 and 2015 respectively. In Rhône-Alpes the natural area network is currently made up of 13 reserves and covers an area of nearly 2,900 hectares (Région Rhône-Alpes NDb). Some of these protected areas were gazetted as recently as March 2015. The region has also identified priority areas for the first six years of implementation of the SRCE (Région Rhône-Alpes NDc). With co-financing from the EU, the region has created a series of "green corridors" in areas where biodiversity is threatened (Rhône-Alpes Region 2016). These corridors are meant to connect or restore different natural core areas in order to preserve the ecological continuity of the region. They are based on a system of land contracts, constructed around a detailed five-year action programme, which are on average financially supported to about 50 percent by the region

In the PACA region, in addition to its (somewhat confusingly titled "Global") Biodiversity Strategy, a new regional environmental profile (Le profil environnemental regional – PER) as well as some action briefs were published in 2015 (Région PACA 2015, DREAL PACA 2015). Particularly relevant for ecological networks is "Action Plan" 2: "Management and creation of protected areas and protection of threatened heritage species". It aims to strengthen the protected area network, to increase its representativeness and functionality, and to complete the regional network of protected areas. The PACA region also produced a map (2013) of the major connectivity needs and pressures for both "green" and "blue" continuum zones (BdCarto 2013).

2.3.3 Germany

Germany has a key federal environmental law, the Federal Nature Conservation Act (Bundesnaturschutzgesetz – BNatSchG) of 2010. The law requires the lasting protection of biodiversity, and specifically demands the maintenance of viable populations of wildlife and wild plants, protection of their habitats and of the possibility of an exchange between populations, migration, and resettlement. This law clearly requires ecological connectivity protection and enhancement measures. There are also a number of additional national environment laws.

Like in Austria, in addition to national laws, there are federal state (provincial) laws and regulations. However, unlike in Austria, the new German Federal Nature Conservation Act of 2010 created for the first time a direct and federally applicable law for conservation that in many areas overrides the nature conservation laws of Germany´s federal states and has led to numerous changes in the current legal situation. In addition to a new emphasis in its objectives, the law includes, above all, innovations in impact regulation and also in the protection of species.

> **The German National Strategy on Biological Diversity** *was first published in November 2007 and is now in its fourth edition (2015) (BMUB 2007).*

In the actionable areas (C – Aktionsfelder), Action C1 is dedicated to ecosystem connectivity and protected area networks. This mentions the expansion of the NATURA 2000 protected area network based on the EU Habitats and Birds Directives. By federal law the German provinces (Länder) are required to establish a network of connected ecosystems covering at least ten percent of the land area, which, in contrast to NATURA 2000, should not only target specially designated habitat types and species but should also include all native animal and plant species as well as their habitats. It places particular emphasis on ecological networks outside protected areas. Action C9 (settlements and traffic) acknowledges that ecological connectivity must be considered when planning federal and provincial traffic infrastructure, and that a federal programme of measures on "fragmentation and networks" ("Zerschneidung – Vernetzung") needs to be developed. Ecological connectivity is also mentioned as essential for allowing migration of species that are impacted by climate change. Similarly, Action C12 (rural development) mentions the need for provincial governments to support the establishment of regional parks and green networks surrounding larger cities.

Only the province of Baden Württemberg and the province (Freistaat – "Free State") of Bavaria contain Alpine territory. Both have already prepared their own biodiversity strategies. Several of the focus areas of these strategies are directly relevant to implementing ecological networks.

Bavaria, which has the largest share of the Alps in Germany, has its own Nature Conservation Act (Bayrisches Naturschutzgesetz), most recently amended in 2015 (Bayrisches Landesamt für Umwelt 2015). This specifically refers to an ecological network as well as species and ecosystem (biotope) protection programmes. In addition to the Nature Conservation Act, the Bavarian Forest Law (Waldgesetz), like the German National Forest Strategy, also requires biodiversity protection. Furthermore, the Bavarian State Development Plan (LEP) includes objectives and principles for a Bavaria-wide ecological ("biotope") network (Platform Ecological Network

2009). Following up on its Biodiversity Strategy of 2008, given that Bavarian biodiversity continues to decline, Bavaria prepared its Biodiversity Programme 2030 (StMUV 2014). Concrete measures are now bundled in this interdepartmentally coordinated programme document.

> **In terms of creating ecological networks,** *Bavaria has made significant progress through its creation of the Bavarian Nature Network ("BayernNetzNatur"), consisting of core areas, buffer zones, and connectivity elements.*

Particularly advanced is the county (Landkreis) of Berchtesgaden, where almost 45 percent of the county territory is under some form of nature protection. The Berchtesgaden National Park is the largest of these protected areas (Landratsamt Berchtesgadener Land 2015). As Germany´s only Alpine National Park, it borders the Austrian federal state of Salzburg. The Park has implemented many projects to enhance biodiversity conservation and ecological connectivity over the last several years (see also the interview with Michael Vogel, Director of Berchtesgaden National Park, in chapter 2). This large protected area (210 square kilometres) is also the core and buffer zone of the biosphere reserve "Berchtesgadener Land" and a Natura 2000 site. It is a pilot area of the Alpine Convention, and as such engages in the Platform Ecological Network. The park management initiated a regional process in the transboundary Pilot Region Berchtesgaden-Salzburg between 2008 and 2011 during the ECONNECT project´s implementation. One of the park management´s current goals is the extension of the JECAMI online mapping software developed by ECONNECT to become an Alps-wide standard.

Similarly, Baden-Württemberg has, among other regulations, its own Nature Conservation Act (Gesetz des Landes Baden-Württemberg zum Schutz der Natur und zur Pflege der Landschaft), which was last amended in 2015 (Landesrecht BW Bürgerservice 2015). This law makes specific reference to the creation and protection of ecological networks, including those across federal state borders. It requires all public planning authorities to take the concerns of ecological networks into account in their planning and actions. Ecological networks are to be secured in regional plans and land use plans to the extent that is required. In 2010 the forest research institute (FVA) of the Ministry for Rural Areas and Consumer Protection developed a general wildlife corridor plan (Generalwildwegeplan – GWP) for Baden-Württemberg (FVA 2010) . It is primarily a forest-related sectoral planning instrument for a broad ecological network and is meant to be an integral part of a national or international ecological network of wildlife corridors. Furthermore, in 2012 the creation of an ecological network that is mandated by the Nature Conservation Act was included in the State´s latest landscape plan (LUBW 2015) .

In addition to the framework laws, there are Land Stewardship Directives (LPR) (Bayerisches Staatsministerium der Finanzen, für Landesentwicklung und Heimat 2015; Ministerium für Ländlichen Raum und Verbraucherschutz Baden-Württemberg 2015) in both provinces, which engage whenever special requirements for the preservation of the cultural landscape and nature conservation need to be considered. Not only farmers and other persons under private law but also organisations, associations and local authorities are taken into account. The provinces grant (partial) financial assistance to communal entities, landscape care associations, NGOs, and property owners for measures addressing the care, maintenance and development of protected areas and areas worthy of protection, as well as individual constituents of nature.

2.3.4 Italy

Mountain regions enjoy special legal protection in the Italian Constitution, and several mountain-related Acts have been enacted since the 1950s, mainly referring to improving the living conditions of mountain communities. Italy´s legal structure also has a degree of federalism (Randier 2009). While there are national environmental laws, specific environmental management competence is transferred to the regions and other local bodies [28]. The term "province" is used differently in Italy than in Austria or Germany. In Italy a province (provincia) is an administrative division between a municipality (comune) and a region (regione). As in the case of France, therefore, the region is the pertinent administrative structure when it comes to the implementation of ecological networks. Spatial and landscape planning is subject to concurrent legislation by both the state and the regions, as are the legal frameworks on protected areas (Minambiente not dated).

Italy prepared its National Biodiversity Strategy through a participatory process that included various institutional, social and economic stakeholders. It was agreed upon between the state and regions in October 2010. The three major pillars of the strategy are biodiversity and ecosystem services; biodiversity and

The Monte Rosa Region in the Italian Aosta Valley was one of the pilot areas in the Alpine Space project ECONNECT.

climate change; and biodiversity and economic policies. The strategy includes specific reference to the need to plan for ecological networks not just by safeguarding protected areas, but rather by assigning "ecological meaning" to other areas as well within the conceptual framework of ecological networks.

However, planning for ecological connectivity in Italy predates the preparation of the National Biodiversity Strategy: In 1999 the Italian Environment Ministry adopted a programme for the definition and implementation of an ecological network for vertebrate species, the National Ecological Network (Rete ecologica nazionale – REN), which ran until 2002 (Martins 2014). The concept, albeit not legally binding for spatial planning, was integrated into some landscape plans and guidelines (for example in South Tyrol). The goal of the programme was to outline the distribution patterns of all Italian vertebrate species and to determine whether protected areas cover all of this distribution or what actions were necessary to improve the conservation of these species. A map was produced, which is to form the basis of an ecological network design, and mountain areas – the Alps and the Apennines in particular – are considered most suitable as core areas for these species (Boitani 2003).

Of Italy´s national parks, four are in the country´s Alpine region (Gran Paradiso, Stelvio, Val Grande, and Dolomiti Bellunesi). Several regions of Italy have established planning for ecological networks in their territorial planning. At the provincial level, the so called "Provincial Coordination Territorial Plan (P.C.T.P.) is used by local administrations, and the number of provinces that make explicit reference to ecological networks in their plans has increased from 90 in 2009 to 95 in 2012 (Minambiente 2014) .

As an example, the Lombardy Region´s spatial plan (piano territoriale regionale, PTR) foresees the creation of an ecological network, which is recognised as an infrastructure of utmost importance (ERSAF 2014). A project was approved in October 2009 entitled "From Parks to Regional Ecological Networks" ("Dai Parchi alla Rete Ecologica Regionale"). Its objectives are to implement some key ecological corridors between biodiversity priority areas; to enhance habitat quality and the ecological value of these priority areas; to promote ecosystem functions; and to create a multi-purpose network that can also deliver landscape functions and recreational value. In the Piemonte Region, the design of a regional ecological network is anchored in a regional law regarding the protection of natural areas and biodiversity. The region has mapped important biodiversity areas and a potential ecological network design.

The autonomous region of Trentino-Alto Adige/South Tyrol is a special case, as by special statute they are accorded autonomy both as a region and as the separate autonomous provinces of South Tyrol/Alto Adige and Trento. In the autonomous South Tyrol province, landscape protection is regulated by a State Law, which defines categories of protection for “objects of special landscape value” (Autonome Provinz Bozen Südtirol 2010). The Landscape Plan also regulates the management and use of ecosystems. In contrast, nature parks are governed by a separate administrative office and are not included in the Landscape Plan. In addition to the Landscape Plan, there is also the Landscape Guiding Principle document (Landschaftsleitbild) of 2002, a guideline for sustainable landscape development (Autonome Provinz Bozen Südtirol 2002). The Trentino Region also anchored the creation of a network of reserves in regional law in 2007, and in 2012 it began preparing a long-term integrated management system and restoration programme through the ongoing T.E.N. Project (Trentino Ecological Network): a focal point for a Pan-Alpine Ecological Network (co-financed under EU Life+).

In the Veneto region, the concept of an ecological network and the valuation of biodiversity were presented to the public, and a consultation process launched in 2008. A regional territorial coordination plan was adopted in 2009. It includes an aspirational map that depicts the region´s ecological network with core zones, parks, and ecological corridors

2.3.5 Slovenia

Slovenia has several national acts and decrees concerned with biodiversity and ecosystem conservation. The Nature Conservation Act defines natural components of an ecological network: a) different types of protected areas (national parks [1], regional parks [3], landscape parks [44]). Taken together, these cover around 12.5 percent of Slovenian territory. These areas are part of much larger areas, such as Natura 2000 sites covering more than 37 percent of the country and so-called “ecologically important areas” and “valuable natural features” (Arih 2015). The protected areas and Natura 2000 network are seen as core zones of an ecological network, while ecologically important areas function as connectors between core areas to establish a functional network.

Unlike in other Alpine countries, nature conservation is administered centrally in Slovenia. The Institute of the Republic of Slovenia for Nature Conservation (IRSNC) is a professional national institution charged with conservation activities by the Nature Conservation Act. It is an umbrella body that has seven regional units. The Kranj Regional Unit operates in the northwestern part

Upper Alpine valley in the Swiss National Park, located in the Pilot Region Raethian Triangle.

of Slovenia, covering 20 councils, including the uplands of the Julian Alps, Western Karavanke mountains and Kamniško-Savinjske Alps, or eleven percent of the entire Slovenian territory. Triglav National Park, the only Slovenian national park, is within its domain. The Slovenian Forest Service and local communities also have a role to play in implementation.

Slovenia adopted a National Environmental Action Programme in 1999, in which biodiversity was featured as one of four priorities, in accordance with Article 104 of the Environmental Protection Act. The Slovenian Biodiversity Conservation Strategy (Slovenian Ministry of the Environment and Spatial Planning 2002) dates back to the end of 2001. The general objective of conserving ecosystems by maintaining a favourable status of habitat types is one of the Strategy´s objectives. There was no explicit mention of ecological connectivity or biodiversity corridors in this first Slovenian Biodiversity Strategy, although one might say it is an implicit goal.

Since then, there has been progress in the mainstreaming of biodiversity conservation into non-environment focused governmental strategies. The 2007 – 2013 National Development Programme includes the conservation and sustainable use of biodiversity, and Slovenia´s new Development Strategy 2014 – 2020 aims not only to achieve economic growth, but also to conserve natural capital for the population´s wellbeing. As such, investments in green infrastructure, measures for nature protection and biodiversity conservation and an initiative for “green growth” are part of the plan. After the adoption of the Aichi Biodiversity Targets (CBD 2015) at the Conference of the Parties of the Convention on Biological Diversity in 2010, Slovenia began preparing a new Biodiversity Conservation Strategy that will run until 2025 (action plan). The proposed targets of the new strategy include at least one concrete measure “to identify and maintain and, where necessary, re-establish ecological connections that enable genetic exchange between populations". This measure covers all species recognised as endangered (red-listed) in Slovenia, and there are also several measures that contribute to ecological connectivity indirectly (for example preserving traditional landscape, encouraging the traditional use of natural resources, restoring abandoned agricultural land and more).

Slovenia has only one, albeit very large, Alpine National Park, the Triglav National Park, with an area of 837 square kilometres . The country´s share of Natura 2000 sites in the national terrestrial area is impressive – close to 38 percent. About a quarter of the Natura 2000 sites belong to the Triglav National Park, or lie within regional and landscape parks, or are designated as nature reserves or natural monuments. The Triglav National Park management plan was approved by the TNP's Council in October 2015, and according to prescribed procedure it is foreseen to be adopted by the Slovenian Government in April of 2016 (Arih 2015). Some concrete activities outlined within the plan relate to transboundary cooperation with the Julian Alps Nature Park. There has been some progress on creating a transnational protected area between Triglav National Park and the Julian Prealps Nature Park in Italy. Implementing ecological connectivity is, however, perceived as difficult in both areas, as was reported by participants in a 2014 GreenAlps workshop. Triglav National Park does not yet have a management plan and is dealing with inadequate infrastructure and traffic problems inside the Park. Reportedly forest owners sometimes obstruct activities meant to advance ecological connectivity. On the Italian side, many municipalities oppose the establishment of a National Park. Some initial steps have been made through the “PALPIS Cross-border participative planning in areas of major naturalistic value in the Southern Julian Alps“ project.

The Slovenian Environment Agency has produced an online environmental atlas (Slovenian Environment Agency, not dated) of the country that enables users to select different layers to overlay on the map. The maps make it apparent that Slovenia has a large share of various protected and Natura 2000 areas, linked by a connectivity network consisting of several ecologically important areas. The latter are, however, less effectively protected due to the absence of specific administrative control and comprehensive management (Arih 2015).

2.3.6 Switzerland

Switzerland, which is not an EU Member State but a Council of Europe Member State, is also a party to the Bern Convention and to the Convention on Biological Diversity (CBD ND), and as such has similar obligations to protect species and habitats as stipulated in EU legislation, though implementation details differ from those in EU countries. Like other Alpine countries, Switzerland has a federal system, but cantons are only able to comment on proposed federal measures that affect them, such as the implementation and financing of environmental measures. The federal government sets out the objectives of environmental protection in federal acts and ordinances, and the cantons are obliged to enforce these federal laws. Through supervision, the national government can ensure that environmental legislation is applied equally throughout Switzerland (FOEN 2015).

Several national laws and regulations, such as the Federal Act on Natural and National Heritage Protection (Bundesgesetz über den Natur und Heimatschutz), the Federal Act on Spatial Planning, and the Federal Ordinance on the Regional Promotion of Quality and Connectivity of Ecological Compensation Areas in Agriculture, to name only a few, are relevant for the conservation of ecological connectivity. They mirror those of other Alpine countries and are equivalent to similar EU regulations.

In the Swiss Landscape Concept *(LKV 1997) and in the 2003 mission statement of the national environment office "Landscape 2020" (Leitbild Landschaft 2020), the development of a functioning national ecological network is of central importance.*

The designation of areas important for conservation and their connectivity axes provides an important tool for the implementation of a strategy for biodiversity and landscape diversity. In spatial planning, the national ecological network (REN) has to be taken into account according to the Spatial Planning Law. The REN forms a national basis for implementation in the various cantons. In some cantons ecological networks have found their way into some of the cantonal guiding spatial plans (Kantonale Richtpläne). In 2011 the Swiss Landscape Concept and Landscape Vision were updated with a new landscape strategy (Landschaftsstrategie, which illustrates the strategic goals of an integrated national landscape policy [FOEN 2011]). One of its principal objectives is securing and improving the landscape´s ecosystem services.

Within the framework of the Swiss National Forest Programme (2004), the importance of connectivity for forests is highlighted (SAEFL 2004). There are implementation regulations for the inclusion of and payments for connectivity based on the Forest Law. The Forest Policy 2020, created in 2013, lays out the conservation and improvement of forest biodiversity as one of its five strategic goals (FOEN 2013). In agriculture, concrete standards are set for connectivity measures by ECO-Quality-Regulation. The regulation also arranges for payments for connectivity measures.

The Swiss Biodiversity Strategy of 2012 contains a number of goals that refer specifically or indirectly to ecosystem connectivity (FOEN 2012). The Biodiversity Strategy also envisioned the preparation of an action plan to provide further details on how to achieve the goals. The preparation of an interim progress report is scheduled for 2017, and an evaluation of whether the goals have been achieved will be made after 2020. In 2013 the Federal Office for the Environment (FOEN) presented first results of the participatory planning process for preparation of the action plan, and in 2014 it began elaborating an implementation schedule for the agreed measures. A central role in the action plan is accorded to ecological connectivity measures.

In order to implement targets that it committed to under the Convention on Biological Diversity, Switzerland has been increasing the number of its protected areas. The country is also involved in the „Emerald"-Network as an equivalent to the Natura 2000 network and in the Pan European Ecological Network (PEEN). As of December 2014, Switzerland listed 37 Emerald sites. At a national level, the Swiss National Park, with an area of over 170 square kilometres, has the distinction of being the oldest Alpine National Park (gazetted in 1914) and an IUCN category 1 nature reserve with the highest protection level.
It is governed by National Park law (Bundesgesetz über den Schweizerischen Nationalpark im Kanton Graubünden) and National Park regulation (Nationalparkordnung). Since 1979 the National Park has also been a designated UNESCO Biosphere Reserve, and work is ongoing to establish Biosfera Val Müstair / Park Naziunal, where the Swiss National Park will be a core zone (FOEN 2012). The designation of a regional park was awarded in 2010 (SNP, not dated). One of the goals of this Biosfera is to conserve the traditional natural and cultural landscape and to develop sustainable economic development strategies.

In addition to the Swiss National Park, there are other protected area categories, including regional nature parks, and "nature discovery parks" (suburban nature parks), all of which are considered parks of national importance. The identity label "Swiss Parks" (Schweizer Pärke) was created to provide visibility. Apart from protected areas there are forest reserves, which in 2012 covered about 4.8 per cent of the Swiss forest area or 58,000 hectares (Wiedmer and Wisler 2014). This is still

In the Intyamon valley (Nature Park Gruyère Pays-d'Enhaut) farmers have grouped parts of their agricultural land to build a local ecological network.

below the national aim of ten percent of forests having reserve status by 2030, and the existing reserves are not necessarily located where forest habitat types and species are most threatened. There are also several running initiatives for ecological connectivity outside protected areas, many of a small scale in agricultural landscapes, in addition to cantonal wildlife corridors.

In spite of the variety of protected areas and park spaces, the Environment Report for Switzerland of 2015 assessed the country´s biodiversity to be in a "poor state", as evidenced by a reduction in valuable habitats and a high number of endangered species, due, inter alia, to landscape fragmentation, soil sealing and intensive agriculture (FOEN 2015). In this, Switzerland is not unique. Similar assessments have been published in other Alpine countries.

2.3.7 Transnational cooperation

Apart from national ecological networks and connectivity measures, there are also several examples of transnational cooperation for ecological connectivity in the Alpine region. The ECONNECT project, financed by the Alpine Space Programme of the European Regional Development Fund, for example, brought together international umbrella nature conservation organisations linked to the Alpine Convention, scientific institutions and local implementation partners in order to demonstrate needs and opportunities for action to enhance ecological connectivity in the Alpine Space. This was the first project to investigate how national and regional legislation affects ecological connectivity. The project produced a number of maps aimed at providing an overview of the location of Pilot Regions in the Alps and visualising connections between protected areas (Exploratory map of Alpine ecological connectivity – Svadlenak-Gomez et al 2014) within each of these regions, as well as priority areas and Alpine-wide results of the continuum suitability analysis. These were further enhanced during the implementation of the GreenAlps project (Svadlenak-Gomez et al 2014). The project also produced the online visualisation tool JECAMI (Joint Ecological Continuum Analysis and Mapping Initiative), which can still be accessed and used online at: *www.jecami.eu*

One of several concrete implementation examples of cooperation between two countries is work towards the reconnection of natural spaces between Geneva (Switzerland) and the French regions across the border. The so-called Franco-Valdo-Geneva conurbation border region is dominated by agricultural and natural areas (80 percent) and an extremely dense core settlement. It is under pressure due to the dynamics of peri-urbanisation and urban sprawl. Since 2010, a number of corridor contracts have been signed in this "Grand Genève" region in order to preserve these spaces and their connections, and several more such contracts are in the planning stages.

2.3.8 Work in progress

In all Alpine countries, the concepts of ecological connectivity and the creation of ecological networks have found their way into global, European, national, and often provincial strategies, regulations, and laws. The degree to which these strategies and laws have been implemented so far varies significantly between countries. Given that the fragmentation of human-dominated landscapes is driven by current socio-economic practices and behaviours that are difficult to change, and the decentralised and usually participatory nature of spatial planning, as well as the challenges of cross-sectoral work, the implementation of functional ecological networks is a slow process. In federal systems it is often difficult to achieve the required cross-provincial collaboration need to ensure networks that cross boundaries. The challenge is all the greater for transnational cooperation, where different laws and management practices may collide. However, the fact that all Alpine countries have ecological connectivity in their biodiversity action plans or strategies may give rise to optimism concerning the restoration of a fully functional Alpine ecological network over the longer term.

2.4 Strategic elements and landscape visions of current Alpine ecological networks

*// **Guido PLASSMANN** //*
Alpine Network of Protected Areas ALPARC, Chambéry, France

The concept of ecological networks is based on a concrete spatial dimension. Ecological networks need to be implemented on the ground in order to be an element of the landscape and to insure functioning ecosystems. This spatial dimension needs to be represented logically in all concepts and strategies. To this end, an overview of the implementation of the overall strategy of ecological networks in the Alps through a well-identified landscape vision may prove helpful.

2.4.1 The trans-sectoral landscape vision of connectivity

The spatial situation and its associated land use (demography, transports, industrial and commercial localisations, recreational areas, and more) in the Alps are subject to constant evolution. This has an immense impact on large scale non-fragmented areas and, through this, on ecological connectivity. The way Alpine territories

Alpine landscapes are characterised by a succession of different types of habitats that contribute to their particular biodiversity, as seen here in South Tyrol. A trans-sectoral landscape vision of connectivity for the Alps needs to integrate this Alpine specificity.

are used or impacted by human activity, and this creates different space categories concerning ecological continuums. The following modelling of landscapes types of connectivity tries to provide a cognitive approach to a trans-sectoral landscape vision for the Alps.

A stronger identification with the Alpine region and Alpine strategies is necessary if a consistent pan-Alpine vision and policy are to be achieved. The Alpine Convention and the macro-regional approach in particular could contribute to a broader definition of such a vision that would also include links between the Alps and their surroundings.

As part of a macro-regional strategy for the Alps, such a landscape vision would make it possible to categorise and prioritise issues such as ecological connectivity. For example, this could be carried out in regions where a special effort is needed to defragment the land, or in regions that are still fairly intact and where conservation policy is necessary to insure that a favourable conservation status is retained (Plassmann, greenAlps, 2014).

The analysis of such regions has been carried out in several previous projects. Map 5, indicating the last non-fragmented areas of the Alps overlaid with protected areas, shows the importance of the latter, especially in the central part of the Alps (see map 5). Map 6 shows population density and protected areas, highlighting zones with higher pressure on protected land (see map 6).

These maps, spatial analyses and expert knowledge of the territory of the Alpine regions have led to the definition of three types of Strategic Alpine Connectivity Areas or so called “areas to act”:

- Areas where fragmentation has already progressed so far that interlinked habitats and a transparent landscape matrix are no longer a realistic option using reasonable, viable interventions. This is the situation in some of the intensively used inner Alpine valleys but also for some valleys of the Alpine Piedmont surrounding the Alps that link with the Alpine macro-region. Here it probably only makes sense to use one-off measures to permit species migration. **Ecological Intervention Areas: ad hoc measures to improve ecological connectivity are recommended (punctuated approach).**
- Areas that still have considerable space for connectivity with non-fragmented surfaces and where connectivity should be conserved. Such areas are characterised by a sparse infrastructure, dispersed settlements and large natural areas at mid-altitude. **Ecological Conservation Areas: a well targeted large scale conservation policy is recommended (passive approach).**
- Areas with a high potential for connectivity in which larger, more or less natural non-fragmented zones could easily be created, especially by connecting protected areas, Natura 2000 sites or other precious biotopes. **Ecological Potential Areas: a spatial planning policy aimed at the creation of large scale non fragmented areas is recommended (active approach) (modified after Plassmann, greenAlps 2014).**

A more global and strategic solution to increase ecological connectivity on an international level entails connecting transboundary protected areas both by harmonising their management systems and by creating common borders.

A trans-sectoral landscape vision for the Alps would allow more cohesion within the different landscape planning activities of the Alpine countries and would incorporate biodiversity protection in a more consistent fashion.

2.4.2 Different solutions for different situations

From the green bridge to an overarching connectivity concept for Alpine biodiversity, solutions depend on the scale and on the specific regional or local situation. The Alps contain a diverse mosaic of habitats exhibiting various levels of multiple human impacts. The trend in land use may lead to further fragmentation of ecosystems and habitats. For example, today large carnivores (lynx, wolf and bear) with high territorial requirements inhabit only a few separated islands (patches) of suitable environment (ANDEL *et al.* 2010). These small areas are further threatened by policies that are unfavourable for these species.

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In order to identify solutions for the three landscape types of ecological connectivity described above, the following elements should be considered:

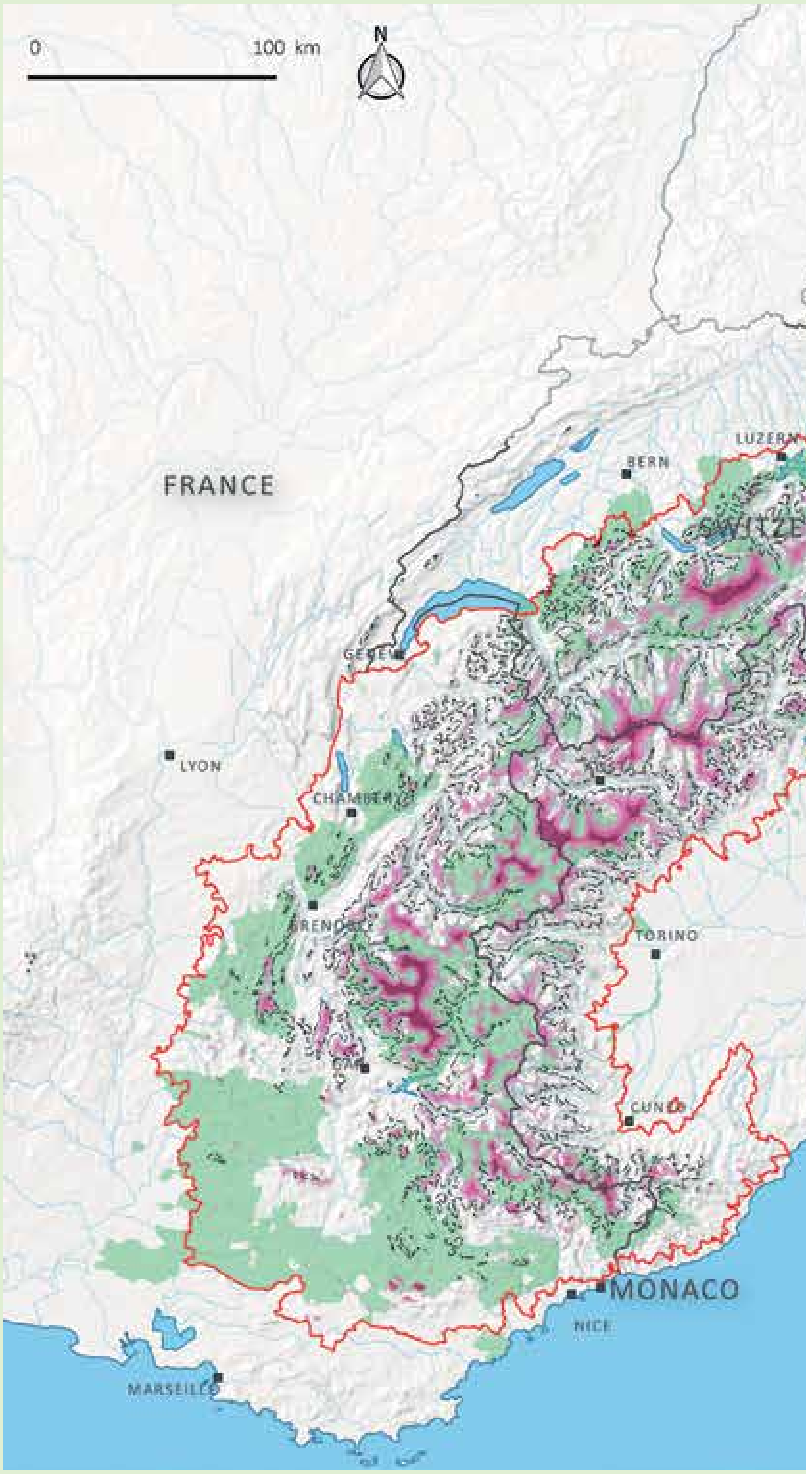
1. Landscape fragmentation due to urban sprawl and rapidly progressing road construction and river engineering entails a number of negative impacts, such as barrier effects, causing a loss of natural connectivity between individual populations of the fauna (SEILER, 2002). These phenomena are linked to an increasingly intensive use of the agricultural land in the densely populated valleys of the Alps and contribute to the first category of landscape and situation specified above (Ecological Intervention Areas).

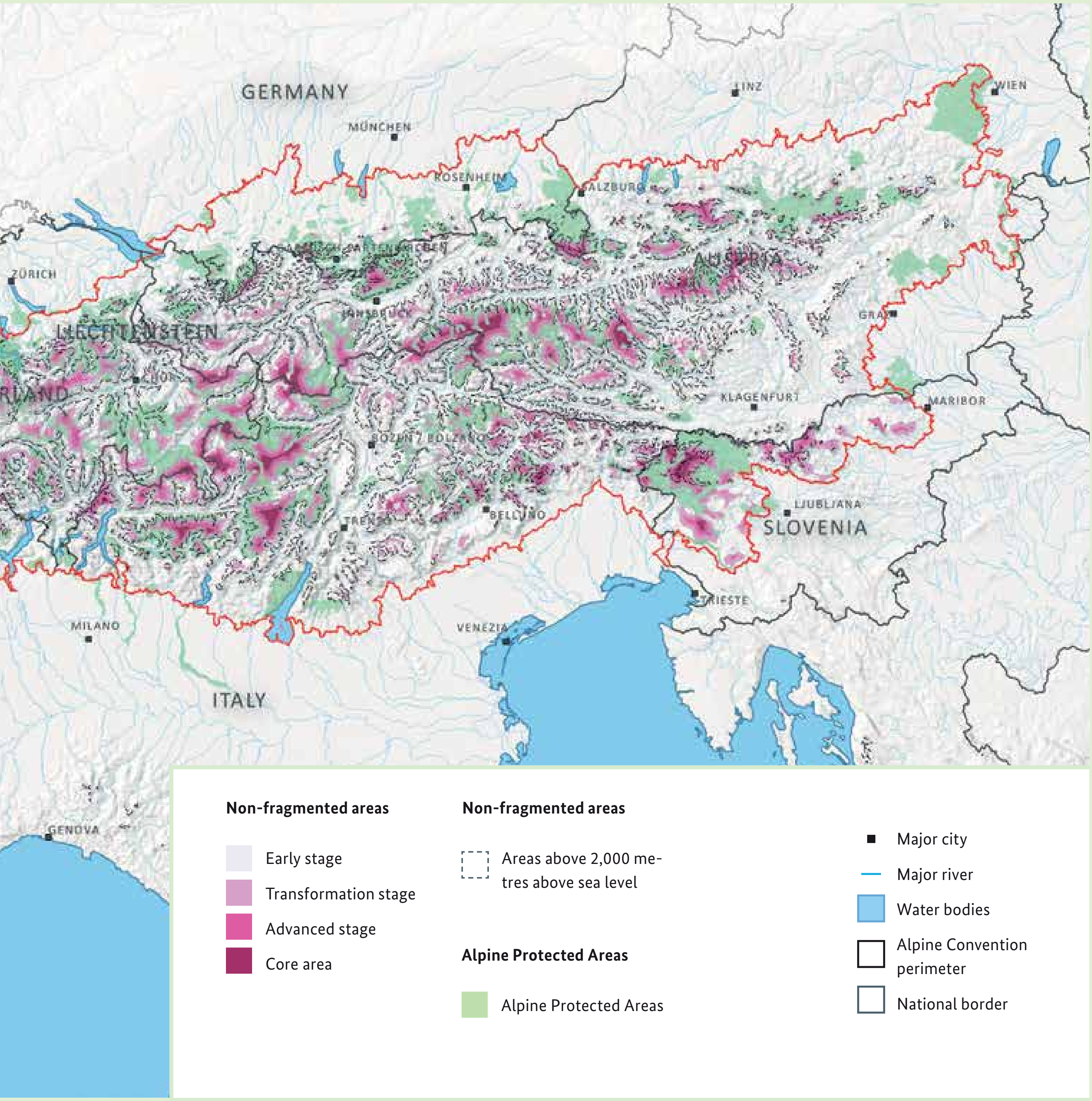
   Solutions to overcome fragmentation in these areas are usually not highly very visible and can be more or less technical. For all new construction and long-term land use strategies, landscape planning should integrate solutions to overcome fragmentation. At a minimum, this could include tunnels, bridges and water channels for the involved species. Costs for these basic measures must be included when calculating the budgets for all new projects, and special programmes must be developed to capitalise on pre-existing infrastructure (= Ecological Intervention Areas).

2. Nevertheless, with regard to ecological connectivity and functioning ecosystems, the Alps are still rich in fairly intact landscapes. These intact areas need to be identified at an Alps-wide scale, and a coherent landscape planning concept for the whole Alpine area should be developed in cooperation with all Alpine states and members of the contracting

River renaturalisation on the Coisetan River, France

// Map 5: Non-fragmented areas and protected areas in the Alps





Source: ALPARC, WWF, ISCAR, CIPRA for non-fragmented areas; data from different national and regional authorities and protected areas managements for delimitations of Alpine Protected Areas (> 100 hectare) ; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note:** This map makes no claim to be exhaustive. **Design:** Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

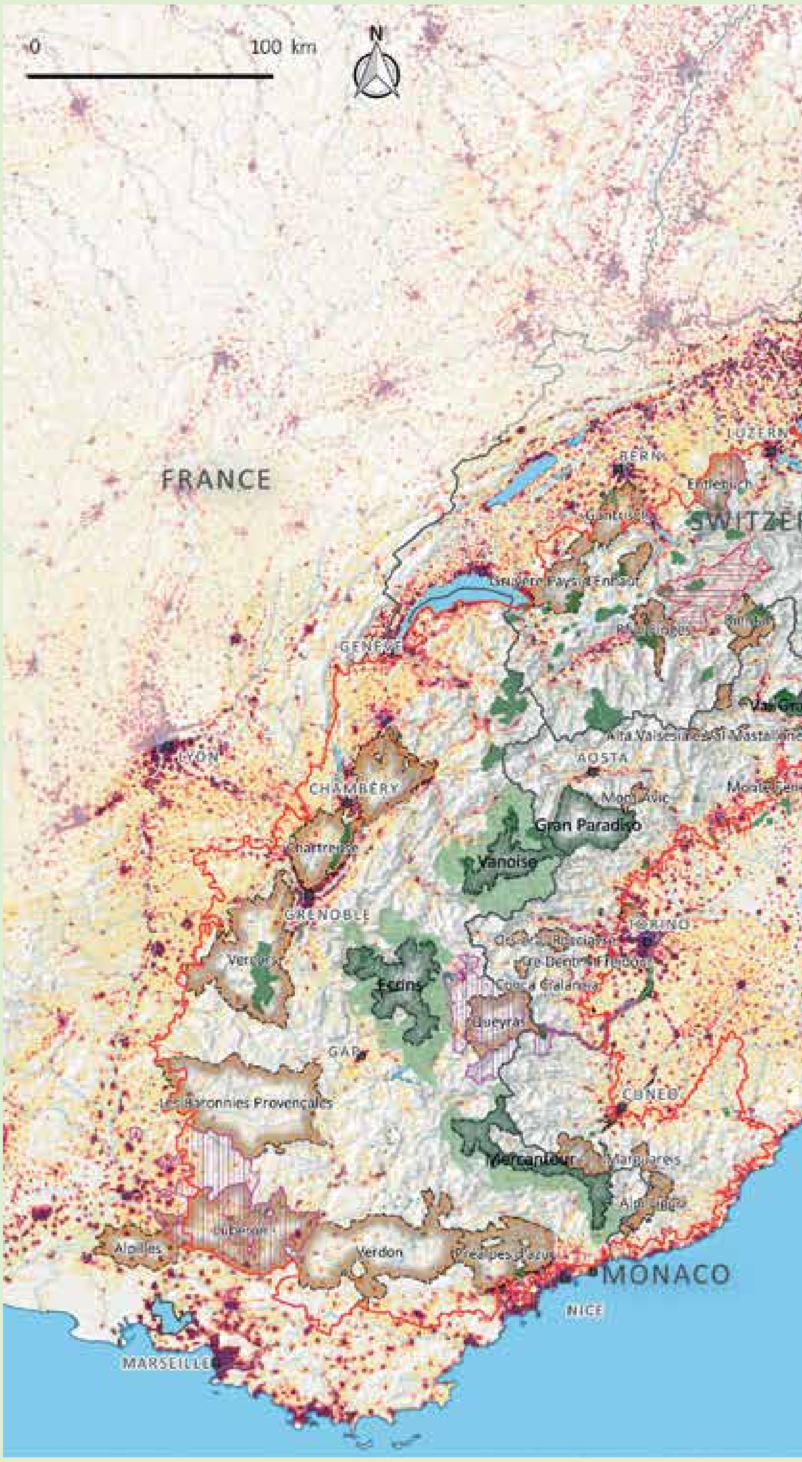
parties of the convention (Monaco, France, Switzerland, Liechtenstein, Austria, Germany, Italy and Slovenia).

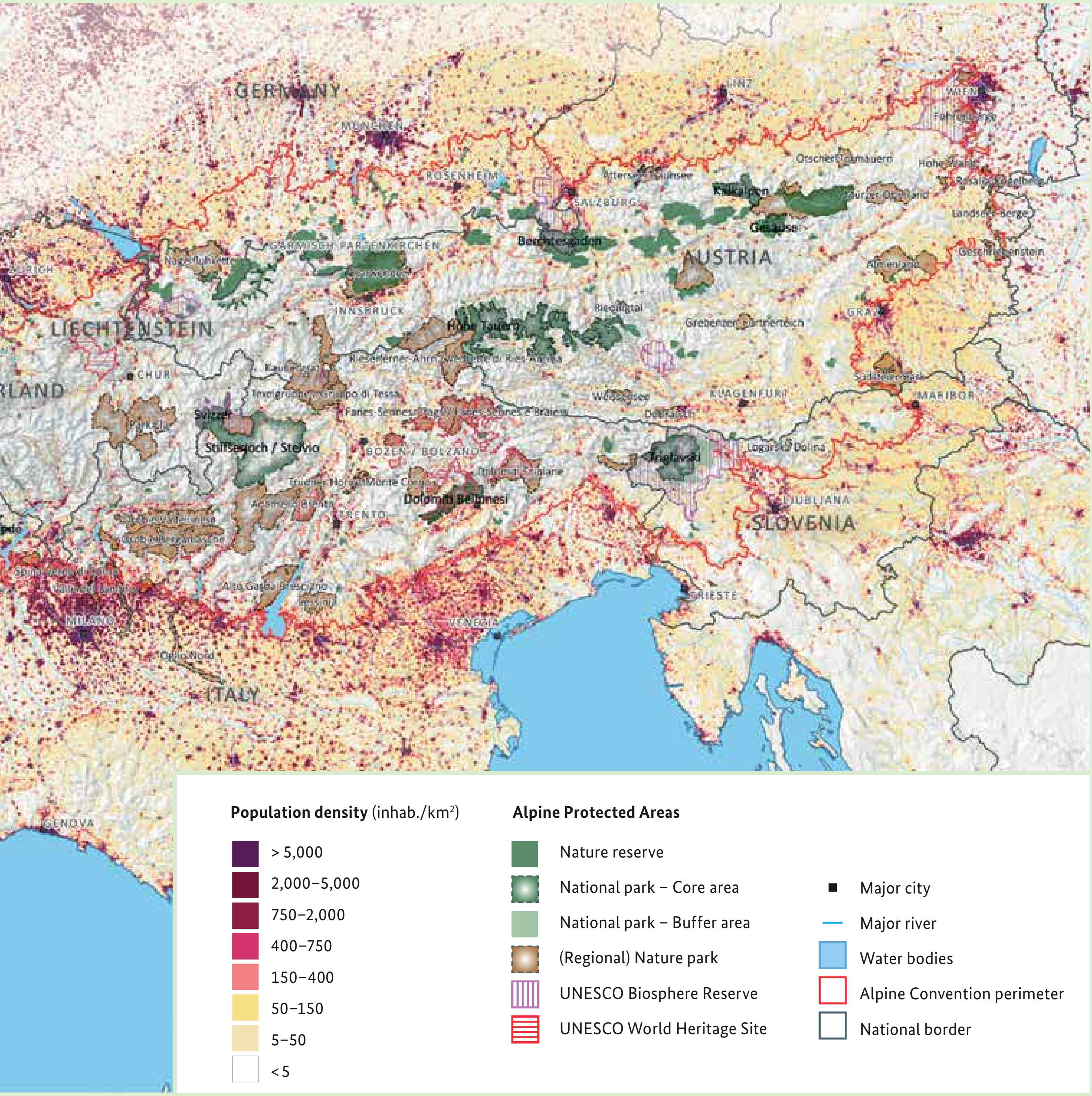
While specific measures for the protection of such sites and areas may not be essential in the majority of situations, it is, nonetheless, necessary to improve knowledge and understanding of these habitats and ecosystems and to appreciate the species, needs for migration potential. A land management plan for each of such sites would help to insure a long-term conservation process of connectivity by including economic, social and cultural features of the site.

Such a land management plan allows an adaptive management and governance of resilience that must not be limited to individual elements of an ecological network (corridors, core zones), but

Intact diverse landscapes, as pictured here in this valley in South Tyrol, still remain in different parts of the Alps. They need to be identified at an Alps-wide scale in order to include them in a coherent landscape planning concept for the whole Alpine area.

// Map 6: Population density and Alpine protected areas





Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); Eurostat, EFGS for the population grid information (2011); Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note:** This map makes no claim to be exhaustive. **Design:** Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

must necessarily be applied to the entire territory (landscape matrix) and across all sectors of society, while enabling non-exclusive, multi-functional spaces for sustainable economic and recreational activities of Alpine communities (modified after ECONNECT Vision in "implementation recommendations", 2011).

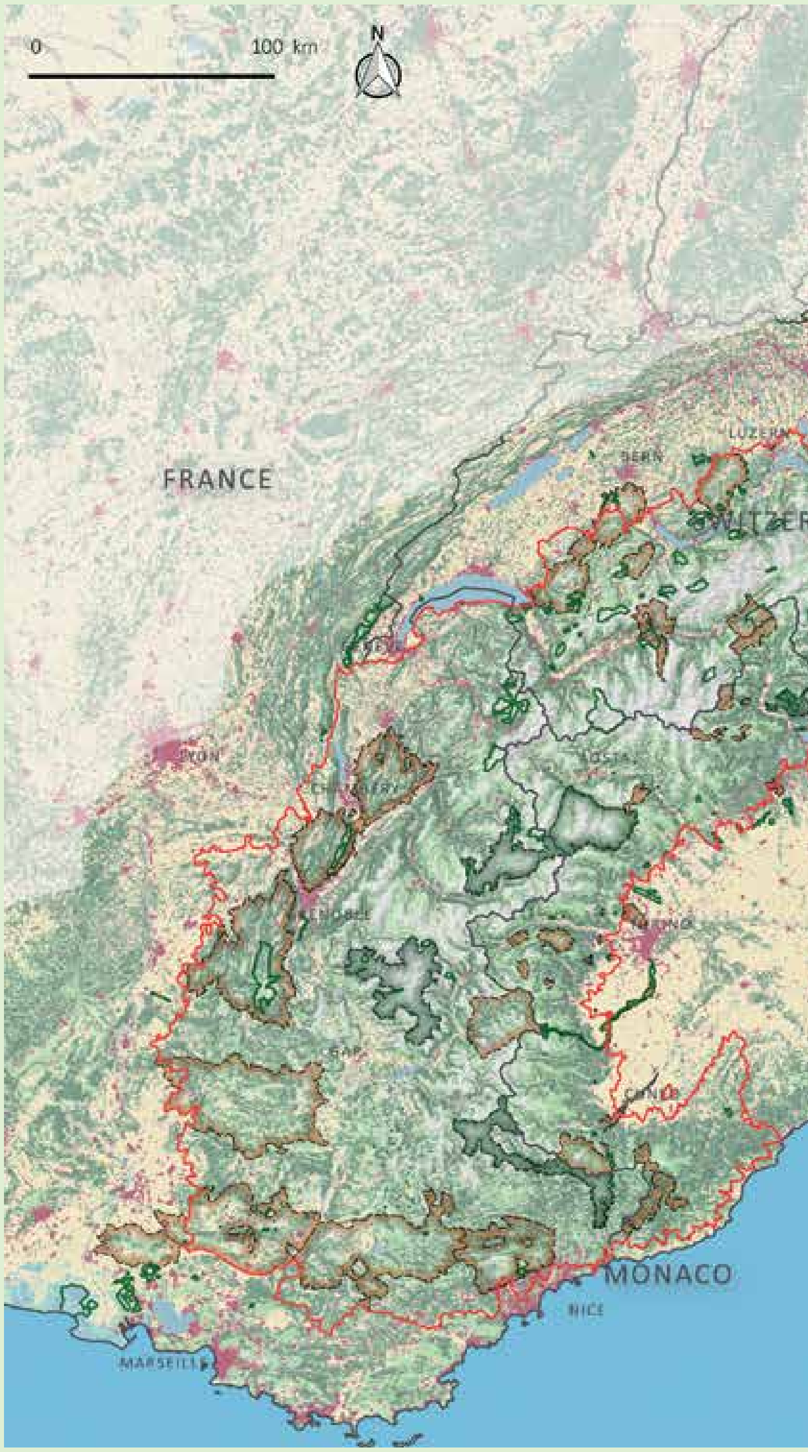
This is a more passively oriented approach that takes into account the needs of ecological connectivity in a conservation policy designed to accommodate many sorts of anthropogenic activity while creating tailored infrastructure in an area that still retains considerable surfaces of non-fragmented landscapes (is equal to Ecological Conservation areas).

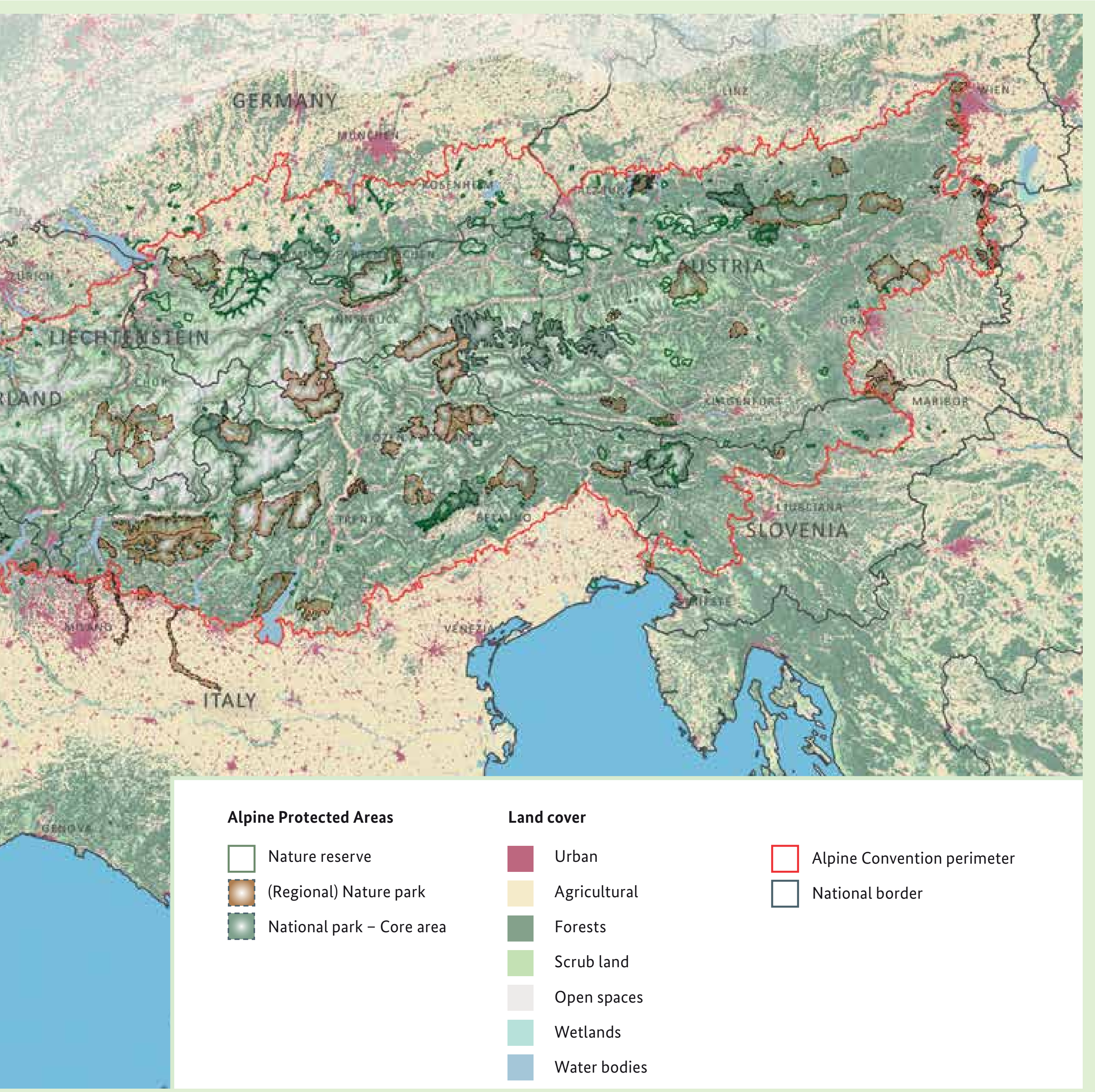
The map 7 overlaying Alpine land use (Corine Data) and existing protected areas of all categories allows an approximate identification of areas in the Alps included in this category.

3. The third situation demonstrates a more active approach by identifying regions where ecological connectivity could be achieved for important spaces by utilising existing core areas (often protected areas) or stepping stones (biotopes, natural spaces) and insuring functional links between them. In the Alps, such valuable regions can be identified by evaluating their geographical distribution, protection status (for example IUCN category), and footprints at different altitudes in order to establish larger interconnected areas that better accommodate the habitat and migration requirements of relevant species. National parks and nature reserves are of particular interest here, but a series of well-protected nature parks could also be considered in this context. The Natura 2000 network could, in many cases, contribute as well, but only when the selected site does not completely overlap with another already protected area, as is currently the case in almost two thirds of the surface area of Natura 2000 sites in the Alps.

   A large non-fragmented area could be established in this context by increasing some protected areas in order to create a common border with a neighbouring protected area. Some examples exist in the Alps where this strategy has already been deployed. Another solution is to target ecological corridors by linking elements or in some cases by tailoring management measures of the land (agriculture, tourism, energy production). In other situations, the 'creation' of non-fragmented

// Map 7: Land use and Alpine Protected Areas





Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); CORINE Land Cover European seamless vector database CLC12 (final product with partial validation) for land cover; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note:** This map makes no claim to be exhaustive. **Design:** Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

spaces can make a conservation concept of spaces in between protected areas possible, thereby insuring a long term evolution of well-functioning ecosystems. In any case, active procedures are required in these situations in order to capitalise on the existing potential (which is equal to Ecological Potential areas). The map number 8 shows the protected areas of the Alps with a relatively strong protection status (IUCN I, II, IV).

Those areas together with some Natura 2000 sites, which can be found at all altitudinal levels, could be a solid foundation for the definition of Ecological Potential areas (see map 9).

2.4.3 Towards a connectivity conservation management framework?

To insure ecological connectivity at an Alps-wide scale, a planning concept and a conservation management framework seems crucial. The Alpine Convention, in concert with the macro-regional strategy of the Alps, could be a political foundation for such a conservation framework by concretely involving the Alpine states and the European Union.

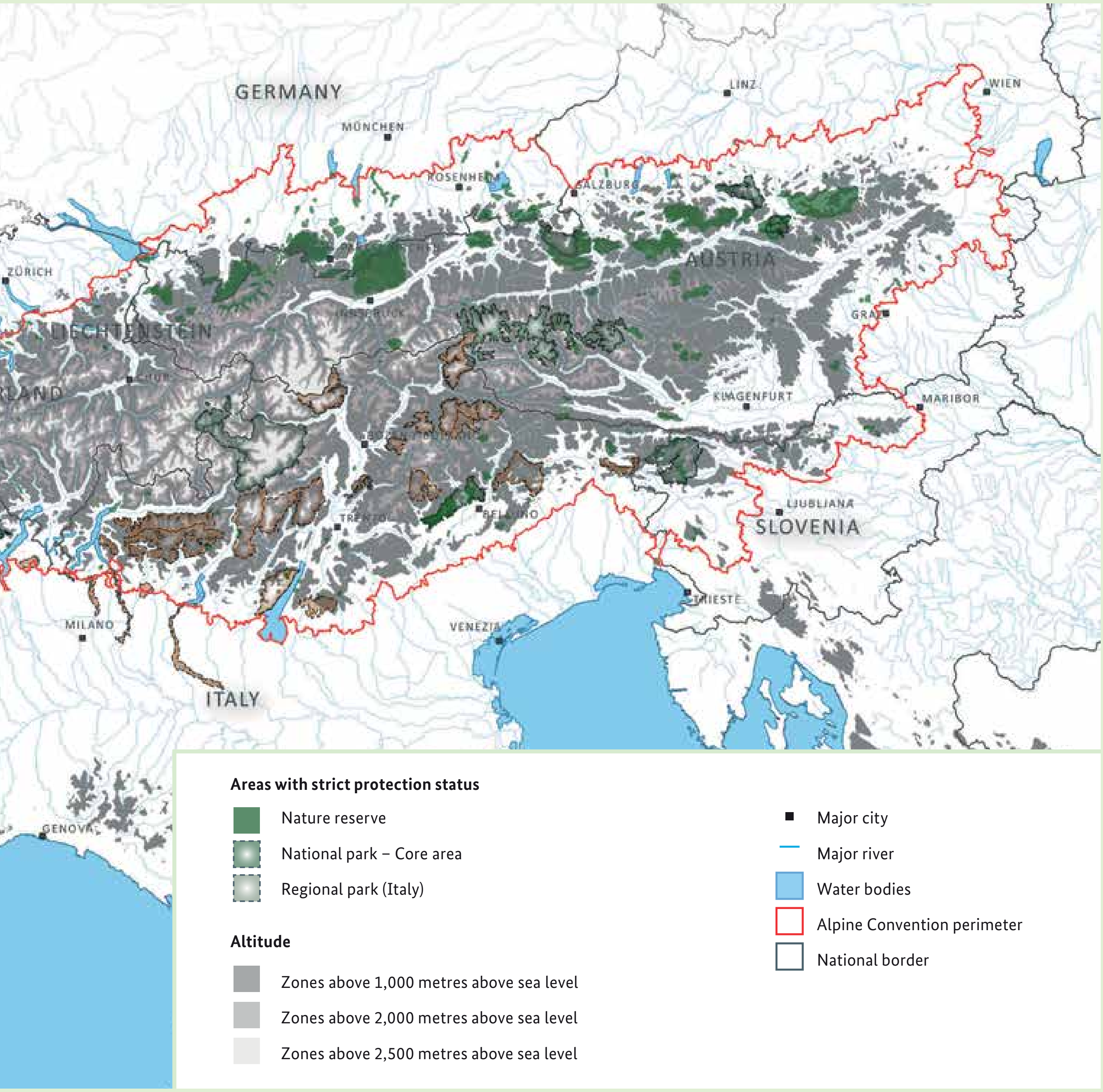
However, such a concept assumes that all measures are based on a common vision with shared elements whose definitions are agreed upon. Connectivity conservation management itself can be classified into three main contextual domains:

NATURE – PEOPLE – MANAGEMENT

The 'nature' context of the Alps is the main driver for connectivity conservation actions, as described above, and requires the involvement of local people, decision makers and experts, which results in the management of those actions. The 'people' context includes aspects like the socio-economic dimension in addition to the natural and spiritual values of a territory or region. The 'management' context tackles issues of how land is legally and institutionally organised, planned and managed (Worboys 2010 in: Implementation Recommendations of ECONNECT, 2010).

A connectivity conservation management framework includes the following management functions, which are structured according to a conventional process of management (see Figure 2, Page 76).

// Map 8: Areas with strict protection status and altitudinal level



Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note:** This map makes no claim to be exhaustive. **Design:** Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

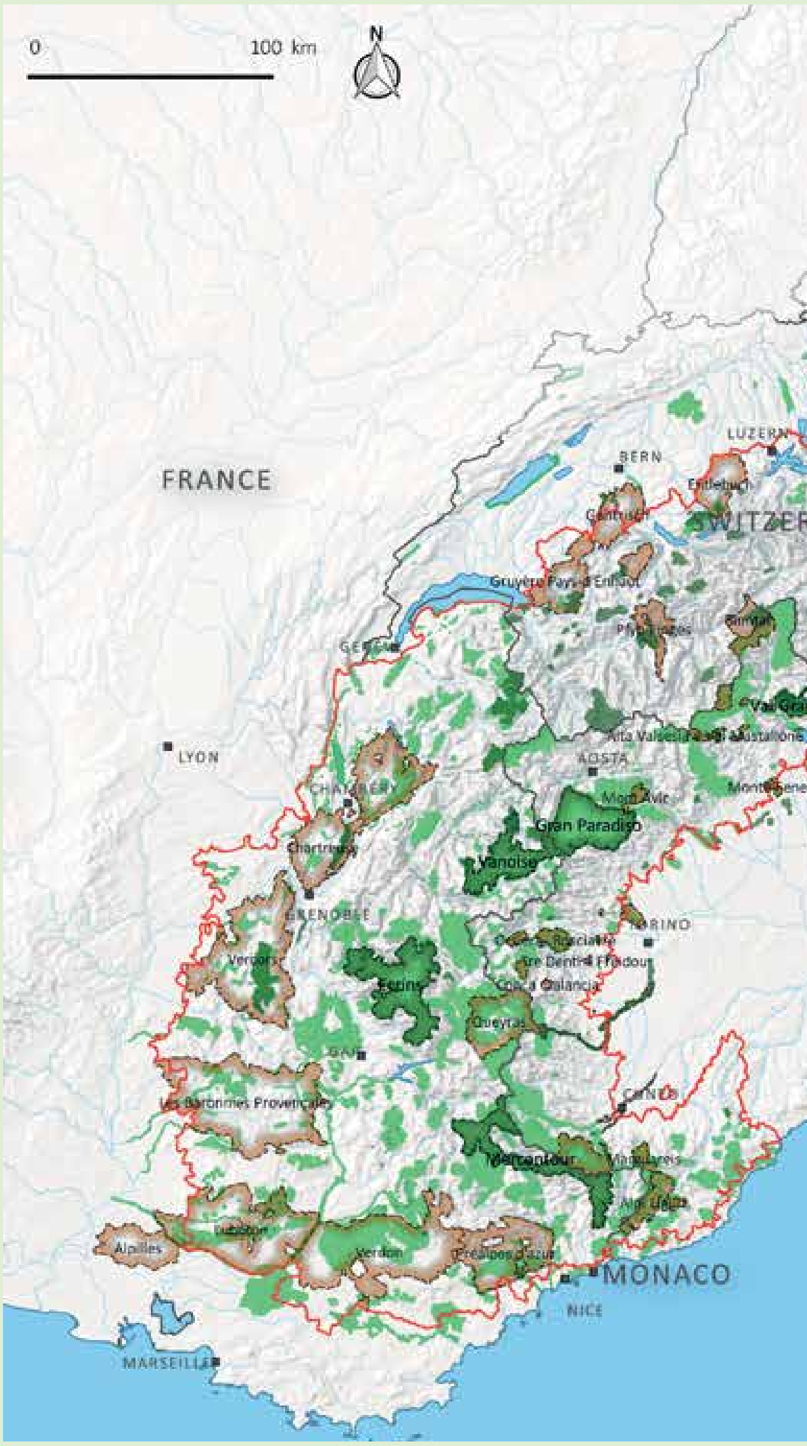
The framework aims to differentiate the aspects of these five management functions as part of the interactive management process: being aware of the three dimensions of the context (nature, people, management), defining leaderships tasks and functions, planning steps that need to be prepared and considered, defining the implementation phase and evaluating activities and the process as a whole. (after ECONNECT implementation recommendations, 2011).

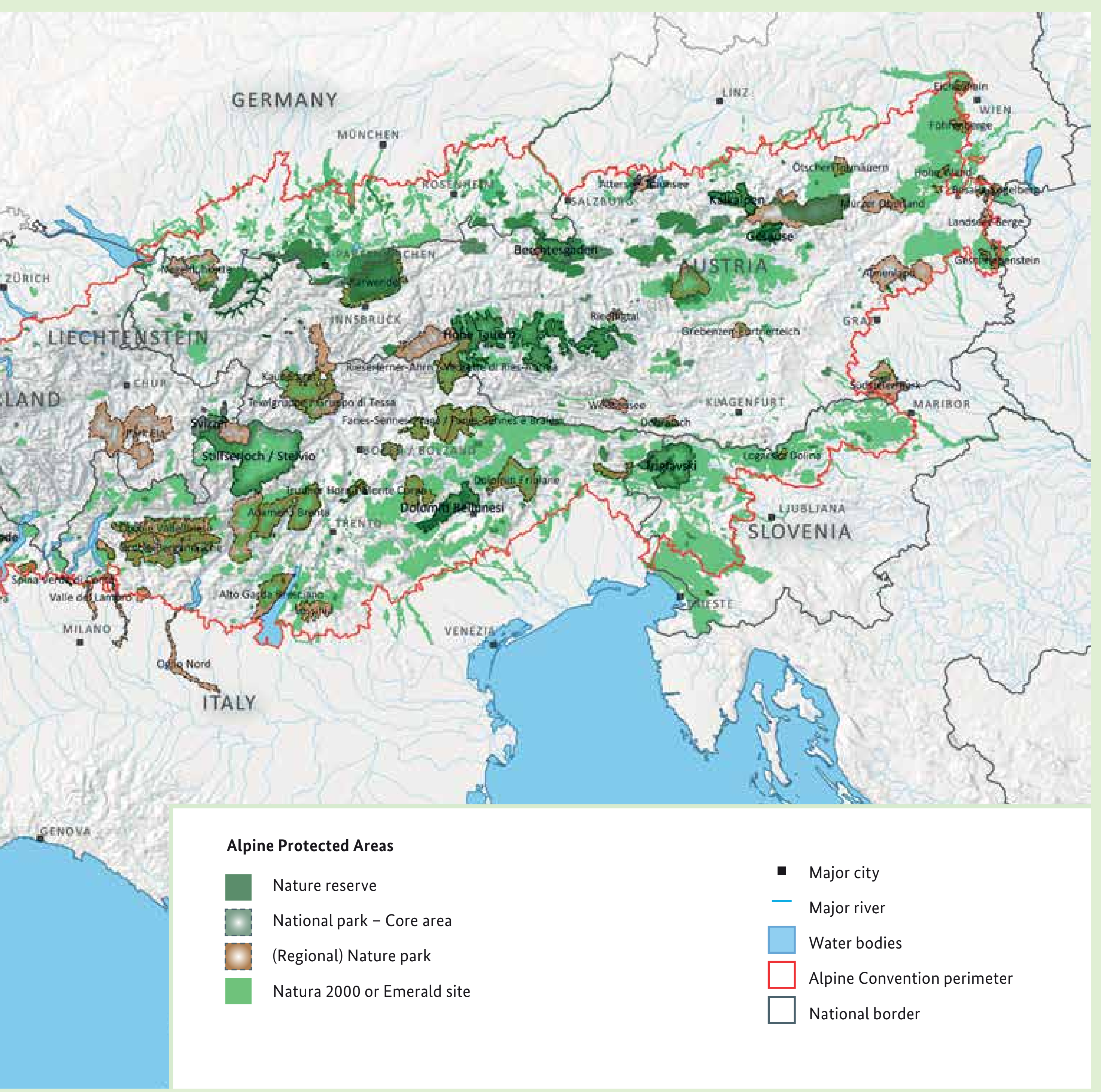
An Alps-wide connectivity conservation management framework proposed and supported by the Alpine Convention as an international treaty with specific implementation protocols could be a highly strategic element in ensuring a long term dimension to the realisation of a well-structured ecological continuum on a regional and transnational scale within the Alps. As major barriers for connectivity also exist around the Alps, the involvement of the macro-regional strategy is crucial.

The strategic elements, visions and legal tools already exist even on an international level – although their concrete use is often governed by political motives.

Nature Reserve Bout-du-Lac at the south end of the Lake Annecy in France.

// **Map 9:** Alpine Protected Areas and Natura 2000/ Emerald sites

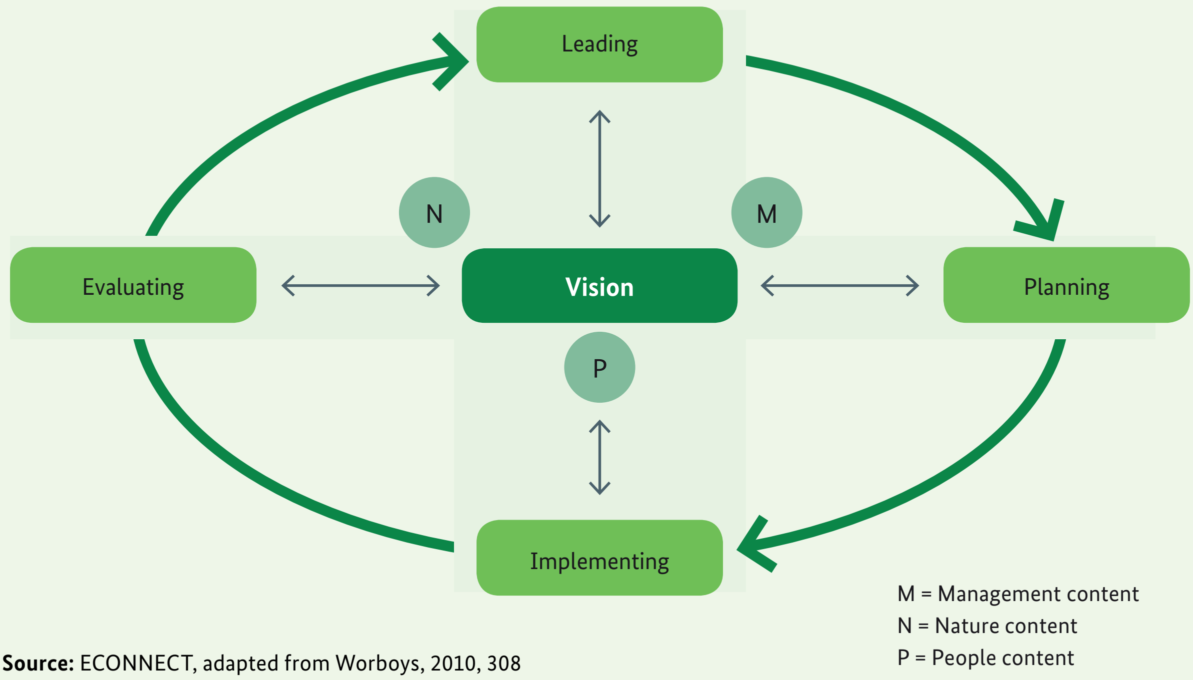




Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); European Environmental Agency for Natura 2000 areas and Emerald sites; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (Original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note:** This map makes no claim to be exhaustive. **Design:** Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

Rural settlement in the Landscape Park Binntal, Switzerland.

// **Figure 2:** Management framework for connectivity conservation management



Source: ECONNECT, adapted from Worboys, 2010, 308

2.5 Netzwerk Naturwald - An innovative network of protected areas in the Northern Limestone Alps

// Christoph NITSCH //
National Park O.ö. Kalkalpen Ges.m.b.H, Molln, Austria

In 2010, the Northern Limestone Alps region in the heart of Austria was honoured as one of five Pilot Regions for ecological connectivity in the Alps within the Platform for Ecological Connectivity of the Alpine Convention. The region is a worthy recipient of this award and can be justifiably proud of it. Three internationally accredited protected areas reflect the great richness of natural gems here: two of them are national parks (Kalkalpen National Park and Gesäuse National Park, both IUCN category II) and one is the only wilderness area in the heart of Europe (Wilderness Dürrenstein, IUCN category I). In 2012, these three protected areas gathered together within Netzwerk Naturwald (which means network of natural forests).

Under the lead of Kalkalpen National Park, this Netzwerk Naturwald adopted the role of trailblazer in establishing an innovative collection of protected areas on a regional level. Initially, significant data collection was required for modelling a network supporting preservation of biodiversity. This network was based on less mobile inhabitants of natural forest like bats, xylobiontic insects and specialised birds and aimed to connect the core habitats of the protected areas via a corridor of selected stepping stones. Since then, the stepping stone concept has been effectively implemented. This innovative concept aims to connect habitats of the protected areas with a long term perspective. By full conservation of carefully selected stepping stones embedded in a matrix of sustainably used forests, the maximum enhancement of connectivity can be gained with limited funding.

It is an important approach within Netzwerk Naturwald to combine conservation measures with sustainable land use in a clever recipe. As forestry is an important economic factor in this structurally underprivileged region far from the urban areas, further implementation of large strictly protected areas would likely be unpopular with a majority of the people living in this region. However, regional popular support for conservation measures is one of the key elements for successful long term conservation policies. Therefore, a well-considered choice of areas dedicated to connectivity is necessary. To find the most effective stepping stone areas, modelling within specialised GIS based software was performed, and the results finally led to a prioritised list of potential stepping stone areas. The results of planning work were published in a proposal that focuses not only on the environmental protection and conservation but also on the potential of the region as an outstanding example of sustainable, nature-based regional development

> *Implementation of Netzwerk Naturwald's plan was also innovative. All activities were based on voluntary participation via bilateral contracts.*

In this way, three stepping stones identified as priority areas were conserved for the long term. About 130 hectares were removed from forestal use permanently, and in exchange for this landowners received a one time payment. So these areas have been dedicated to ecological connectivity perpetually without concern for future financing, as would be the case with comparable short term contracts. Areas remain property of the previous landowners but are taken out of forestal use. This brings several administrative and financial advantages not only for Netzwerk Naturwald but also for the landowners involved.

The first of these contracts was completed in autumn 2014 in cooperation with the Styrian federal state forests (SLF). It involved a stepping stone of about 40 hectares within natural forest in Styria on a direct route from Kalkalpen National Park to Gesäuse National Park. In June 2015, together with the competent Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) and the Austrian State Forests (ÖBf AG), two more stepping stones were created. All three areas are important links in the ecological network connecting the outstanding habitats in the protected areas. Both landowners are important partners within Netzwerk Naturwald, as about two thirds of potential stepping stone areas are owned by them, and these owners play an active role in implementing the assembly of protected areas. Furthermore, as responsible forest enterprises, they are interested in conservation of the outstanding biodiversity, which is also a great benefit for a sustainable use of resource wood in the long term.

Work on the collective of protected areas in the Pilot Region started within the project ECONNECT under the lead of Gesäuse National Park. At the conclusion of the EU funded project ECONNECT, the task was taken over by Swiss MAVA Foundation pour la nature. Since then the work on ecological connectivity within Netzwerk Naturwald has been generously funded by this private organisation.

The Alpine arc is one of MAVA's core areas for their funding of work on ecological connectivity, and the Northern Limestone Alps region naturally draws their attention, as it is one of the last remaining large areas in the Alps widely covered by forest without major fragmentation. For this reason, European conservation policies related to biodiversity in the Alps should focus on this area in future. Here there is still a largely intact area that is worthy of protection for future generations.

In the coming years, in addition to implementation of the collective of protected areas, Netzwerk Naturwald will work on transfer of knowledge gained in its Alps-wide projects as a best-practice example. Collaboration is planned with other Pilot Regions in the Alpine Space project ALP.BIO.NET2030 and other projects. In addition to ecological connectivity, a high priority goal of the Netzwerk Naturwald project team is to raise awareness of the outstanding natural resources of the Northern Limestones Alps amongst the local population as well as stakeholders and decision makers. It should be common sense that biodiversity, its conservation and its sustainable use represent the greatest opportunities of this region in the competition between regions throughout Europe. Perhaps an UNESCO Biosphere Reserve spreading over the three protected areas and therefore useful for all three federal states of Austria would be an ideal treasure chest in which to showcase the gemstones in an attractive way and also gain economic advantages from these natural jewels.

Primeval forest as it should be: conserved and restored in the core areas and stepping stones of the Netzwerk Naturwald forest network.

2.6 Linking policy, science and implementation – The Platform Ecological Network of the Alpine Convention

// ***Bettina HEDDEN-DUNKHORST*** //
Federal Agency for Nature Conservation, Division of International Nature Conservation, Bonn, Germany

// ***Marie-Odile GUTH*** //
Ministry of Environment, Energy and the Sea, Paris, France

2.6.1 Background and objectives

The Alpine Convention, an international treaty between eight Alpine countries (Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland) and the European Union, became effective in 1995. The convention provides a framework for cooperation aiming to promote sustainable development by balancing environmental protection, economic growth, and social welfare in the Alpine space. Details for the implementation of the convention are specified in nine protocols that primarily relate to: environmental protection and nature conservation, planning and management, economic activities (farming, forestry, tourism) as well as energy and transport. The Protocol of Nature and Landscape Protection aims to foster measures to protect and – where necessary – restore nature and the landscape and to maintain biodiversity and ecosystem functions in the Alpine region. Article 12 of the protocol relates to establishing an ecological network and calls upon contracting Parties to "pursue the measures appropriate for creating a national and cross-border network of protected areas, biotopes and other environmental assets protected or acknowledged as worthy of protection." This protocol, especially Article 12, laid the foundation for the establishment of the Platform Ecological Network that was decided upon at the 9th Alpine Conference in Alpbach (Austria) in November 2006. Since then, the Platform has been chaired by Germany and France, two member states that continuously supported activities concerning biodiversity conservation and ecological connectivity in the context of the Alpine Convention.

The Platform brings together subject matter experts from all member states of the Alpine Convention, research organisations and NGOs to serve as a core group. It aims to foster exchange, cooperation and implementation related to ecological connectivity in member states, across borders and in the Alps as a whole. More specifically, the Platform seeks to gather, discuss and expose best practice and to support project activities for the implementation of an ecological network. It further encourages and supports connectivity related research and provides a forum to discuss methodological approaches. Beyond this, the Platform provides information on the importance and potential of connectivity measures to stakeholder and the public and contributes to capacity building and awareness-raising. The Platform operates on the basis of a mandate that, upon further demand, is renewed every two years after approval by the Alpine Conference of the Parties. The biennial mandate allows for stock taking of progress achieved, priority setting and adjusting the focus according to new developments.

2.6.2 Selected activities and achievements

Since its inauguration in 2007, the Platform Ecological Network has supported and partly initiated a number of key activities. One of them is the preparation of a "Catalogue of possible measures to improve ecological connectivity in the Alps" (Kohler *et al.* 2011). The catalogue describes and briefly analyses more than 70 measures related to different sectors (agriculture, forestry, tourism, education, spatial planning and more) and comprehensively illustrates the potential to implement connectivity in practice. In addition, the Platform supported the compilation of several subject matter publications and informational material for various stakeholders.

An important impetus for advancing the concept of connectivity is given by related projects and initiatives. Since the beginning of the last decade, a number of projects have been carried out by different environmental organisations – some of them being represented in the Platform. The project "ECONNECT – Restoring the Web of Life" (2009 – 2011), carried out by 16 partner organisations across the Alps – and primarily funded by the European Union (EU) – was one of the largest projects. It was followed by other EU supported projects for example “recharge.green – Balancing Alpine Energy and Nature” and “greenAlps – Connecting Mountains People Nature”. In parallel, several transboundary connectivity related projects - also co-funded in part by the EU- as well as national and regional Alpine initiatives were carried out. The Platform supports project activities in different aspects, as analytical observers or by promoting the distribution and implementation of their results.

ECONNECT worked with a set of Pilot Regions in order to test connectivity measures and instruments developed within the framework of the project. Each Pilot Region consisted of a protected area and its surroundings, and most of them were transboundary. To recognise the achievements of the Pilot Regions and to encourage other regions to strengthen ecological connectivity in their territory, the Platform decided to develop and set up a mechanism to nominate Pilot Regions of Ecological Connectivity of the Alpine Convention. Subsequently, eight regions have been nominated, and further regions are invited to become part of the network that supports implementation at local to regional levels. Being linked to these levels also helps to ground the Platform’s work.

2.6.3 Added value

This publication, apart from demonstrating the activities and results reached in more than ten years of efforts to foster ecological connectivity in the Alps, also illustrates that establishing an ecological network in the Alpine space is a stepwise process that requires constant adaptations and the involvement of many actors and institutions at different levels. In this context, the Platform Ecological Network – apart from the above mentioned contributions – adds value by linking policy, science and implementation. This provides an opportunity to channel knowledge, research results, experiences and policy proposals to decision makers. Moreover, because the Platform is part of the Alpine Convention, the multi-national level can be reached, which is specifically important in the context of ecological connectivity, as species require habitats and migration corridors across borders. The Platform also facilitates linkage to related initiatives beyond the Alps (for example EU Green Infrastructure, the Green Belt Initiative, the Convention on Biological Diversity, the Carpathian Convention and more) and thereby enhances exchange of expertise and mutual learning. Last but not least, not being a project with a limited life span but rather an entity in the framework of an international treaty is a clear advantage of the Platform. It guarantees continuity in the process of establishing an ecological network.

Measures in favour of ecological connectivity along a highway in the Alps-Carpathians-Corridor area visited by the members of the Platform Ecological Network.

2.6.4 Looking ahead – Exploring further opportunities

However, making better use of added values is still a challenge for the Platform, particularly as human resources are limited and Platforms or Working Groups of the Alpine Convention are not endowed with financial resources. New opportunities are expected from the Convention’s efforts to foster cooperation between its Platforms and Working Groups and thereby support a more holistic and less sectoral approach. This is of particular relevance for the Platform Ecological Network that, by working on a cross-cutting topic, relates to a number of subjects elaborated in various Platforms and Working Groups of the Convention (for example large carnivores, wild ungulates and society; transport; natural hazards; water management; agriculture; forestry; sustainable tourism). Opportunities also arise from the Convention’s efforts to promote a green economy in the Alps, as measures to advance an ecological network address various economic sectors and, at the same time, have a potential to contribute to a greening of the economy. The recently established EU Macroregional Strategy for the Alpine Region (EUSALP) creates additional opportunities to promote the development of an ecological network in and beyond the Alps, particularly because an Action Group on connectivity has been put in place. This may also open up further EU funding sources and invites new actors to foster the process.

Box 2: Ecological connectivity across provincial borders (Netzwerk Naturwald)

Interview with
// DI Andreas HOLZINGER //
Director, Styrian Provincial Forests Service, Admont, Austria

As Director of the Styrian Provincial Forests, you participated actively in the establishment of the "Netzwerk Naturwald" (natural forest network) project, which aims to create ecological connectivity across provincial borders between two national parks. What was most important for you during the first steps?

The two large protected areas, Kalkalpen National Park (about 20,000 hectare) and Gesäuse National Park (about 12,000 hectare) have designated sizeable core zones (unmanaged areas) as areas with a high degree of naturalness and undisturbed development potential for classic habitats such as broad-leafed old growth (with corresponding sensitive flora and fauna). So one can think of our first "nature forest" cell of 40 hectares as a connecting line or stepping-stone.

In addition to recognising its value as a natural area, the (Kalkalpen NP) partner's clear commitment to nature conservation by contract – and so the fact that there was compensation for setting aside the land (irrespective of the actual amount of money involved) – was decisive in our willingness to contribute the area.

What is the role of the Styrian Provincial Forests in creating ecological networks of protected areas?

Our role was in setting an example and providing an initial spark for potential future area designations. I should mention that voluntary measures of protection and land sparing of suitable areas are also being contemplated.

In general, what is the role of forestry in this context? How can it contribute?

The role of forestry can indeed be one of partnership with nature conservation, providing a solid foundation of expertise in the area (for example by implementation of technical monitoring activities, but not research). Foresters can contribute field knowledge, many years of documented knowledge about hunting areas, and of public acceptance.

What do you feel is especially difficult when establishing such networks?

The use of forest spatial planning could be both obstructive and useful: Areas that are taken out of use could (should) be offset by other areas with sustainable use! Meaning not every hectare has to be managed for maximum profit, not every hunting area needs a contractual protection status.

For economic reasons, however, land that is used also needs a meaningful spatial connection (a network), just like their counterparts, the so-called "stepping stone ecosystems". But the general problem remains long term funding security (even an unused area costs taxes and has maintenance costs!).

What would your advice be to other areas where such networks are to be established?

Keep the communication going and discuss goals jointly. Involve the landowners; they have to be taken seriously. A partnership approach – be wary of the "expert mischief" of NGOs that want to profile themselves on others' property.

Box 3: Working with stakeholders in the Pilot Region Berchtesgaden-Salzburg

Interview with
// Dr. Michael VOGEL //
Director National Park Berchtesgaden, Berchtesgaden, Germany

Because of your many years working towards ecological connectivity in the Berchtesgaden region you have a lot of experience in networking with various local stakeholders. What is the best way to start building such stakeholder networks?

There are no recipes. It is important to analyse the complexity of the question or topic. Mono-thematic questions tend to lead to single individuals, multi-thematic questions to several people that sometimes also have some kind of relationship to one another. You have to be willing to invest a lot of time to find a personal connection through meeting and talking processes, and eventually to find common ground for all the concerned parties. Then I am able to bring them together around a table and to negotiate things in a positive communicative atmosphere and to get to a result that is carried by everyone. It´s not the organisations and institutions that have to act together, but their representatives, people like you and me.

How can one get the local population interested in the sometimes rather abstract topics of ecological connectivity?

It is very important to translate the results of projects and studies into the language and thinking of the people who live there, using examples that they are familiar with and know from their daily life. For this you need excellent communication skills, a lot of imagination, and the conviction and tenacity to stay on topic. Ideally you get outside support and don´t have to go it alone.

In Berchtesgaden was it possible to bring about a general appreciation of biodiversity and ecosystem services? If so, how?

Yes, I think so. Local people know exactly from their daily lives and work that together one can achieve more and that there can be an added value for them from this. It is the same for biodiversity and ecosystem services. If you have a protected area with the principal goal of conserving biodiversity and natural processes at your doorstep, from which you get services and, in addition, many visitors and tourists, then as a protected area manager you have to be able to clearly illustrate this added value for the region. As a consequence one can assign a purely people-centred monetary value to this protected area with its biodiversity and its ecosystem services – and this leads to a feeling of belonging to a distinctive region with something special. But this does not happen by itself. For this you need research for your database, communication for implementation, readiness to act as service provider (for example with offers of a well maintained trail network), solid educational activities (guided tours and environmental education events), and you also have to realise that the region with its protected area is also people´s home, and their living and economic space.

How does working with stakeholders affect implementation measures for ecological connectivity in practical terms?

We have actually reached a point where we no longer have to discuss the need for or the meaning of ecological networks. It has become commonly accepted opinion that such connectivity has many advantages, and also that you have to do something for it. Together with the communities, the state administrations, various (nature-) user groups and private interest groups, we have implemented many results from projects on ecological connectivity, creating legally binding practices, but also voluntary actions. We have redesigned the landscape and land use plans of municipalities and created an overall landscape master plan with set measures at set points. This is the result of consensus, and all the actors I mentioned implement these measures in their respective areas of responsibility. These may be, for example, more extensive agricultural practices with and without state compensation, arrangements for land use or settlement development, and active species conservation and management measures. We have also built infrastructure for visitors and inhabitants, such as a cross-border thematic trail on ecological connectivity. Such actions are taken without a lot of bureaucracy, sometimes a bit "unofficially", but always results- and task-oriented.

What would you recommend to other regions that may just be starting out with the establishment of ecological networks? Where does one start, what is most important?

The local situation matters a great deal. Such networks always include representatives of very different organisations, administrations and social groups. All of them have to be willing and able to listen to one another, they have to be willing to compromise, and, importantly, they have to be entitled to make decisions. And even after difficult discussions it has to be possible to have a beer together afterwards. After all we are always talking about people dealing with people. Viewed from the technical point you need an organisation/individual who takes the lead, who provides the process with content, numbers, data, and facts. It is important to keep repeating that we do not live by the power from the socket, but that we depend on our natural foundations for life. These we have to conserve, promote, or improve. And here we are again, back to biodiversity, ecosystem services and ecological connectivity.

What would be the most important next steps in Berchtesgaden?

My answer may not surprise you. We have a number of larger, quite costly measures on our wish list. At the moment all of us, each in their area of responsibility, are looking for suitable projects and/or funds to carry out these plans. I can promise that we will all sit around the table again to shape the implementation of new connectivity measures.

During the ECONNECT project, measures to improve ecological connectivity for various fish species were realised on the River Saletbach between the Königssee and the Oberseelakes in the National Park Berchtesgaden. Further actions are currently realised in this area, also in cooperation with the local fishermen.

3 The challenges of engendering ecological connectivity – Topics and impacts

Introduction

This chapter investigates the multitude of challenges that arise when planning and implementing ecological connectivity measures. In the first contribution, Thomas Scheurer, from ISCAR, looks at the planning process in dynamic landscapes and discusses the opportunities and limitations of spatial planning in this process. In the second contribution, Karin Svadlenak-Gomez from the FIWI and Marianne Badura from blue! look at the pressing problem of stakeholder participation in the decision-making process. They describe and discuss the "empty chair" situation encountered by numerous initiatives that fail to motivate and engage adequate stakeholder representation. In the following contribution, Florian Kraxner and his colleagues from IIASA, examine the expansion of renewable energy production and the opportunities and conflicts that arise in reconciling this development with biodiversity and ecological connectivity conservation. ►

Similarly, in the fourth contribution, Stefan Marzelli and Harry Seybert, from ifuplan-Institut für Umweltplanung und Raumentwicklung and the Bavarian State Ministry of the Interior for Building and Transport respectively, look at the effects of the expansion of transport in and across the Alps on fragmentation of the landscape and ecological connectivity. With some 95 million overnight visits in the Alps, tourism is an important factor in defining the landscape, and Barbara Engels from the German Bundesamt für Naturschutz looks at the impacts in her contribution. While for the most part enhancing connectivity is viewed as a positive effect on biodiversity conservation, Jake Alexander and Christoph Kueffer from the ETH Zurich and HSR Rapperswil describe how connectivity promotes the spread of invasive species at global as well as landscape scales. Chris Walzer from the FIWI, similarly describes how changing the spatial structure of a landscape invariably also changes host-parasite abundance, distribution and persistence. Hunting is an often underestimated and neglected factor influencing the ecological connectivity of a landscape, and Fritz Reimoser examines the effect and the opportunities offered by wildlife and game management. Riccardo Santolini from the University of Urbino and his colleagues provide an Italian perspective and insights into the nexus of ecological connectivity and ecosystem services. Finally, Filippo Favilli from EURAC reviews and examines in detail the interconnection between agricultural development and the maintenance of an ecological continuum and biodiversity conservation.

3.1 Planning dynamic landscapes: Opportunities and limitations of spatial planning in creating ecological networks

// Thomas SCHEURER //
ISCAR – International Scientific Committee on Research in the Alps, Bern, Switzerland

Ecological connectivity is a fundamental function of landscapes. Ecological connectivity provides open space for human activities and enables mobility and exchange between habitats for flora and fauna. Furthermore, the maintenance of connectivity in urbanised or human-exploited landscapes is one of the main goals of ecological networks and is included in national biodiversity strategies (for example France, Germany, Switzerland), or, in a more citizen-oriented sense, of green infrastructure (GI), as adopted by the EU (2013, see box 4).

Awareness of the significance of ecological connectivity (EC) and ecological networks (EN) when facing climate and land use change has grown in the last decade. EN (and GI) can be seen as the most recent concepts for nature protection and conservation of biodiversity. Advancing beyond approaches that focused on the protection of endangered or rare species (and their main habitats or biotopes) and the creation of spatially delimited nature reserves and protected areas (segregation), EN and GI aim to harmonise species habitats with human land use and presence (aggregation) and to enhance the connection between existing protected areas.

Various studies emphasise that conservation of biodiversity will need between 30 and 40 percent of the total territory. Within these areas biodiversity must be the priority in land use and management practices (for example in Switzerland: Guntern *et al.* 2013). For the Alpine area the required territory has been estimated to be as much as 40 percent. Since the nearly 1,000 nature reserves and other types of pre-existing protected areas currently cover approximately 25 percent of the territory of the Alpine Convention (ALPARC 2016), a further 10 – 15 percent of the surface must be protected in order to improve EC and EN. This proportion is inherently higher in areas with a lower percentage or density of nature reserves or protected areas.

3.1.1 Spatial planning: Biodiversity matters

Hence, biodiversity conservation is an important element in spatial planning and of relevance to the organisation of land use. Instruments of current spatial planning allow the definition of priority areas for biodiversity (such as Natura 2000, Important Bird Areas and more) , as far as they can be clearly delimited based on legally binding frameworks, such as ordinances, inventories, or property rights. This is mainly the case when designing nature reserves or protected areas, even if the priority setting in protection status ranges from "very

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strict" (nature reserves) to "recommended" (for example areas in regional parks).

Furthermore, spatial and especially landscape planning offer a large range of instruments for the co-ordination of multiple types of land uses and interests (including nature and landscape protection). These instruments aim to create a common alignment of spatial or landscape development while respecting varied interests. Experience has taught us that there are significant challenges in promoting and implementing nature and landscape protection. While economically relevant land use (infrastructure, production, urbanisation) can focus on specific areas, nature and landscape have to be considered trans-sectorally and often overlap with human land use. In land use planning, economically driven land use will usually secure the most suitable locations with optimal conditions in an unchallenged manner, while nature and landscape conservation entities are forced to defend most of their stated requirements. Therefore, it is crucial that evidence for biodiversity conservation and corresponding know-how be based on scientific research. This is also true for EN (and GI). In the successful introduction of EN (and GI) issues into in spatial planning, precise argumentation and the verification of social benefits are essential preconditions. In other words, basic understanding of EC and EN is the foundation for integrating ecological networks into spatial planning. Thus, scientific research as well as methodology and strategy development concerning EN (and GI) must be enhanced.

3.1.2 Top down or bottom up?

Regarding spatial planning, good instruments for the designation or delimitation of EN are rare. The most common method is to break down national or regional concepts, such as the Swiss national ecological network (REN; BAFU 2004) or Ecological Network of Isère Department (France; Conseil Général de l`Isère 2009), to the level of regional or municipal planning. The results of such top down approaches are, presently, not very promising, since the cascade down to the actual landowner in respect to legally-binding planning and implementation of measures is very slow. The break down is more efficient, when measures for the maintenance of ecological networks (such as green bridges) can be integrated in to urbanisation or infrastructure projects. To efficiently move forward on implementing EN measures, large-scale concepts (for example the Pan-European Ecological Network, the Green Belt, or Alpine Priority Conservation Areas), as initiated by the European Centre for Nature Conservation or the Continuum Initiative (see box 5) are needed. Top-down concepts help to focus action on the most important and promising areas.

On the other hand, bottom up planning on a local or regional level is often driven by feasibility or problems concerning specific species, and therefore often does not take into account the larger context. The integration of EN into local or regional planning can be supported by a systematic analysis of landscape connectivity, as proposed by JECAMI tool (*www.jecami.eu*). With tools like this, the wider landscape and habitat context and even long-term changes in landscapes can be addressed. The combination of landscape analysis tools with spatial planning tools must be further developed, following for instance the example of systematic conservation planning in the Netherlands.

3.1.3 Structural or functional connectivity?

Ecological connectivity can be regarded from a structural or from a functional perspective. Structural connectivity describes the shape, size and location of features in the landscape (Brooks 2003). Functional connectivity entails the extent to which a species or population can move among landscape elements in a mosaic of habitat types (Hilty *et al.* 2006). Structural connectivity meshes better with spatial planning, as features in the landscape can be selected in a land use system, while interrelations between habitats are vastly more difficult to define and delineate. For this reason, structural connectivity should be the first consideration in spatial planning processes. Nonetheless, functional connectivity has to be considered, when specific requirements of important species (isolation or dissection of relevant habitats) are concerned, and landscape dynamics are changing the mosaic of habitats.

These statements are mainly valid for terrestrial connectivity. Aquatic and aerial connectivity are often forgotten in spatial planning. While water-courses are regulated by specific laws, the aerial (third) dimension is widely neglected in spatial and landscape planning. Specific efforts will be needed to integrate these aspects into future EN planning.

3.1.4 Control or dynamic?

Many species or communities of flora and fauna are sensitive to changing conditions, such as those caused by urbanisation, land use change, habitat fragmentation, or climate change. Flexibility in the use of habitat patches (for example dislocation to new habitat elements) is crucial for adaptation to such changes. However, instruments for spatial planning have been designed primarily to define and control land use and spatial development. Dealing with EN issues, spatial planning tends to statically fix spatial structures or corridors in a present-day given state, without considering landscape dynamics and the necessary flexibility in habitat use for flora and fauna. Furthermore, GI as defined by EU (see box 4) represents such a method of locating spatial structures of natural and semi-natural areas in a given land use context. Practically, instruments for land use planning are hardly appropriate to manage change with regard to EN or GI. One of the main challenges when integrating EN into spatial planning will be to develop concepts for multi-functional land use (for example by defining land use types in the interest of biodiversity) and new tools for adaptive land management.

3.1.5 Connect administrations and sectors

Spatial planning faces a central challenge in trying to assure ecological or landscape connectivity. A second and even more challenging task within spatial planning is connecting the multiple land users involved in the various sectors of administration and among different territories with specific competences and given boundaries. As EN must be planned beyond such present-day legal and administrative frameworks, the main task is often to begin by addressing socio-political issues in order to ascertain how to establish EN or how to organise elements of these networks. Connecting people from different administrations or sectors and addressing EN enhances the likelihood of success in spatial planning, as long as it is possible to overcome sectoral and territorial borders. Awareness concerning the needs and benefits of connectivity in spatial development must be raised within all concerned target groups, and this must extend beyond the basic concept of nature protection. Such campaigns based on scientific evidence are important to attract necessary partners and involve them in the planning processes.

3.1.6 Conclusion

Instruments for spatial and landscape planning allow for the consideration of ecological networks but only on quite large scales and/or with low legally binding character. Moreover, spatial planning currently limits the scope of decisions favouring ecological networks in several ways: land use planning follows the principle of segregation and rarely encourages multiple use plans that include biodiversity; and the differentiation of planning authorities (multi-level governance) often hinders cross-border planning, which is needed when planning ecological networks. In the future, the needs for planning ecological networks have the potential to develop instruments for more trans-sectoral, more cross-border, more dynamic and more integrative practices in spatial planning.

Box 4: Green Infrastructure

Green Infrastructure addresses the spatial structure of natural and semi-natural areas as well as other environmental features that enable citizens to benefit from its multiple services. The underlying principle of Green Infrastructure is that the same area of land can frequently offer multiple benefits if its ecosystems are in a healthy state. Green Infrastructure investments are generally characterised by a high level of return over time, they provide job opportunities, and they can be a cost-effective alternative or be complementary to 'grey' infrastructure and intensive land use change. GI serves the interests of both people and nature. Source: *www.ec.europa.eu/environment/nature/ecosystems/index_en.htm*

3.2 Networking for nature – The challenges of bringing the "right" people together

*// **Karin SVADLENAK-GOMEZ** //*
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Biology and Evolution, University of Veterinary Medicine, Vienna, Austria

*// **Marianne BADURA** //*
blue! advancing european projects GbR – consulting&engineering, Munich, Germany

Stakeholder participation in decision-making on issues of public concern, whether at an international, national, or regional and local level, is a frequently quoted requirement for the success and sustainability of any project or measure. Although the participatory process is fraught with numerous challenges, participation is nonetheless viewed as increasing the legitimacy and quality of environmental governance, and conservation funding is often contingent on participatory approaches.

Stakeholder involvement can be viewed from two different angles: The interaction with stakeholders in order to comply with legal provisions has to be distinguished from proactive involvement of stakeholders from the inception of new initiatives or projects. The former may not necessarily lead to desirable conservation outcomes. For example, stakeholder consultation is an obligatory part of environmental assessment procedures for large infrastructure or construction projects in municipalities[4]. In many instances, expert opinions issued by nature conservation administrations are subsequently ignored or overruled in the approval process due to pressure from more powerful interest groups (greenAlps, 2014). Dominant stakeholder interests also influence inappropriate land use practices within Natura 2000 areas or river catchments, contravening applicable environment legislation. Thus, in situations where the political framework favours some stakeholder interests over others, lobbying of powerful stakeholder groups (for example infrastructure planning or agriculture) can, paradoxically, lead to a less effective implementation of nature conservation stipulations than if no stakeholder consultation had taken place and the law had been applied to the letter. Nature conservation measures are more likely to be successful if a proactive and precautionary stakeholder involvement and participation process is implemented in the early stages of planning, and if it is possible, the diverging interests of various stakeholder groups are reconciled by finding common ground.

The interests of different stakeholder groups tend often to very different directions – working on ecological connectivity also entails the challenges of bringing the "right" people together.

> **For effective participatory** *processes it is very important to be clear on the "why, what, who, and how much" of participation from the initial planning stages through to the implementation and follow-up stages of any initiative that requires broad, often trans-sectoral, support.*

Unfortunately there are numerous reports on the difficulty of involving stakeholders from key sectors in meaningful ways in nature protection activities. The institutional frameworks within which such processes are to be carried out may or may not be adequate, and there must be a genuine willingness to make use of stakeholder contributions so that participation does not end up being a perfunctory exercise. The quality of decisions made through stakeholder participation depends a lot on the nature of the process leading up to them (Reed, 2008). Organisational cultures can hinder or facilitate participatory processes – they have to be able to accept and process the negotiated goals and uncertain outcomes of the stakeholder participation process. Truly participatory processes entail the inherent risk that the outcomes will not be those desired by the project management authorities. Participation is costly and takes time, and some groups that lack skills or resources to participate may end up being excluded (Nared *et al.*, 2015). There are also examples in the literature where community participation was attempted but resulted in negative outcomes for the project proponents or where the circumstances made a participatory approach less than ideal (Irvin and Stansbury, 2004). Furthermore, to identify the most relevant stakeholders, an in-depth knowledge of the situation is needed. A stakeholder analysis must precede any such process. Depending on the setting, a variety of tools for such analysis exist (Reed, 2008).

3.2.1 Deficits in trans-sectoral stakeholder involvement

It has been widely confirmed that a participatory approach that integrates sustainability criteria (that is a balance of ecological, economic and socio-cultural factors) tends to lead to the best results (Torre-Marín *et al.*, 2012). This applies to all projects, but especially to biodiversity conservation and initiatives for the preservation or restoration of ecological connectivity, which by their very nature require an integrated, trans-sectoral approach. Yet current political and legal systems are not designed to effectively deal with this complexity.

In order to be successful, organisations or projects implementing biodiversity strategies therefore necessarily have to be very creative in identifying and motivating key stakeholders, who can help or hinder project success, to participate in the decision-making processes.

The proponents of nature protection projects often find it difficult to involve stakeholders from a mix of all sectors that have an impact on biodiversity and ecosystems. For some sectors, such as agriculture, forestry and fisheries, there is a direct dependence on functioning ecosystems and the services they provide, while activities in those sectors also tend to have an immediate impact on ecosystems. Depending on how these activities are carried out, the effects on biodiversity can be both positive and negative. The tourism sector in the Alpine region benefits from landscape beauty and often uses this as a selling point, but tourism is also frequently (though again not necessarily) a contributor to habitat disturbance, fragmentation, and loss. Other sectors, such as energy, transport and infrastructure, tend to have a large impact on ecosystems (for example through habitat loss and fragmentation and pollution). The dependence of these sectors on ecosystems is less obvious. These individual and markedly different sectors sometimes have conflicting goals, and it is therefore difficult to implement trans-sectoral biodiversity policies. This is compounded by difficulties in motivating stakeholders from these key sectors to collaborate in valuing and protecting ecosystems and their services. Land-use planning should by default be trans-sectoral, but the local realities of spatial planning are fraught with difficulties.

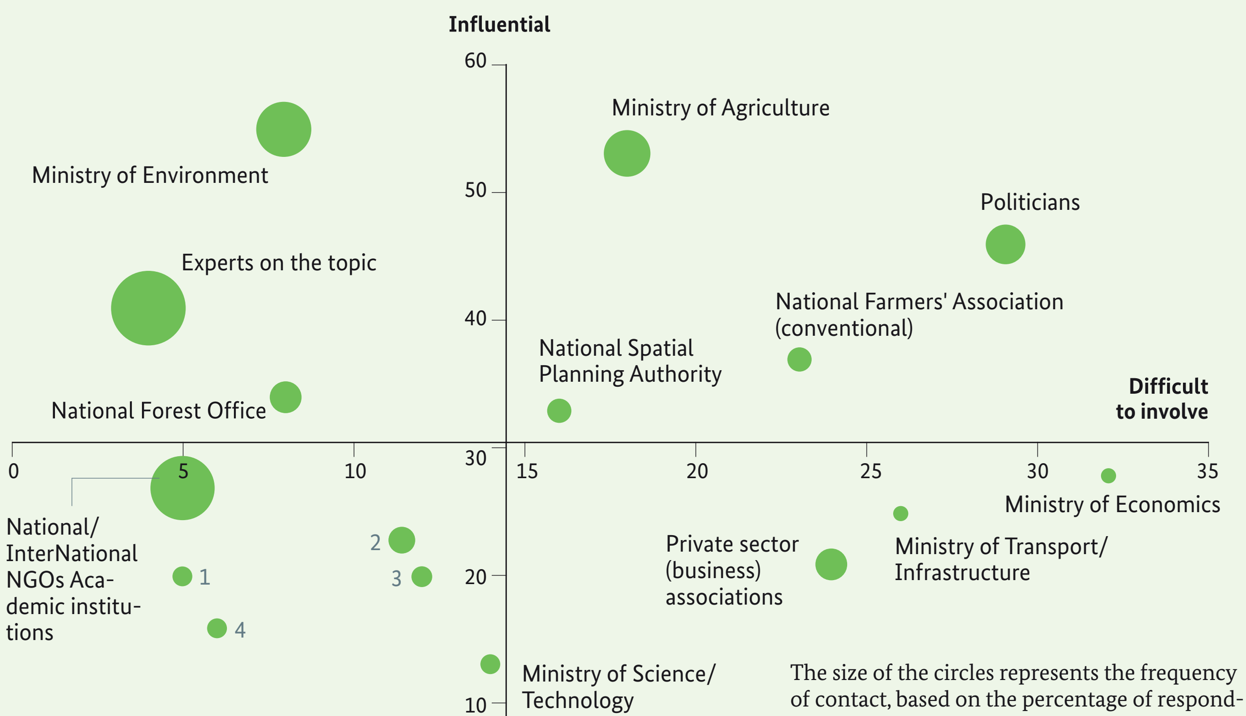
Based on expert surveys, the greenAlps project (co-financed by the ETC Alpine Space Programme) identified important stakeholders and key actors that impact biodiversity conservation, ecological connectivity and the provision of ecosystem services in the Alpine region (Svadlenak-Gomez *et al.*, 2014). The analysis showed, not surprisingly, that the very important stakeholders with power and political interests (politicians, ministries and more) appear to be more difficult to involve than those with knowledge and interest (academic researchers, experts, NGOs and more). Many survey respondents criticised a lack of coordination between different sectors. Responses concerning the frequency of contacts among nature conservation stakeholders showed that most people primarily communicate within their own peer group, that is experts have contact with experts, academics with academics, NGOs with NGOs and more stakeholders from different sectors often talk about each other rather than to each other. An analysis comparing the responses received on a national level to those on local levels also showed that there are no large differences in this pattern between the national and local levels.

These survey results were confirmed by a gap analysis of important stakeholders in EU biodiversity projects within the European Territorial Co-operation (ETC) programmes. Only a few of the sectors that have an important influence on biodiversity and ecosystems were involved in the sample of projects reviewed. Most of the stakeholders involved in projects dealing with the environment and nature came from institutions for which biodiversity conservation constitutes a core activity. These included protected area administrations, public administration bodies and, to a lesser extent, conservation NGOs.

As the ETC Alpine Space programme mainly targets administrative strategies and questions, it is not surprising that the number of stakeholders from public authorities or related to government bodies at different levels is quite large. Of the stakeholders dealing with different aspects of protected area management, the largest number work in the public administration sector. An analysis of the institutional provenance of stakeholders (divided here into NGOs, private sector/consultants, and the public sector) revealed that the majority of persons working with Alpine Space projects come from the public sector. A considerable share (20 percent) work for NGOs. The private sector percentage is very low (eight to ten percent), which is noteworthy, as this means that actors with a significant (mostly negative) impact on nature are largely absent. This may be due to a lack of incentives for businesses to take part in such projects or to the simple fact that the respective business are not under economic pressure to respond to this type of request.

In general, the framework conditions for trans-sectoral cooperation have to be established at the highest policy level and translated into mandatory policies at the regional and local level, especially in countries with federal systems where provinces and municipalities tend to have autonomy in planning. A review of the legal

// **Figure 3:** Matrix of stakeholders at a national level regarding their perceived importance (y-axis), the perceived difficulty to involve (x-axis), and the frequency of contact (z-axis)



1 National Farmers' Association (organic/bio)
2 National Hunting Association
3 National Tourism Association
4 National Fishing Association

The size of the circles represents the frequency of contact, based on the percentage of respondents who stated to have contact with the stakeholder group.

z-axis = Contact nominations (quite often).
n = 53 – 65 depending on dimension and stakeholder group.

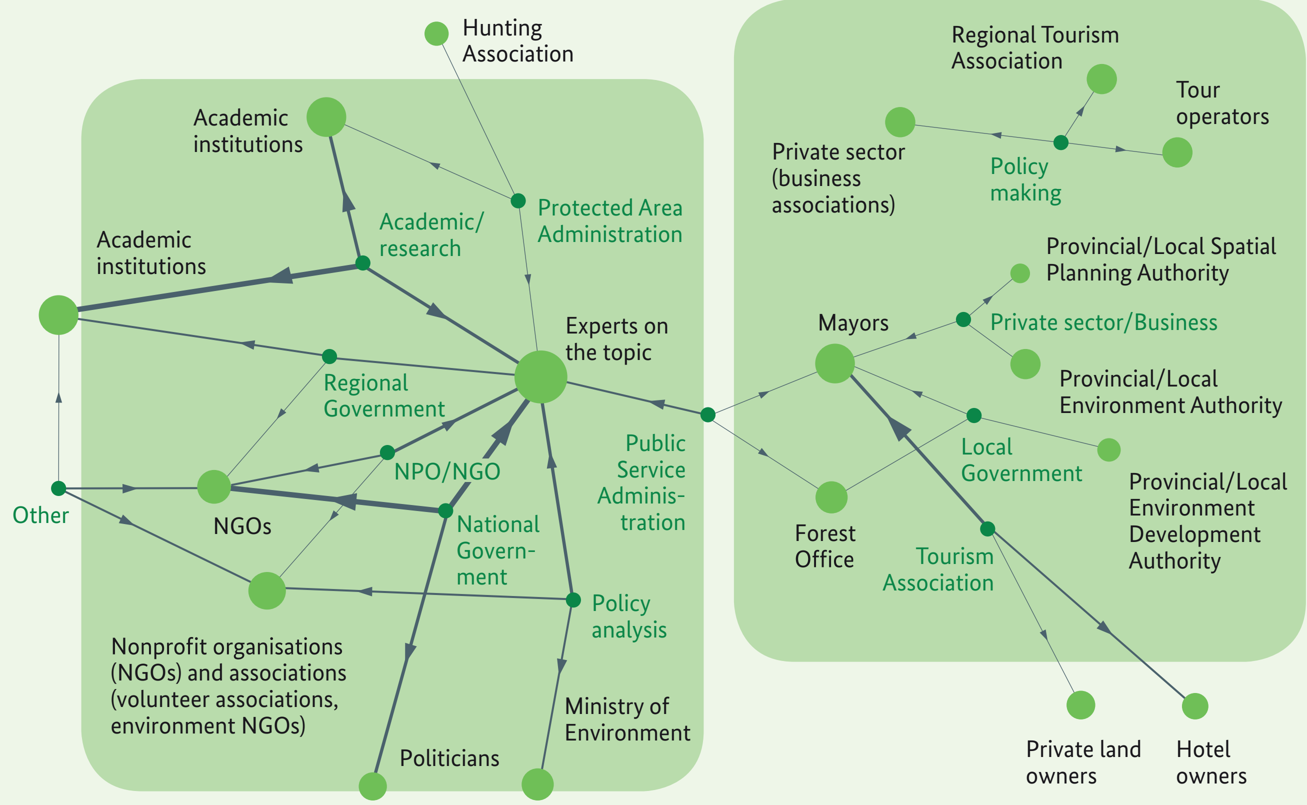
Source: 2014 FASresearch, reprinted from "Biodiversity Stakeholder Networks in the Alpine Space" frameworks for spatial planning in Alpine countries performed within the scope of the WIKIAlps project (also co-financed by the Alpine Space Programme) points to great variation among these countries and often within these countries from one province or region to another (Nared *et al.*, 2015). In some countries there is legislation that makes participatory processes in spatial planning mandatory, while in others there are merely recommendations, which may result in private interests trumping public interests such as nature conservation. In some instances, implementation practice does not correspond to the legislative framework, while in others there is at least a quite well established public consultation process.

Where political support is lacking at the top, it is not easy for "downstream" actors to overcome the various barriers to co-operation. On the other hand, there are several examples of successful trans-sectoral cooperation at the regional or local level. Good examples can be seen, for instance, in the processes that were applied for biodiversity and ecological connectivity-centred spatial planning in the Berchtesgaden region (see box 3), or the planning processes for ski lifts that are applied in Austria´s Salzburg Province (Svadlenak-Gomez *et al* 2014b).

3.2.2 The need for better coordination from the start

At the outset of the project planning phase, it is essential to launch an intensive dialogue with key stakeholders, particularly from those economic development and growth related sectors that have a significant impact on biodiversity. Stakeholders from all sectors have an obligation, as specified in various national laws and EU Directives, to avoid harming the natural environment and thus uphold an essential public good. It is crucial that this process is started at project inception and not merely as an add-on in the later stages. Not only will early integration raise awareness of the importance of conservation efforts in the various sectors, but it will also lead to projects that integrate a diversity of views and thus have more realistic goals, ultimately ensuring that these goals are more likely to be reached. When it comes

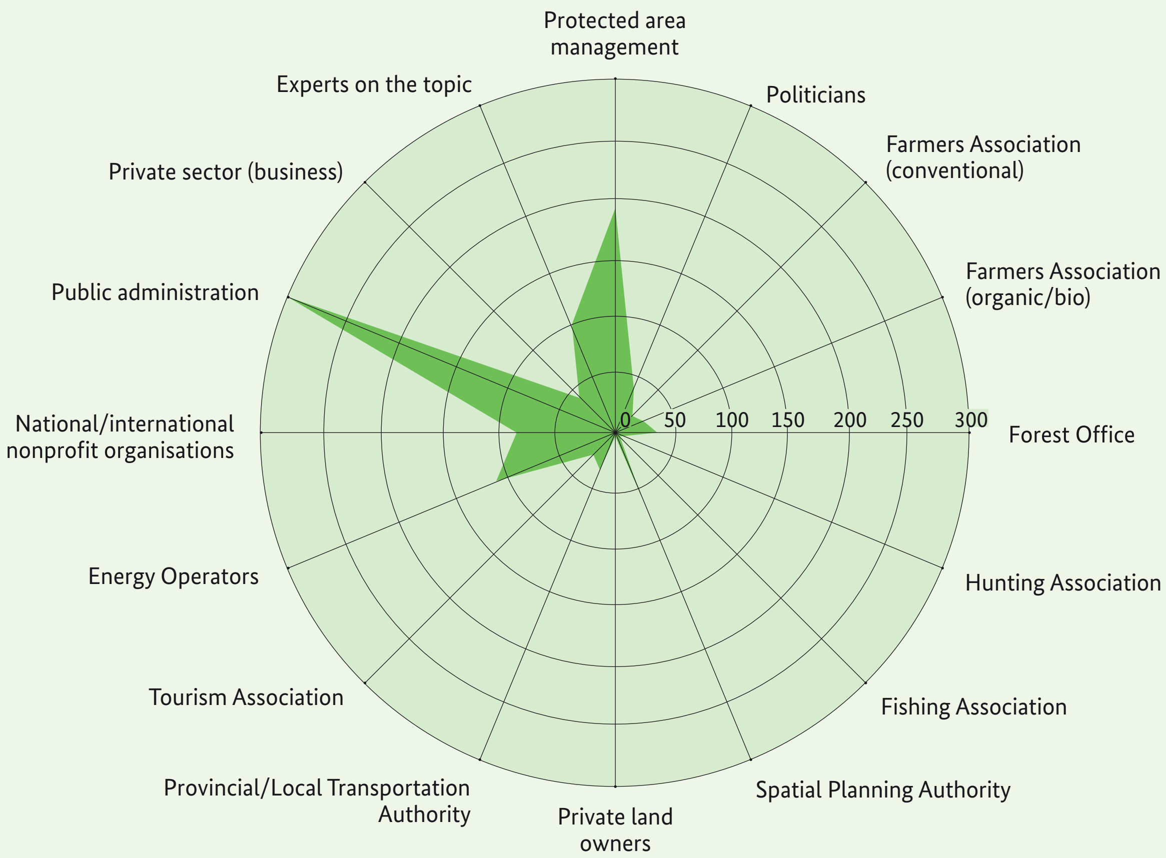
// **Figure 4:** Network diagram of contacts between stakeholders



Source: 2014 FAS research, reprinted from"Biodiversity Stakeholder Networks in the Alpine Space" to establishing new conservation areas or "nature-friendly" methods in sectors such as agriculture or infrastructure development, one of the key components in the ecological connectivity "toolkit" is public perception, as it can significantly influence project outcome. An example from Slovenia points to a potential disparity between the expected and desired costs and benefits of the establishment of a new protected area, and differences in perceptions between local stakeholders and the proponents of park establishment (Nastran, 2015). A failure to involve important stakeholders (for example land owners) before launching such initiatives can lead to distrust and unnecessary opposition and may jeopardise the success of such projects.

While the role of stakeholder participation in the Alpine region spatial planning has been gradually increasing, it often has a pro-forma nature, as there is insufficient knowledge and willingness to implement the appropriate realisation of such approaches (Nared *et al.* 2015). When launching participatory processes it is important to provide skilled facilitation resources. In order to create or maintain a multi-permeable landscape matrix that maintains and preserves connectivity within the Alps and their surrounding regions, several different stakeholder groups and governance levels have to be involved. For many of them, a paradigm shift is needed, which can only be meaningfully communicated at a high political level (for example the German energy transition – "Energiewende"). At all levels and with all stakeholder groups, politically motivated debates about the value of nature and the obligation to consider respective sectoral goals and needs are indispensable. Facilitation to manage and mitigate conflicts is likely to be needed (Reed, 2008), but such an elaborate and time-consuming process will pay off in the long run if it results in the Alps becoming a model region for sustainable development.

// **Figure 5:** Composition of stakeholders in a sample of biodiversity-relevant ETC ASP projects



Source: 2014 blue! advancing European projects, reprinted from"Biodiversity Stakeholder Networks in the Alpine Space"

3.3 Expanding renewable energy within the Alpine ecological network

// *Florian KRAXNER* [1] // *Sylvain LEDUC* [1] // *Hernán Serrano LEÓN* [1] //
// *Sabine FUSS* [1, 2] // *Piera PATRIZIO* [1,3] // *Ping YOWARGANA* [1] //

1) *Ecosystems Services and Management Program (ESM), International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria*
2) *Working group "Sustainable Resource Management and Global Change", Mercator Research Institute on Global Commons and Climate Change (MCC), Berlin, Germany*
3) *Department of Electrical, Mechanical and Management Engineering (DIEGM), University of Udine, Udine, Italy*

The Alpine ecosystems have delivered living space, food, and energy to their populations for millennia (Yamagata *et al.*, 2010). Nowadays, a diversification of renewable energy (RE) production is taking place. Traditional RE technologies, such as bioenergy and hydropower, are seen as only one part of the broad energy portfolio in the Alps and are now inter-alia complemented by wind power, solar, and geothermal energy. However, the expansion of all these technologies in competition with other land uses may increase landscape fragmentation (Svadlenak-Gomez *et al.*, 2013). If a functional ecological continuum is not ensured in the Alpine landscapes, their biodiversity and the provision of ecosystem services for the local populations may be threatened. Despite the general public support for RE expansion, such sustainability concerns can reduce public acceptance in certain locations. Proper spatial planning of RE expansion should consider ecosystem

The Roselend Dam is located in the Savoie department in the French Alps. Its construction was completed in 1962 for the primary purpose of hydroelectric power generation, and it supports the 546 MW La Bâthie Power Station.

connectivity so that environmental benefits from green energy production are not neutralised by its potential environmental impacts (Füreder and Kastlunger, 2011).

The traditional tool to conserve biodiversity from human activities has been the creation of strict protected areas (PAs) such as national parks and nature reserves (UNEP-WCMC, 2014). However, functional ecosystems and threatened species populations cannot be maintained if PAs are fragmented within the landscape (Dudley, 2008). In spite of this potential fragmentation, there are conservation strategies, such as the Natura 2000 network, which aim to increase the ecological connectivity between biodiversity Pas (EEA, 2014).

On the other hand, the diversity of PAs also gives room for integration of nature conservation with sustainable RE development strategies (Svadlenak-Gomez *et al.*, 2013). The Alps have a large variety of PAs that fall under different categories and classifications. Different RE systems can be more or less sustainable with respect to their impact on the ecosystems and their services. Thus, an RE technology could be suitable in protection categories allowing for sustainable use of natural resources but at the same time incompatible with stricter categories. The potential for RE energy in the Alpine region will depend on the protection constraints determined by the network of PAs. Furthermore, the mountainous topography of the Alps, that is accessibility, adds to the complexities involved in planning a system balanced between RE production and environmental protection. Social factors, infrastructure requirements, economic constraints and environmental parameters have to be considered and integrated into a sustainable system. Thus, a spatial approach is needed to address these issues in a comprehensive way.

Excursion to the Pilot Region Berchtesgaden/Salzburg.

Researchers at the *International Institute for Applied Systems Analysis* (IIASA) and the *Mercator Research Institute on Global Commons and Climate Change* (MCC), jointly with colleagues from the Alpine Space Project *recharge.green* developed a decision support system (DSS) for the entire Alpine region, aiming at quantifying RE potentials balanced with the protection of nature and ecosystem services. The underlying scenarios for the DSS are based on a comparative GIS approach identifying and aggregating the large set of PAs, as well as their suitability for the different RE types. To assess the different local RE potentials and impacts, a harmonisation methodology has been developed based on the International Union for Conservation of Nature's (IUCN) System of Protected Areas, with different scenarios depending on the protection constraints. *A low protection* scenario represents the fragmentation of PAs without considering ecological connectivity networks. *A high protection* scenario puts emphasis on inter-connecting protected landscapes to maintain a functional ecological continuum. This scenario, which includes the Natura 2000 network and additional buffer zones in strictest PAs, assumes increasing protection constraints in all PAs.

Figure 6 shows the harmonisation results, where the *low protection* scenario allows two-thirds of the Alpine area to be used without constraints for RE production, while only three percent is incompatible with RE production. The *high protection* scenario only features half of the Alpine space as unconstrained, while the other half is incompatible or only marginally compatible with RE production (Serrano León, 2015).

Thus, there are considerable trade-offs between nature protection and the potential for RE production. The available area and the potential for RE production can be notably reduced by higher conservation demand, which could be enhanced by the additional buffer restrictions of the strictest protection categories, or through the exclusion of the Natura 2000 network for RE production.

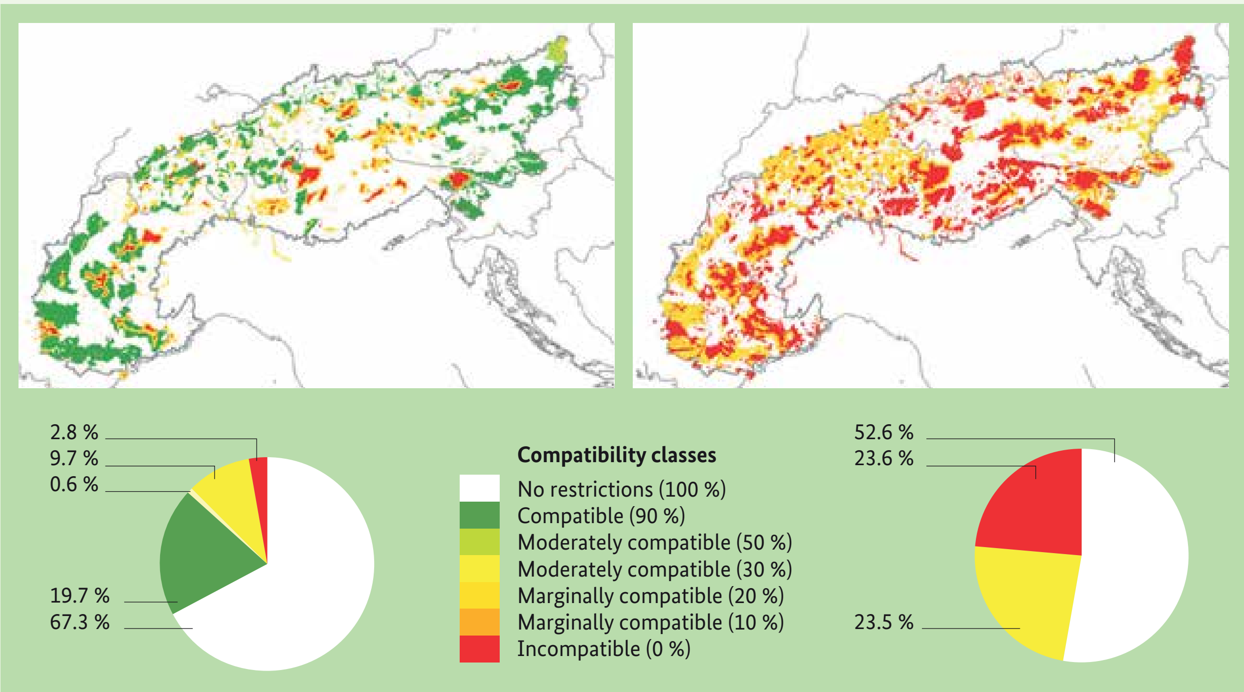
In a next step, the techno-economic engineering model *BeWhere* (Schmidt *et al.*, 2011; Leduc *et al.*, 2012) has been applied to carry out the spatial optimisation of the Alpine RE potentials for bioenergy, hydropower, wind power and solar energy. *BeWhere* models the entire supply chain of an energy technology, its costs and carbon emissions. The optimal location of green field plants and their capacities can be identified based on a detailed supply and demand assessment, thereby determining the optimal RE mix for the region in different scenarios (Leduc *et al.*, 2015a). Each of the four RE technologies can be assessed in isolation, but also in the presence of each other, thus taking into account competition between them. Based on the harmonisation results for protection categories explained earlier, Figure 7 visualises scenario results from *BeWhere* for the four RE technologies. In particular, the optimal production locations and plant capacities for each RE technology are displayed. The results reveal substantial differences with respect to suitable locations, but also the changing focus areas under different assumptions in *low protection* and *high protection* scenarios (Kraxner *et al.*, 2015a).

The results of the harmonisation approach are finally fed into the Decision Support System (DSS) visualising results online and making them publicly accessible through an inter-active user interface on the *Joint Ecological Continuum Analysing and Mapping Initiative* (JECAMI). This online application targets a variety of stakeholders such as energy experts, technical contractors, locals and also policymakers from local administrations interested in future RE options for the Alps (Figure 8, Leduc *et al.*, 2015b).

Stakeholders can interactively access over 100 different scenarios for optimal RE production balanced with ecosystem services protection depending on their preferences and needs. The geographically explicit visualisation enables stakeholders to get a first-glance understanding of their region of interest.

// **Figure 6:** Harmonisation of environmental protection areas

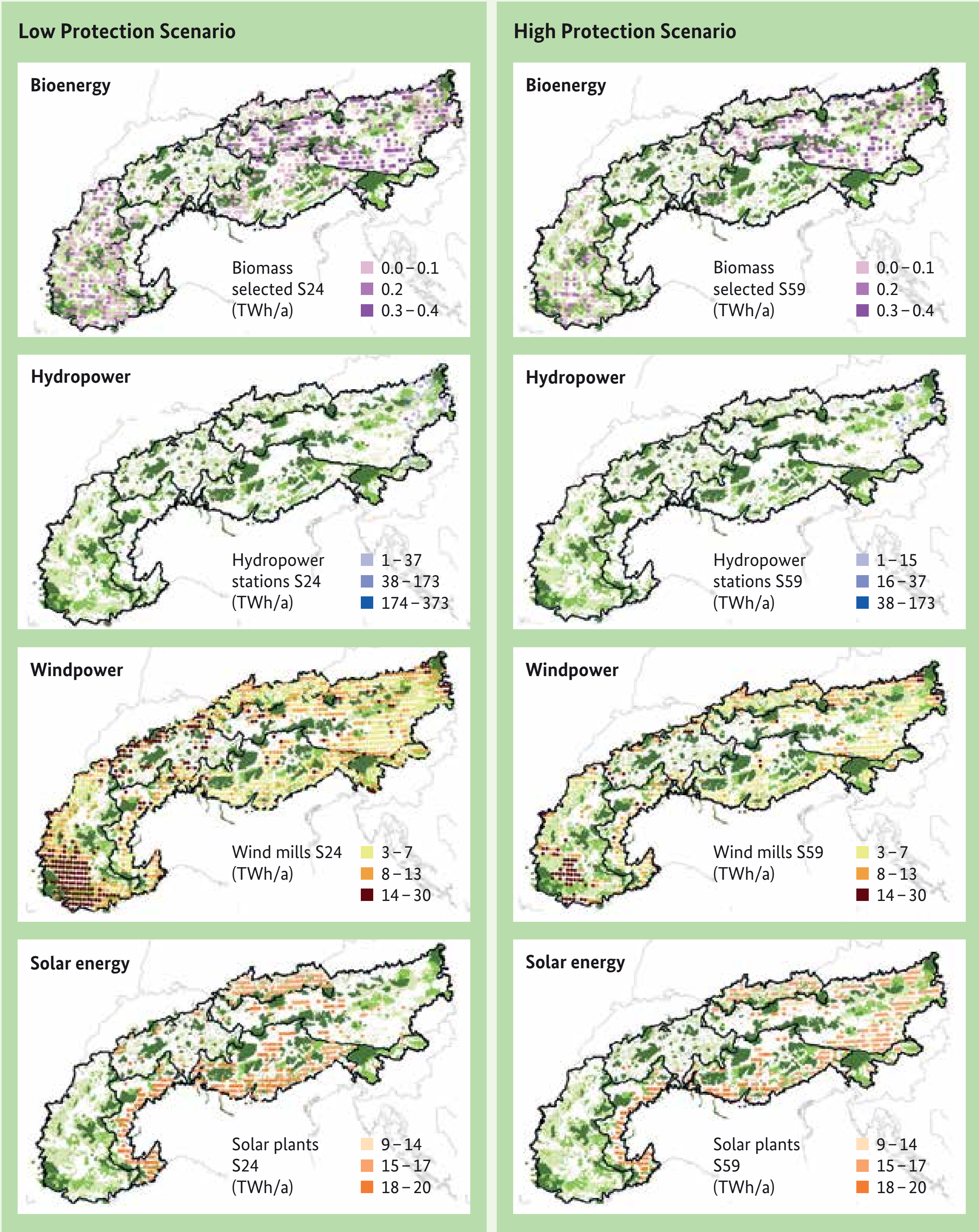
Low Protection Scenario **High Protection Scenario**



The protected areas have been harmonised with the list of IUCN categories to define priorities. The low protection scenario (left) shows substantially more unconstrained and compatible areas for RE production than the high protection scenario (right). The compatibility categories are indicated by the color ramp in the legend, and compatibility shares of the total Alpine space are indicated in the pie charts.

Source: adapted from EEA 2014, UNEP-WCMC 2014

// **Figure 7:** Renewable potentials and plant locations for two set of scenarios *



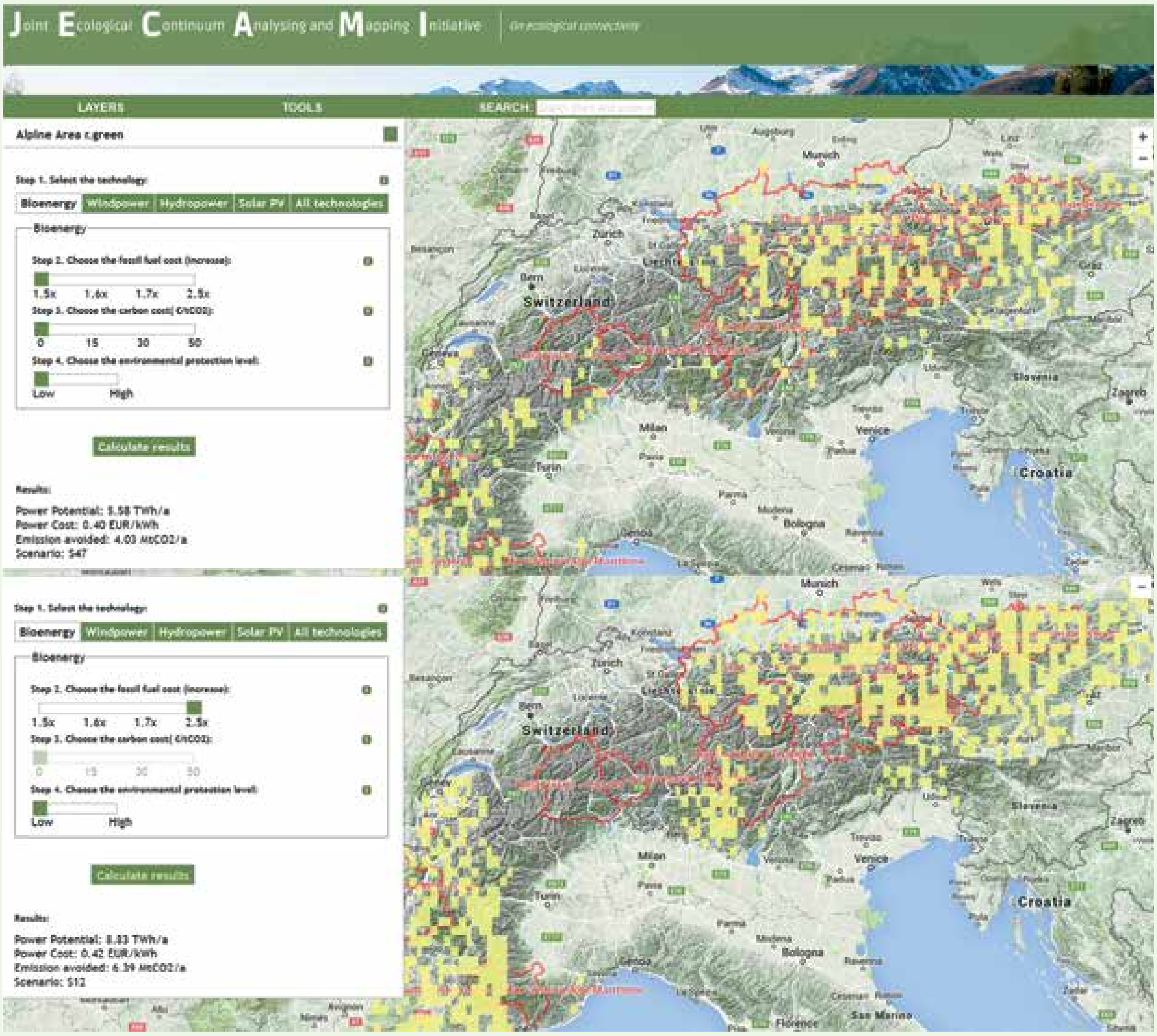
* Small colored dots indicate the potential production sites and the legend indicates the capacities by colour.

High
Medium
Low

Source: BeWhere, IIASA, 2015

The results of this new approach show considerable trade-offs between nature protection and the potential for RE production, with significant differences depending on scenario assumptions. Available area and potential for RE production are notably reduced when higher restrictions are assumed (Kraxner *et al.*, 2013). With the help of the DSS, RE potentials can be quantified under different conservation and ecological connectivity scenarios (Kraxner *et al.*, 2015b). Furthermore, it demonstrates the importance of clearly defining policy objectives in order to balance protection and RE needs (recharge.green, 2015). Increased coherence between PA definitions across national boundaries would provide an improved basis for ensuring the long-term sustainability of RE production in the Alpine space.

// **Figure 8:** Screen shots from the interactive DSS user interface on JECAMI



BeWhere model runs for 100+ scenarios, based on the harmonisation of protection area, displayed on JECAMI. The box on the left hand allows the user to interactively switch between the different RE technologies. Furthermore, the user can set different fossil fuel costs (reference scenario/subsidies to RE), the desired cost per ton of CO_2, or switch between protection levels (high/low). The upper screenshot shows optimal harvesting and production areas (yellow squares) of bioenergy under a very low subsidy rate (1.5 times higher fossil fuel costs). The lower screen shot shows the substantially increased area after increasing the subsidies (2.5 times the fossil fuel costs). Detailed energy production potentials, costs and emissions avoided can be read from the lower part of the settings box.

Source: BeWhere, IIASA, 2015, modified screenshots from JECAMI

3.4 Ecological connectivity and expansion of transport in the Alps

// Stefan MARZELLI //
ifuplan – Institute for Environmental Planning and Spatial Development, Munich, Germany

// Harry SEYBERT //
Bavarian Ministry of the Interior, structures and transport, Munich, Germany

Connectivity of ecosystems and habitats is very often compromised by transport infrastructure and impacts of traffic. There is a basic contradiction between the objectives, requirements and development of (grey) transport infrastructures and the development of green infrastructures according to the EU Biodiversity Strategy or the EU Green Infrastructure Initiative.

As already outlined in chapter 2 of this publication, the Alps have to be considered as an area with a high density of biodiversity hot spots. This is indicated by the extensive network of protected areas, and the large proportion of natural areas, semi-natural areas, and farmed land with a high nature value. Different studies and projects such as WWF (2004), ECONNECT or green.alps have strived to delineate areas of major relevance for biodiversity conservation and ecological connectivity.

It is well established that ecological connectivity cannot be limited to protected areas but must necessarily be constructed via semi-natural habitats and landscape structures to create an ecological continuum outside of the protected areas. This interconnection of habitats is of particular relevance for migrating species.

Transport infrastructures have manifold effects on flora, fauna and habitats. Roads and railways represent a different quality of habitat in terms of microclimate, soil, surface texture and hydrology. The neighbourhood of such infrastructures is affected by air pollutants, road salt, noise, and visual effects of transport infrastructure itself as well as that of the traffic (movements, lights, air pressure). Finally, animals crossing such infrastructures are often killed in traffic accidents. Traffic related effects depend on traffic density and are severe

Numerous accidents with wildlife were observed in the past on this section of the RD1090 in the department Isère in France. During the project “Path of Life” this road section was secured by installing some alarm systems indicating to drivers the current presence of wildlife near the road using special flashing road signs.

Rail infrastructure along the large Alpine valleys.

along motorways and high-speed railways when compared to country roads or light railways.

It is important to mention that these effects are not only relevant for fauna and flora but also for human wellbeing: air pollution and noise have serious impacts on human health, and visual impacts and noise depreciate landscape amenities and recreation options. Therefore, large unspoilt landscapes, free of technical infrastructures are of value in their own right.

The impact of fragmentation on ecological connectivity depends on the character of habitats, species kind and abundance, type of transport infrastructure and transport density. In the projects green.alps and ECONNECT, main barriers for ecological connectivity have been analysed based on the transport network (map 14 [page 178] and map 15 [page 180]). The ecological connectivity platform has analysed the existing network of protected areas, remaining gaps and the needs to harmonise different national approaches to ecological connectivity. In this study it is obvious that there will be no single solution.

Development of transport occurs in two dimensions: the extension of the transport network and the increase of transport activities. Often the increase in traffic triggers the construction of further transport infrastructures, as it is often observed when through traffic in a town increases, and a bypass is built due to noise, air pollution and traffic congestion in the town.

Presently, within the Alpine Convention perimeter, about 4,200 kilometres of main roads[5] and 8,300 kilometres of railways exist (AC 2007). Transport infrastructure increases are most visible with big construction projects, but the densification of smaller road networks must also be considered. In recent years, data from all countries show that the area of transport infrastructure has increased, and it is most likely that fragmentation effects have increased too. As an example, the Swiss land use statistics show an increase of motorway area between 1979/1985 and 2004 by about 1,300 hectares, which is almost 50 percent; roads have increased by about 7,000 hectares, which is about 12 percent; and railway infrastructure by about 270 hectares, which a amounts to three percent (Swiss statistics 2016).

In general, transport across the Alps has increased within the last few years. Passenger transport has increased by about 45 percent in the period 1995 to 2005, and a further increase is predicted. Total freight transport across the Alps has also increased by about 44 percent from 1994 to 2004 (Alpenkonvention 2007). Due to the economic crisis, trans-Alpine freight transport volumes declined by 16.2 percent but then increased again from 2009 to 2011 by 12.5 percent (Commission européenne DG MOVE. Confédération Suisse Office Fédéral des Transports (OFT) 2016). Therefore, at least transport intensity – in terms of noise, pollution, and potential accidents – has increased as well.

For large species in particular crossing of such transport infrastructures is a major problem. Although in the Alps tunnels and bridges may offer options for crossings, there are still areas in which barriers are difficult or even impossible to overcome. One should also bear in mind that for many species even distant disturbing effects are sufficient to prevent them from crossing roads or railways.

How can ecological connectivity be better considered in transport development? There is the overall objective to avoid unneeded transport and to decouple economic activity and transport as far as possible. This could be a responsibility of spatial planning and development to limit and diminish needs for further transport infrastructures in the Alps. If improvements of transport infrastructures are unavoidable, all required environmental planning tools such as environmental impact assessments, Natura 2000 assessments and species protection measures are to be applied. Furthermore, for the existing transport network, mitigation measures such as bridges, tunnels, green bridges, noise barriers or screens could moderate impacts on ecological connectivity. Also many further measures for single species such as nesting boxes, artificial habitats for reptiles, and amphibian passages could mitigate negative effects and support population. Although conflicts between ecological connectivity and transport are likely to persist in the future, use of innovative instruments offers hope for improved outcomes.

3.5 Tourism in the Alps – A nature and biodiversity perspective

// Barbara ENGELS //
Federal Nature Conservation Agency (BfN), Division "Nature Protection and Society", Bonn, Germany

Tourism in the Alps has been estimated to account for 95 million overnight visits and 60 million day tripper visitors per year and contributes notably to the economy of Alpine countries (50 billion euro yearly) (PSAC, 2013). The richness of natural features and the "purity of natural resources" of the Alps play a strong role in the image of Alpine tourism. Nature and landscape also present the basis for most touristic activities in the Alps where light or intense sports activities (ranking from hiking to all variations of winter sports) are prominent. Even wellness and food related tourism opportunity strongly rely upon healthy nature and environments (PSAC, 2013).

The touristic and landscape attractiveness can be assessed through an evaluation combining the degree of fragmentation, forest cover, energy of the relief (for example the difference in altitude between the highest and lowest point in a individual section of the map), the existence of water courses and coastlines, as well as the number of overnight stays. Using these indicators, the Alps rank highest in touristic attractiveness together with coastal areas (analysis available for Germany, Bundesamt für Bauwesen und Raumordnung 2005). This coincides with the tourism use intensity, which can also be judged through other indicators such as the intensity of overnight stays per square kilometre (or per inhabitant). It is notable in this context that all administrative districts in Germany (so-called" Landkreise") that belong to the Alps are characterised by a tourism intensity of > 5,000 overnight stays/square kilometre and are among the most intense tourism areas in Germany. For the Alpine region a "population based tourism function index" has been elaborated. This indicates that there is "a decline in intensity from the highly touristic centres towards the periphery, that is from the north and south as well from the centre to the west and east (PSAC 2013).

Ski touring is one of the multiple tourism activities in the Landscape Park Binntal in Switzerland.

In addition, tourism presents a variety of demands on nature and landscape. Although the quantitative demand for land consumption through tourism is rather difficult to determine, due to the number of different tourism activities, information on the qualitative demands exist (Engels 2008). Land consumption through tourism includes different sectors such as hotels, gastronomy, transport infrastructure, leisure areas, as well as sport infrastructure (for example snow canons or lifts).

In general, it is rather difficult to obtain data on environmental impacts of tourism, therefore case studies and qualitative data have to be used instead (PSAC, 2013). These studies show that tourism infrastructure is preferentially located in attractive landscapes, which are simultaneously often characterised by sensitive ecosystems and biodiversity (Engels, 2008). This means that even a low-level infrastructure development may cause significant impacts on nature and biodiversity (Umweltbundesamt, 2002). These impacts include fragmentation or even loss of natural habitats. In the Alps, the construction of cableways, ski-lifts, chair-lifts, funicular railways and more as well as ski slopes presents a major impact factor on habitats such as mountain forests or species-rich meadows through clearing and bulldozing (Federal Agency for Nature Conservation, 1997).

Protected areas such as national parks, nature parks and biosphere reserves continue to attract an ever-increasing number of tourists. Higher visitor numbers often demand more infrastructure maintenance and, if inadequately managed, may cause negative effects and in consequence even lead to a loss of attractiveness (Engels, 2008). On the other hand, these protected areas generate considerable regional economic benefits. This can be illustrated by the case of Berchtesgaden National Park in Germany: in 2014 the national park tourism generated a 47 million euro income, which accounts for an equivalent of 2,103 jobs (Job *et al.*, 2016)

In conclusion, the growing demand of nature tourism, especially that in protected areas, presents ever increasing challenges for the management of these areas but also offers great opportunities for regional income generation as well as education and increased awareness.

3.6 Ecological connectivity and alien species

// ***Jake ALEXANDER*** //
ETH Zurich, Institute of Integrative Biology, Department of Environmental Systems Science, Zurich, Switzerland

// ***Christoph KUEFFER*** //
HSR University of Applied Sciences Rapperswil, Institute for Landscape and Open Space, Rapperswil, Switzerland

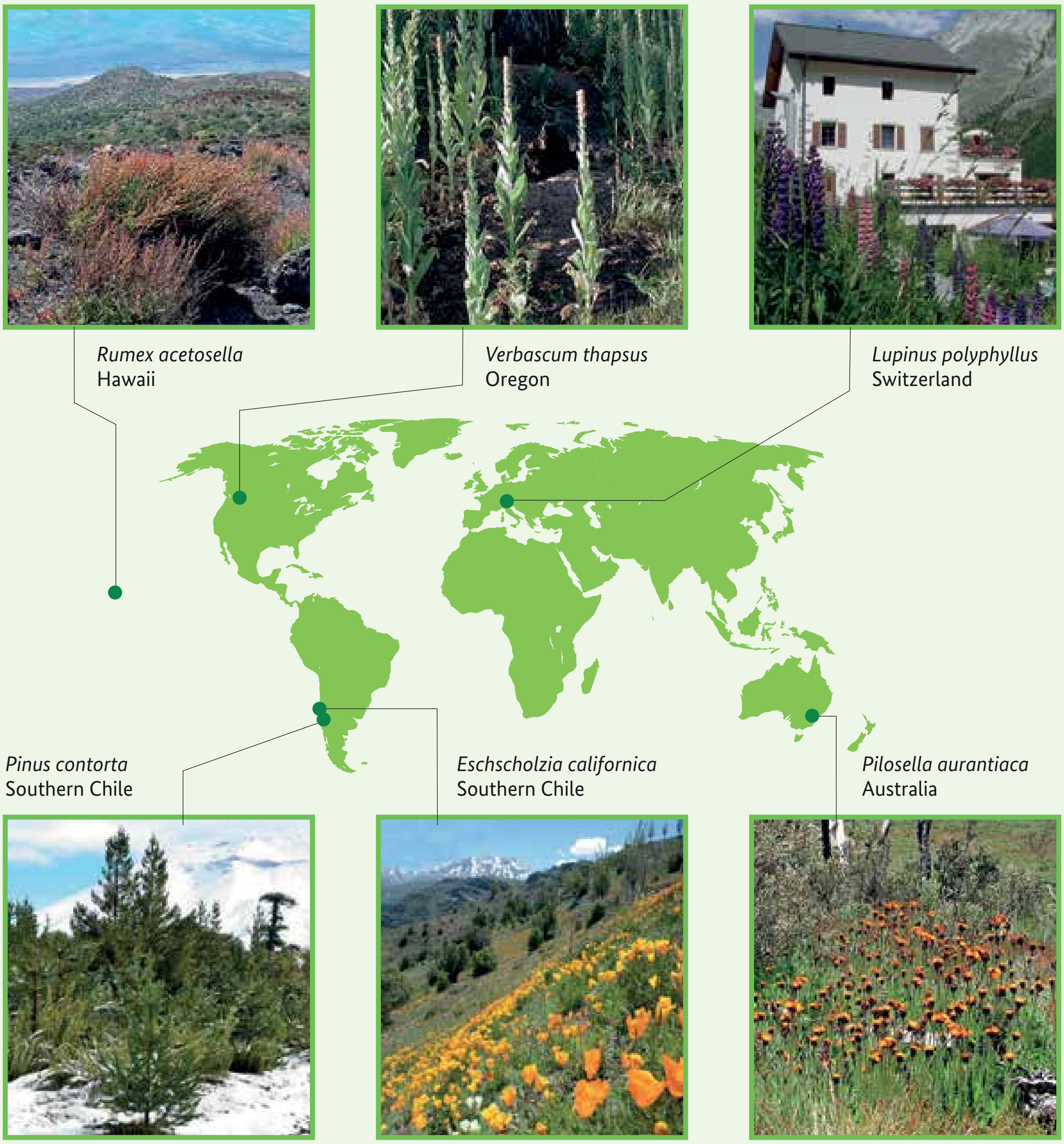
Embankments along railways, highways or rivers often function as propagation paths for alien species if not managed in an adapted way.

Connectivity promotes the spread of invasive species at global (Hulme 2009) as well as landscape scales (With 2002, Hermoso *et al.* 2015). Greater connectivity among source and recipient regions increases the probability that species will successfully establish (Seebens *et al.* 2013). Following initial establishment, subsequent spread within the invaded region typically does not occur as an advancing front but through the successive establishment and expansion from invasion “hubs” (Moody and Mack 1988, With 2002, Florance *et al.* 2011). Landscape features such as roads and rivers often provide important corridors connecting these hubs, promoting the rapid expansion of alien species (Christen and Matlack 2006), and potentially providing conduits into protected areas (Pauchard and Alaback 2004).

In mountain regions, the spread of alien species has been extensively studied for plants (Kueffer *et al.* 2013a), and there is growing information on other groups of organisms (Pauchard *et al.* in revision). Spread is shaped either by connectivity between low and high elevation areas, or connectivity directly among high elevation areas. The first scenario seems to have been the dominant one up to now for alien plants; the majority of alien plants in mountain regions have reached high elevations from adjacent lowlands (McDougall *et al.* 2011a). As a consequence, in most cases alien species found at high elevations are a subset of the species pool found at low elevation in a particular mountain region (Alexander *et al.* 2011). Road networks act as corridors that promote the expansion of alien plants into mountain areas, as well as providing important habitat for what are predominantly ruderal species (Seipel *et al.* 2012).

Because historically the predominant introduction pathway for alien plants in mountains has been from low to high elevation, alien plants at high elevation tend to be ecological generalists, capable of growth across broad climatic gradients (Alexander *et al.* 2011). Few of these species expand away from disturbed habitats (Seipel *et al.* 2012), and rarely have they had substantial impacts on native communities (but for exceptions see Kueffer *et al.* 2013a), although research on impacts is largely lacking. However, a small minority of invaders at high elevation are cold-environment specialists. These species likely spread through an alternative second scenario: they were directly introduced from one mountain area to another. Direct introduction of mountain specialists is likely to increase with changing trade patterns (Kueffer *et al.* 2013b, Humair *et al.* 2015). For example, mountain plants have been planted as ornamentals in tourist facilities at high elevation (McDougall *et al.* 2011a), and might be transported by hikers and tourists (Pickering and Mount 2010). Climate warming is also expected to facilitate the expansion of alien species (Petitpierre *et al.* 2015). Because many invasive species are already present in lowland areas, their invasion to higher elevations – once climatic barriers are removed – will be much faster than traditional invasions that are limited by long-distance dispersal and adaptation to the new environment.

// **Figure 9:** Examples of non-native plants in mountain regions from around the world



Source: MIREN; www.mountaininvasions.org

The risk of alien species invasions should not restrict the establishment of ecological connections between protected areas. However, management capacity should be established so that the control of newly spreading invasive species is coordinated and can be quickly enacted (McDougall *et al.* 2011b). Invasive species often spread slowly initially (lag phase) before entering a phase of rapid spread (Sakai 2001). Hence, an early detection and warning system may be needed in the future. Preventative measures against invasive species establishment are the most efficient way to limit spread, especially when targeted towards key invasion hubs (Florance *et al.* 2011, McDougall *et al.* 2011b, Stewart-Koster *et al.* 2015). In mountains, this might involve management of low-elevation source populations outside of protected areas (McDougall *et al.* 2011a, McDougall *et al.* 2011b, Kueffer *et al.* 2013a), especially since high-elevation populations are often naturally characterised by high rates of turnover (Seipel *et al.* in revision). A further challenge will be how to manage range-expanding native species that might have undesirable effects, and whose spread might be promoted by connectivity in a similar way to alien species.

3.7 Enhancing ecological connectivity in the Alps – A catch-22 situation in respect to disease spread in wildlife and livestock?

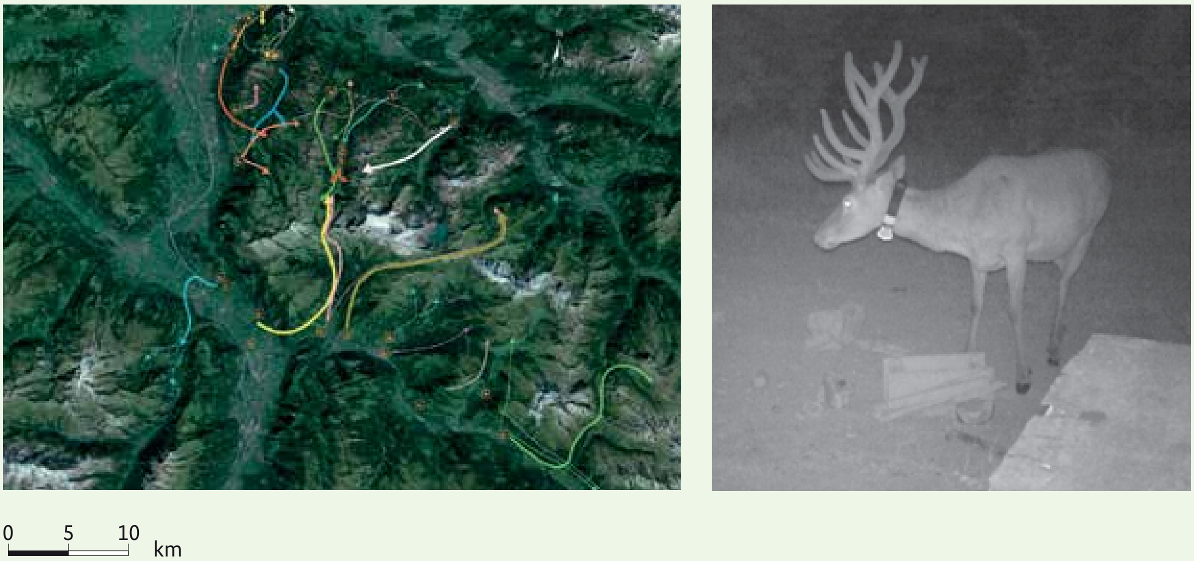
// Chris WALZER //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Ecology and Evolution, University of Veterinary Medicine, Vienna, Austria

Conservation of Alpine biodiversity during the past 100 years has been driven by a "protected areas" approach – isolated patches, separated from the rest of the Alpine space. However, in today's increasingly human-dominated landscapes and in the face of global climate change, this approach is being revised. Conservation efforts aim at preserving and restoring a permeable landscape-matrix, where the movement of flora and fauna is not hampered by barriers, through the implementation of ecological networks. Conventions, such as the CBD, the Alpine Convention and directives, like the "Habitat Directive"(92/43/EEC) and "Water Framework Directive"(2000/60/EC), emphasise the importance of the ecological networks. Additionally, numerous EU-funded projects and initiatives (for example Green Infrastructure Initiative, ECONNECT) strive to enhance ecological continuity across the Alps and Europe. While landscape-level connectivity clearly benefits biodiversity, it potentially facilitates the emergence, exchange and movement of pathogens.

Within the field of conservation biology, metapopulation theory has replaced island biogeography in describing the dynamics of spatially structured populations (Handski and Simberloff, 1997). Amongst many other effects, it has been shown that connecting locally at-risk populations increases asynchronies between the populations subsequently decreasing the risk of population extinction as dispersing individuals from neighbouring populations can re-colonize vacant sites (for example Allen *et al.* 1993). It is important to understand that these populations also constitute patches of disease hosts, which in turn individually provide habitat for their respective parasites and other infectious agents.

Changing the spatial structure of a landscape invariably also changes host abundance, distribution and persistence. Hosts and the landscape on which they reside can both be viewed as respective individual patches on different scales. In order to investigate and predict

// Figure 10: Movement of GPS-radio-collared red deer across international borders in the three country triangle: Austria, Liechtenstein and Switzerland and camera trap photo of a red deer with a GPS (Global Positioning System) radio-collar at a feeding site in Vorarlberg, Austria



Source: Georg Duscher, Digital Globe, 2015 disease progression and risk in a landscape, it is important to gain insights on these two distinct but interrelated spatial scales: i) the exploitation by pathogens within a patch (as represented by the individual host) ii) the movement of infected hosts (carrying the pathogens) between patches (as represented by geographical spaces). This can be demonstrated in the following example: host abundance is an important factor in roundworm infections of mammals – there is a positive relationship between host density and roundworm prevalence (a host is equal to occupied patch) with increasing host density leading to increased colonization of patches (Arneberg *et al.* 1997). Similarly, amongst the hosts, the number of patches occupied most often increases with decreasing patch isolation (for example Thomas and Jones, 1993). Put simply, the more occupied patches there are and the more connected these patches become, the greater the potential for population growth.

> **These similarities between** *wildlife (hosts) and parasite dynamics allow for broad generalizations about the role of patch density and occupation in the exploitation of fragmented landscapes.*

Understanding the risk of spreading disease across a landscape is dependent on several factors beyond the host population. These include: pathogen characteristics, transmission frequency within and between patches containing susceptible hosts and the frequency of dispersal events (Hess *et al.*, 2001). The emergence of a pathogen within hosts of a distinct patch clearly has other consequences if infected hosts can move freely between patches. When only considering patches with susceptible and infected individuals it has been shown that highly contagious diseases of moderate clinical severity (or long incubation periods) spread widely, increasing the probability of metapopulation extinction and/or disease persistence (for example Hess 1994, Hess *et al.*, 2001). However, if movement between the individual patches is limited (single population quarantine) then extinction probability from pathogens was greatly reduced (Hess 1996).

Today, Alpine wildlife lives in a spatially heterogeneous multi-use landscape. This landscape, due to fragmentation, anthropogenic changes and utilisation, is structurally very dynamic and, while negatively impacting the survival of some species (for example large carnivores), enhances the survival of certain wildlife species of economic importance such as the red deer (*Cervus elaphus*). In the past decade several infectious diseases have re-emerged in wildlife and livestock across the Alpine landscape; most notably, bovine tuberculosis (*Mycobacterium bovis and caprae*) in Germany, Austria and Switzerland (Fink *et al.* 2015) and brucellosis in France (Mick *et al.* 2014). These diseases have wildlife reservoirs (red deer for tuberculosis and ibex (*Capra ibex*) for brucellosis) that harbour the infectious agent without injury to themselves and serve as a source from which other individuals, species and patches can be infected. Both brucellosis and tuberculosis are major zoonotic diseases, that is, they can infect humans. Most importantly, when a spillover or spillback from the wildlife reservoir to livestock occurs, this has wide-reaching and severe economic repercussions. While localised remedial disease management actions (inter alia: *culling* to reduce red deer density and removal of feeding sites) have been successfully implemented within the core patches in Tyrol, the disease has progressed westwards into Vorarlberg. An enhanced ecological continuum from Austria westwards into Switzerland will quite possibly accelerate the spatial spread of tuberculosis in wildlife and subsequently livestock in the Alpine arch. The recently identified persistence of brucellosis (*B. melitensis bv 2*) in ibex is presently confined to a relatively isolated population in the intensively managed population of the Bargy Massif, Haute-Savoie. While spillback events to cattle and a human have occurred, it appears that the disease has to date not spread beyond this patch. Enhancing connectivity towards the south, the Beaufortin massiv and the Grand Paradiso National Park could firmly re-establish the disease in the Alpine arch.

Today we broadly acknowledge the fundamental biological association between environmental variables and disease occurrence and distribution. When developing ecological continuum strategies it is therefore essential to recognise that landscape changes will also affect wildlife location, density and subsequently pathogen distribution. It appears prudent to firmly integrate metapopulation modelling into spatially explicit landscape epidemiological analyses. This will allow the development of linked host-pathogen-landscape models to assess potential disease risk, emergence hotspots and pathogen dispersal in the Alpine arch (and beyond) in the face of ecological connectivity initiatives (Hess *et al.*, 2001). A clear understanding of the interaction of pathogens and enhanced ecological connectivity appears critical to human health and economic well being in the Alps and beyond.

3.8 Alpine ecological connectivity and management of hunting

// **Friedrich REIMOSER** //
Research Institute of Wildlife Ecology, Department of Integrative Ecology and Evolution, University of Veterinary Medicine, Vienna, Austria

The connectivity of wild mammal populations depends on fragmentation of their habitats (natural barriers, barriers through settlements and fences, infrastructure for traffic and tourism, measures of agriculture and forestry and more) as well as on behaviour and habitat use of the animals. These latter elements can be strongly influenced by hunting methods and wildlife management strategies.

> **In the Alps** *there exists a wide variety of national and regional traditions as well as legal regulations dealing with wildlife.*

A harmonisation of measures along the border areas is mostly non-existent or is not sufficient. This lack of consistency can produce considerable problems for population connectivity for some species, particularly those with large home ranges, such as red deer and large carnivores.

The hunting systems of the individual Alpine states differ considerably. In some countries the hunting right is tied to the land ownership (for example “Revier” hunting system in Germany and Austria), in others it lies in public authority, for example in the Principality of Liechtenstein (district hunting system) and in Switzerland (patent hunting system or district hunt system, depending on the canton). The hunting seasons on ungulates can also vary considerably among countries and regions. This ranges from a very short three-week season (Grisons, Switzerland) to a season of more than eight months (Germany and Austria). In some areas, supplementary feeding of game in winter is prohibited for example in some cantons of Switzerland, whereas in Germany and Austria it is allowed or in part even mandatory.

Resting zones (undisturbed wildlife habitats) are mandated in some regions, for example in the canton Grisons by the municipalities, whereas in some federal states of Austria official rest zones for hunted wildlife species do not exist. The preservation of habitat corridors for wildlife connectivity in cooperation with the hunters is rarely embodied in the hunting law (for example Carinthia). While hunting and wildlife management for example in Germany and Austria are mainly administered by hunters themselves in their leisure time, these activities fall under the management of publicly employed professional staff in other countries (for example: gamekeepers in Switzerland).

In the Mountain Forest Protocol of the Alpine Convention (1996), the contracting parties commit towards considering the objectives of this protocol in their respective policies and political frameworks. This is also valid for the management of hoofed-animal populations (Article 2.b): "In the border areas, the contracting parties undertake to harmonise their measures for regulating the game animals." Until recently, this occurred only in rare cases for example in the “Rätikon”, the tri-border region including Vorarlberg (Austria), Grisons (Switzerland) and the Principality of Liechtenstein.
A project optimising the management of the cross-border red-deer population was carried out by these three countries (Reimoser *et al.*, 2015). Together with the Research Institute of Wildlife Ecology (Vetmeduni Vienna) habitat use, activity patterns and physiological

Chamois, an important game species throughout the Alpine arch.

The European lynx has been reintroduced to several locations in the Alps.

parameters of red deer were examined. 67 animals were provided with GPS-GSM collars and the collected data was analysed. The study served as a basis for an efficient harmonisation of wildlife management measures between Vorarlberg, Grisons, and Liechtenstein, enabling seasonal migration while mitigating red-deer-human-forestry conflicts. Migration routes of red deer and respective barriers for the animals were documented, and the influences of weather conditions and disturbance factors were evaluated. The daily and seasonal activity patterns of red deer showed marked differences between the three countries. Here in particular, a strong influence of the supplementary winter-feeding in Vorarlberg and distinct effects of the hunting system (duration of hunting season, hunting method, disturbance by hunters) were clearly demonstrated. Quiet resting zones as well as the location of winter-feeding stations had a large influence on migration and habitat use of the red deer. In order to obtain better information for the enlargement of protected areas, the influence of different habitat factors on behaviour and habitat use of the animals was examined.

Prior to this "Rätikon-Project" efforts were already underway by the late 1980's, attempting to include all hunted ungulate species. At that time a "Wildlife Ecological Spatial Planning" (WESP) was developed on a national level with the different stakeholders in a collaborative approach. This tool was implemented in the hunting laws of the three countries to support large-scale and integrated management of wildlife species (Reimoser, 1996, 1999). The WESP-tool was again used later in other federal states and regions for the harmonisation of wildlife management between national parks and the relevant game-ecological environment (Zink *et al.*, 2008, Reimoser *et al.*, 2012). WESP could also be further developed with regard to Alpine ecological connectivity and management of hunting species integrated into general spatial planning.

To date, cross-border harmonisation of wildlife management and hunting remains in a long lasting "dormancy state" within the Alpine region. It is obviously difficult to move forward from the entrenched individual practices within the regions towards an Alps-wide cross-linked and integrated approach. However, as some positive examples show, a lot can be achieved when people cooperate constructively and put common goals ahead of discordant customs.

3.9 Connectivity and ecosystem services in the Alps

// Riccardo SANTOLINI //
// Elisa MORRI //
Department of Earth, Life and Environment (DISTEVA), Carlo Bo University of Urbino, Urbino, Italy

// Serena D'AMBROGI //
ISPRA, Institute for Environmental Protection and Research acts under the vigilance and policy guidance of the Italian Ministry for the Environment and the Protection of Land and Sea, Rome, Italy

3.9.1 Introduction

The Alpine region is a sensitive bio-geographical area subject to many pressures such as climate change, ecosystem transformation, winter sports industry, and mass tourism. The area plays a strategic role because it provides ecosystem goods and services to the resident population (14 million inhabitants, 190,000 square kilometres), as well as to the sectors of tourism, industry and agriculture. 25 percent of the total area covered by the Alpine Convention is represented by protected areas (> 100 hectares). The Italian Alps alone house four national parks, 32 regional parks and over 100 protected biotopes.

The Natura 2000 *network was created with a dual purpose: to stop the degradation of biodiversity and of ecosystem services (ESs) in the EU by 2020, and to preserve and restore ecosystems and related services (Objective 2 of the EU Biodiversity Strategy to 2020).*

In order to address some of these issues, the ECONNECT project (2011) was established. This project employed a multidisciplinary approach aimed at protecting biodiversity and enhancing the value of ecological connectivity and envisioned the Pilot Region as an integrated space around and between protected areas. The Pilot Region can include high biodiversity habitats and/or functional connectivity elements as essential instruments to achieve ecological connectivity in the Alpine landscape. In fact, many studies related to changes of land use and global change have focused on some of the weaknesses of the management strategies and policies for the conservation of protected areas at different levels (Haslett *et al.*, 2010). This is particularly true for Natura 2000 sites (Crofts, 2014), though the benefits produced by Natura 2000 in Europe amount to a value ranging between 200 and 300 billion euro per year (Marino 2014).

The main reasons for such land-use shifts in the Alpine region (as well as in the rest of Europe) are the depletion of natural habitats, the degradation of cultural landscapes, and the fragmentation of vital areas for flora and fauna (Jaeger *et al.*, 2005). These phenomena mainly occur outside protected areas, causing habitat isolation (Romano & Zullo 2014; Scolozzi *et al.* 2014). In order to mediate these fragmentations and the progressive isolation phenomena, ecosystems need effective connections among core areas of adequate dimensions.

Preserving biodiversity and ecosystem functionality depends on the conservation not just of the most natural ecosystems and on sustainable human activities, but also on the protection of the territories that bridge the major ecosystems, often characterised by ecotones that allow for exchange of energy, information, and individuals. For these reasons, it is important to consider an ecological and functional area (functional ecologic unit or FEU), for example a water catchment (Santolini 2014) (Figure 11), so that its natural dynamics and ecological functions are safeguarded as far as possible while providing services for human wellbeing.

In this context, the concept of ecosystem services (ESS) has a great potential in supporting conservation (Goldman & Tallis, 2009) and in maintaining the resilience of landscapes (Gibelli & Santolini, 2015), which is all too often ignored by the European legislation on conservation (Heneberg, 2013). Various studies have assessed the costs and benefits of Natura 2000 sites (for example ten Brink, 2011; Bastian, 2013; Schirpke *et al.*, 2014; LIFE+MGN project[6]), whose benefits amount to between three and seven times the cost for their annual management (Gantioler *et al.*, 2010).

The awareness of these opportunities is due to the economic assessment of ecological functions, which requires cross-sectorial approaches, a long-term holistic technical management vision and a broader territorial planning strategy (Palomo *et al.* 2013).

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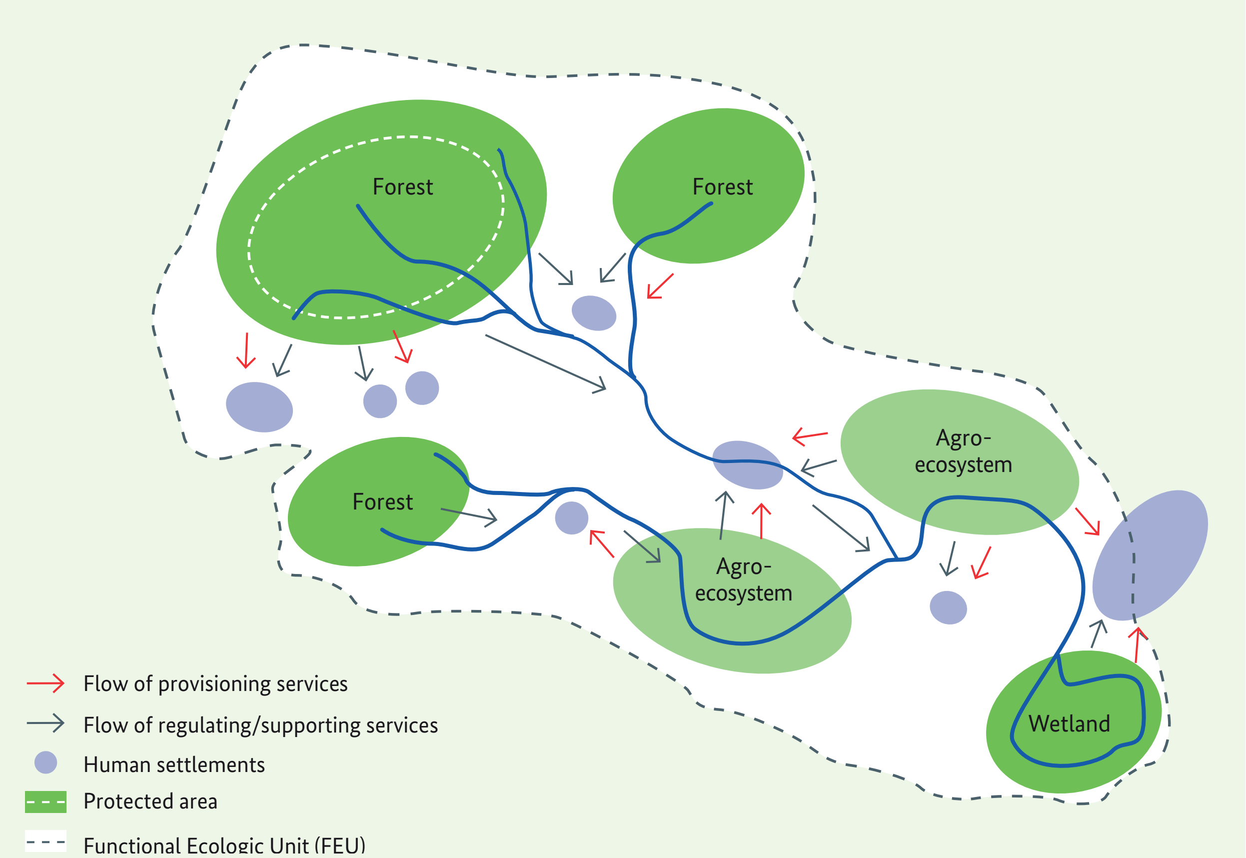
3.9.2 Connectivity: role and limits

Functional and interconnected ecosystems enable the development and maintenance of functions that positively affect biodiversity. In contrast, fragmentation is a dynamic process, generally human-induced, that divides a natural environment into more or less disconnected fragments, thus reducing its original surface area. It also affects the physiology, the behaviour and the movement patterns of many plant and animal species (Debinski and Holt 2000). It is a process linked to progressive environmental change (land use, intensive agriculture, urbanisation, territorial infrastructure) and weakens the maintenance of viable populations and the persistence of communities, habitats, ecosystems and ecological processes.

In essence, the natural elements must be relatively large and connected together in order to preserve the ecological functions necessary for the maintenance of biodiversity in a landscape (Crook and Sanjayan 2006) while safeguarding the necessary biodiversity for the conservation of the ecosystem services (ESS) of that landscape. Therefore, connectivity guarantees continuity – in physical, territorial, ecological, and functional terms – among ecosystems that can be different in terms of naturalness and response to the effects of fragmentation on populations and communities (Bennet, 2003). Connectivity also gauges the processes by which populations are interconnected. (Ferrari 2011).

It is therefore appropriate to underline the difference between the physical-territorial aspects and the functional-ecological ones. The connectedness indicates the physical connection among ecosystem varieties or populations. Connectivity, on the other hand, can be characterised by species objectified parameters related to the structural and qualitative components in an ecological spatial mosaic (including the infrastructural elements representing the obstacles to movement). It is becoming more and more important that landscape scale connectivity progressively replaces the dated

// **Figure 11:** Flow of biophysical ESS needs for the functioning of ecosystems in a FEU



Source: Palomo *et al.* 2013, mod

corridor concept. Therefore, the landscape connectivity model combines the physical structure of habitats/ ecosystems with the behavioural response of a species, or group of species to that structure (Taylor et al 2006). The structure and dynamic of populations, and the movements of individuals between the patches are favoured or limited by the type, the quantity and the distribution of habitats/ecosystems and by the level of suitability of the matrix.

Nevertheless, the connectivity approach can cause ecosystem degradation if used in a superficial and non-integrated fashion. If used as a compensation and mitigation tool to justify territorial transformations without profound territorial analysis, it can facilitate the development of barren areas (for example corridors) with resulting degradation of habitat and loss of ecological functions. Therefore, ecosystem restoration can be disastrous if the exact intervention type and location is not being considered at the appropriate scale and temporal resolution and if appropriate biological indicators are not being used. For these reasons, when creating the connectivity models, it is very important to ascertain the best spatial resolution with which to make calculations on environmental data (Cornell and Lawton, 1992; Kuczynski *et al.*, 2010; Morelli et al 2013).

The strategic-action approach depends on the context, the scale and the targeted species as defined previously by Bennett (2003) and requires particular interventions that promote the balance of such actions:

1. Enlargement of the remaining habitat/ecosystem surface;

2. Increase in quality of remaining habitat/ecosystem;

3. Enhancement of the species specific connectivity or that of the target species;

4. Reduction of matrix disruption by making a space more suitable and fit for the species dispersion.

It is also necessary to implement actions through territorial planning raising awareness concerning the role that connective areas potentially have through protection of

Several biological corridors were restored in the densely urbanised area around Grenoble in France in the project “Path of Life”. The corridors were designed to serve multiple purposes and are also linked to ecosystem services like air quality and leisure.

the dispersion dynamics of species and /or functional communities (Lambeck 1997). When taken into consideration, this approach can help maximise the overall benefits derived from the development of landscape conservation processes and functionality.

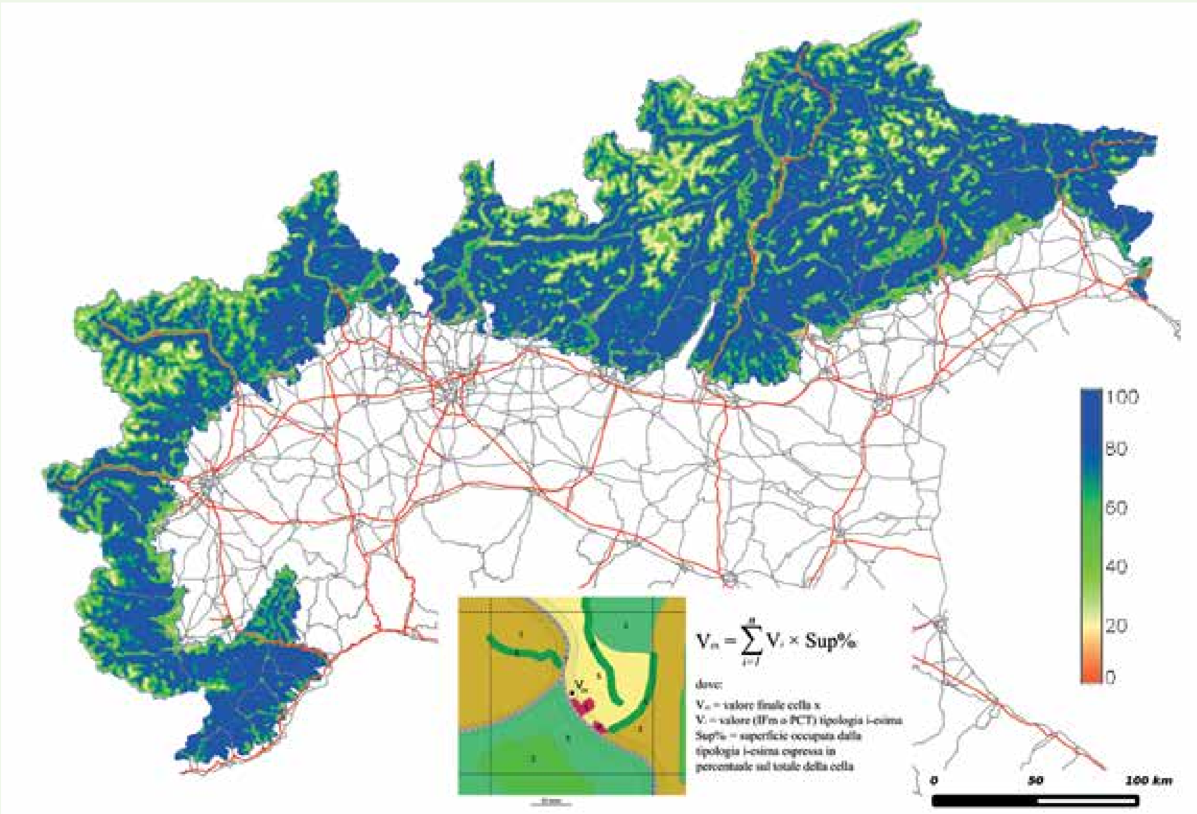
3.9.3 Biodiversity, ecological functionality and bioindicators

Initiatives in recent years (for example TEEB 2010) have facilitated consideration of the relationship between biological diversity and ecological functions. It is clearly evident that biodiversity has positive effects on ecological functions (Balvanera et al 2006). Considering that the diversity of species in an ecosystem corresponds to the complexity of their respective interactions and the number of ways along which energy and information can pass through a community, any alteration of biodiversity (determined by direct and indirect factors and also induced by the transformations of the landscape) due to changes in the ecosystem stability induces a progressive dystrophy (loss of function) that is a reduction in the habitats' and ecosystems' functionality. The combination of niche overlap within the same scale and between different scales produces a strengthening of ecological resilience and thus the maintenance of a certain level of ecological functionality (Peterson *et al.* 1998).

It is important to appreciate that while ecosystem services are the functional characteristics of ecosystems as a whole or a community, the functions supporting them often depend on key species, guild or habitat types (Kremen 2005). Therefore, it is the combination of redundancy among different species and scales that determines the robustness of the functional ecological resilience. As a consequence of this, considering only a single process (for example the species distribution), risks implementing actions that are inadequate in maintaining ecosystem multifunctionality (Santolini 2010).

As a consequence, species, richness and their relative abundance become control tools and good indicators for the integrity, diversity, vulnerability and dystrophy of ecosystems. For this reason, many species-based groups are suitable to be used in environmental evaluations (AAVV 1983) and for the control of environmental alteration. For example, an aggregate index in Europe has

// **Figure 12:** Performance of ESS soil use model in the Alps



Source: CLC 2012

been developed for birds (Gregory at al. 2003, 2005) on the basis of environmental selectivity, where several aggregate indices are calculated: one for a rural species (FBI or farmland birds index), one for forest environments and one for the remaining common species in the CAP's rural development plan (Common Agricultural Policy) .

Ecological indicators provide information about the sum and the integration effects of biological parameters, expressing the sensitivity of the same indicator in relation to the quality of its habitat/ecosystem. In this way they use the reactive behavioural properties of the organisms to a complex of factors expressing a cumulative effect over time. This facilitates, through the use of synthetic indexes, relatively objective evaluations.

3.9.4 Ecosystem functions and landscape connectivity

It is not always possible to have original biodiversity data. Therefore, it is useful to have tools with which it is possible to indirectly estimate biodiversity variability in a region. A more recently devised approach is the expert-based one (Amici and Battisti 2009) using the Delphi method. Another option is to find measurable attributes that can be used as indicators. These attributes can be derived from environmental or cartographical databases (Noss, 1990; Morelli et al 2013).

Indicators of landscape metrics can be measurable surrogates of environmental characteristics such as biodiversity. Their use should be part of a global strategy to analyse the quality of the landscape by focusing on a guild of species, ecosystem and habitat keys, including connecting areas, mosaics, and other landscape structures. (Blondel 1986; Paoletti, 1999; Santolini 2012, 2014). Soil use and landscape metrics can be used as indicators of landscape heterogeneity and potentially as biodiversity indicators (Lindenmayer et al., 2002). Therefore, variations in the use of the soil can lead, in some cases, to a decrease in the performance of the ecosystem service provision (Scolozzi et al. 2012; Burkhard and Muller 2015) (Figure 12). Furthermore, it must be noted that in ecology, habitat diversity is associated with an increase in the niche availability for species (Kisel et al., 2011; Morelli et al 2013).

Spatial and temporal characteristics of an individual mosaic patch determine the potential ability to provide a series of ecosystem services. Fragmentation of habitats, ecosystems and landscape diversity can engender changes in the abundance of species and biodiversity. Consequently, this is all the more important when the altering factor acts on the spatial characteristics of the landscape that generates the ecosystem service, since some ESS necessarily depend on their spatial and temporal characteristics (Costanza 2008; Mitchell et al 2013).

Landscape metrics thus influence the ecological functionality of an area in a way that is closely related to the geometry of the elements that make up the landscape and the spatial positioning of service supply and demand. Landscape services include contributions of elements (flora and fauna) and ecosystems (for example wood, grassland) of the landscape itself. Landscape services are the emergent properties of more focused anthropogenic effects on landscape (for example, land use), since the term landscape explicitly includes the interaction between humans and their environment.

It is well-known (Costanza et al., 2007) that at larger spatial and time scales, a higher biodiversity is required to supply a regular flow of goods and ecosystem services. For this reason, biodiversity becomes a key element in fulfilling the objectives of economic, ecological and social management (Hooper et al., 2005; EEA 2007). Networks of landscape elements (like a green infrastructure) are interpreted as supporting and enhancing nature, natural processes and natural capital. They capture at a large scale two of the main elements, which are the delivery of multiple ecosystem services and the provision and supporting of ecosystem services for habitat/ecosystem connectivity. An environmentally sustainable spatial plan must consider the various aspects related to the ecological functions and the territorial elements that generate these functions. In contrast a plan focused solely on maximising economic gain creates landscapes with lower levels of biodiversity and less able to provide ecosystem services (Nelson et al., 2009).

3.9.5 The ESS concept/approach/ framework and spatial planning

In the effort to improve management of ecosystems and landscapes, the ESS concept recognises the need for territorial planning and informs decision makers about the benefits that biodiversity provides to both local populations and their economic development as well as the inter-dependence of local and distant ecosystems (Wilkinson C., 2013). Likewise, it enables the exchange with other components and factors of the landscape such as demographics, health, security, education and culture. Thus the ESS framework has the potential to make ecological issues more transparent and can be used to inform spatial planning processes.

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The ESS framework could also be a useful interface between science and decision-making. Spatial planning could benefit from adopting or adapting new tools and methods being developed by scientists. In this regard, a more detailed understanding of how ESS trade-offs are currently being implemented in decision processes would be valuable in order to enhance the development of novel systematic tools by ecologists. Developing tools based on detailed knowledge of the institutional context and reflecting the political climate in which the spatial plan is implemented would greatly improve the decision-making capacity in respect to ESS trade-offs. Moreover, the use of an explicit ESS framework has the potential to improve the quality of spatial planning by better understanding how ecological dynamics and human actions shape and modulate multiple ESS (Wilkinson 2013).

> **Knowledge about ecosystem** *and landscape services and values should be investigated, assessed and necessarily clearly communicated to policy makers, stakeholders and the general public.*

In addition, although much has been achieved, there is a further need to develop widely shared definitions of key concepts and typologies (of services, benefits, values), measurements, reporting practices and standards for ecological socio-cultural and economic values robustly based on an underlying conceptual framework and widely shared among practitioners of the ESS approach to ensure comparability and transferability (de Groot, 2010). However, recent efforts in this regard have changed the terms of discussion on nature conservation, natural resource management, and other areas of public policy. It is widely recognised that nature conservation and conservation management strategies do not always necessitate a trade-off between the environment and development. Rather investments in conservation, restoration and sustainable ecosystem use, can generate substantial (ecological, social and economic) benefits (de Groot, 2010).

Therefore, the challenges to the structural integration of ESS in planning and design usually entail applying ESS assessments and valuations to environmental management processes and subsequently finding solutions to generate a comprehensive and practical implementation framework (de Groot, 2010). In this way the concept of ESS can be mainstreamed into environmental planning and management at all levels of the decision-making process (Daily *et al.*, 2009; de Groot, 2010).

3.9.6 Which ecosystem services for Alpine connectivity?

The ecosystem services topic is a central issue of the international political agenda under the auspices of the UN (MEA 2005) and parallel to the development and promotion of payment mechanisms and remuneration for these services (Engel *et al.*, 2008).

Definition of the four ESS categories proposed by MEA (2005) remains of topical interest, and these terms are widespread in their use. In the past few years, this categorisation has been retrieved and adapted in TEEB (2010) and in the Common International Classification of Ecosystem Services developed by European Environment Agency (Haines-Young and Potschin, 2013)

The supporting and regulating biophysical ESS are of elemental importance for the use of natural capital and other services. This constitutes ecological functions and processes from ecosystems, that guarantee the flow of energy, information and labour for the functioning of the ecosystem itself. Considering the Total Economic Value (TEV), (MEA 2005) of an ecosystem, these services are characterised through the indirect use by humans – services from which they will benefit regardless of whether they choose to or not. For this reason, they are particularly important public and collective goods, together with option value and existence value. For this reason, supporting and regulating services should be evaluated as the primary basis for the following direct use of selected resources (for example use of wood for fire). This evaluation is necessary for the sustainable preservation of collective ESS goods and economic – ecological budgeting in the landscape (Functional Ecologic Unit FEU, for example water catchment).

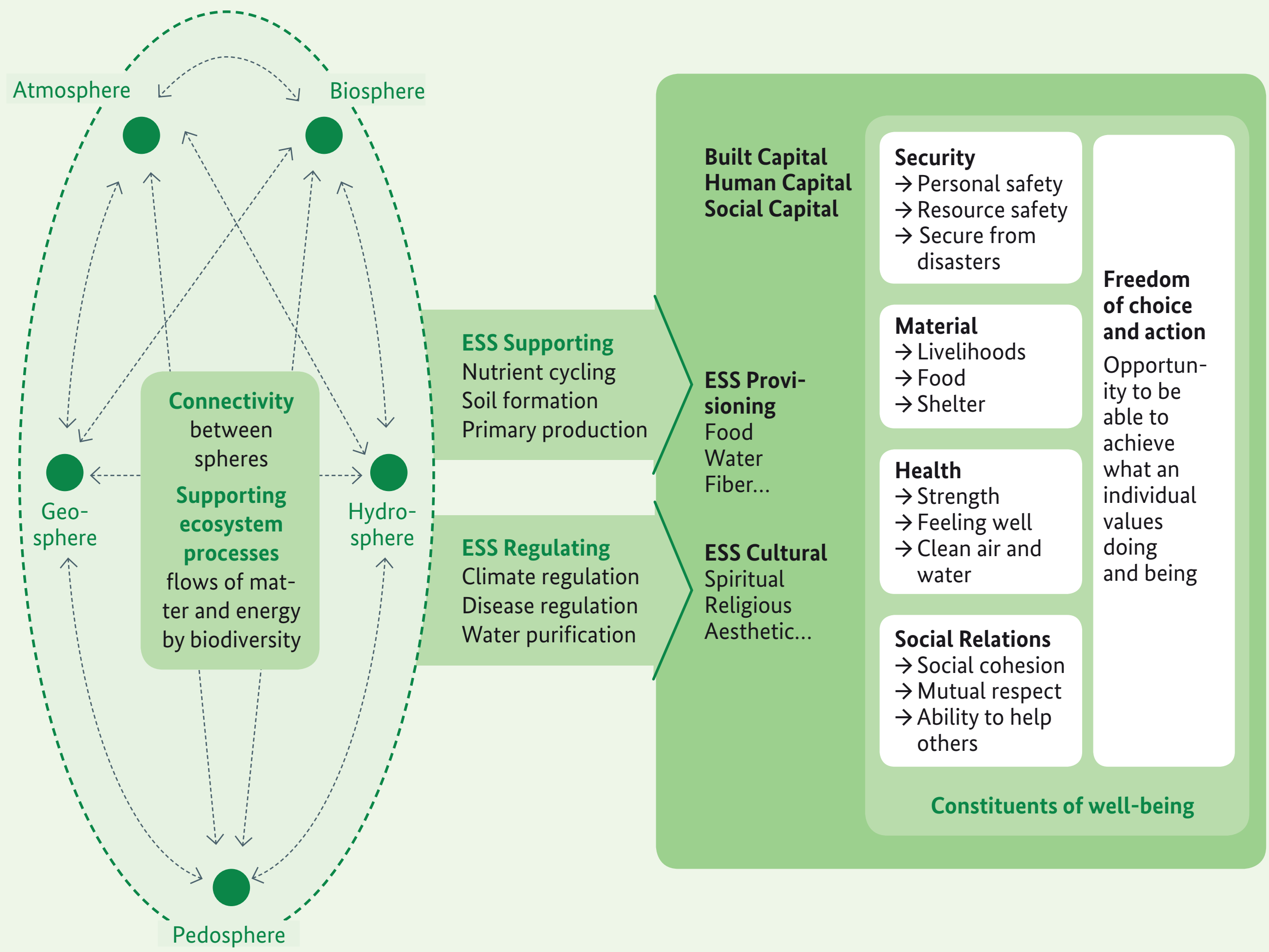
The ESS concept constitutes an important support framework in combining conservation objectives with the sustainable development of territories, especially in the mountain areas (Hastik *et al.* 2015; Gret-Regamey *et al.* 2012; Gibelli and Santolini 2015). Therefore, the evaluation of local and regional demand is crucial when developing appropriate management strategies.

The preliminary evaluation of the carrying capacity of biophysical ESS, should be developed in order to assess the compatibility of competing direct uses, while considering and conserving public ESS goods. For example, a poor forest management plan, based solely on harvesting trees, will ultimately engender erosion and ecological dystrophy (loss of biophysical functions and consequently following ESS, for example cultural ESS). Therefore, in the Alpine region, farmers could stand as guardians for supporting and regulating ESS. In this approach they would, through their activities, become keepers of the landscape, maintaining the biophysical ESS, which in turn support touristic-recreational ESS.

When assessing ESS, it is important to adequately differentiate biophysical ESS – elemental ESS and the basis of a good quality of life – from cultural/recreational ESS. Furthermore, the biophysical ESS are components of non-renewable natural capital, or at best, multigenerational renewable and cannot be replenished with components of manmade capital (Turner *et al.*, 1996). For the implementation of robust management strategies, it is important to evaluate the ESS demand both at a regional and local level, thus avoiding the risk of being misled by global values. Biophysical ESS depend on ecologic and structural factors at a regional and local level. The biophysical ESS interact strongly with each other, so much so that it is necessary to identify clusters of ESS. For example, the water related ESS integrate functions from different ecosystems (for example river and riparian forest) as denoted in the Water Framework Directive 2000/60/EC and Risk of floods 2007/60/EC (for example water quality and quantity, absorption capacity, fishing and more) (Figure 13).

This observation and classification allows for the identification of more reasonable and objective answers to the improvement needs of mountain territories both from an ecologic and an economic perspective, since

// **Figure 13:** Framework for natural capital and biophysical ESS base for ecologic functionality and wellbeing



Source: Dominati 2010 mod

carrying capacity can be defined as the capacity of the functioning ecosystem to supply a certain stream of services. Calculation of the ESS supply and demand ratios needs an in-depth knowledge of the socio-ecological processes and related inter-connections (Grêt-Regamey *et al.* 2014). This suggests a new identity for the mountain territories along an ecological and economic gradient of functions and services offered and maintained by varying compatible activities and defined by a Payment of Ecosystem Services (PES) approach. This approach has recently been highlighted in the relationship between the need for renewable energy production, and ESS preservation (Hastik *et al.*, 2015), where the definition of the adequate procedures in identifying sustainable strategies, mitigates the difficulties and draws attention to the benefits of ESS, which is of paramount importance.

3.9.7 Conclusions

The Alpine region is composed of a mosaic of habitats and ecosystems subject to varying degrees of anthropogenic impact that influence the ecological balance through increased fragmentation and decreased territorial connectivity (ECONNECT 2011). Ecological connectivity is closely related to biodiversity, and there is strong evidence that biodiversity has a positive effect on the delivery of important ecosystem services. These concepts are directly relevant to the conservation of functioning ecosystems that enable our survival as individuals. Through its components, including ecological dynamics, ecosystem limitation, and landscape dystrophy, nature conservation is a primordial element of human existence. Any aspect of human wellbeing must be seen in the context of this assumption (Morelli and Møller 2015). Based on this knowledge, the following key recommendations are provided to identify strategies of sustainable management resources in an Alpine context:

Hay harvest in Nature Park Gruyère Pays-d'Enhaut.

Researchers must develop tools to analyse and assess ESS in a meaningful and harmonised fashion and contribute towards a more accurate and reliable decision-making model. This will ensure that results are comparable, (Grêt-Regamey *et al.* 2014; Santolini 2014).

Based on the variety of available methodologies (regarding connectivity conservation, landscape connectivity, ecological functionality), it is important to start with one, clear, well-defined and framed objective, in order to avoid subsequent misunderstandings during the development of planning strategies and the associated implementation decisions while consolidating the Ecological Network (Santolini 2014) and the Green Infrastructure (EEA 2013).

The ecological-economic assessment of biophysical ESS is elemental to the other types of ESS and provides the basis in assessing the carrying capacity of a FEU. This priority assessment improves the compatibility of the direct use of natural capital, and preserves the functions that sustain the ecosystem and the landscape, while reducing conflicts between competing uses (Bastian 2013).

The integration of ESS and natural capital values into economic processes by means of tools such as PES offers the opportunity to improve habitat condition, connectivity, and the ecosystem functionality. This has the potential to re-establish the economic balance between users and producers and to maintain functional ecosystems, to the benefit of the mountain population living and working in those areas.

3.10 Agriculture and ecological connectivity

// *Filippo FAVILLI* //

EURAC Research, Institute for Regional Development and Location Management, Bolzano, Italy

3.10.1 The link between agriculture production, biodiversity and ecological connectivity

The European Alpine landscape shows a great diversity of habitats and species, characterised by strong natural gradients and large spatial and temporal heterogeneity (Theurillat *et al.*, 2003). The great biodiversity of the Alps has been highly shaped by human impact on land use, especially below the tree line, where most grasslands are manmade. These grasslands contribute to the diverse mosaic of pastures, meadows and forests, making the cultural landscape of the Alps one of the most plant-species rich in Europe (Väre *et al.*, 2003). Human development in mountain areas through farming has contributed over the centuries to the creation and maintenance of a variety of valuable semi-natural habitats (Ailte *et al.*, 2007) that play a key role in maintaining the biodiversity richness of the natural environment among highly disturbed crop fields. Agricultural landscapes are, or should be, fine-grained mosaics of crops and semi-natural habitats, which make a significant contribution to human well-being and provide vital goods and services for people. Among the different habitats, permanent meadows have always provided a wide range of ecosystem services of high socioeconomic value to human society, and, at the same time, they have contributed significantly to the biodiversity of mountain agro-ecosystems (Sala and Peruelo, 1997). We may argue that, the more biodiversity there is, the higher socioeconomic value for human society a territory has. Biodiversity is important not only for wildlife species, but also for human well-being. Biodiversity increases the stability of most types of ecosystems, allowing sustainable resource exploitation (Balvanera *et al.*, 2006).

Today, these semi-natural habitats shape the majority of the Europe's landscapes and host much of Europe's richest wildlife. More than 40 percent of threatened species in Europe are dependent on extensively managed agricultural landscape systems (Ailte *et al.*, 2007). Nonetheless, since the second half of the 20th century, the intensification of land-use practices and the abandonment of high altitude areas have accelerated the decline of semi-natural habitats. Today only 15 to 25 percent of Europe's once extensive high nature value farmland remains, and only seven percent of habitats and three percent of species protected by the Habitats Directive that depend on agricultural practices have a favourable conservation status (CEC, 2011b).

The intensification of agricultural practices in Europe has been the major driver of farmland biodiversity loss at local, regional and global scales (Norris, 2008). Over the same period, in many European countries, a structural transformation of farms has also been observed (MacDonald *et al.*, 2000). The number of small, traditional farms has been decreasing, as they are replaced by larger, more modern and specialized farms (EUROSTAT, *www.europa.eu/*). These changes are particularly evident in traditional extensive agricultural systems, such as those found in marginal boreal and mountain areas (Pykälä, 2000; Streifeneder and Ruffini, 2007, Ruffini *et al.*, 2011).

Additional effects of land use intensification can be found in the drastic reduction of farmland bird populations, which have decreased by about 50 percent since 1980 (though this figure has since levelled off), and in the 70 percent decrease of farmland butterfly populations since 1990, which show no signs of recovery (CEC, 2011a).

The increasing economic pressure in maintaining farm incomes in mountain areas has resulted in intensification of the flatter and more productive soils and in a partial abandonment of steep areas characterised by high labour requirements (MacDonald *et al.*, 2000). Despite the headline target in the EU Biodiversity Strategy to halt the loss of biodiversity and the degradation of ecosystems in the EU by 2020, and restoring them as far as possible (CEC, 2011b), farmland biodiversity continues to decline across the European Union (EEA ,2015; Langhout, 2015).

If a habitat is lost due to factors such as land use conversion, landscapes become more fragmented, less ecologically connected, and less bio-diverse, engendering negative effects on biodiversity and on the quality of the ecosystem services provided (Fahrig, 2003). Fragmented landscapes increasingly isolate populations and communities, while simultaneously decreasing the likelihood of dispersal between them. The reduction of

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potential and effective connectivity in the longer term can have reinforcing negative effects on a population's long-term viability through the homogenisation of genetic diversity (Lienert, 2004).

It is worth considering connectivity on a larger scale, but it is fundamental to act at local scale, because the loss of local connectivity also has consequences at regional and international scales. Ecological connectivity follows the phrase "Think globally, act locally" (Geddes, 1915). Local activities of habitat conversion, or building of human infrastructures may seem initially innocuous with respect to free movement of animals, but in the long-term and on a wider scale, they may become an insurmountable barrier for many wildlife species. Furthermore, in agricultural environments, connectivity is an important prerequisite for species to travel the long distances required to avoid extinction due to anthropogenic climate and land use change (Krosby *et al.* 2010). The profound connection between ecological connectivity and agriculture exemplifies the way that any landscape use change can have a greater effect than initially thought. For this reason, it is essential to think and act in a more interdisciplinary way in order to take into consideration all the side effects of practices within a certain territory.

The Italian Ministry of Environment is currently involved in a series of meetings with stakeholders, protected areas managers and experts to discuss the status of the protection of biodiversity and agro-biodiversity, and the future challenges of Alpine Protected Areas and the Mediterranean territories (MATTM, 2015). In the Italian Alpine and Mediterranean protected areas, the current situation shows an increase in landscape fragmentation and the only-partial integration and utilisation of agricultural financial resources for the promotion of extensive and biological agriculture, which allow only "emergency interventions", rather than the creation of a broad-based strategy with local actors. There are indeed many projects in the primary sector, but they are neither supported by a strong political endorsement, nor are they inserted into an integrated inter-regional and/or trans-national development strategy, which would be able to relate each single project to a long-term spatial planning effort. Many experts and protected areas' managers highlight the absence of political will to address the paucity of funds available for the promotion of extensive agriculture and the protection of local cultivations and biodiversity, and to consider the public's appreciation of conservation and biodiversity topics.

As an example, the Natura 2000 network is still almost unknown to the public at large. People do not see the Natura 2000 network as a potential source of ecological and socioeconomic welfare but mainly as a "net of prohibitions", preventing local mountain people from utilising natural resources in the way they were taught by tradition (Favilli *et al.*, 2013a). This sort of indifference or opposition from the public at large, as well as from the local administrators, combined with the lack of funding and of management plans for Natura 2000 sites, often creates a significant disparity between the adherence to the national strategy and the concrete actions on the ground. As in ecological connectivity, the disconnect between important projects on agriculture and those for the protection of biodiversity does not engender creation of a structured and functional long-term strategy for the Alpine territories for the sake of all the actors, be they humans, plants or wildlife species. In this sense, ecological connectivity is the common platform for different actors to harmonise their interests and understand the mutual benefits that can be gained using a wider and integrated approach.

> **Many experts** *have agreed on the necessity of making available agricultural funding accessible for biodiversity conservation actions that are also, compatible with the agro-economic system.*

In this sense, farmers may also become Natura 2000 managers in order to underline the importance of valorising actions and projects that may correctly consider these aspects in the granting process, and to enhance the transparency of actual funding utilisation. Additionally, experts agreed to further explore the potential offered by European funding, particularly the opportunity to address LEADER funds for Natura 2000 management sites. This opportunity would also allow a greater understanding of the importance of ecological networks for biodiversity in agriculture and would stimulate local stakeholders to act in a more collaborative way with other sectors of interest, avoiding conflicts.

Spatial planning should be the main executive instrument for local people to share and integrate different interests within the territory and for the common adoption of habitat and biodiversity conservation strategies. In many cases (for example in Italy), plans are highly fragmented and often limited to the municipality level. A special case is the National Park Berchtesgaden in Germany, where a platform for the dialogue between the park administration and the local stakeholders has been in operation for several years with the goal of producing common spatial plans of the entire region. The presence of the park benefits the development of a common spatial plan, since it provides an effective stage on which different actors may try to facilitate the resolution of conflicts among stakeholders and detect new socioeconomic opportunities for the territory (Favilli, 2014).

These practices show that the steps necessary for the promotion of coordinated and integrated strategies between ecological connectivity and agriculture, and the required biodiversity conservation actions grow from the development of a participatory process with different regions and actors. As expressed by Baudry *et al.*, (2002), *"the key to tease out points of actions in the system is to understand the mechanisms that lead to land use decision"*. In order to do that, negotiation between farmers and biodiversity stakeholders is an essential starting point.

3.10.2 What do ecological networks mean in agricultural areas?

Ecological networks provide for several functions in the maintenance of the health of the environment. They enable the conservation of biodiversity at ecosystem and regional scales, putting an emphasis on the reinforcement of ecological coherence and continuum and integrating biodiversity conservation into broad environmental management plans. Ecological networks may buffer critical areas from the effects of potentially damaging activities and help in the restoration of degraded ecosystems. Ensuring the ecological continuum, without limiting human development, contributes to the promotion of sustainable use of natural resources and to the raising of people's awareness in respect to a pacific coexistence and sharing of common spaces with wildlife species (Favilli *et al.*, 2013, 2015).

Ecological networks can greatly contribute to the maintenance or the protection of the biodiversity of agricultural areas. Ecological networks connect areas of habitat and allow animals and plants to move through the countryside. This potential for free movements is an important factor for the survival of many species in relation to changes in land use patterns and climate. As well as being vital for the functioning of ecosystems, ecological networks and corridors, greenways and landscape linkages also have aesthetic value that may contribute to increasing the attractiveness of living and working environments. Ecological networks are not only for wildlife species. They may have important recreational and touristic value and can offer further economic benefits by protecting property and businesses

Agricultural landscape in the Nature Park Kaunergrat.

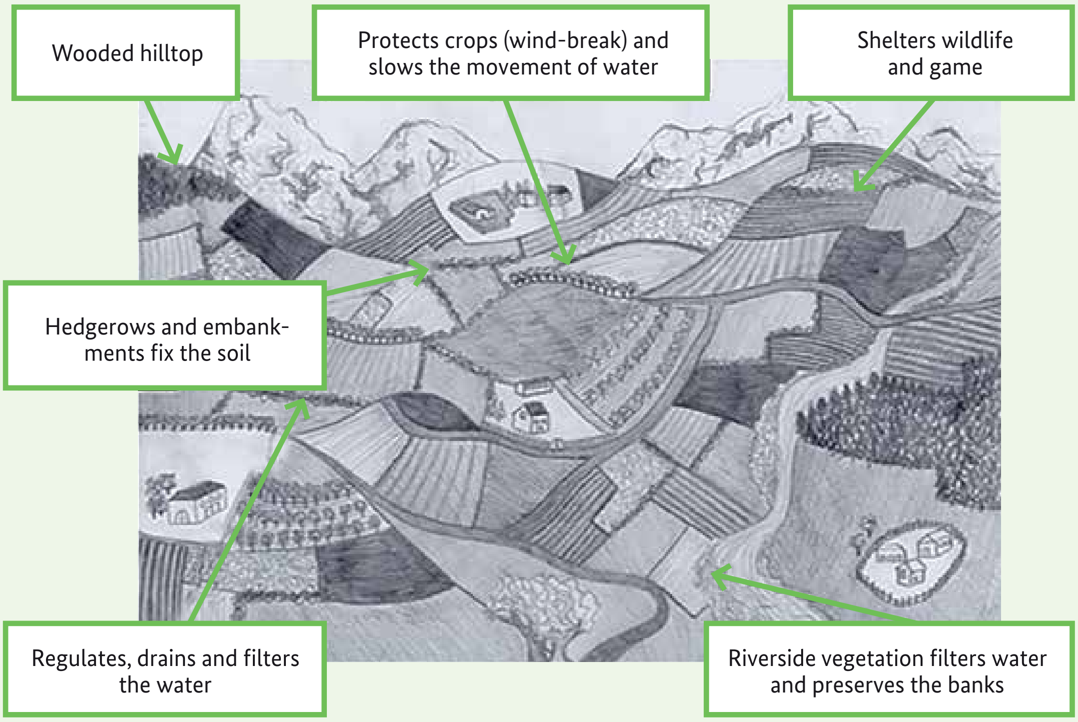
from environmental impacts or providing a source of food, fuel and building materials (Ailte *et al.*, 2007).

Farming may have a crucial impact on biodiversity in the Alps that can be either negative or positive. On one hand, intensive agriculture in valleys is a major obstacle to the migration of fauna and the spread of wild plants. On the other hand, extensively farmed high fields can still be of outstanding biodiversity value, although the abandonment of traditional farming practices increasingly threatens these fields. In intensively worked fields, for example, connectivity can be enhanced through green margins or structural linear elements like hedges and dry-stone walls. Extensive forms of management, without the use of fertilisers or insecticides, for example, help to maintain biodiversity and ecological networks and can enhance control of weeds, diseases, and arthropod pests and increase pollination services. Furthermore, they increase soil quality, carbon sequestration, and water-holding capacity in surface soils, energy-use efficiency, and resistance and resilience to climate change (Kremer and Miles, 2012).

The general public should be aware of what farmers can do to promote connectivity, and to protect the high socioeconomic value of the ecosystem services that rural and mountain areas provide. Farmers should receive appropriate compensation for this contribution, because these measures are helping to conserve biodiversity as a basis for life and to create an attractive living environment for the whole of society (Kohler and Heinrichs, 2011).

Many environmental improvements (Genghini, 1994) can play a key role in the maintenance of the structural and functional connectivity of the landscape. Different species can use them as seasonal refuges and/or core areas and, therefore, these improvements are extremely useful for the survival of biodiversity. Agricultural landscapes can also contribute positively to the establishment and maintenance of ecological connectivity. Small linear features such as hedgerows, field margins, verges, or remnants of semi- margins, help to enhance diversification of the environment (Figure 14).

// Figure 14: The illustration depicts a farmed landscape in which connectivity is high. It contains many features that are desirable for wildlife but which can also contribute to farming practice and game management



Source: Adapted from Bonnin *et al.*, 2007

Interventions that can be made by farmers and land managers to support ecological corridors in the territories of their competencies (CIPRA, 2010) range from the restoration or maintenance of landscape elements to a wider landscape management scheme. Single measures have to be inserted into a strategy combining the creation of an ecological network with the maintenance of traditional agriculture.

These single measures usually take the form of strips of vegetation that have been deliberately planted for a variety of purposes including: shelter, reduction of soil erosion, provision of timber sources, creation of wildlife habitat or for aesthetic qualities. The agricultural field margins not only provide a habitat for rare species of plants and contribute to the protection of soils and water resources, they also constitute important linear transit routes and form buffer zones between various forms of land use. Along fields and paths, the field margins form a network of linear connecting elements. Inclusion of these areas in local plans increases this positive impact significantly.

The new structural elements display great variation in origin, floristic composition and structure, but there are several common features:

- They are linear (but not always straight) and usually form grid-like networks of habitat
- They frequently provide links between remaining natural and semi-natural habitats
- They are closely associated with agricultural land, since past and present agricultural land management strongly influence their composition and structure.

They take forms such as:

- **Hedgerows**: linear strips of shrubs, small and sometimes large trees planted along the boundaries of fields, roadways, fences and other no-cropped areas.
- **Stone walls**: replacement for hedges, particularly in upland and arid areas, where shrubs do not grow so well.
- **Fencerows**: narrow strips of rough land that have developed by the natural regeneration of plants in neglected strips of land between fields, by roads and water bodies. Their vegetation ranges from that dominated by grasses and herbs, to narrow lines of shrubs, to broad strips with mature woodland trees.
- **Wind-breaks**: barriers usually consisting of trees or shrubs that are used to reduce and redirect wind.
- **Filter strips**: areas planted with vegetation to control soil erosion; they slow down water runoff and capture and prevent sediments and nutrients from entering waterways.

They are used:

- As nesting, roosting and feeding habitat, and cover by forest-edge, farmland and game birds and significantly increase their number and diversity
- By mammals, amphibians and reptiles as breeding areas, shelter, temporary refuge, or foraging habitat (species include badger and fox, small mammals such as field mice and bank voles, and amphibians)
- By insects to gain nectar and pollen, prey and shelter (this includes ladybugs, hover flies, ladybird beetles, green and brown lacewings, parasitic and predatory wasps and spiders – many of them beneficial to agriculture as natural pest control agents).

Nevertheless, these particular landscape and agricultural structures are negatively impacted by herbicides, pesticides or manure through leaching and transport by soil water or airborne deposition from adjacent fields. At the landscape level, the removal of linear elements, such as hedges and walls, is of great importance. This is a slow process mainly driven by changes in the agricultural system. Crops, in contrast, vary more rapidly on a yearly basis (Burel, 2002). On one hand, many species have grown accustomed to extensive agricultural systems, since these systems include small features that can help animals in their basic need for movement; on the other hand, certain species have also adapted to some intensively managed areas (for example wet grasslands, wet areas with rice cultivation). Examples include breeding and wintering water birds in the Netherlands, Belgium and northern Germany, and species (for example badgers, certain birds) of hedgerow landscapes in France, UK and Ireland (Hoffmann, 2001).

All of these structural elements need to be managed with care. Where they are absent, these features can be created. In many areas of Europe financial subsidies and advice, written or in the form of farm conservation advisers who are able to visit farms and even create wildlife management plans, are available to farmers and land managers. This can be focused on both the ongoing management of habitats and features that provide connectivity, as well as on the creation of new areas for wildlife. Other measures that can be carried out in agricultural fields to improve ecological connectivity include (Kohler and Heinrichs, 2011):

Land set-aside: Areas of wild herbs on agricultural fields provide important areas for resting, breeding, feeding, mating or cover. Set-aside areas distributed across the agricultural landscape can create high-quality habitats for wild fauna and flora and thus contribute on a sustainable basis to the conservation of characteristic communities in open farmland.

Fallow areas act as stepping stone biotopes. Their inclusion in local spatial planning greatly increase their positive impact

Extensive use of grasslands and organic farming: Extensively used grasslands are extremely important for the biotope network due to their species richness. Their extensive use with zero to moderate fertilization, no use of plant protection products, no ploughing up of grassland or sowing, and low frequency of cutting and specific mowing techniques can also help to improve biotope functions. The impact on an ecological network is increased if individual areas are integrated into a network of extensively used margins and scattered dry meadows. Organic farming has an extremely important role to play; one reason being that it avoids and reduces the environmental stresses that can otherwise arise in farming. Furthermore, the targeted creation of landscape elements, ecological compensation areas such as hedgerows, fallow areas, forest strips and extensive meadows make an important contribution towards the promotion of biological diversity.

Species-rich seeding on agricultural fields: Species-rich seeding of wild and cultivated plants on set-aside or

Structure rich rural landscape in the Mercantour National Park in France.

"green" areas created in compensation for natural spaces lost through construction of roads or fallow land in residential areas can enrich the landscape's appearance and make a valuable contribution to the biotope network. Seeding with wild species provides a source of food and cover for wild fauna and, depending on the mix of seeds used, can also provide habitats for insects.

Maintenance and preservation of mixed orchards: Mixed orchards are a characteristic and attractive feature of the cultural landscape in many Alpine regions and are among the most valuable patch biotopes. The structural diversity in mixed orchards and the resulting diverse mosaic-type habitats provide a habitat for a wide range of species of flora and fauna. In intensively used agricultural landscapes, they constitute important connective structures in the local biotope network. The conservation measures for these areas must include arrangements for mowing, fertilising, management and maintenance, the preservation of ageing trees and more.

Encouragement of unpaved paths: Depending on their type and the way in which they are built, paths can have a low to high barrier effect. Pathway systems and their peripheral areas do not necessarily have a fragmenting effect on all species of flora and fauna, and if properly designed, they can also form important elements of the biotope network. They provide routes through the landscape and form buffer zones to intensively farmed areas.

Additional measures can include the maintenance and restoration of traditional irrigation systems, the promotion of traditional pasturing with sheep cultivation areas in a sustainable way, the maintenance of open areas by controlled burning, and tree maintenance and preservation of pollarded trees.

3.10.3 Conclusions

Models and policies often focus either on landscape design (that is implementation of corridors) or land use practices (that is less pesticide), while sound management needs to combine both. The main reason is that corridor quality is not independent of adjacent land use (Le Coeur *et al.* 2002), and that solely changing practices is not enough in providing new landscape elements, especially perennial ones (strip of grass, hedgerows). The territorial policies, particularly with regard to biodiversity and to conservation of biological and extensive agriculture and of local products, are often used only as an opportunity for political propaganda, without being integrated in to a strategy that requires actions (and funding) that are immediately available yet persistent in the long-term. It is therefore fundamental to see processes as composite and not only punctualted and simple. These processes must include a bottom-up phase. The different actors must employ multiple modalities and address a variety of issues. They must operate on the basis of a solid and informed technical/scientific background in order to manage integrated actions for larger spaces. This warrants the creation of governance processes inspired by real problems within the territory and capable of amending decisions taken in haste.

Box 5:

The Ecological Continuum Initiative – Catalysing and multiplying connectivity in the Alpine area

Since 2007, this Initiative has offered an open forum for developing joint strategies and actions concerning ecological connectivtiy primarily in the Alpine area and beyond. The Continuum Initiative aims to create a common Alps-wide framework for transboundary and trans-sectoral cooperation in order to raise awareness for ecological connectivity and to protect or restore ecological networks linking flora and fauna habitats and protected areas.

The Initiative focuses on three targets:

1. Initiating, promoting and mentoring activities: The Initiative`s work and commitment have led to the establishment of the Ecological Network Platform of the Alpine Convention and the initiation of the EU Alpine Space project ECONNECT. Since 2010, the Continuum Initiative has gathered a large number of experts in a think tank.

2. Providing know-how: The initiative provides a website with a catalogue of measures for improving ecological connectivity and a database of publications, research projects, and experts from research and practice: *www.alpine-ecological-network.org*

3. Awareness-building: The Initiative organises communication campaigns addressing different target audiences via a series of ten factsheets on the integration of connectivity into land use practices, such as: the film “For hermits and fire salamanders”[7] in order to raise awareness for connectivity among municipalities, and the campaign “The Wall”, placed in pedestrian areas of large cities as Milan, Zurich or Munich.

The Ecological Continuum Initiative has been promoted by the Alpine Network of Protected Areas (ALPARC), the International Commission for the Protection of the Alps (CIPRA), the WWF Alpine Programme, and the International Scientific Committee for Alpine Research (ISCAR). These organisations have been collaborating on this issue since 2002, and their work has been partly funded by the Swiss MAVA Foundation for Nature.

3.11 The Alps and their soils

// Clemens GEITNER //
// Jasmin BARUCK //
Institute of Geography, University of Innsbruck, Innsbruck, Austria

The Alps constitute the highest mountain range in Europe extending over eight countries from Austria in the East to the Mediterranean shores of France. The range is located in the transition zone from temperate to Mediterranean climate. In terms of soil formation, the Alps hold a singular position as the intensity and relative importance of soil forming factors differ considerably from other landscapes (Egli *et al.*, 2006, 2008, 2014; Kilian, 2010; Price and Harden, 2013; Stöhr, 2007). On the one hand Alpine soils are highly modulated by disturbances due to natural processes (Hagedorn *et al.*, 2010), on the other they are strongly influenced by ancient and current human activities (Bätzing, 2005a, 2005b, 2005c; Blum, 2004; FAO, 2015; Geitner, 2010, Hagedorn *et al.*, 2010).

Soils are an essential non-renewable resource that plays a fundamental role for ecosystems (Arnold *et al.*, 1990) – a fact often forgotten or neglected. Soils provide a large variety of ecological functions but are also highly vulnerable to change (Hagedorn et al, 2010). The characteristics of soils are very persistent and not as readily altered by anthropogenic use as, for example, vegetation. Due to this fact, soils can serve as an important component in restoration efforts. During the International Year of Soil 2015, two comprehensive overviews were published on mountain soils (FAO 2015) and soils in the Alps (Baruck *et al.* 2016). Both reviews focus on the special characteristics in the development and the pattern of Alpine soils, including available soil information, soil classification and soil mapping in the Alpine area. More importantly, as mountain soils are more often than not neglected in discussions on biodiversity conservation, these resources are discussed in a worldwide perspective in terms of human activities, climate change, related threats and cultural heritage (FAO 2015). However, these studies cannot conceal the fact that there is a huge gap in knowledge concerning soils in the Alps. While quite a lot is known about the soils supporting agriculture, far less is known about forest soils in the Alps, and hardly any information exists about soils above the treeline (Geitner, 2007; Kilian, 2010).

Soil forming conditions in the Alpine environment, including sites from the valleys up to the mountain peaks, are characterised by: i) a wide range of climatic regimes from North to South and West to East (Schär *et al.*, 1998) due to topography, altitudinal and exposure related changes and variations in temperature, precipitation, and wind, ii) a climatic elevation gradient with distinct vegetation belts denoting nine different vegetation zones (Grabherr, 1997; Theurillat *et al.*, 1998), iii) a very high topographical variability at all scales (Egli *et al.*, 2005, 2006; Geitner *et al.* 2011b), determining meso- and microclimate as well as the local water budget, iv) a steep relief favouring strong morphodynamics, in particular gravitational and fluvial processes, v) a great spatial variability of parent materials with a high proportion of young unconsolidated deposits, predominantly from the Pleistocene period with glacial, periglacial and aeolian deposits vi) highly diverse (historical) land-use practises with patterns that are variable over short spatial ranges.

Due to both the strong Pleistocene impact and the general exposure to morphodynamic processes, “time” must be considered as a special soil forming condition in the Alps. Beyond the factor of time, spatial cohesion, which enables the movement of soil components, is also an important prerequisite for sustainable soil formation and conservation. The material removal, transport and accumulation processes along the slopes determine soil genesis and soil depth (Kilian, 2010; Scalenghe *et al.*, 2002; Theurillat *et al.*, 1998); so that well developed soils, even from the same parent material, may occur in the direct neighbourhood of initial soils (Baize and Roque, 1998; Minghetti *et al.*, 1997; Sartori *et al.*, 2001). When developing infrastructure there is a risk that the natural flow of soil formation is interrupted. Therefore, it appears prudent to clearly understand and consider soil formation processes before interrupting the ecological continuum. We remind the reader here that services rendered by soils constitute a primary and essential Ecosystem Service. Soil is not only the basis for a multitude of ESS but is also a bio-diverse rich habitat in itself, though poorly understood and seldom investigated.

Given the great variety of soil forming conditions, the inherent properties and spatial distribution of Alpine soils are characterised by:

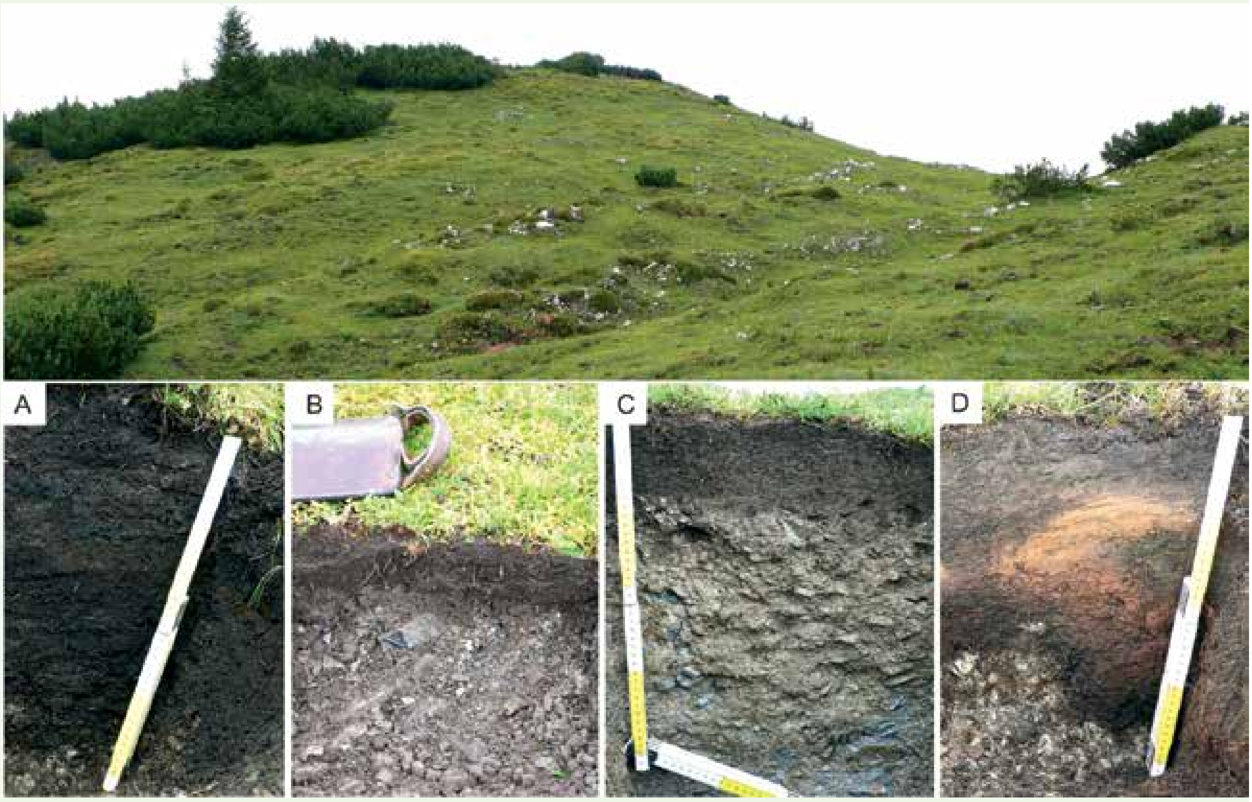
- high variability over very short spatial scales (humus forms often at the metre scale) leading to complex patterns of soil characteristics (Egli *et al.*, 2005; FAO, 2015; Geitner, 2007; Hagedorn *et al.*, 2010; Kilian 2010; Theurillat *et al.*, 1998; Veit 2002)

- typical elevation gradients of some soil properties – by and large the portions of fine grain sizes, pH-values, exchange capacity, stability of aggregates and the incorporation of organic matter decreases with altitude

- multi-layered soil profiles and buried soils, which are quite common in this environment especially at geomorphologically active sites (FAO, 2015; Geitner *et al.*, 2011a; Veit *et al.*, 2002).

Based on these conditions, specific problems arise when surveying but especially when modelling, and interpreting soils in the Alpine environment. The appropriate extrapolation from point to area (from the profile site to a cartographic unit) remains challenging (Baruck *et al.*, 2016). This fact as well as some typical soil features in the Alps and their high spatial variety can be seen from Figure 15.

// Figure 15: Shows a plot of around 100 metres by 100 metres at the largely treeless dolomite hilltop Gaisberg (1,750 metres, Brixen Valley, Tyrol, Austria) illustrating small-scale variability of soils and their features, in particular organic matter content and distribution, grain size and stone content, as well as degree and depth of weathering



Above the timberline in the Alpine zone, microtopography dominates the soil pattern. Accordingly, the differing soil characteristics of profiles B and C are mainly due to topography, while those of profile D are probably due to allochthon aeolic sediments. Profile A represents a thick organic layer ("Tangelhumus"), which in patches covers calcareous bedrock in higher elevations, often developing beneath stocks of Pinus mugo (Photos: C. Geitner, 2009) (after Baruck *et al.*, 2016). The knowledge of soil properties and soil pattern is an essential prerequisite for sustainable land use management and should be mainstreamed into spatial planning processes. The mosaic-like juxtaposition of soil types is a relevant issue at all scales, as the high spatial variability also determines soil functions and therefore also soil related services for the society (FAO, 2015).

Source: Geitner, C., adapted from Baruck *et al.* 2016

Box 6:

The Contribution of ecological connectivity to greening the economy

// ***Bettina HEDDEN-DUNKHORST*** //
Federal Agency for Nature Conservation, Division of International Nature Conservation, Bonn, Germany

// ***Yann KOHLER*** //
Alpine Network of Protected Areas ALPARC, Chambéry, France

Greening the economy is a new paradigm that globally emerges as knowledge and awareness about planetary boundaries and limits to natural resources increase. According to UNEP's (United Nations Environment Programme) widely used definition, "... a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive. Practically speaking, a green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services."

An ecological network for the Alps - that aims to link existing habitats and to provide new ones for Alpine species – is an important tool to maintain biodiversity and to safeguard ecosystem services. Besides, a number of activities and measures related to ecological connectivity also have a potential to generate economic benefits (ECOTEC 2008). These measures can affect different socio-economic sectors like education, tourism, spatial planning, agriculture, forestry, water management etc. They include the establishment of green infrastructure such as fish ladders, green bridges, hedges, educational hiking trails etc. Furthermore, they incorporate numerous other activities across sectors, for instance, wetland restoration that safeguards water related biological functions and at the same time provides for other ecosystem services like flood prevention or nutrient retention. Similarly, afforestation measures can on the one hand contribute to developing corridors and stepping stones for species and on the other hand provide services like erosion control or water purification. As such, connectivity measures are often multi-functional and affect diverse ecosystem services, sometimes at different periods in time.

Apart from environmental effects, connectivity measures can generate economic benefits (Nauman et al. 2011). These may be realised in terms of i) capital investments for infrastructure, ii) additional business or employment opportunities in different sectors (planning, counseling, manufacturing), iii) reduced costs, for example for water purification or flood control, or iv) the diversification or expansion of value-added chains, for instance, in the tourism sector.

In order to further explore and to make better use of the synergies between connectivity measures and efforts to green the economy in the Alps, the following actions should be taken. More evidence is needed on economic benefits and costs of connectivity measures, including the valuation of multiple ecosystem services. Besides, the narratives of best practices should be made available to depict the potential of linking connectivity to sustainable development. Last but not least, more awareness raising for utilising synergies and long-term effects of ecological networking in the process of greening the economy is necessary to ultimately broaden the network of conservation actors.

4 Connectivity contributes to continuity

Introduction

This chapter looks at implementing an ecological continuum on the ground. Yann Kohler discusses methodological approaches and indicators employed during the past decades in establishing ecological connectivity. Complementing this, Alessandro Paletto discusses participatory processes and social impact assessments that necessarily constitute the basis for any successful cooperative process. Based on several decades of experience, Andy Goetz and Wolfgang Pfefferkorn take a very distinct approach to describe the importance and practical implications of participatory approaches in the Alps. JECAMI has established itself as a core tool in planning and evaluating connectivity in the Alpine arch. In two contributions, Ruedi Haller, who developed and is constantly upgrading this singular tool, provides a clear overview of its functions and delineates its use in determining connectivity hotspots. Thomas Scheurer and Chris Walzer report on their endeavour to determine the most important scientific questions related to the Alpine ecological network. Valorising connectivity using an Alpine-adapted ecosystem services approach is the theme of Richard Hastik's contribution. In a second contribution, Yann Kohler explains the Pilot Region concept and the role these defined regions have as stepping-stones and testing areas when establishing connectivity measures.

4.1 Methods and tools for connectivity implementation in the Alps

// *Yann KOHLER* //
Alpine Network of Protected Areas ALPARC, Chambéry, France

The Alpine vision for a mountain massif spanning ecological network is one of an "enduringly restored and maintained ecological continuum, consisting of interconnected landscapes (...) where biodiversity will be conserved for future generations and the resilience of ecological processes will be enhanced"(Belardi et al. 2011). In order to make this vision reality, particular methodological procedures responding to the Alpine specifics had to be defined at the outset, and based on this fundamental conceptual framework, some tailor-made tools were developed and promoted in order to achieve a shared pan-Alpine approach for ecological connectivity implementation.

4.1.1 Methodological approach

Implementing an ecological network is a long-term and complex task. No global recipe exists that explains how this can be successfully done. According to the individual context, scale and objectives, different methods can be applied.

Nature conservation and spatial planning are the fields that have the highest involvement in the creation of ecological networks. The ecological network concept is becoming a framework that facilitates synergy between protection of biodiversity and sustainable social and economic development. It applies at different geographical scales, from local to international. Approaches by countries or regions in designing ecological networks differ depending on their historical tradition in land planning as well as on their biogeographical context.

In 2002 WWF, ALPARC, CIPRA and ISCAR made a proposal regarding how regions with a high biodiversity can be connected among one another on a pan-Alpine scale (Arduino *et al.* 2006). With its study "Transboundary Ecological Network" in 2004 and the following seminar "Establishment of an ecological network of protected areas" in 2005, ALPARC put the focus on the role of protected areas for the creation of an ecological network across the Alps (Kohler & Plassmann 2004; Kohler 2005).

On a smaller scale and where data was available, the Swiss approach of the National Ecological Network, had been identified as a possible option (Berthoud *et al.* 2004). In some Alpine regions, initiatives based on this approach have been implemented (Michelot et al. 2015). Nevertheless, a shared trans-Alpine approach based on this methodology has proved impossible due to lack of necessary data.

At the continental level, the Pan-European Ecological Network is promoted by the Council of Europe (Bonnin et al. 2007). The Ecological Continuum Initiative assessed these different approaches and explained in what contexts each of the approaches could be helpful (Scheurer et al. 2009).

After the emergence of ecological connectivity as a key topic for nature protection on a pan-Alpine level in 2004, some regions have been particularly motivated to contribute to the realisation of functioning ecological networks. A study commissioned by the German Federal Agency for Nature Conservation shows how "Pilot Regions", as territories to test connectivity implementation measures and methods, could be appointed based on objective criteria (Righetti & Wegelin 2009).

For the implementation of the pan-Alpine ecological network, the partners that were involved in the first large scale international Alpine project, ECONNECT, have finalised a common methodology (ECONNECT 2010) based on the earlier findings by the Ecological Continuum Initiative (Methodology assessment from Scheurer *et al.* 2011, Guidelines for Pilot Regions in Scheurer & Kohler 2008). The proposed procedure serves as an implementation guideline for the activities in the Alpine Pilot Regions. It is structured in three main steps, each comprising several activities:

1. Preparation, contact with stakeholders, organisation

2. Target setting and analysis, selecting priority activities

3. Detailed planning and realisation of the identified activities in the Pilot Regions

The first step includes the identification of the main stakeholders and the establishment of a participation and cooperation process in the Pilot Region. This should lead to an exact cartographic delimitation of the Pilot Region as the basis for all following steps. The second step involves the definition of specific goals for the defined Pilot Region as well as selection of target species and a series of indices among a defined list. Indeed, the methodology includes the choice of a set of seven species that are relevant on the pan-Alpine scale and the commitment to harmonise data in order to show connectivity problems and potentials. Finally, the third step includes the implementation of a regional action plan of possible measures and actions to be realised, including monitoring and evaluation aspects.

Nevertheless, the proposed methodology that is supposed to be applied in the Alpine Pilot Regions for ecological connectivity, a key element of the Alpine approach, gives enough leeway to make selections (for example of priority species and habitats) and adaptations (concerning the main stakeholders to involve, for example) according to the local context, and gives freedom to select which connectivity measures should be implemented. This common methodology is, nevertheless, necessary in order to ensure a harmonised approach of the Pilot Regions and to guarantee a basic level of comparability between the different initiatives.

4.1.2 Implementation

All legal, theoretic and methodological work will be of no use if nothing concrete is done on the ground to enhance ecological connectivity. This challenging task needs the cooperation of a very wide range of different stakeholders that can give their support in many ways. Action is demanded not only by political decision makers but also from concerned sectors such as transport and forestry. Every single inhabitant and visitor of the Alpine region can make a small but valuable contribution to the pan-Alpine ecological network by measures such as maintaining a near-natural garden, joining environmentalist organisations in order to help amphibians cross roads or buying products that support the local traditional mountain agriculture with its particular habitats for plants and animals.

Functioning ecological networks require ecologically compatible action across the entire space, particularly outside protected areas. The landscape can be enhanced through targeted measures and support programmes that focus on nature conservation. These can contribute to the implementation of an ecological network by facilitating the connectivity of habitats and protected areas. Different measures and actions, even on a small scale, can be undertaken to create, conserve or restore areas and structures so that they act as connecting elements within an ecological network.

Often the functionality of individual spaces can be greatly enhanced without the imposition of prohibitions or restrictions. For the Alps, a large selection of possible measures to improve ecological connectivity has been compiled in the “Measure Catalogue” (Kohler & Heinrichs 2009). The contents of this document can also be browsed and searched according to the individual needs by the means of a database (*www.alpine-ecological-network.org/information-services/measure-catalogue/measure-database/measure-database?set_language=en*).

It lists a number of exemplary measures from the various Alpine countries that can contribute to the implementation of ecological networks. The catalogue is intended to offer different stakeholders in the field of ecological connectivity examples and ideas and also provides practical information such as the names of contact persons and references. In addition, the descriptions of the various measures include a brief evaluation of economic and ecological aspects. It identifies practical examples and can thus act as a valuable source of ideas for users in the Pilot Regions. The catalogue also provides an overview of the various sectors and areas in which measures to improve ecological connectivity could be beneficial.

> **Based on the information** *contained in the Catalogue of Measures, a series of “fact sheets” was elaborated, addressing a wide range of different target groups.*

They summarise the most important facts in terms of ecological connectivity for each target group. The main objective of the fact sheets is to outline how the particular stakeholders can contribute to an ecological network in the Alps. Each Fact Sheet contains information about the importance of ecological networks in general. Moreover, existing links between the target groups and ecological connectivity are analysed, giving examples of possible contributions of each target group. A set of potential measures is presented that can be undertaken in order to enhance ecological connectivity. One best practice example, which has been implemented in the Alps, is described in detail.

By raising awareness of the topic and giving concrete examples of how an improvement of the situation is feasible, the respective target group are being motivated to take action and contribute to an ecological network in the Alps.

The example of the Pilot Region Workshop in Val Müstair illustrates how the implementation process can be started in a region (Scheurer et al. 2008), following the three recommended steps. Since 2008, different measures have already been implemented in the Pilot Region Rhaetian Triangle, including the restoration of connectivity in dry grassland habitats (involving local schools) and river management improvement on the Rombach river.

Underpath for amphibians in the Pilot Region Isère, France.

An Alpine database offers the possibility to search for expertise on specific topics linked to ecological connectivity (*www.alpine-ecological-network.org/information-services/experts*). If Pilot Regions or other stakeholders involved in a connectivity initiative need scientific or technical advice, they may find a competent expert in this pool of contacts regularly updated by the Swiss Academy of Sciences. A large group of these experts has also worked together on an innovative scientific experiment to define “the 50 most important questions on ecological connectivity in the Alps” (see chapter 4.5).

4.1.3 Awareness raising and communication

Connectivity is a crucial element of biodiversity. However, the ideas, concepts and notions that are behind connectivity can be difficult for the general public and certain stakeholders to grasp. Moreover these people sometimes turn a blind eye to some of the actors that are essential in ensuring that connectivity is safeguarded. Therefore communication is strategically important to explain why connectivity is important. People who realise the significance of connectivity will be more easily moved to action.

On the one hand, making the general public more aware of the importance of connectivity (and how it relates to biodiversity as a whole) can help create a favourable environment for the connectivity activities that are underway at the different levels from local to international. On the other hand, targeted communication can help bring about the conditions for stakeholders, politicians and planners to make more concerned and connectivity-conducive decisions.

As the previous chapters have shown, ecological networks can only be successfully implemented if many different actors contribute to this shared objective. Communication and awareness-raising are indispensable to explain to all these actors the importance of ecological connectivity and the role they can play to improve it. Different communication tools have been developed to accomplish this.

Public information material, like the publication “Restoring the web of life”, explains this especially to non-experts in an easily understandable way. On websites and by means of newsletters and other publications, the Alpine actors give up-to-date information on what they are doing. Central homepages (like *www.alpine-ecological-network.org* or the homepage of the Platform Ecological Network) offer many documents for download and access to databases that list experts, projects, publications, links and events that are related to the topic of ecological connectivity.

Stakeholder specific information is offered to ten different stakeholder groups from tourism to land owners in three languages by the "fact sheets" (see above).

4.1.4. First promising results in the Alpine Pilot Regions for ecological connectivity

Although ecological networks in the Alps and beyond are set up at the spatial level, the temporal aspect should not be forgotten: indeed the measures in question should be implemented on the ground over a long-term period. Thus, the ecological networks approach is both spatial and temporal and, in a certain sense, even cultural, since it reorganises relations between users of the area and encourages new actors to co-operate with one another in a novel common vision. This long-term common vision needs to be further deepened and put into practice by coherent strategies of all different actors leading to the success of the same Alpine-wide objective.

The first experiences from the work carried out in the Pilot Regions indicate that this new approach strikes the right chord. The approach aims at getting local actors involved and making them responsible for the different aspects of protection relating to the daily lives of the local population. The involvement, also financial, of numerous actors is indispensable and needs to be supported by appropriate target group oriented communication with the general public. An ecological network project can thus facilitate co-operation between different areas by providing the possibility of formulating problems and identifying a common solution. Given that the bases of the ecological network concept are relatively easy to communicate and understand and offer the possibility for each actor to contribute at his particular level, this may lead to a real change in methods to protect the natural environment.

Road sign reading "caution marmots", Großglockner, Austria.

4.2 Participatory processes and social impact assessment

// Alessandro PALETTO //
CREA-MPF, Villazzano di Trento, Italy

4.2.1 Social acceptance as prerequisite for success of ecological connectivity implementation projects

Social acceptance is an important issue shaping the implementation of environmental strategies and policies, and it can be measured through the level of public agreement. In the development of renewable energy and the implementation of new technologies needed to achieve the EU energy policy targets (Renewable Energy Directive 2009/28/EC) social acceptance holds a central role. It is necessary to understand stakeholders' perspectives and opinions on the use of the natural resources for energy production and the impacts on the environment. These issues in the Alpine, human dominated multi-use landscapes are potential recurring causes of social conflict (Van der Horst, 2007).

Social conflict and acceptance are explained in double effects of political decisions on natural and human environment. For this reason, these kind of social conflicts could be called "green on green" conflicts. For example, implementing connectivity measures and renewable energy development generates global environmental benefits on the one hand, and potential negative local impacts on visual landscape, nature conservation and wildlife on the other hand. In order to address these conflicts and to increase the social acceptance of decisions, a possible solution is to use a participatory approach in decision-making processes (Bell *et al.*, 2005).

Public participation is a voluntary process whereby the public, composed of individuals and/or organised groups, can exchange information, express opinions, articulate interests, and influence decisions or outcomes of the matter in hand. The participatory process implies the involvement of different interest groups – interest group participation approach and/or the involvement of people – direct citizen participation approach (Elsasser, 2007). The interest group participation approach refers to the principles of representative democracy, where citizens' interests are represented in groups (that is non-profit associations, private organizations, public administrations). Conversely, the direct citizen participation approach refers to the concept of direct democracy that assumes that such groups cannot represent the complexity of society's interests and therefore can be an obstacle to real democracy (Dryzek, 2000).

4.2.2 A four-step participatory process

Using the ASP recharge.green project (*www.recharge-green.eu*) as an example, we describe a four-step participatory process for renewable energy planning on the local scale (Pilot Regions). Both interest group approach and direct citizen participation approach were used with the aim of integrating all relevant opinions of local communities in the decision-making process. Therefore, this participatory process involved experts, stakeholders representing interest groups, and citizens. The four steps of participatory process were: (1) expert consultation; (2) stakeholder analysis; (3) valuing and mapping of ecosystem services; and (4) stakeholder involvement. A similar approach and process can be used to resolve other environmental conflicts in multi-use landscapes.

Expert consultation

The first step of the participatory process was an expert consultation aimed at gathering information about the status quo of renewable energy in the Pilot Regions. The main pieces of information collected during this step were: (1) potential development of renewable energy sources (that is hydropower, wind power, solar thermal energy and forest biomass); (2) potential impacts of renewable energy development on ecosystem services and local socio-economic characteristics; and (3) map of the stakeholders to be involved in future steps of the decision-making process (stakeholder analysis). All this information was collected with specific reference to each Pilot Region.

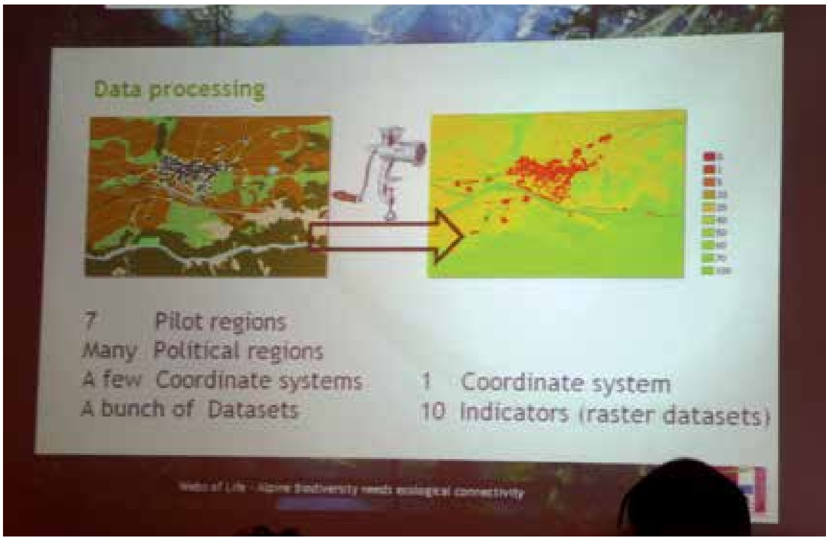
The experts were identified by the partners of the project taking into account three main criteria: (1) expertise on ecosystem services and/or renewable energy, (2) knowledge of the local context, (3) no direct stake in the activities of the project. The required information was collected through semi-structured questionnaires in face-to-face interviews with the previously identified local experts. The positive and negative impacts of renewable energy development on the baseline scenario were evaluated by the experts using a 5-point Likert scale (from very negative to very positive impacts). This was done for eight ecosystem services belonging to three categories (provisioning, regulating and cultural services). In addition, the impacts of renewable energy development were assessed taking into account ten socio-economic indicators related to a standard Social Impact Assessment (SIA) procedure, such as local market diversification, local entrepreneurship, waste management system, resource efficiency, employment of local workforce, income growth per capita, social and community aggregation, political stability, human health and property rights and rights of use. All information collected through questionnaires was used for assessing strengths (development potential) and weaknesses (environmental and social impacts) of the development of renewable energy in the Pilot Regions.

Stakeholder analysis

The term “stakeholder” refers to any individual or group of people, organised or unorganised, who share a common interest or stake in a particular issue or system. Stakeholder analysis is aimed at identifying and classifying the stakeholders in order to determine the extent of their future involvement in the participatory decision-making process. This stage is particularly delicate, because on the one hand a large number of stakeholders can delay the decision-making process, while on the other hand the exclusion of relevant stakeholders may compromise the process, delegitimise the decisions taken and increase conflicts between interest groups.

In the recharge.green project the stakeholder analysis was performed by experts in three phases: (1) in the first phase all the stakeholders who affect and/or are affected by the policies, decisions, and actions of the system were recognised and listed (brainstorming session); (2) in the second phase stakeholders previously identified were classified considering some personal characteristics (that is power, legitimacy, urgency and proximity); (3) in the third phase the stakeholders’ professional relationships were analysed (Social Network Analysis). During the second phase the stakeholders were also divided into three main categories: i) Key stakeholders are those who can significantly influence or are important for the success of the project; ii) Primary stakeholders are those who are affected either positively (beneficiaries) or negatively by the results of the project; iii) Secondary stakeholders are those who have a marginal effect on the results of the project. In addition, the stakeholders were also analysed from a relational point of view using a Social Network Analysis (SNA) approach.

SNA is a formal theory to define and analyse the relationships that stakeholders have with each other. This technique is crucial when addressing a diverse set of issues that are important to society and can help facilitate conflict resolution among the users, increase opportunities for peer-to-peer learning and collective actions, and foster the dissemination of information. In this context, SNA was applied to identify which key stakeholders were in a central position in the social network for each Pilot Region. In particular, the network was analysed considering professional relationships in the management of natural resources and renewable energy development, and the strength of these relationships (strong tie and weak tie). Stakeholders with a strong tie tend to have a similar background, they share similar views and, due to ease of communication, their communication is effective even when dealing with complex information. Conversely, weak ties are generally characterised by low emotional intensity and sporadic communication among different actors, not structured to transmit complex information. Key stakeholders – identified through the stakeholder analysis and classified using the SNA approach



Working with the JECAMI tool. Presentation of a JECAMI analysis in the municipality of Poschiavo, Switzerland.

– were invited to participate actively in the last step of the process (round tables).

Valuing and mapping ecosystem services

In the third step of the process the ecosystem services were assessed in each Pilot Region, and the relationship between ecosystem services and stakeholders was analysed through the lens of economic evaluation and spatial distribution of the benefits to society. In each Pilot Region three categories of ecosystem services were evaluated from an economic point of view using the Total Economic Value (TEV) approach (Paletto *et al.*, 2015): provisioning services (for example wood and non-wood products), regulating services (for example carbon sequestration and protection against natural hazards) and cultural services (for example recreation). In addition, the economic values of ecosystem services were made spatially explicit using a Geographical Information System (GIS) approach, and taking into account the ecological characteristics of each ecosystem service. The spatial distribution of ecosystem services could provide useful information for decision makers, allowing them to better define and implement renewable energy development strategies.

Stakeholder Involvement

In the last step stakeholders (individual citizens and interest groups) were involved in a participatory process to collect their opinions on and preferences for scenarios of renewable energy development and the potential impact of renewable energy development on ecosystem services and the local economy. Public administrations, associations and non-governmental organizations (NGOs), private companies and citizens add value to decisions. Effectively, participants can improve decisions with their local knowledge and opinions.

The most important element of participatory techniques is paying attention to people through the creation of mechanisms of trust, mutual listening, and social learning. Discussion is an instrument through which it is possible to understand the thoughts and feelings of participants. Round tables are appropriate means for considering all participants' points of view. Consequently, during the organisation of round tables the following key aspects were taken into account: i) stakeholders to be involved in the process; ii) tools to be used; iii) issues to be addressed; iv) objectives to be achieved.

The choice of stakeholders to be involved in round tables is of crucial importance because they play a key role in the definition of priorities and in data collection. In this process key stakeholders – previously identified during the stakeholder analysis – were invited to participate in round tables, with project leaders trying to highlight the importance of their collaboration in the decision-making process.

> **The involvement of all the important** *residents and groups of interest created a local map of viewpoints and goals (for example production versus environmentalism).*

Round tables are valuable tools to employ in the participatory process. In the recharge.green project, local stakeholders, facilitators and partners of the project were involved in round tables on different issues that lasted from 90 to 120 minutes. During these meetings, many instruments were used (maps, colours and posters) to collect information and preferences from participants, with the facilitator playing an arbitration and mediation role.

When organising a round table there are many aspects to be considered. First and foremost are the issues to be addressed during the participatory process. In our case, it was decided to address general issues related to renewable energy (for example "What are positive/negative aspects of renewable energy in the Rilot Region?"), and then focus on the results of the Decision Support System. Secondly, clear objectives and language are important to collect results from participants in a round table. The competencies, knowledge, and cultural background of participants are fundamental elements of the participatory process. Attention to the characteristics, viewpoints and language of participants is key to defining a shared scenario of renewable energy development and collecting perceptions of impacts of different renewable energies on ecosystem services and economy. The agreed scenario should be clearly described at the end of the round table or in a follow-up paper.

The involvement of as many essential local residents and interest groups as possible is important for the success of the participatory meeting, for the identification and resolution of conflicts and for the incremental improvement of social acceptance of renewable energy decisions.

4.3 Interference welcome!

// Wolfgang PFEFFERKORN //
CIPRA International, Schaan, Liechtenstein and Rosinak&Partner, Vienna, Austria

// Andi GÖTZ //
Former executive director of CIPRA International, Schaan, Liechtenstein

The world is too complex to be left to specialists alone. Everyone's knowledge is required to shape the future. Participation and cooperative decision models are therefore needed – that is often the only way viable decisions can be made.

4.3.1 Flaz

In the fifties, the Flaz mountain river was re-routed into a complex network of concrete canals near Samedan in Oberengadin and reinforced with increasingly high dams. In July 1987, the flood water was a mere twenty centimetres below the dam crests; the Samedan districts that were built on the plains in the 20th century only narrowly escaped flooding. Authorities were therefore looking into re-naturalising the Flaz. Before humankind interfered with its course, it had been meandering for thousands of years through the plains of Samedan and deposited 70 metres of thick gravel since the last ice age. What if the Flaz was allowed to flow across the flat ground, namely along the somewhat lower valley edge somewhat distanced from Samedan in such a way that it would then only flood fields and not houses? And what if the Flaz only flowed into the Inn after Samedan? The problem would then be solved, Mayor Thomas Nievergelt thought. He took the greatest care in investigating the plans. Opponents were invited to take part in workgroups. Clear rules were defined together with farmers and land owners.

An "ecological monitoring committee" advised the planners. Representatives of the fishery association, nature conservationists and experts from the canton looked for shortcomings and considered how the project could best be undertaken in harmony with nature. And Mayor Nievergelt informed and convinced voters through numerous personal discussions. The ballot was held in the year 2000. 145 citizens voted against the project, 459 in favour. Four years of construction saw a new, four kilometre long riverbed excavated for the Flaz. The river has been flowing through the new bed since 2004, and Samedan is safe from flooding.

4.3.2 Verwall

Changing location to Vorarlberg: the nomination of the Natura 2000 region Verwall in Montafon, Vorarlberg in the late 1990s faced great public resistance. The 12,000 hectare isolated region was nominated as a Natura 2000 region due to the presence of various grouse and woodpecker species in accordance with the EU Birds Directive. Upland moors and a mountain lake also fulfilled the criteria of the Habitats Directive. In the affected towns of Klösterle, Silbertal, St. Gallenkirch and Gaschurn, which count 5,500 inhabitants and 1.2 million overnight tourist stays, people were very anxious, felt ignored and feared massive restrictions to their business and land use activities. The disputes had a long history and threatened to boil over. Given the emergency situation, the Vorarlberg state government decided to initiate a mediation procedure during which, together with the affected persons, agreements would be made as to what would and would not be allowed in the future in the Natura 2000 region. In a mediation process involving intense debates that lasted for one and a half years, the more than 30 participants from agriculture and forestry, hunting, tourism and nature conservation finally agreed on a management plan and founded the "Verwall Forum", which supervised the implementation of the agreements in the following years. Today, more than ten years later, the structures are established, an area management has been put into place and dialogue between the various interest groups is working.

Alpine rivers and Natura 2000 regions are important elements of ecological networking in the Alpine space. These two examples demonstrate that, in many cases, public participation is a considerable success factor, particularly in the creation of large potential connectivity areas and the prevention of further fragmentation of valuable natural and close-to-nature areas (by infrastructure projects, for instance) due to land use conflicts.

Public discussion with the local population about the importance of ecological connectivity in Chambéry.

4.3.3 Assertion of power or cooperation?

Political decision-making is becoming increasingly more complex – and increasingly less transparent and more difficult for citizens to understand. At the same time our society is becoming more and more diverse and is splitting into different lifestyle groups: hobby anglers share hardly any common ground with farmers, ornithologists have different interests to mountain bikers. As a result, competition between various individual interests and lobby groups is increasing. Economic powers used to and still do tend to prevail – contrary to better ecological knowledge.

Sustainable development – the balance between economic, social and ecological goals – therefore requires a new political culture. All affected societal groups must be involved in decisions in order to achieve a balance between interests on a local and regional level as well. For personal reasons alone, the local elite should listen to other peoples' opinions: decisions that go against the grain for large sectors of the population or ecology are not viable in the long term.

However, politicians and authorities often consider involvement of citizens' demands in decisions to be undue interference in their affairs. But anyone who presents their finalised plans and projects “from on high” will be left with unhappy citizens with no other recourse than opposition and resistance. These politicians create enemies for themselves, whilst through sharing the participatory processes, the other parties are viewed as partners to help improve the content of plans and often also accelerate them: objections, legal action and court proceedings are kept to a minimum. This also results in savings for public authorities and the economy.

In the last 10 to 15 years, aspects of good governance, cooperative approaches and participation have considerably gained in importance in ecological planning too. This is due on the one hand to political instruments from above, on the other hand to the increasing professionalism of citizens' movements and civil society organisations from below. More and more districts and regions as well as project applicants and conservation area officials involve interest groups and citizens in planning proposals. That often generates surprising and innovative results, which are then fed back into conventional administration processes and political structures.

4.3.4 How does participation work?

There are three levels of participation process. The lowest is simple citizen information, for example via post, posters and exhibitions. However, it is debatable whether this can even be referred to as true participation. The second level, consultation, allows those affected to voice their opinions – at workshops, in interviews, at debate events. At the third level, participants are directly involved in the decision, for instance in mediation processes or cooperative planning projects.

Participants' great expectations are not always fulfilled in such processes. Absolute consensus is not always possible – and also not always necessary. However, participation offers the opportunity to find viable solutions within a fair negotiation process. People who can implement something on their own will do so, but anyone who also needs others to achieve their goals, for example drawing up a management plan for a conservation area, is well advised to form alliances and cooperate with other groups.

Costs are a common argument against participation processes at a local level, even though they are low in comparison to the overall costs: in large infrastructure projects such as building power plants, roads or production facilities, they are a mere fraction of the construction costs. They are also entirely manageable in local and regional ecologically-oriented planning and development concepts and are a good investment, especially if one considers the costs that professional participation can avert: court fees, costs caused by massive delays and blocking, costs for extensive information campaigns, costs for recurring new demands and more. Moreover, successful cooperative processes reinforce participants' trust in one another (farmers, foresters, hunters, ecologists, tourism professionals, etc.), simplify future partnerships and make decisions easier – and this also goes hand in hand with significant cost reductions.

4.3.5 How can a participation process work?

There is no ideal and universal recipe for participation processes. But there are generally valid principles such as transparency, trustworthiness, clarity about one's own interests, respect for the interests and opinions of other participants, and the willingness to compromise.

In many planning projects, participants focus too much on content aspects from the beginning, while process and structure related issues are neglected. For promising participation projects, it can be helpful to consider the following process steps:

1. **Clarify the starting point:** Which problems need to be solved? Who is affected? What is the legal framework? How much time is available? What is the desired end result?

2. **Analyse interests, tensions and conflicts:** Who is in conflict with whom? Who is pursuing which interests? These are the future solutions!

3. **Consider possible actions:** What are the goals of participation? Where should citizens and interest groups be involved – and where not? What would be a possible plausible procedure?

4. **Prepare the negotiation process and do the fine-tuning:** What exactly needs to be addressed, and what does not? What happens when? Who is responsible for what? How are the public dealt with?

5. **Select suitable methods:** The respective “correct” method depends on many parameters: the subject of negotiation, the scope of negotiation, the intensity of conflict, the number of participants, time and money.

6. **Negotiate and make decisions:** Only after steps one to five can the actual negotiation process begin: the participants voice their interests in several rounds of negotiation and together look for viable solutions.

7. **Implement the results:** What is implemented when and by whom? What has priority? What has to be given special attention during implementation?

8. **Monitor implementation:** Is everything being implemented in accordance with agreements? Where do adjustments need to be made?

This article is based in part on the chapter of the same name in “Wir Alpen!” by CIPRA, page 232 ff., author Bernd Hauser with the participation of Wolfgang Pfefferkorn and Andi Götz.

4.4 Mapping relevant factors for ecological connectivity – The JECAMI mapping service

// Rudolf HALLER //
Swiss National Park, Zernez, Switzerland

4.4.1 Introduction

Ecological connectivity is a core global issue in biodiversity conservation (Crooks and Sanjayanm 2006). In Europe, it is especially important in the Alps due to the region's rich biodiversity and variety of habitats, but it is extremely limited nowadays by human activities, particularly in valley bottoms. Ecological connectivity concerns all Alpine territories at all governance levels (regions, communities and more) and can only be ensured in the future by a common cross-sectoral and cross-scaling approach (Van Dyke 2008).

The question within the Interreg IV project ECONNECT – Restoring the web of life (Füreder Leopold *et al.* 2011) formulated in the application proposal was as simple as it was demanding: "Mapping the relevant factors of ecological connectivity". But what are the relevant factors and for whom? How can the potential for ecological connectivity be described for a landscape?

During the INTERREG IV project ECONNECT we investigated this complex requirement throughout the Alps and in seven Pilot Regions. We separated structural and functional connectivity (Baguette *et al.* 2013; Crooks and Sanjayanm 2006; Hilty, Lidicker, and Merenlender 2006; Van Dyke 2008) based on particular species. In order to increase public awareness, we added to the pure ecological question a set of additional basic requirements:

1. Generally applicable criteria to evaluate connectivity across the landscape had to be worked out.

2. Access to the results for all stakeholders.

3. Add spatial analysis tools available to all stakeholders both across the Alps and locally.

4. Allow for quality assessment comprehensible to experts.

5. Analysis of the landscape in terms of ecological connectivity should be comparable with specific requirements of individual species.

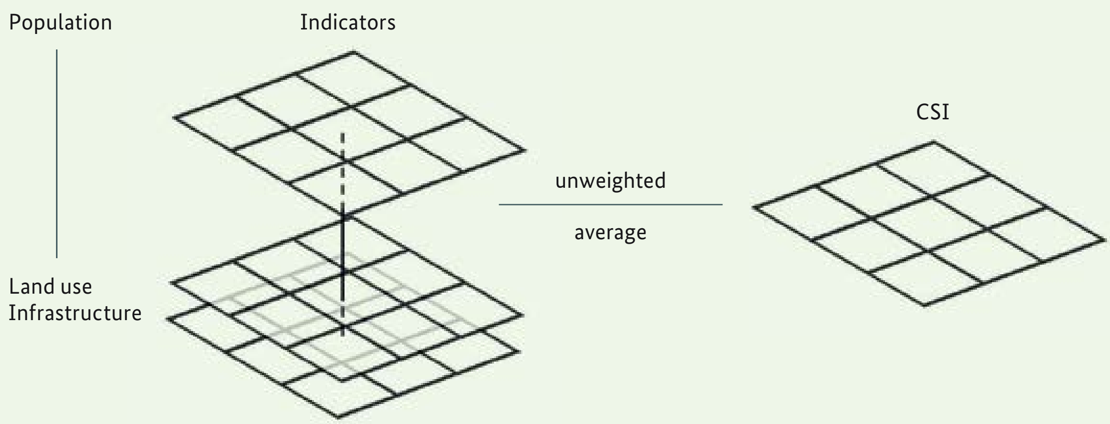
Green bridge on French highway.

// **Table 4:** List of indicators representing the Continuum Suitability Index (CSI)

1. Population (POP)	Represents the impact of human pressure. The indicator refers to the density of inhabitants and tourist overnight stays. A high indicator value describes a low density of human impact and expresses positive connectivity conditions.
2. Land Use (LAN)	Can have a large impact on connectivity, and depending on this impact, different values were defined by a group of experts. These values range from 1 – negative influence to 100 – positive influence on connectivity.
3. Patch Cohesion (COH)	Describes the continuity between areas of the same land cover type. The more connected the patches of one type (with few interruptions or barriers), the higher the index. The only aspects considered are the size and shape of the area.
4. Edge Density (ED)	The length of edges between different land cover types within an area. The impact of high edge density on connectivity depends on the species.
5. Fragmentation (FRA)	Describes the degree of fragmentation by roads, dams, railroads and more. The degree of fragmentation is expressed by the size of the area between barriers. The higher the index, the less fragmented the area, which indicates good conditions for connectivity.
6. Altitude and Topography (TOP)	Includes elevation above sea level: the assumption is that conditions get worse with increasing elevation due to decreasing temperature and vegetation cover, for example. This only refers to natural aspects rather than human impacts and pressure. Indicator values thus decrease with increasing elevation. The measure also accounts for elevation relative to surrounding areas: relative elevations indicate whether the area is a valley, a flat surface, a medium slope or a hilltop. The more the landform changes, the lower the connectivity.
7. Infrastructure (INF)	Evaluates the impact of diverse infrastructure on ecological integrity. Data on infrastructure objects are implemented such as power lines, ski slopes, ski lifts, cable cars, and more.
8. Environmental Protection (ENV)	Refers to protected areas in the region and to their level of protection under international law. A high degree of protection corresponds to a high indicator value.
9. Land Use Planning (LAP)	Refers to protected areas at the regional level and evaluates future developments which could have consequences on ecological connectivity.
10. Ecol	Quantifies small-scale existing environmental protection measures and local protected areas such as, for example, the construction of wildlife overpasses. Again, a high degree of protection translates into a high indicator value.

Source: adapted from Affolter, 2010

// **Figure 16:** Calculation of the CSI index



Source: adapted from Affolter, 2010

4.4.2 The JECAMI Framework

In order to reach the above-mentioned requirements, we built a framework called JECAMI – Joint Ecological Connectivity Analysis and Mapping Initiative. JECAMI is a web application based on Google Maps API, built by the Swiss National Park to help users analyse the connectivity and barriers of the landscape and to assess an area based on very specific criteria. The application was initially built using version two of Google Maps API in 2010, and rebuilt using Google Maps API v3 in 2014.

JECAMI incorporates a set of methodological ecological connectivity approaches. The tool is enriched with exhaustive documentation on data and methodology, as well as geoprocessing tools, which allow the user to analyse certain areas in detail or calculate a path of an animal through its habitat.

In order to stimulate discussion on structural and functional connectivity, JECAMI allows for a comparison of the two approaches, the so-called "Continuum Suitability Index" (CSI) and Species Map application (SMA), respectively. In certain regions, we also tested the potential of the application for aquatic and semi-aquatic species (Connectivity Analysis of Riverine Landscape – CARL). The CSI was built for two spatial scales: a general approach with consistent but coarse data over the entire Alps and a more spatially and thematically detailed approach within several sub-regions.

4.4.3 The continuum suitability index – A structural connectivity approach

The CSI has been developed to evaluate the current potential of an area with respect to its structural connectivity. Taking the general approach of green infrastructure (Mazza *et al.* 2011) further, the CSI evaluates every patch within a landscape based on positive (green) structural elements, but also negative barrier effects. Moreover, the CSI assigns an effect on ecological connectivity to each patch and therefore offers an enhanced perspective to the current discussion. The landscape is considered as a matrix where each pixel or patch promotes ecological connectivity. The aim of the index is to illustrate where conditions for an ecological continuum already exist and which areas require improvement.

An expert group (Plassmann 2009) evaluated factors for structural connectivity and defined the data required for corresponding indicators. While it was not possible to derive spatially and thematically detailed datasets from original data such as remote sensing imagery within the project, we concentrated on existing data for the Alps and for the Pilot Regions, keeping the advantages and disadvantages of this heterogeneous approach in mind. Moreover, not all desired data were available for all regions. However, as we wanted to work at the local level with local stakeholders within Pilot Regions, we accepted the lack of data homogeneity throughout the Alps in favour of gaining detailed insights into certain regions, which would not have been possible with a data homogenisation process.

Today, the CSI for the sub-regions consists of ten different indicators that reflect different thematic criteria that influence ecological connectivity, involving biological, landscape-ecological, as well as geographical and socio-economic issues (Table 4).

An assessment of each indicator within each patch – normally at a resolution of three to five metres at the regional level – has been developed individually and based on existing scientific publications (Affolter 2010). Each indicator has been implemented as a raster surface to represent a continuous characteristic with values between one (most unsuitable) and 100 (most suitable) in order to set up a common value scale (Figure 16).
The index was originally developed with regional data for seven Pilot Regions in the Alps, but has also been calculated for the whole Alpine arch at a lower resolution, with data available across Europe. As this was a limiting factor, the Alpine-wide calculation only consists of six out of the ten original indicators due to missing data.

Calculation of the CSI for a predefined area

The calculation is based on an unweighted mean of all raster cells inside the defined area of analysis. Thus, JECAMI outputs ten mean values – one for each indicator. The quality values of the various administrative divisions then have to be weighted by the percentage of area for the calculation of quality parameters (quality indicator). No weighting is required for the Alpine-wide CSI approach because the data quality is the same all over the Alps. The results of the CSI calculations are displayed in JECAMI as a vertical bar chart and a table (Figure 17). Both can be exported as PDF's.

Data quality

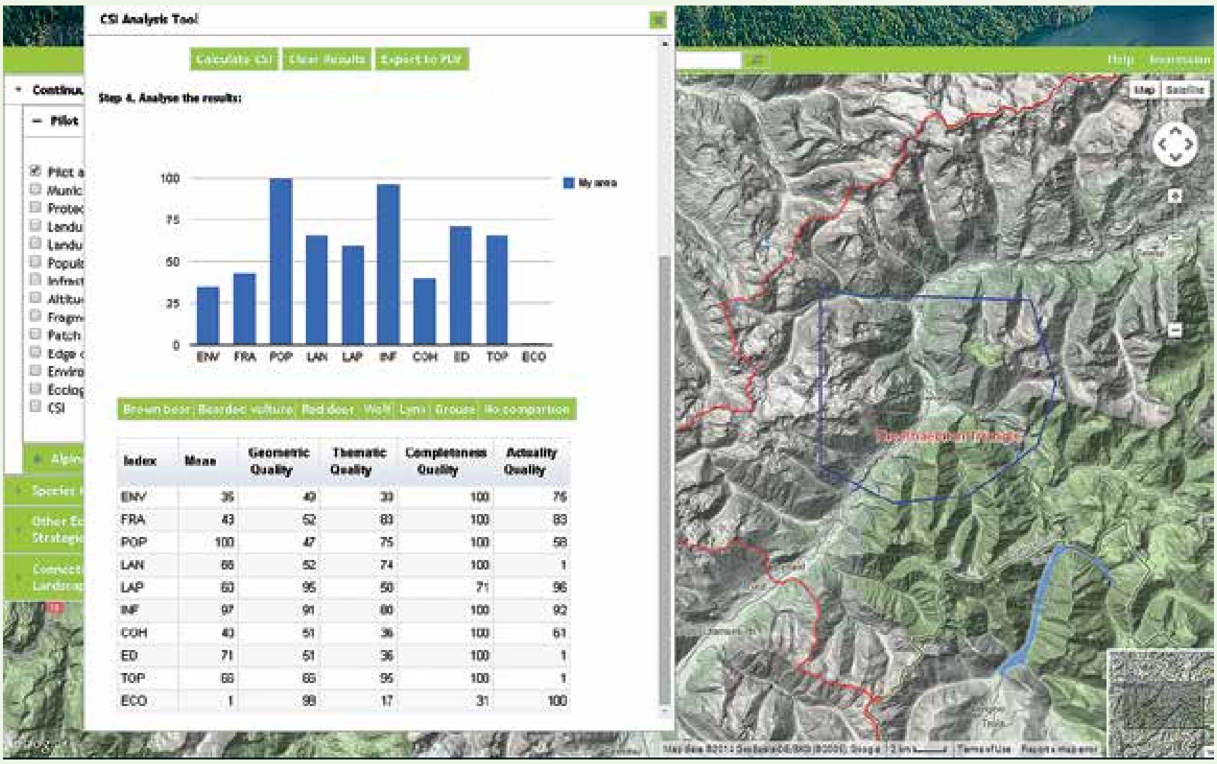
An indicator value of "80" or higher for a certain location suggests high suitability for the Ecological Continuum. However, in order to obtain a complete picture of the suitability, the quality of the database also needs to be considered. Therefore, a quality indicator was created that indicates the geometric and thematic resolution, the completeness and actuality of the data for all ten indicators inside an administrative division (dataset Data_Q). The resulting CSI values from different regions based on different databases are thus comparable.

4.4.4 Mapping species migration areas and corridors

Habitat and migration studies of several animal species were conducted by several partners during the ECONNECT project (Signer and Sedy 2010; Walzer *et al.* 2013; Füreder Leopold *et al.* 2011). Within JECAMI, we integrated the final results, a potential habitat map and a potential migration map based on an approach called GUIDOS (Vogt 2013). This integration – named Species Map Application (SMA) – helps detect and visualise possible barriers or corridors for various animal species. The SMA consists of habitat distribution and connectivity models (GUIDOS) for particular species (key species). These models were developed at a spatial resolution of 1,500 metres by the Austrian Federal Environment Office (Signer and Sedy 2010). An exception is the model for the brown bear, which has a resolution of 375 metres. We included additional geoprocessing functionality to the application, allowing

The Species Mapping Application Tool (SMA) included in JECAMI shows which areas are suitable for different species. The SMA tool calculates an optimal path for a selected species, such as the brown bear, and shows the barriers and corridors along the path.

// **Figure 17:** CSI result for a predefined area within an ecological connectivity Pilot Region in the Alps



Source: adapted from Affolter, 2010

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the user to predict a possible path from one point in the Alps to another. Using a cost path function, the tool returns modelled virtual tracks of wolf, bear, lynx, red deer and black grouse between two given points. Figure 18 shows an example of a calculated path for a bear from Zernez to Bormio.

4.4.5 Technical solution

The technical solution encompasses a set of segments, including the creation of a comprehensive geodatabase, incorporation of adjusted geoprocessing tools, suitable cartography, a map publishing service and a superposed web application. Figure 19 shows the general functionality. Based on ArcGIS technology, we are currently preparing the data and geoprocessing tools in ArcGIS Desktop 10.2.2. The spatial data are published on ArcGIS Server (10.2.2), the web application based on Apache Web Server. For the online service, we use a set of external libraries including the Google maps API, the Google visualization API, different java libraries and geoxml.

4.4.6 A case study with JECAMI: Defining ecological connectivity hotspots in the Alps

In this study, realised under the Life Belt Alps Project, a European follow-up project of ECONNECT, a reclassification method of the CSI was developed to define the most important action areas and hotspots in the Alps. Action areas generally have low ecological connectivity and are located on important intersections between areas with good ecological connectivity (hotspots such

// **Figure 18:** An example of a virtual path for a brown bear in the central Alps, overlaid over a habitat map developed during the project ECONNECT

Source: www.jecami.eu

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as a protected areas), fragmenting them into two parts. They are mostly located in a valley bottom, where land use and infrastructure dominate. Action areas are situated in locations where measures to improve ecological connectivity are important and feasible. The aim of this study was a definition of these action areas and hotspots over the Alpine arch.

Materials and methods

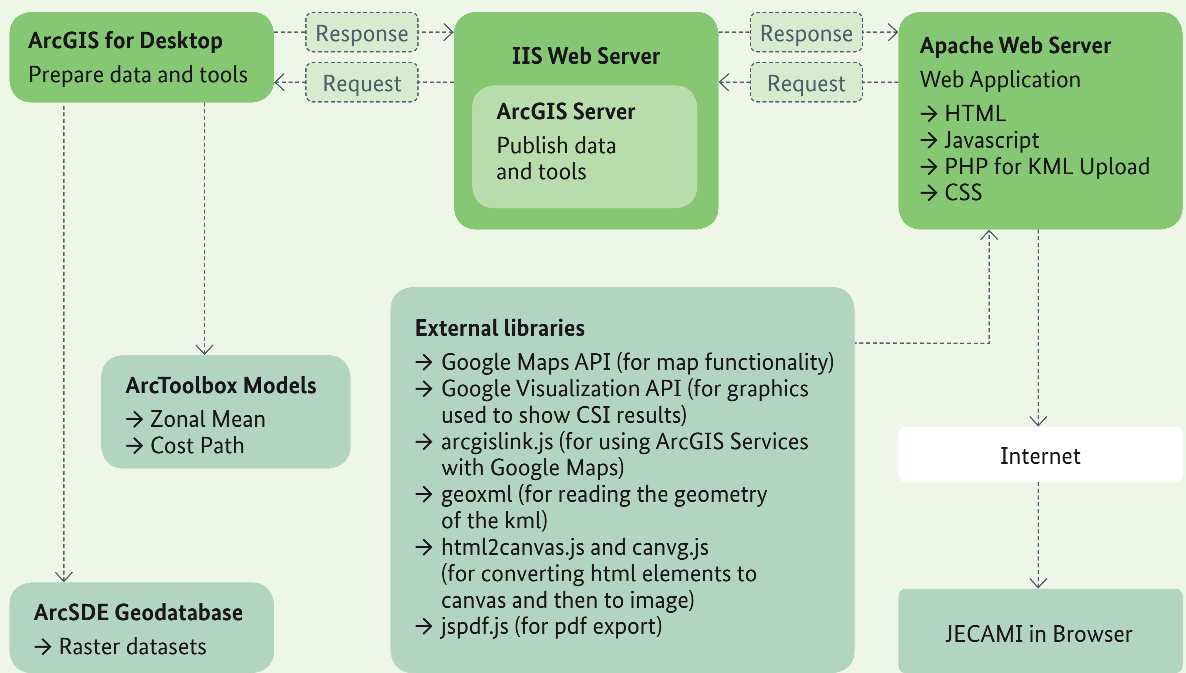
During a Life Belt Alps meeting in 2015, an expert group determined 36 spatially explicit action areas and 16 hotspots in the Alps as reference points for an Alpine-wide analysis. The structural connectivity within these locations was analysed with the JECAMI tool for a rectangle of ten square kilometres (two kilometre × five kilometre) shaped over the central point and aligned along the valley bottom. For these plots, we computed the CSI statistics based on the Alpine-wide dataset. We only considered the land use (LAN), population (POP) and environmental protection (ENV) indicators for this analysis, as they contribute most significantly to the overall CSI. The indicators land use (LAN) and population (POP) were given double weight (double) to avoid existing protected areas contributing too much to the recalculated CSI:

CSI-Alps_adopted = (2xLAN + 2xPOP + 1xENV) / 5

Predefined action areas and hotspots were re-evaluated based on this new CSI raster. A normal distribution of extracted CSI values was then computed in order to obtain CSI thresholds for predicting action areas and hotspots more generally.

The new CSI was reclassified based on these thresholds to model 4 different zones over the entire Alps: poor area, action area, transition zone and hotspot. Areas at altitudes higher than 1,800 metres above sea level were not taken into consideration. It was assumed that ecological connectivity was less of a problem at higher altitudes due to lower degrees of land use and lower human population densities. Focusing the analysis on lower altitudes (<1,800 metres above the sea level) also highlighted hotspots. This new map was integrated into the existing web map application *www.jecami.eu*. Furthermore, some priority action areas were sketched along the major axis across the Alps. They were selected visually at a scale of 1:3,000,000, based on large linear barriers within locations that

// **Figure 19:** System structure of JECAMI



Source: adapted from Affolter, 2010

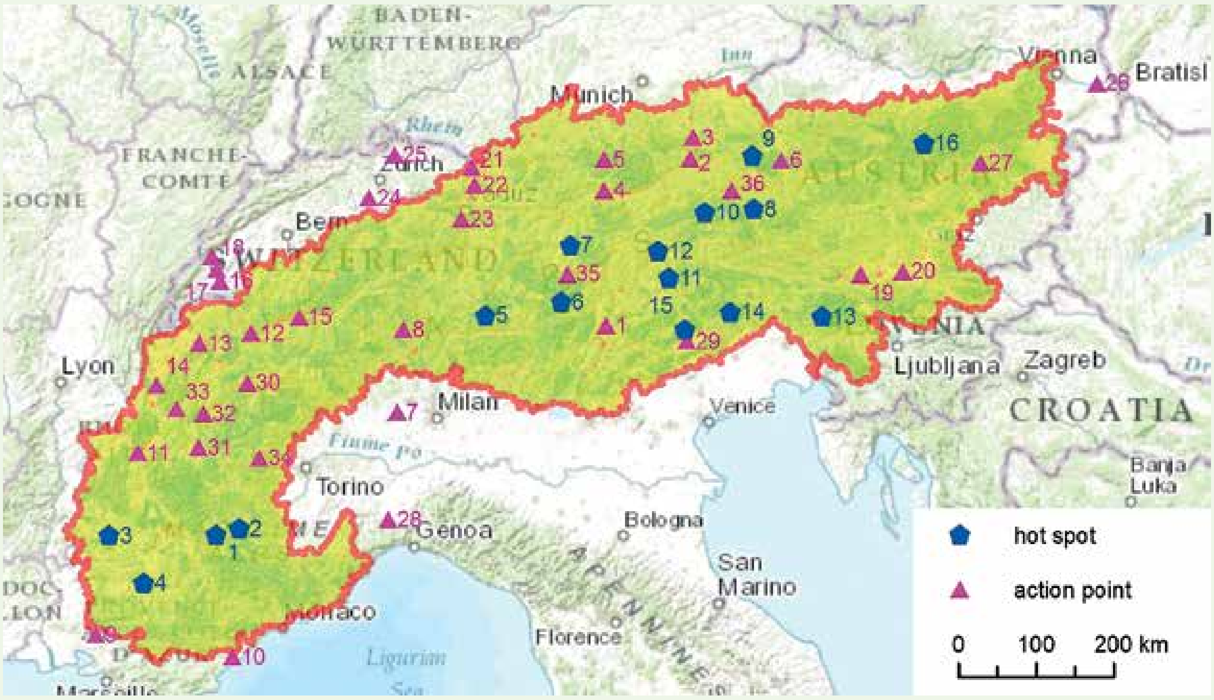
The valley of the river En (Inn) in the Pilot Region Raethian Triangle was one of the territories analysed in detail using the GIS tool JECAMI.

represented the best passage to cross with respect to the reclassified CSI.

Results and discussion

Figure 20 shows the 36 action areas and 16 hotspots plotted by the expert group as points over the Alpine arch, together with their resulting CSI statistics (Tables 5 and 6). Mean CSI's for action areas are between 40 and 60. Areas with high environmental protection (ENV) have high values. Land use (LAN) values are generally low and have the greatest influence on the overall CSI. Areas at lower altitudes score better for topography (TOP) than areas at overall higher elevations or with more variable terrain. The pattern for the population (POP) indicator shows maximum values for sparsely populated areas compared to densely populated areas such as St. Margrethen or Grenoble. Cohesion (COH) shows higher values compared to edge density (ED). This means that landscape patterns are more clumped or aggregated in their distribution. Mean CSI's of hotspots range from 60 to 70, which is higher compared to the action

// Figure 20: Overview of hotspots and action points (defined by an expert group) shown with the perimeter of the CSI for the Alpine arch



Source: ALPARC, Life Belt Alps Project, 2016

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areas. Only Embrun /Les Orres and Vandoies show a low CSI value of 50. This is due to the fact that they are located in areas without protection (lowest ENV) and have relatively low LAN compared with other hotspots. ED is even lower, and COH overall higher than for the action areas, as the hotspots are located in more remote areas with larger coherent landscape patches by comparison to action areas. TOP shows lower values caused by the generally higher elevations of hotspots. On the other hand, POP shows maximum values as they are typically located in sparsely populated areas.

// Table 5: Recalculated CSI for the Alpine area with only significant indicators LAN, POP and ENV included

Action area	CSI_{new}	Hotspot	CSI_{new}
Mezzocorona	56	Embrun / Les Orres	71
Kufstein	59	Saint-Paul-sur-Ubaye	95
Flintsbach	66	La Motte Chalancon	64
Telfs	53	Monts de Vaucluse	81
Farchant	74	Bergeller Kette	94
Tenneck	79	Ortler Alpen	98
Locarno	50	Kaunertal	94
Grenoble	46	Grossglockner, Hochalpenstrasse	83
Dorénaz	58	Hintertal	97
Bonneville	50	Obersulzbach	92
La Biolle	60	Badia	93
Salgesch	64	Vandoies	60
Saag	51	Lepena	89
Völkermarkt	46	Forni di Sopra	82
St. Margrethen	44	Mis	82
Altstätten – Götzis	39	Gams bei Hieflau	76
Sargans – Balzers	59	–	–
Kindberg	61	–	–
Belluno	55	–	–
Palleusieux	64	–	–
Saint-Jean-de-Maurienne	74	–	–
Aigueblanche	60	–	–

Source: ALPARC, Life Belt Alps Project, 2016

Table 5 shows the new CSI for action areas and hotspots. Values are within a similar range as with the regular CSI. Based on the computed normal distribution, CSI thresholds were selected to define hotspots, transition zones, action areas and poor areas (Table 6 and Figure 21). Light green lines show the selected range of 54 to 61 for modelling action areas (all values above normal F of 0.4.).

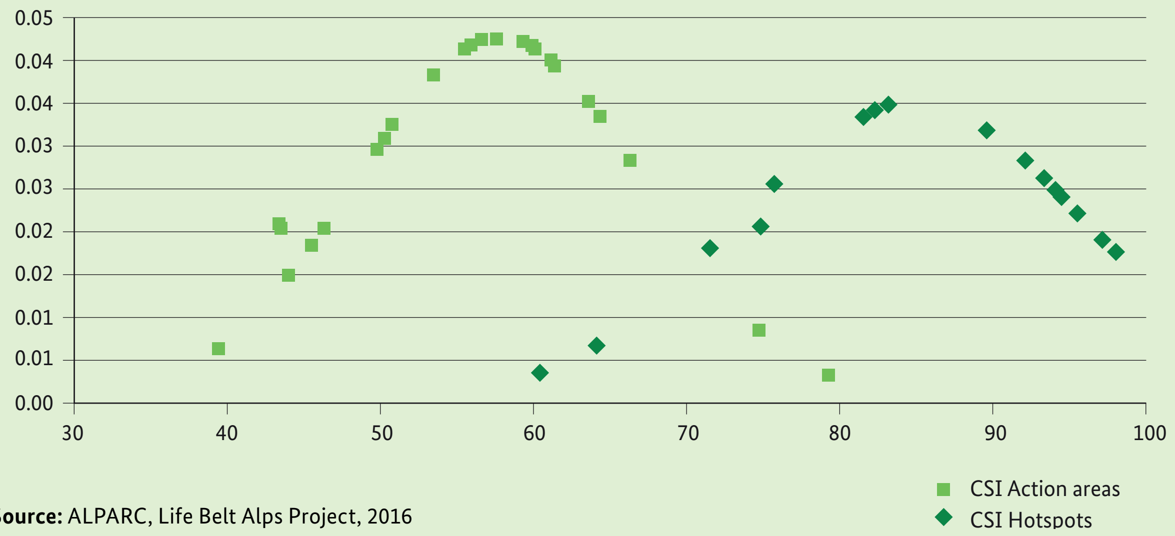
The dark green line shows the CSI threshold for hotspots. The four categories defining the quality of ecological connectivity were mapped using this reclassification (map 10). Some priority action areas located along the major axis across the Alps were sketched on the map with black crosses. The priority action areas are all important Alpine valleys with high land use and major traffic routes, which are located between CSI hotspots (see map 10).

Conclusions

The aim of this analysis was the definition of action areas and hotspots in the Alps regarding ecological connectivity. This was achieved with a recalculation of the CSI Alps including the most important indicators, a result of ECONNECT.

The CSI was first investigated for predefined action areas and hotspots that had previously been selected by an expert group. The CSI Alps was recalculated with only the most important indicators included. General action areas and hotspots were then modelled with a reclassification of the new CSI Alps. The output of the model has been mapped and integrated into the existing web map application *www.jecami.eu*. This map can be studied for the definition of priority action areas where measures to improve ecological connectivity are useful and feasible.

// **Figure 21:** Normal distribution of recalculated CSI values for action areas (light green) and hotspots (dark green), and indicated CSI thresholds for modelling



Source: ALPARC, Life Belt Alps Project, 2016

// **Table 6:** Reclassification values of the CSI

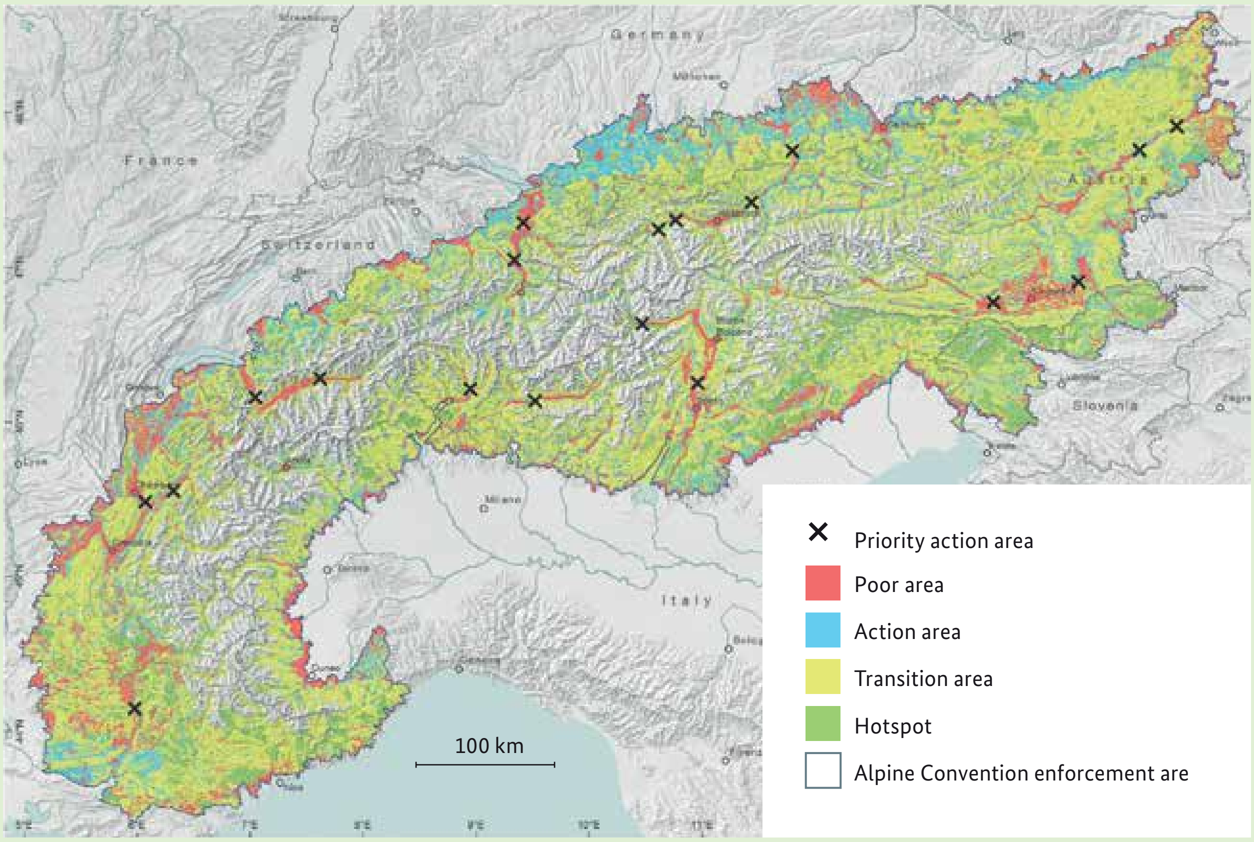
CSI reclassified	
poor area	1 – 53
action area	54 – 61
transition zone	62 – 79
H	80 – 100

Source: ALPARC, Life Belt Alps Project, 2016

Specific information like data from inventories of wetlands or other areas can be considered in the JECAMI analysis when available.

Traditional land use in the area of National Park Vanoise. Land use is one of the indicators used in JECAMI for the calculation of the Continuum Suitability Index.

// **Map 10:** Reclassified CSI Alps for areas below 1,800 metres above sea level with priority action areas



Source: SNP, ALPARC, ESRI Data, Swisstopo

4.5 The 50 most important questions relating to the maintenance and restoration of an ecological continuum in the European Alps

// Chris WALZER //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Ecology and Evolution, University of Veterinary Medicine, Vienna, Austria

// Thomas SCHEURER //
ISCAR – International Scientific Committee on Research in the Alps, Bern, Switzerland

The European Alps harbour a unique and species-rich biodiversity that is increasingly impacted by habitat fragmentation through land-use changes, urbanisation and expanding transport infrastructure. Within ECONNECT, a project funded by the EU within the framework of the European Territorial Cooperation Alpine Space Programme and co-funded by the European Regional Development Fund, we initiated and implemented a trans-national priority setting exercise, inviting researchers, practitioners, NGOs, policy makers and other stakeholders from the Alpine region to participate. The aim of this study was to identify and analyse gaps of knowledge with respect to achieving, restoring and maintaining an ecological continuum in the European Alps. The exercise was composed of an initial call for pertinent questions, a first online evaluation of the received questions and a final discussion and selection process during a joint workshop. The participating 48 institutions generated 484 initial questions, which were condensed to the 50 most important questions by 16 workshop participants.

This exercise proved a useful and efficient tool to compile inputs from various researchers, practitioners, administrators, stakeholders and policy makers from different countries with a relatively low initial effort. Although we invited six policy makers to join the initiative, only two generated initial questions and only one participated in the final workshop. This problem of a non-representative group of experts lacking valuable perspectives has been pointed out by previous authors and in chapter 4.2 in this publication (Svadlenak-Gomez, Badura and Walzer). The majority of the process was performed via e-mail communication and was administered by one part-time employee. We feel that this resource-saving method is a strong argument in favour of this approach, especially given the generally limited resources for connectivity conservation.

The process identified the 50 most important questions relating to the maintenance and restoration of an ecological continuum – the connectedness of ecological processes across many scales including trophic relationship and disturbance processes and hydro-ecological flows in the European Alps. The non-prioritised list of the 50 most important questions concerning an ecological continuum in the Alps is shown in Table 7. The resulting questions were individually classified broadly in nature, people and management contexts (NC, PC, MC). The largest proportion of questions (46 percent) was attributed to the nature context. This is followed by the management context (44 percent) where by far the largest proportion of questions relates to the legislation, policy and planning needs subtopic (63 percent). Finally the people context makes up a mere ten percent of the total questions. From the 50 questions, the clear majority (60 percent) were formulated as "how" questions, followed by "what" (26 percent) and "which" questions (14 percent). Consequently, most attention was given to transformation processes aiming at practices to improve the current situation in Alpine connectivity.

The gaps of knowledge in conserving and restoring connectivity emphasised in this exercise make it evident that the assessment involves highly dynamic and interconnected processes rather than a simplistic and straightforward approach. It appears essential to reconcile the dynamic and complex nature of the problem with the available problem solving approaches. Inadequate simplification of the interdependencies will possibly lead to results that are not relevant in forming policy. Furthermore, our results indicate that maintaining and restoring ecological connectivity in the Alps is most likely a "super- wicked problem", and this implies the need for novel approaches in addressing the issue. As has been previously suggested by other authors, we also feel strongly that the usual retrograde method of

// **Table 7:** Non-prioritised list of the 50 most important questions

01	Which landscape elements and land use types enhance or moderate gaps in connectivity?
02	How are corridors best implemented; with clearly spatially defined borders or as functional units integrated in wide ecological continuums?
03	How do major land use changes affect ecological connectivity across the Alps?
04	What is the relative importance of climate/land-use change to changes in the ecological continuum of Alpine regions?
05	Which indicators reflect the changes in connectivity that result from climate or human induced changes in Alpine landscapes?
06	How important is connectivity in maintaining key ecosystem services?
07	How can ecological connectivity maintain the adaptive capacity of ecosystems in the face of environmental change?
08	Which of the habitat types important for landscape connectivity are most affected by climate change
09	How does alternative energy production impact on connectivity and natural habitats?
10	What is the best method to design corridors for multiple species?
11	How severe is the current lack of connectivity between populations of alpine species?
12	What are indicators for a multi-species continuum?
13	What impacts do various seasonal leisure activities (including low-impact practices) have on ecological connectivity across the Alps?
14	How can wilderness areas (wildlife, recreation, tourism) contribute to ecological connectivity?
15	What is an effective set of indicators (that is, for species and habitats) that can be used to evaluate and monitor ecological connectivity at different scales?
16	How does the return of large carnivores affect ecosystems in the Alpine ecological network?
17	What is the impact of gene flow through an ecological continuum on genetic adaptation to climate change?
18	How does the ecological continuum allow shifts in species distribution to keep pace with climate change?
19	Are artificially engineered ecological networks a threat or a benefit to endemic species?
20	What are the consequences for both genetic and species diversity if the system of natural barriers changes?
21	How will future changes in species distribution affect connectivity and fitness among interacting species?
22	How much gene flow fostered by connectivity is beneficial to populations and species without disrupting local adaptations?
23	How can the spread of invasive species and diseases be minimized, while ensuring connectivity for native species?
24	How do elements of the ecological network affect human welfare and perception?
25	How can agricultural and silvicultural land use be optimised in order to promote and conserve ecological connectivity?
26	How can connectivity for biodiversity and ecosystem conservation become and be managed as a public good?
27	How do demographic changes in the Alps affect the future ecological continuum?

Source: Adapted from: Walzer et al. (2013). PLoS ONE, 8(1).

28	How do the aims of ecological connectivity and tourism conflict?
29	What is the most effective way to employ the different categories of protected areas to ensure connectivity and the provision of ecosystem services in the Alps?
30	How can we use and integrate existing instruments and programmes to enhance trans-sectoral funding for ecological connectivity?
31	How can ecological connectivity be integrated into spatial and infrastructural planning and legislation at various administrative levels?
32	How can legal and conceptual tools stimulate the development of trans-border connectivity?
33	How is it possible to harmonise contradictory, competing spatial sectoral policies in order to enhance connectivity?
34	Which policy-measures are necessary to safeguard the ecological network beyond protected areas?
35	Which of the existing sectoral funding systems have a positive and which have a negative effect on connectivity?
36	What incentives for agriculture and forestry are needed to maintain and restore ecological connectivity in different Alpine areas?
37	Which strategy, integration or segregation, is more appropriate for promoting ecological connectivity in different alpine areas?
38	How can we effectively manage areas heavily affected by tourism in order to maintain their function within an ecological continuum?
39	How can we enhance sharing of theoretical and empirical good practice knowledge amongst and between sectors?
40	How can the management of protected areas better incorporate functional relationships with surrounding areas?
41	Which specific restoration measures can increase connectivity?
42	What kind of monitoring is needed to evaluate the long-term efficiency of connectivity measures in the face of dynamic anthropogenic change?
43	How can an alpine-wide, accessible and effective connectivity data platform be created?
44	How can databases for existing or emerging bio- and geo-data be improved for the promotion of connectivity projects in the Alps?
45	What is the effectiveness of different methods (for example sensor data) to monitor the consequences of structural connectivity or its elements across different spatial and temporal scales?
46	What is the effectiveness of different methods to record the effectiveness of functional connectivity or its elements across different spatial and temporal scales?
47	How can we use evidence-based education to increase public awareness of ecological networks?
48	How can methods of conflict resolution be adapted and/or used to mitigate concerns and obstruction to ecological networks?
49	How should we integrate spatial and temporal dynamics into the realisation of the Alpine ecological continuum?
50	How can the species and habitat approac hes to designing ecological connectivity be integrated into the process of landscape planning?

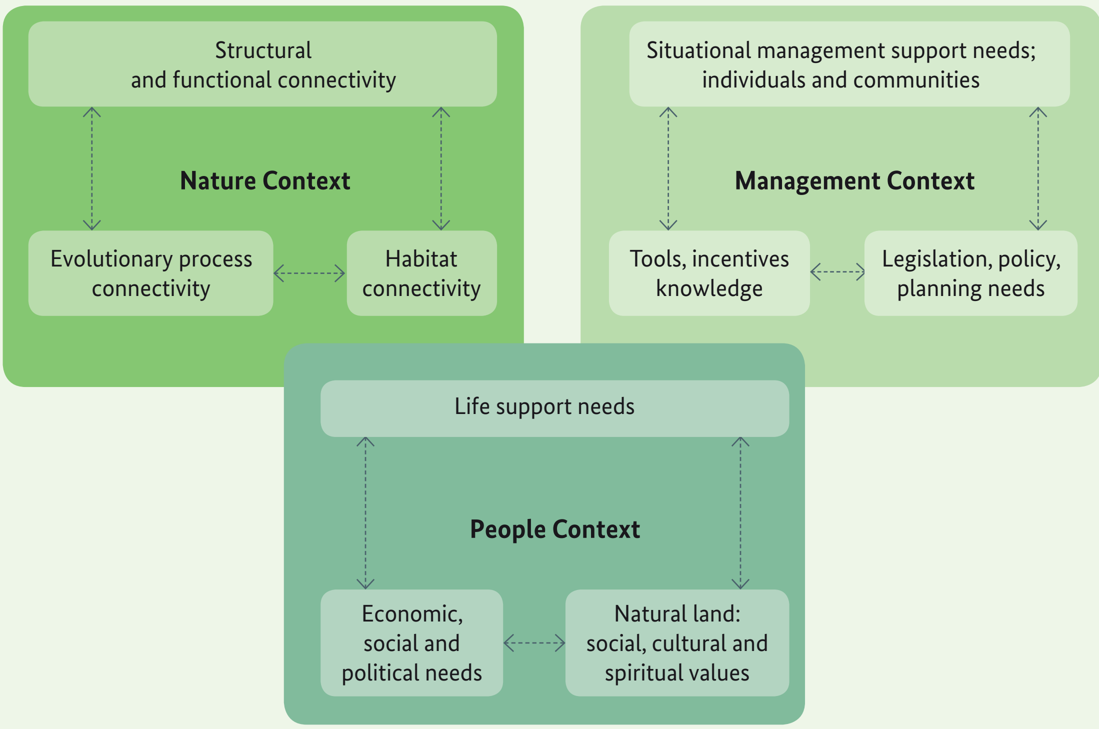
Source: Adapted from: Walzer et al. (2013). PLoS ONE, 8(1).

investigating the past and generating selective and singular predictions, is only sufficient for "tame problems" but inadequate for a highly dynamic and interconnected process such as ecological connectivity.

In order to address the complex issue of an Alpine ecological continuum, it appears necessary to apply a forward reasoning approach that identifies possible future scenarios and integrates uncertainties. It is somewhat surprising that questions concerning how ecological connectivity is affected and can be managed make up the largest percentage (60 percent) of the generated questions. Authors from the field of transdisciplinary research have termed knowledge related to this type of question "transformation knowledge". These questions deal with the genesis and future development of a problem and subsequently with the interpretation and perception of the problem in the "real world". "What" questions address determining factors of connectivity, and answers to such questions provide "system knowledge". Finally, "which" questions address desired goals and better practices. This has been termed "target knowledge". Each of these knowledge forms has specific challenges, and "system knowledge" in particular must confront uncertainties. It is essential to understand that solutions are only possible when the other postulated forms of knowledge, "target-" and "transformation knowledge", are integrated into the solution-mix.

The visual "chaos" and multi-structural character of our results reflect the sectoral structure of society, governance and administration with respect to environmental problems in general (see Figure 22). To overcome this, an integrative transdisciplinary approach is necessary. What appears to be missing, in the search for a starting point to address the problem of the Alpine ecological continuum, is a common strategy or vision. In the authors' view, this is also supported by the fact that the largest percentage of the formulated questions investigated the manner, condition or quality of ecological connectivity. This exemplifies the necessity of generating "system knowledge" and confronting uncertainties. Total conformity among all actors in the search for a common denominator is unrealistic and cannot be an achievable goal, as previously pointed out, but a clear vision that "expresses the joint aspirations of leaders,

// **Figure 22:** The three inter-related context areas of connectivity conservation



Source: adapted from Worboys *et al.* (2010). Every context area consists of three different sub-topics which interact with each other.

managers and participants in the initiative, without closing off avenues for constructive debate and disputation" to support and sustain connectivity conservation may be a starting point. Possibly, ecological connectivity can constitute a common "anchor" for trans-sectoral deliberations on biodiversity conservation. However, in order to not become overburdened by the complexity of the issue, it appears essential to address the inherent complexity within a well-reflected investigational framework.

For this type of study *to provide guidance and contribute towards conservation-action implementation, the results must be disseminated accordingly.*

As has been pointed out previously, bridging the gap of knowledge between research and conservation practice cannot be achieved with unidirectional platforms. While other authors have suggested that new platforms of bidirectional knowledge dissemination must be developed, the authors of this study believe, that it is more efficient to employ and if necessary adapt existing information platforms inherently providing bidirectional links between policy makers, the scientific community and practitioners while encouraging more efficient cooperation with other sectors.

In the opinion of this study's authors, an initial task of the information platform should be to organise and facilitate research and conservation-action activities centred on the inter-dependent questions identified in this study. It is the authors' opinion that this priority setting exercise and the subsequent dissemination of results will support research and funding institutions in channelling their capacities and resources towards questions that need to be urgently addressed in order to facilitate significant progress in biodiversity conservation in Europe and specifically in the Alps. Furthermore, the definition of 50 most important questions is an important first step towards a common and harmonised approach in maintaining and enhancing ecological connectivity across the heterogeneous Alpine arch (Further reading: Adapted from: Walzer et al. [2013]. PLoS ONE, 8[1]).

Landscape impression in the Pilot Region Raethian Triangle.

4.6 Introduction to the ecosystem services approach

// Richard HASTIK //
University of Innsbruck, Institute of Geography, Innsbruck, Austria

// Clemens GEITNER //
Centre for Climate Change Adaptation, Innsbruck, Austria

// Christin HAIDA //
University of Innsbruck, Institute of Ecology, Innsbruck, Austria

The ecosystem services concept was first proposed in 1983 by Paul Ehrlich and Harold Mooney, and since then its use in the scientific literature has grown rapidly. Ecosystem services are defined in the Millennium Ecosystem Assessment (MEA) as the "benefits people obtain from ecosystems". These ecosystem services include a multitude of aspects such as food and fodder production, provision of raw materials, pollination, climate and water regulation, water supply, erosion control, soil formation, nutrient cycling, carbon sink, green-house gas cycling, biological control, genetic resources, recreation and cultural values.

Over the years, several classification schemes of ecosystem services have been elaborated, for instance the classifications used by the above-mentioned MEA, by TEEB (The Economics of Ecosystems and Biodiversity), or by CICES (Common International Classification of Ecosystem Services). These classification schemes differentiate ecosystem services on the basis of their function: i) Provisioning services: material or energy outputs from ecosystem such as food production (for example fish, meat, honey, mushrooms and berries), provision of raw materials (for example timber, wood for bioenergy), water supply; ii) Regulating services: benefits obtained from the regulation of ecosystem processes such as water and climate regulation, pollination, hydrogeological protection, soil erosion control; iii) Cultural services: non-material benefits that people obtain from forests through spiritual enrichment, cognitive development, recreation and aesthetic experience and iv) Supporting services: necessary for the production of all other ecosystem services such as natural diversity, plant production, soil formation and nutrient cycling.

There are some noted differences between the various classification schemes. For example, in contrast to the

Sport activities and leisure figure among the most important ecosystem services for certain categories of protected areas.

TEEB and MEA classifications, CICES regards "biodiversity" as the total sum of life and the basis for all (biotic) ecosystem services and not as an ecosystem service itself. Despite the problems related to varying categorisations and definitions of ecosystem services, the importance of ecosystem services for human wellbeing is widely recognized by both the scientific community and political decision makers. Simply put, preserving ecosystem services means preserving the life of terrestrial ecosystems. Human wellbeing depends on ecosystem services, and most of these services cannot be replaced. Therefore, their preservation and maintenance is a crucial challenge towards a sustainable future on earth.

However, current management practices often lead to a loss of ecosystem functions. This trend is particularly visible in mountain areas, including in the Alps. Habitat fragmentation, the loss of ecological connectivity and the development of renewable energy production are but two of a multitude of anthropogenic pressures that threaten Alpine ecosystems. These directly threaten the region´s high levels of biodiversity, fragile ecosystems, recreational value and the diversity of cultural identities. Alpine ecosystems provide several goods and services such as protection against natural hazards (that is landslides, avalanches and rock falls), carbon dioxide sequestration, fodder, timber, renewable raw material for energy production (bio-energy), tourism and recreation (hiking, biking, hunting, and more), freshwater, and biodiversity.

In the Alpine multi-use landscapes, potential conflicts may and often do develop between nature conservation and infrastructure development. The development of the different renewable energy sources (that is hydropower, wind power, solar thermal energy and forest biomass) can have an effect on ecosystems and biodiversity, with negative consequences on the quality of the benefits provided by ecosystem services. Similar to other infrastructure measures, renewable energy development can cause soil loss and degradation and a loss of biodiversity. In addition, it may have a negative effect on the landscape´s aesthetic appeal.

Notwithstanding the above, the effects of infrastructure development on the environment are not purely negative. It is necessary to balance the positive impact (for example reduction of the dependence on fossil fuels through the development of renewable energy sources), with other aspects of nature conservation, which leads to a trade-off situation. Unsustainable practices are driven by a market logic that presently does not account for social and environmental costs. Generally speaking, the value of ecosystem services, more often than not, is disregarded in the political decision making process as many benefits supplied by nature have no market value. So-called "negative externalities" (the external costs of economic activities that impose a negative effect on third parties, often society at large) of unsustainable production or consumption practices occur because natural resources tend to be public goods (such as air, which people may use freely without payment). As public goods are perceived as "free for all", their real value is not as obvious to users as that of private and marketable goods. In the absence of market price and trading, the economic value of these benefits is not clearly defined, and subsequently the cost of ecosystem conservation appears higher than the benefits it generates.

However, in reality, the benefits of conservation would be high if properly accounted for. In order to overcome this limitation, many economic valuation methods have been developed and applied to the assessment of various ecosystem service values. The economic valuation methods – such as: i) contingent valuation (CV); ii) travel cost method (TCM); iii) replacement cost method; iv) choice experiments, and v) the benefit transfer method – enable valorisation of ecosystem services, even in the absence of a market. Benefits might include, for example, climate and water regulation, protection against natural hazards, or landscape amenity and recreation (See Science: Total Economic Value (TEV) of ecosystem services).

Alpine space projects (for example recharge.green) have evaluated both market and non-market ecosystem services in some of the Alpine Pilot Regions. Based on information from these evaluations, decision makers can now formulate effective strategies and choose optimal locations for renewable energy that will preserve the environment while concurrently producing renewable energy efficiently.

Box 7: Total Economic Value (TEV) of ecosystem services

The Economics of Ecosystem and Biodiversity (TEEB) study emphasises that ecosystem services are closely linked to economics. The main goal of TEEB is to define a reliable methodology for valuing ecosystem services, trying to understand the environmental costs and benefits of exploiting natural resources. The underlying idea of TEEB is that the value of an ecosystem is not only related to exploitable goods, but that there are several other benefits whose value is less clear because they have no market price. If the non-market benefits were included in planning, the damages associated with the exploitation of the environment could be assessed more comprehensively. In a recent study a list of nine priority ecosystem services for the Alps was developed.

These ecosystem services were divided into three main groups: provisioning services, regulating and maintenance services and cultural services as proposed by the CICES classification. This concept is strictly linked to the total economic value (TEV) approach, stating that the value of natural resources is composed of several components:

- Direct use value: the benefit obtained from a direct consumption of the resource;
- Indirect use value: the benefit derived from an interaction between users and nature but without consumption of the resource (for example recreation in a forest);
- Option value: the value of conserving resources unused today in order to obtain higher benefits in the future (mainly derived from the current rate of interest);
- Quasi-option value: the value of leaving resources untouched today in order to obtain future benefits from alternative – and still to be discovered – uses;
- Non-use values: values of the resources themselves, without considering the interactions with humans (that is existence value, intrinsic and bequest values).

The TEV approach focuses on the fact that the value of nature is more complex than the mere consumption of goods. Managing resources based only on harvestable quantities of goods may considerably deplete the total benefits people obtain from ecosystems. Including conservation-related and non-use values in the planning phase of decision-making is fundamental to determining the actual costs and effects of development on the environment.

4.7 Alpine Pilot Regions for ecological connectivity

// *Yann KOHLER* //
Alpine Network of Protected Areas ALPARC, Chambéry, France

4.7.1 The Alpine Pilot Regions

In the past, conservation efforts focused on maximising biodiversity in protected areas (Brudvik *et al.* 2009), and these areas were chosen to include most of the territories' biodiversity, their natural and cultural heritage. Considering the resource needs of the worlds growing population, it is unlikely that enough land can be directly protected to facilitate the needs of all species and communities (Mawdley *et al.* 2009). Given that the number of threatened species is steadily rising and protecting land only represents a static approach, the concept of protected areas is insufficient. Acknowledging this evidence, a Pilot Region approach was proposed for the Alps as this kind of implementation was considered to be more dynamic and to include modern ideas of conservation connectivity.

A first assessment of Alpine activities in the field of ecological connectivity published in 2004 had already identified the Alpine Protected Areas as key elements of a coherent ecological network in the Alps (ALPARC 2004). Based on this analysis, first proposals for Pilot Regions were made. These Pilot Regions, composed of protected areas but also integrating areas around and between protected areas, had to meet a variety of different criteria: a high potential for ecological connectivity in specific importance for biodiversity conservation, a balanced geographic distribution throughout the Alpine Arc and motivated partners at local level.

A first selection of Pilot Regions was made during the EU funded ETC Alpine Space Project ECONNECT (2008 to 2012). The definition and selection of the ECONNECT Pilot Regions followed a step-by-step procedure, based on prior definitions of quality criteria in order to represent a significant variety of situations, natural conditions and ecological challenges of territories in the Alpine Arc (Haller *et al.* 2011). This proceeding intended to achieve the development and test of concrete implementation strategies and measures in order to improve ecological connectivity. The seven regions selected differed considerably concerning their features and framework conditions, but all of them participated in a common methodological approach. Although common, it was intended to allow a sufficient flexibility in order to insure the possibility of adaptation to the very specific local situations and to launch a very detailed planning process with an intense involvement of stakeholders and landowners.

Considering their contribution to the implementation of an pan-Alpine ecological network and the experiences made during the ECONNECT project with the stakeholders, in particular for the policy level, a number of ECONNECT Pilot Regions requested that the Platform Ecological Network of the Alpine Convention officially support and recognise their efforts. As a response to this request, the Platform Ecological Network of the Alpine Convention developed and adopted procedures in 2010 for the nomination of official Pilot Regions for Ecological Connectivity of the Alpine Convention.

The procedure allows nominations at each Alpine Conference taking place every two years. The decision to recognise a Pilot Region is based on a questionnaire completed by the applicant regions. The questionnaire uses a number of criteria to gather details both on a region's ecological characteristics and its active contribution to sustainable development, as well as on concrete projects and measures that help to promote an ecological network in the Alps. The completed questionnaire is evaluated according to a scoring system. In order to be nominated, an area must obtain a minimum number of points and/or, depending on the final scores, must have singularity status. The nomination is valid for a limited duration, but can be renewed after an evaluation.

Since the adoption of this procedure, eight Alpine regions have been officially recognised as Pilot Regions for Ecological Connectivity of the Alpine Convention, some of them having participated in former projects, others not (from south-west to north-east):

- South-western Alps (National Park Mercantour/ Nature Park Alpi Marittime)
- French Department Isère
- Transboundary ecoregion Gran Paradiso – Mont Avic – Mont Emilius
- Ecoregion Alpe Veglia ed Alpe Devero
- Rhaetian triangle (Engadin/Southtyrol/Trentino/ Tyrol)
- Transboundary region Berchtesgaden – Salzburg
- Transboundary ecoregion Prealpi Giulie/Triglav
- Northern Limestone Alps region

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4.7.2 Protected areas in the heart of Pilot Regions

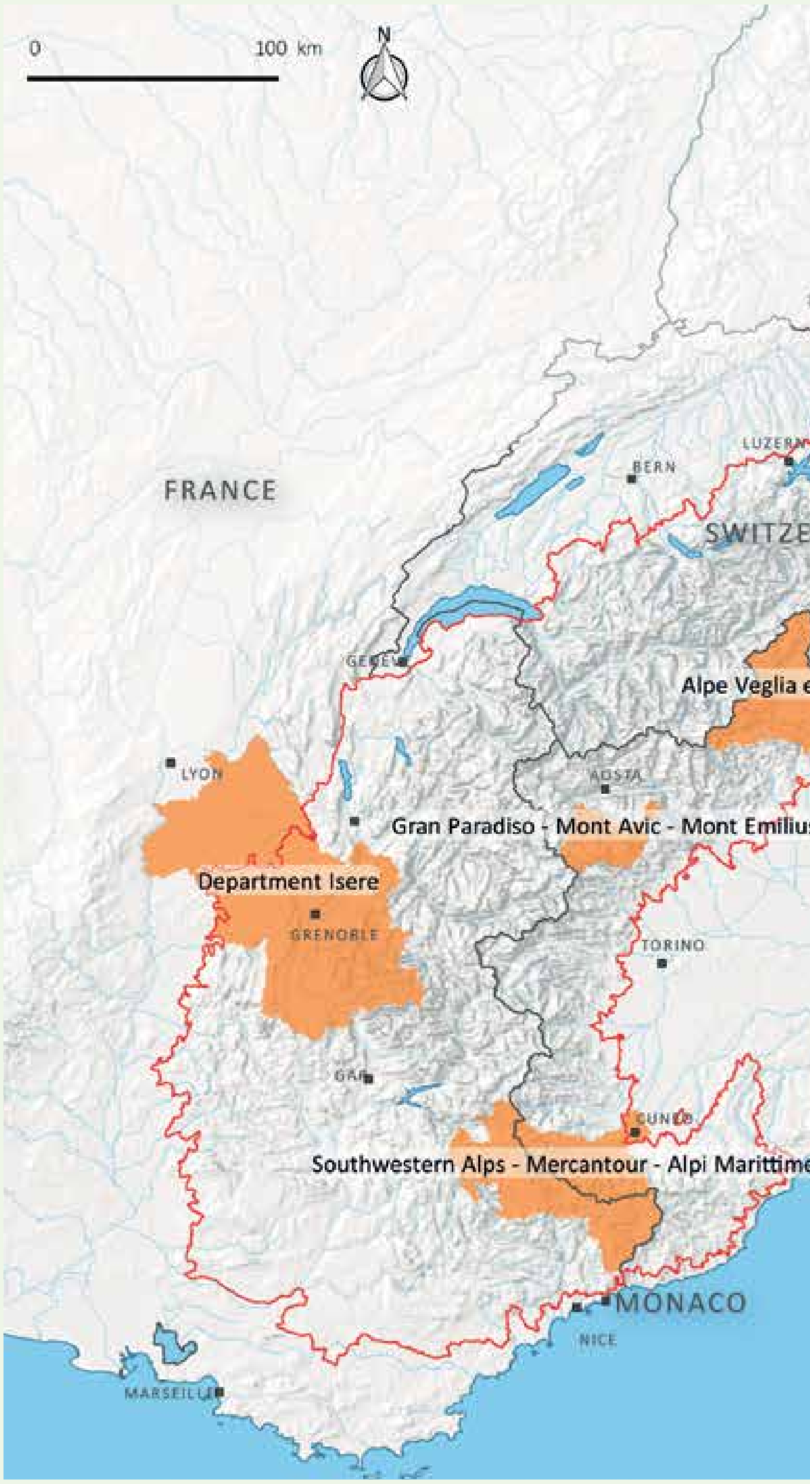
Most Pilot Regions are made up of several protected areas and other zones situated between and around these areas. In almost all cases the protected area managing authorities, for example the national park administrations, are acting as the coordinating and moderating institutions. This approach is based on the consideration that usually protected areas in the Pilot Regions have various distinguished links and interactions with the surrounding areas and relevant regional actors.

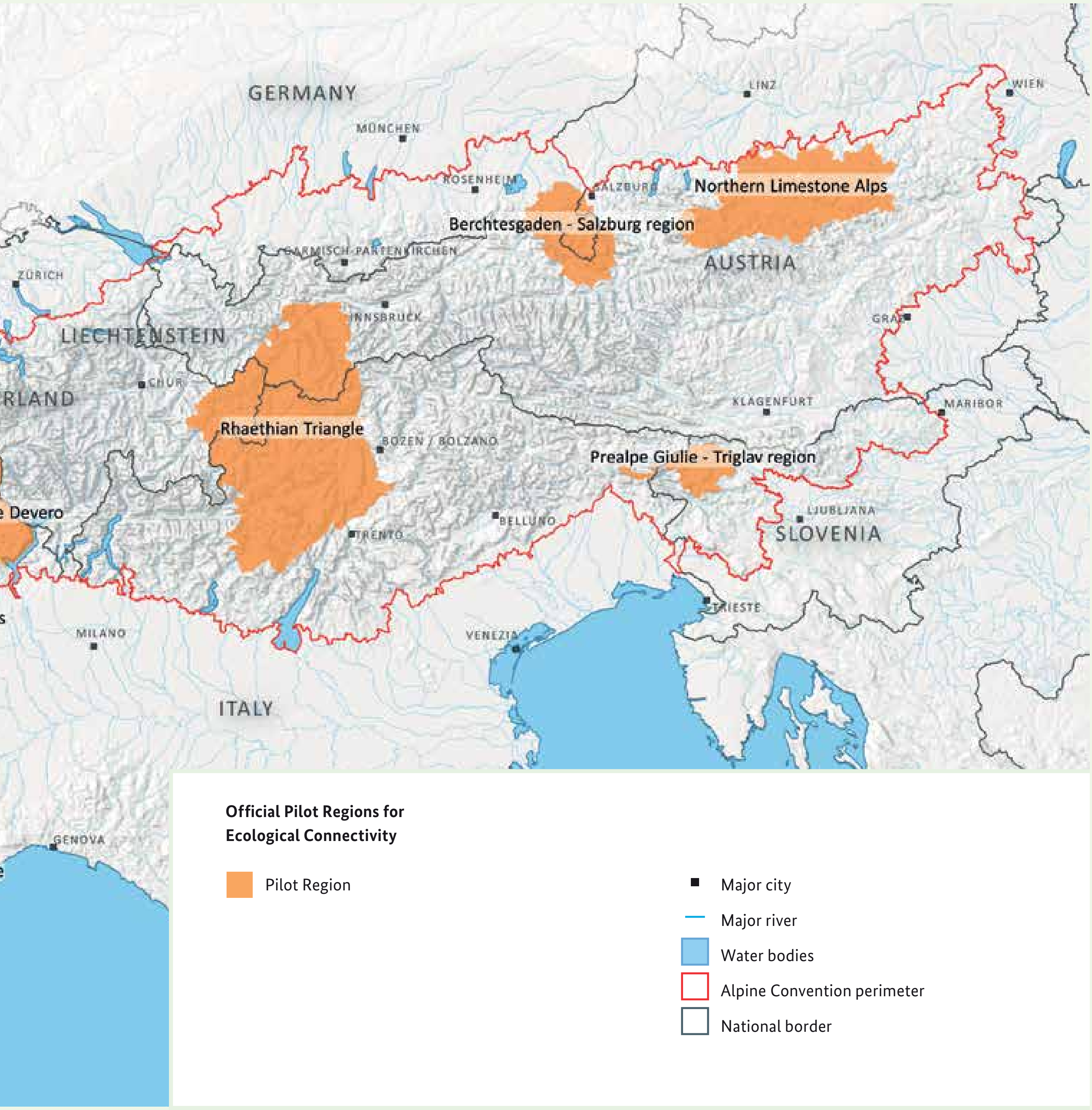
The Pilot Region approach was shown to be a sound way to bring cooperation and coordination between private and public actors forward. Beyond supporting local implementations of individual conservation arrangements, in almost all Pilot Regions networks could be built where measures, management plans and projects between the cooperation partners were coordinated. As a holistic approach it pays attention to other policy sectors like spatial development, economic activities and infrastructure. Ecological connectivity doesn't stop at administrative borders, nor does it exist in protected areas only: the Pilot Region approach takes this knowledge into account. Pilot Regions allow the analysis of entire landscapes – the matrix of the territory as the research object – by collaboratively using existing structures and data in these regions.

In order to support the Pilot Regions in their efforts to analyse and understand the specific challenges concerning ecological connectivity in their area and define actions for conservation and restoration, an extensive planning process is proposed to them, which includes detailed habitat mapping, landscape modelling and the identification of the landscapes' potential of connectivity, to link important habitats and to ensure migration possibilities for particular species. Moreover, an intense dialogue with stakeholders and/or landowners is recommended, and various tools to support this governance process are offered.

During the ECONNECT project, concrete measures to enhance ecological connectivity have been chosen by every Pilot Region, thus showing that it is possible to improve ecological connectivity by targeted measures on the ground. At the same time the results of the planning process will be a key element for further physical planning of the territory making sure that spaces not yet fragmented and important for migration of species

// Map 11: Official Alpine Convention Pilot Regions for Ecological Connectivity





Source: ALPARC work based on data from different national and regional authorities and protected area managements for Pilot Region of Ecological Connectivity perimeters; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; ©EuroGeographics EuroGlobalMap opendata (Original product is freely available) for rivers, lakes, built-up areas and localities; ©EuroGeographics for the administrative boundaries; European Environmental Agency/SRTM for the digital elevation model. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

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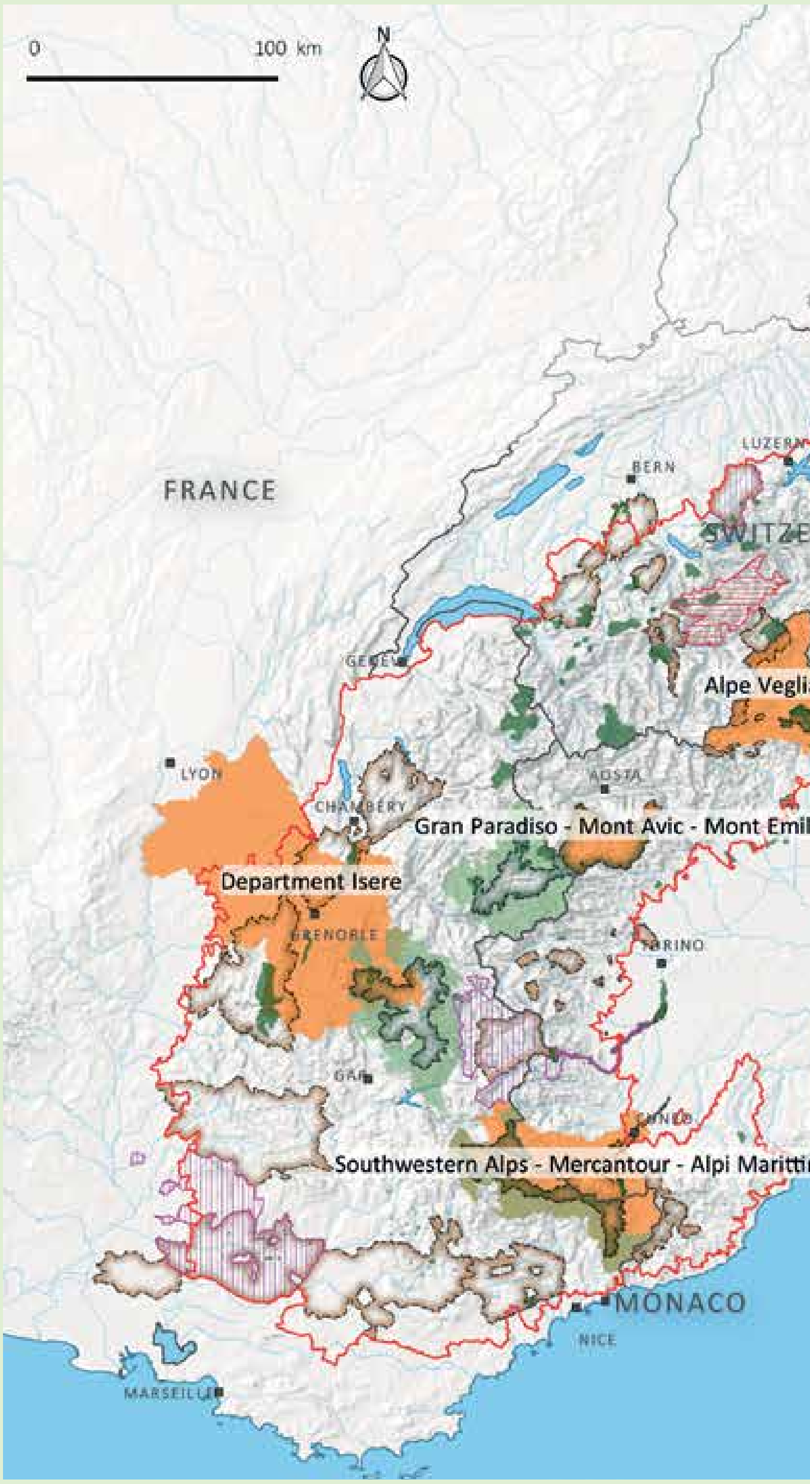
and special habitats will be conserved. In the Transboundary Area Berchtesgaden-Salzburg, the revitalisation of the Saletbach improved the ecological quality of a human influenced river by supporting natural dynamics and restoring the natural connections between aquatic and terrestrial habitats. Restoration measures included also the river channel, which had been degraded by human activity before.

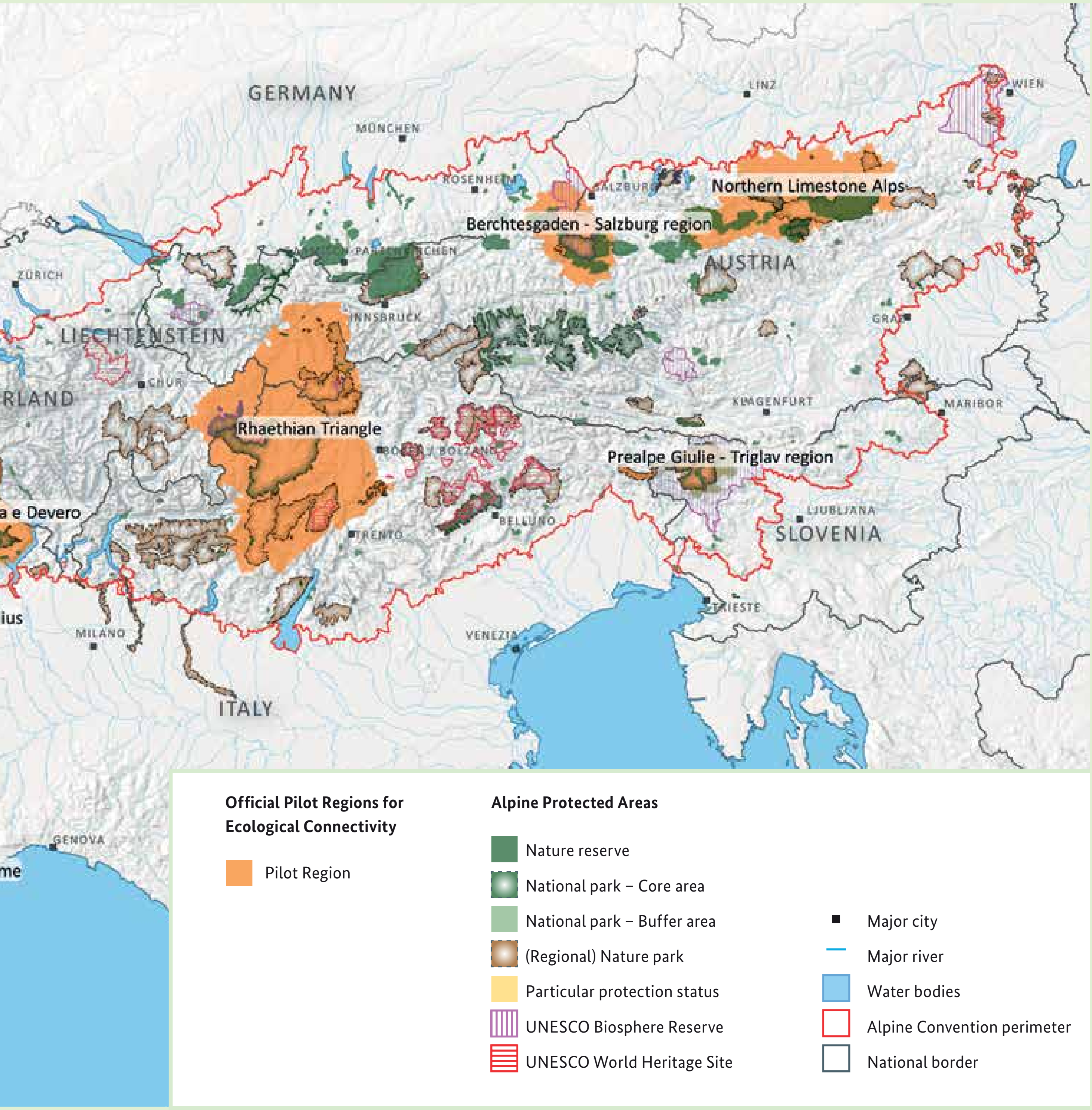
In several Alpine Pilot Regions individual larger projects to improve ecological connectivity were carried out. The French department Isère, for example, launched a process to define and restore the most important biological corridors of the region in 2001 (Berthoud 2001). It was the first French department to do so and also among the first territories in the Alps to concretise such an ambitious project, the project Path of Life. A presentation of the project's results was provided in May 2015, showing not only an important investment in road crossing infrastructure for fauna migration but also important awareness raising measures and training efforts with local stakeholders. These stakeholders included farmers, who had been a particularly invested and highly involved group. The example of Isère is noteworthy among the activities in the Pilot regions, and because of its pioneer character, it is promoted as good practice example in the Pilot Region exchange. Another point worth mentioning concerning this project is the sound scientific evaluation of the activities employed including a sociologic study of the stakeholder involvement and participation process (Observatoire social de Lyon 2013).

The example of the Austrian project NetzwerkNaturwald illustrates the link and synergies between the activities at a local level and the pan-Alpine vision insuring the coherence of the activities throughout the Alpine mountain range. It was possible to finance this project (see box 2 and chapter 2.5), concerning the Pilot Region Northern Limestone Alps around the National Parks Kalkalpen and Gesäuse, via a private foundation based on the former involvement of the region in the Alpine activities on ecological network. Keeping a close link to the international Alpine level via the Platform Ecological Network and to other Pilot Regions guarantees the complementarity of the actions on the ground and the vision developed for the Alpine Arc.

Like pieces of a puzzle the activities of the Alpine Pilot Regions should slowly build up the area-wide Alpine ecological network. The emancipation and autonomy of

// **Maps 12:** Pilot Regions for ecological connectivity and Alpine Protected Areas





Source: ALPARC work based on data from different national and regional authorities and protected area managements for Pilot Region of Ecological Connectivity perimeters; Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 ha); Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; ©EuroGeographics EuroGlobalMap opendata (Original product is freely available) for rivers, lakes, built-up areas and localities; ©EuroGeographics for the administrative boundaries, European Environmental Agency/SRTM for the digital elevation model. **Note:** This map makes no claim to be exhaustive. **Design:** Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

the single initiatives is necessary, as long as they all stick to the overall goal and agree on the shared vision for the Alps. This is an obligation mandated by the Platform Ecological Network of the Alpine Convention as well as in the frame of the larger international Alpine projects on the topic (such as ECONNECT or greenAlps).

4.7.3 Governance of Pilot Regions

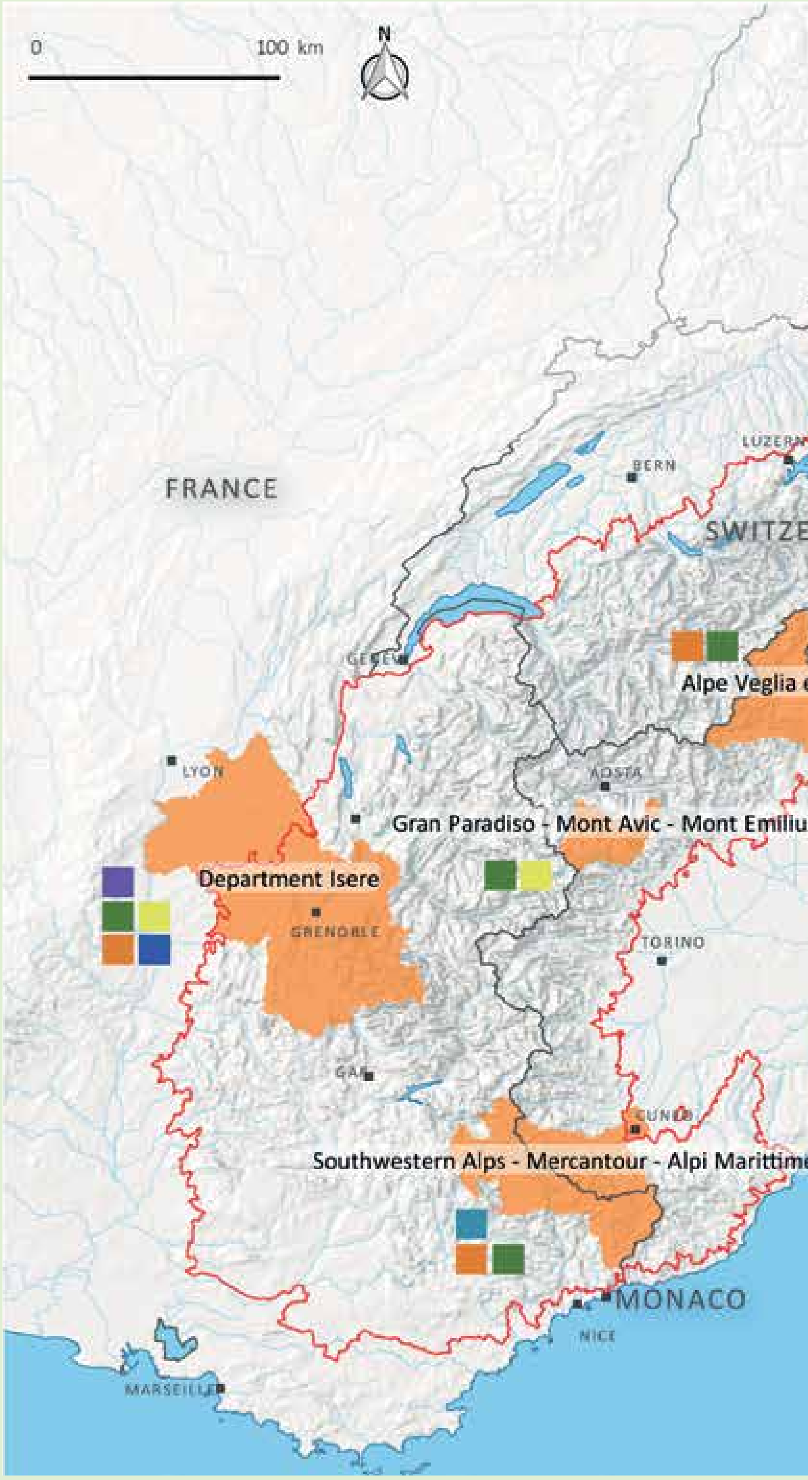
The governance of the Pilot region is an important issue that has been addressed in very different ways. As already stated, the notion of a protected area's administration acting outside the boundaries of its territory on such a subject is new to the protected areas' managers as well as to the stakeholders, and depending on the local situation, is not always the best solution. It may be successful as in the Berchtesgaden-Salzburg Pilot Region, where the National Park had the chance to be closely involved in the spatial planning processes and could support the strong consideration of connectivity aspects in the planning tools. In other regions like the Rhaetian Triangle, the Swiss National Park, the administrations that initially promoted the issue then handed it over to a local foundation, insuring governance procedures closer to the local stakeholders.

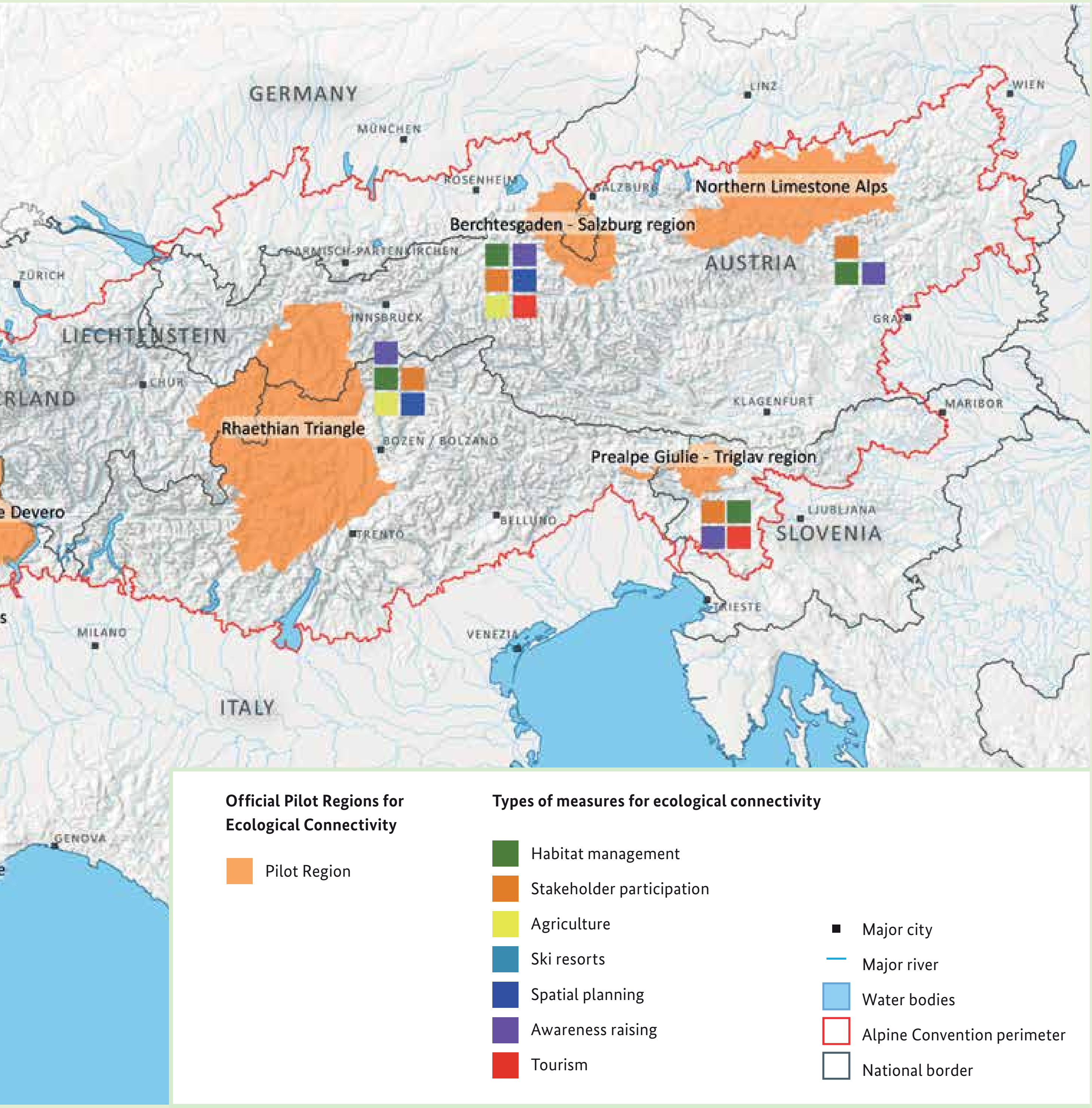
The activities of the Pilot Region can also support regional tendencies to find alternative ways of cooperating in this field as well as others. The idea of creating transboundary Biosphere Reserves as one answer to the governance challenge in Pilot Regions is currently being analysed in Austria and at the Italian-Slovenian border. This represents an option that not only facilitates the cooperation across borders but would also create an additional link between different sectors and give the opportunity to place ecological connectivity as a transversal working subject for all topics treated in the frame of such a regional cooperation.

4.7.4 Results in Pilot Regions

The range of results achieved in Pilot Regions is as broad as the dynamics of the single regions are diverse. It goes from small scale specific actions like the installation of signal ball on aerial cables in skiing areas to prevent bird collisions in a sensitive area in the Southwestern Alps Pilot Region, through the restoration and preservation of the six main biological corridors in the Gresivaudan valley (French Department Isère), to strategic planning actions such as the Transboundary region Berchtesgaden – Salzburg. The origins of the

// Map 13: Pilot Regions for ecological connectivity and types of implemented measures





Source: ALPARC work based on data from different national and regional authorities and protected area managements for Pilot Region of Ecological Connectivity perimeters; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; ©EuroGeographics EuroGlobalMap opendata (Original product is freely available) for rivers, lakes, built-up areas and localities; ©EuroGeographics for the administrative boundaries, European Environmental Agency/SRTM for the digital elevation model.
Design: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

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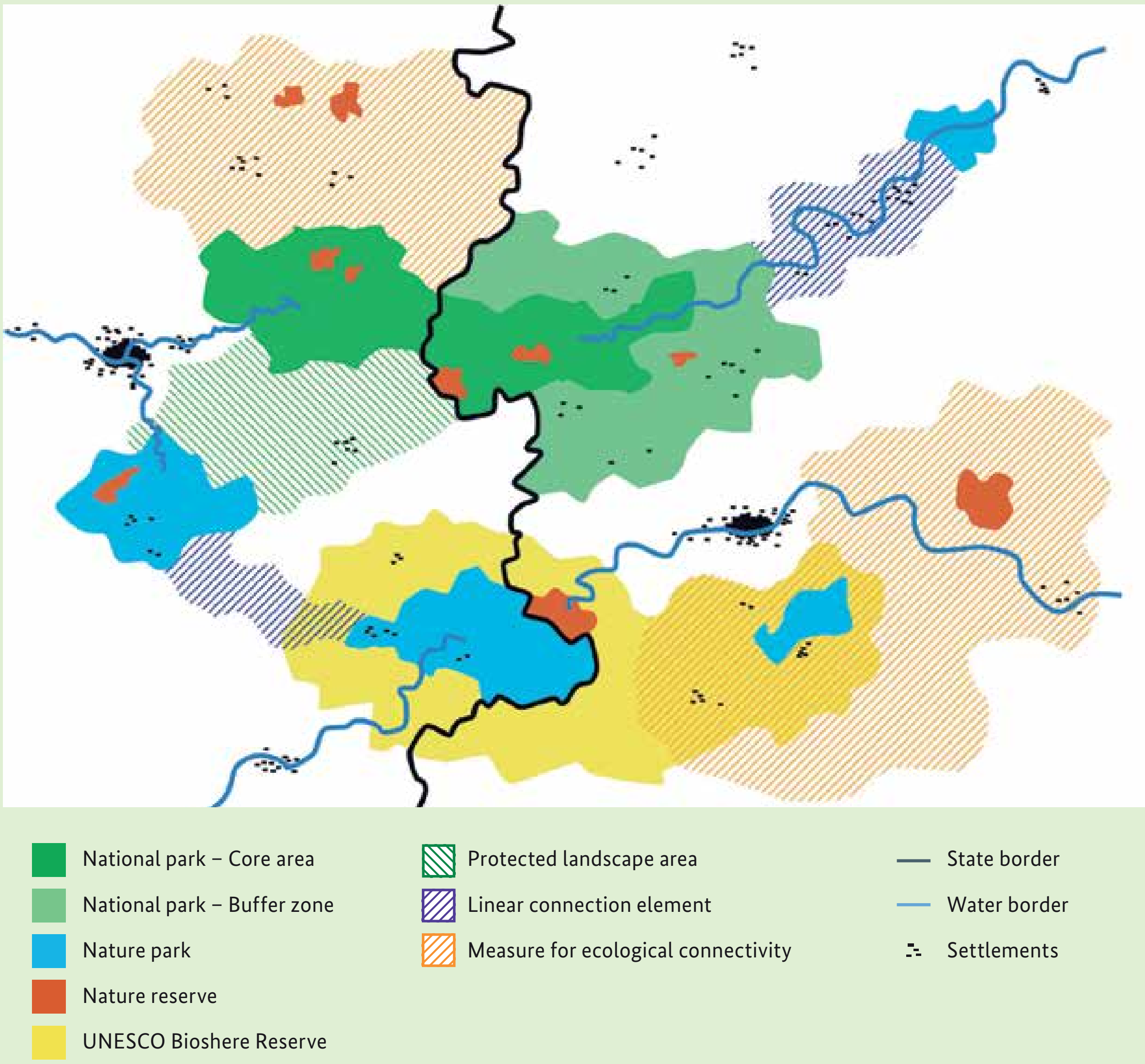
// **Figure 23:** Concept of a transboundary ecological network of protected areas



Source: from Kohler & Plassmann 2004

funds for these activities (project linked, specific public funds, private donors, and more) as well as the range of involved partners and the range of consequences are highly heterogeneous and illustrate the need for the Pilot Regions to be able to rely upon solutions and approaches tailored to their specific needs.

The Alpine Pilot Regions have proven their capacity to allow important contribution to the implementation of a coherent ecological connectivity approach thought the Alps. The degree of activity is not homogeneous among all Pilot Regions and depends considerably on external drivers like available funds (due to projects or specific allocations). In general, they have contributed significantly to promotion of the topic in their region and are a basis for future work. The Alpine Arc will not be entirely covered by Pilot Regions, and this approach needs to be complemented by others, as described in chapter 2.2, but they are key driving elements on the path to creating the pan-Alpine ecological network.

Box 8: Ecological connectivity in mixed-use landscapes

Interview with
// Friedrich REIMOSER //
Research Institute of Wildlife Ecology, University of Veterinary Medicine, Vienna, Austria

You have many years of experience with processes of forest and wildlife management and wildlife focused spatial planning in multi-use landscapes. How can spatial planning and wildlife management be used to conserve or re-establish ecological networks?

The WESP-method (Wildlife Ecological Spatial Planning), a conception of spatial planning and integral management of wildlife and their habitats was initially developed and applied for wild ungulate species in Austria's province Vorarlberg and continuous parts of adjoining countries (Duchy of Liechtenstein, Switzerland), as well as the province of Salzburg. Planning is systematically subdivided into: (a) large scale basic planning (countrywide); (b) detailed regional planning; and (c) international coordination of measures. The main aims of WESP are protection and connection of wildlife habitats and the avoidance of wildlife damage to forests by achieving better distribution of ungulate game and lessening negative land-use impacts. The planning criteria and management principles include optimising and co-ordinating diverse forms of land use towards sustainable use of natural resources in an ecologically and socio-economically acceptable fashion, and solving conflicts at a local level interactively with all interest groups concerned. This method can also be used as a basis to establish suitable corridor areas between sub-populations across country borders, particularly for wide roaming wild mammals such as ungulates and large predators.

What influence do different approaches to wildlife management have on ecological connectivity? Can you think of any examples where wildlife management favours connectivity?

In the Alps very different traditions and legal regulations dealing with wildlife according to country and region exist. Because of that, considerable problems for population connectivity can result for some species. A harmonisation of management measures particularly along the border areas of neighbouring countries is necessary. The "Raetikon" project of Vorarlberg (Austria), Grisons (Switzerland), and Liechtenstein gives a good example for such a cooperation to promote connectivity.

Do you see a connection between human/wildlife conflicts and ecological connectivity?

Yes. An example: where the habitat connectivity is lost and "dead ends" for ungulate migration are caused (with animals staying longer in these areas than before), the risk for game damage to the forest vegetation by intensive twig browsing and bark peeling is in general much higher. This is in particular problematic in Alpine forests with protection function against avalanches, rock fall, floodwaters, and more.

What is most important for avoiding human wildlife conflicts?

We need a more holistic approach in wildlife management, "integral" instead of the traditionally "sectorial" management – and this on a large enough scale for the Alpine region, across national borders. This means better teamwork between

foresters, farmers, hunters, outdoor recreationists, conservationists, experts for traffic infrastructure and spatial planning, and public authorities. All these interest groups should consider wildlife as a sensitive, complexly influenced site factor in an ecological and economic context. Also the different legal regulations, sectorial for the land users that have consequences for wildlife, habitat quality and habitat connectivity should be harmonised in a more holistic way to avoid human wildlife conflicts. Otherwise the conflicts are often system immanent and hardly to solve.

Box 9: Restructuring forest to enhance biodiversity

Interview with
// Ales POLJANEC //
University of Ljubljana, Ljubljana, Slovenia

Forests have an important function in ecological networks. Why is it important what type of forest management is used? How do different management approaches influence ecological connectivity?

In general, nature conservation in forest management follows two main approaches: a segregation or an integration approach. In a segregation approach, one part of the entire forest area is allocated for nature conservation as a protected forest area. Biodiversity preservation is thus limited mainly to designated areas, while other management objectives are maximised in the remaining larger forest areas. Protected areas are therefore the main tool for the protection of forest biodiversity in this approach. Usually this approach is seen as less complementary with nature conservation, as in most cases biodiversity decreases in larger (unprotected) parts of forest area and ecological connectivity between designated areas is hindered. In contrast, an integrative approach takes into account ecological, social and economic aspects of forest management and therefore enables biodiversity preservation and ecological connectivity to a significant extent in the entire forest area. Therefore, the integrative approach is much more challenging and complex.

In practice both models encompass many variants that combine elements of each approach, and they both include protected forest areas. Concerning biodiversity and ecological connectivity in densely populated areas such as Central Europe and also in its mountain regions, an integrative approach that includes nature based forest management and spatially well distributed networks of protected forest areas seems to be most appropriate.

You have concrete experience with the establishment of an ecological network between Triglav National Park in Slovenia and the Prealpi Giulie Nature Park across the border in Italy. Are there differences in how forests are managed on different sides of the border? If so, what are the main differences, and how might they affect biodiversity?

The idea for cooperation between both protected areas, the Triglav National Park (TNP) and the Nature Park Prealpi Giulie (NPPG), started in 1996, first as collaboration in the field of promotion and cultural heritage protection. Both parks are members of the Europarc Federation and are part of the Alpine Protected Areas Network. After application for a transboundary certification in 2007, they were designated as the Europarc's "Julian Alps Transboundary Ecoregion" in 2009 and thus became the first transboundary parks with Europarc certification among Alpine Protected Areas. The importance of the area for ecological connectivity and biodiversity conservation was further recognised by the Alpine Convention, which, at the XII Alpine Conference in Torino in 2014, nominated both parks as official Transboundary Pilot Regions for ecological connectivity. This official nomination strengthened already existing close and fruitful cooperation between both protected areas, provided a legal framework for common joint activities in both parks and

contributed to the implementation of the Alpine Convention in both countries.

In both protected areas, forest management is based on sustainable and multi-objective principles and is, due to the protection regime and harsh natural conditions, practiced only to a limited extent. Forest management in both parks follows close to nature management principles and is seen as a part of the biodiversity management of the protected area. Timber production is mainly limited to the buffer zone and is more intensive in TNP than in NPPG, where the extraction of timber is an important management objective for a limited number of forest owners. In the core protection zone, nature conservation management objectives prevail. Management plans are prepared in both areas. In TNP forest management plans (FMP) are provided by the Slovenia Forest Service and are not limited only to protected areas, but cover the entire forest area in Slovenia (regardless of ownership). The plans are approved by the Ministry of Agriculture, Forestry and Food, and the formal influence of the municipalities and the Institute for Nature Conservation of the Republic of Slovenia is legally mandated. In NPPG the plans are prepared by municipalities in agreement with the park authority and differ from FMP outside the protected area. FMP in both sites include rules and projects that aim to preserve and enrich biodiversity (for example guidelines for natural regeneration, measures to improve forest structure and species composition, special measures to improve biodiversity, guidelines for encroachments in forest space, spatiotemporal limitations of forest management, recreation and more) that are adapted to the different management regimes. The FMP's in Slovenia are also considered as management plans for Natura 2000 forest habitat sites. In NPPG, on the other hand, separate spatial plans are prepared for Natura 2000 sites, and FMP's are strictly and coherently connected with the park management plans.

Forest management in both parks provides important bases for biodiversity conservation and ecological connectivity. As forestry is not seen as a major problem concerning nature protection in either both park, not much transboundary cooperation in the field of forest management was practiced in past years, but cooperative efforts were mainly focused on the following activities: general management (project application, international activities), nature conservation (species, habitats monitoring and management), education and public awareness (junior ranger programs, raising environmental awareness, information, media), tourism (visitor management, tourism development), cultural heritage (local products and skills, sustainable activities). Nevertheless, a connectivity principle has been used by both protected areas as well as project partners in some EU financed projects, such as ERA Eco Region (Interreg IIIA Slovenia – Austria), Palpis – Cross-border participative planning in areas of major naturalistic value in the Southern Julian Alps (Interreg IIIA Slovenia – Italy), Climaparks – Monitoring and studying the effects of climate changes (Interreg IIIA Slovenia – Italy) and GreenAlps – Valorising connectivity and sustainable use of resources for successful ecosystem management policies in the Alps (Alpine space Program). As a Transboundary Pilot Region for ecological connectivity, management authorities of both protected areas are active within the project ForAdapt – Decision support toolkit FOR ADAPTive management of forest ecosystem services across borders in the face of climate change and economic scarcity in Europe led by the University of Natural Resources and Life Sciences, Vienna (BOKU). Through the process of implementing the project, key transboundary management objectives have been identified with long-term

conservation and monitoring of wildlife species and their habitats. Further transboundary collaboration is recognised as a priority, especially in the elaboration of common transboundary management plans focusing on connectivity issues. Forests are the dominant natural ecosystem in the area, and forestry will therefore have an important role.

When thinking of forest management, it is probably also important to think of non-forestry activities that take place in forests and that can affect biodiversity and ecological connectivity, such as recreational activities, wildlife management and more. How do these get considered in forest management planning?

In Slovenia as well as in most Central European countries, the integrative approach in forest management is practiced where different management objectives can be realised by overlapping uses in the same forest area. Nature conservation is generally integrated in forest management, representing a principle to which management objectives should be subordinated. Possible management alternatives are therefore reduced to more ecologically acceptable forms. In forests where forest management is primarily oriented towards nature conservation (for example forest reserves, protective forests, national parks, Natura 2000 sites, and ecosystem restoration), biodiversity preservation and ecological connectivity can also be seen as an additional or special management objective.

To optimise all relevant objectives and reduce negative effects on forest biodiversity and ecological connectivity, careful planning and monitoring are needed. Within the management planning procedure the number and hierarchy of management objectives are set through a participatory process and different sets of activities are elaborated to ensure sustainability of forests for selected uses. Important tools to prevent negative effects of timber production and other forest-based activities on biodiversity are the spatial and temporal coordination of forest activities, some additional limitations on forest use (such as the prohibition of activities during particular times of year), and some special measures such as leaving habitat trees and a certain amount of dead wood in the forests, creating key habitats, planting tree species with fruits that are important food sources for wildlife and more. The careful assessment of acceptability of encroachments into forest areas is another important tool to prevent negative effects on ecological connectivity.

What would you say is the most important consideration if the goal is to maintain or re-create ecological connectivity?

The most important consideration to maintain and ensure biodiversity and ecological connectivity of larger forest areas (landscape, national level) is how to integrate nature conservation into regular management practice. In the areas where biodiversity and ecological connectivity prevail, a management objective of close to nature forestry and a cognitive approach with constant monitoring, planning and evaluation of realised measures could be most appropriate. Beyond that, some specific measures are also important to improve habitat suitability for specific species. Usually these measures are not considered as a part of regular forest management, and therefore they should be, especially in private forests, well communicated and supported by different financial instruments (for example state, EU).

In countries where nature-oriented forest management is regularly practiced, ensuring ecological connectivity and biodiversity in forest areas is generally not problematic. More important is how the landscape is managed, where and to what extent encroachments into forest space will be allowed and how they will fragment the forest matrix. As some encroachments are necessary for the development of regions and even states (for example , infrastructure), we cannot completely avoid them. In that case encroachments upon the natural landscape must be supported with special measures to re-create ecological connectivity (for example wildlife crossings, artificial corridors). It would be important that these measures are part of the investment project. These activities usually go beyond the forestry profession and must be coordinated intersectorally.

5 The future: Beyond the current continuum

Introduction

This last chapter gives a perspective on the question of how ecological connectivity could look in 2030, in which context it will be placed, how it could be financed and what are the influencing factors for this essential issue of Alpine biodiversity. Marianne Badura and colleagues analyse the Macro-Regional Strategy context, which has just arisen for the Alps and provides a new, larger political context for the management of the Alpine space as well as for ecological topics. Dorothea Palenberg and Marianne Badura also describe the funding opportunities for ecological connectivity within EU programmes and the development of adapted funding strategies. Green Infrastructure is a current topic of the EU commission, and Julie Raynal gives some clear statements about the procedures and requirements of the commission determining how to improve this structural element of connectivity for Europe and especially for the Alpine space. Reaching further, the importance of the transition to the outer-Alpine areas becomes very clear with the map presented in the article from Ruedi Haller, Maja Rapp and Guido Plassmann demonstrating that the biggest barriers for ecological connectivity are around the Alps. ▶

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▶ *The perspectives on connectivity are drafted in the collective article from all the editors of this publication, simulating the situation in 2030 according to possible future scenarios, and a detailed outlook is given in the conclusion article of the editors "steps to undertake – the Alpine ecological vision 2030". Two zooms are made from a political point of view into special topics such as Alpine connectivity towards neighbour mountain massifs (with the examples of the Danube corridor between Alps and Carpathians) and the EUSALP (Alpine Macro-Regional Strategy). This last chapter aims to summarise the central topics of the publication, to highlight the main statements and to advocate for the implementation of Alpine ecological connectivity.*

5.1 Description of the macro-regional context (EUSALP) and the opportunities of the Macro Region

// Marianne BADURA //
// Dorothea PALENBERG //
blue! advancing european projects GbR – consulting&engineering, Munich, Germany

The Alpine Region is one of the most fascinating landscapes in Europe comprised of mountainous areas, surrounding foothills as well as lowland areas. This massive landscape is uniquely rich in natural and biodiversity resources, hosts different communities of inhabitants and attracts millions of tourists and visitors yearly. The region has huge economic and spatial development potentials, which also pose concurrent sustainability and conservation challenges. For this reason, different regional and spatial development initiatives have been pursued over the years, under the auspices of the national countries and the European Union (EU), to develop Alpine based co-operation that would protect this remarkable European landscape. Over time, these initiatives set the stage for creation of the European Union Strategy for the Alpine Region (EUSALP).

The EUSALP is the fourth European Macro-Regional Strategy drawn up by the European Commission (EC), in collaboration with Member States involved, to foster closer transnational co-operation in the Alpine region (Schmitt *et al* 2009). It is a key element of the implementation strategy of the European Territorial Co-operation (ETC) for Cohesion Policy, whose main objective is to improve the competitiveness, prosperity and cohesion of the Alpine region Member States (EC [2014]) ('Europe 2020 – EU-Wide Headline Targets for Economic Growth – European Commission').

As previously stated, co-operation programmes are not new in the Alps and have been seen as largely successful (Bauer 2014). Within the cooperative mechanisms mentioned, the Alpine Convention (Alpine Convention [1990] [AC]) can be considered as a very effective and particular entity, as it constitutes a binding legal instrument under international law and is willing to contribute its longstanding experience to the EUSALP process by involving its Alpine networks and stakeholders (PSAC [2013]: Beitrag der Alpenkonvention zum Prozess einer makroregionalen Strategie für den Alpenraum – ein **"**Input Paper**"**). Moreover, the AC provides the legal basis for the protection of the Alps wherever the national legal framework does not sufficiently apply (Schmid 2015).

However, the AC and the EU programmes have had shortcomings in terms of discordance of topics, policy levels and instruments, territories and stakeholders, which can create redundancy and discontinuity. With EUSALP, Alpine regional Member States could work more closely together to further address their common challenges and in so doing benefit from prevailing opportunities in the region.

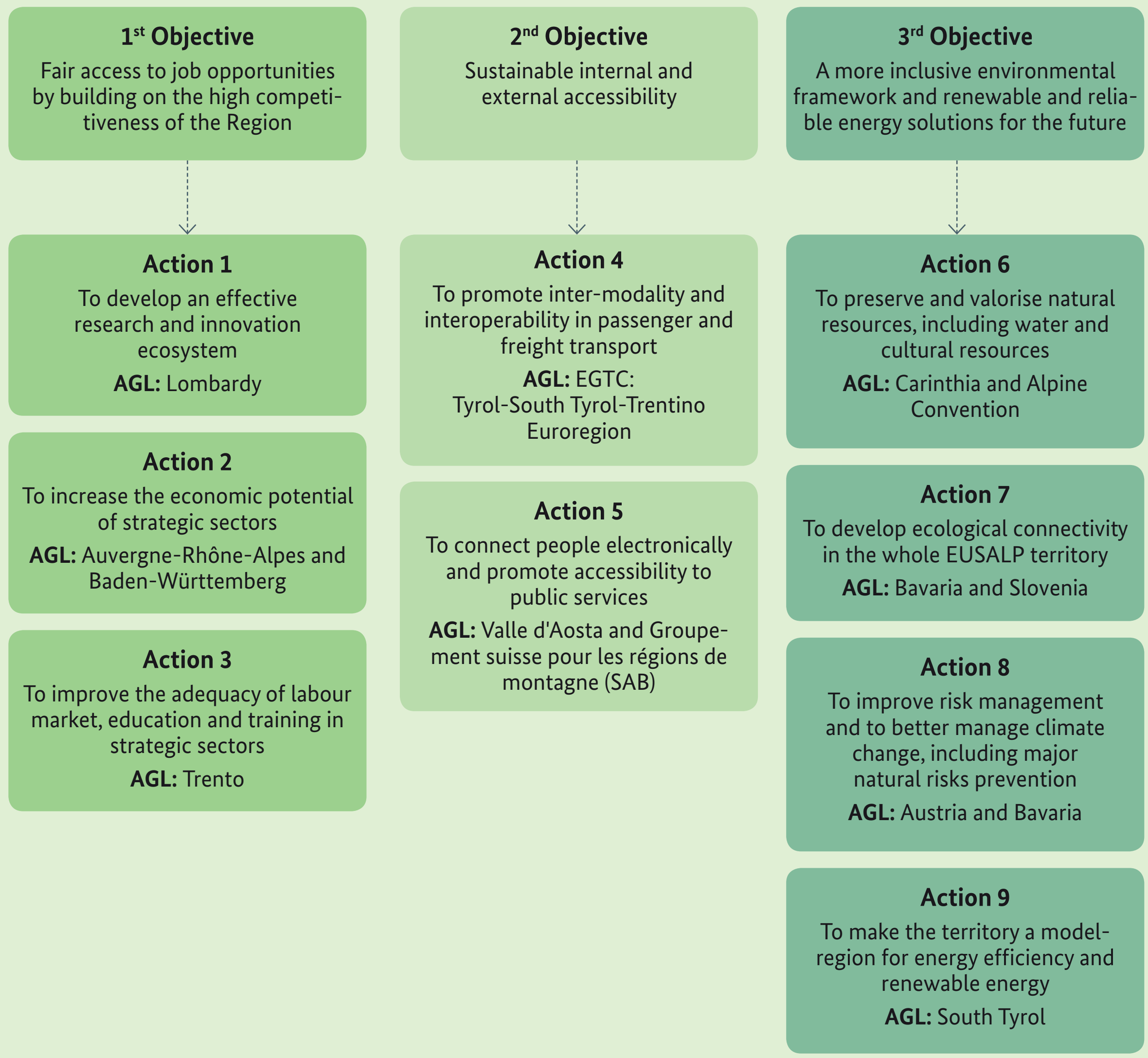
Ecological network: Significance and opportunities of the EUSALP

Environment is one significant policy focus of the EUSALP, since its integrity is essential for sustenance of socio-economic activities in the region and the well-being of its inhabitants. The EC's EUSALP Action Plan (EU [2015b] EUSALP Action Plan [2015]) identifies the environment as an important area where macro-regional co-operation is needed: objective 3 calls for "A more inclusive environmental framework for all renewable and reliable energy solutions for the future". Within objective 3, a set of three so-called 'Action Groups' tackle different aspects of environmental protection and resource management. At an operational level, there are two main Action Groups, numbers 6 and 7 (EC [2016]:

The EU Strategy for the Alpine Region [EUSALP]), will work to achieve this goal, with cross-references to the other seven actions of the Macro-Regional Strategy.

The topic of ecological connectivity is particularly addressed (Action Group 7) in trying to link the Alpine core areas with the surrounding lowlands and metropolitan areas. “All of this shows that often only the Alps as such are regarded as a protected and ‘recreational area’, whereas the so-called surroundings or the hinterland are considered to be ‘land for use’. In this regard we need a change of mind-set, a better-integrated view and more environmental accountability. The promotion of ecological connectivity will therefore be an important priority.” (EUSALP 2015). Therefore EUSALP shows great promise of supporting conclusions of the Alpine Space Programme objectives ‘Liveable Alps’ (EU (2015): ASP Cooperation Programme) as well as being instrumental for better economic, social and territorial cohesion (EC Action Plan 2015). The participation of the Alpine Convention (both contracting parties as well as observer organisations from civil society) and the Alpine Space Programme during the development stages of EUSALP is already a significant step that helps to circumvent previous co-operation shortcomings in the region.

Figure 24: Overview on EUSALP Action Groups (AG)



Source: EC (2016): The EU Strategy for the Alpine Region (EUSALP)

VADEMECUM (2010) paints an interesting picture of an Alps without boundaries highlighting the benefits achievable from connected sustainable ecological networks. EUSALP addresses territorial or regional cohesion issues in the region and is projected to greatly improve ecological connectivity and guarantee continued maintenance of its environmental benefits. Still of concern are the political implications of territorial boundaries, particularly government territorial interests (Faludi (2015) discusses some very interesting issues bordering on the EU-Cohesion Policy objectives, which strongly highlights how political territorial interests would almost always thwart trans-border co-operation initiatives). These will continue to require very strong committed actions from the governments involved. A first step to improve the governance models which are applied in the different regions within the EUSALP territory is development of a common operation at project level of all EUSALP Action Groups (*www.alpine-space.eu/project-application/call-2/terms-of-reference_eusalp.pdf*).

The ETC Alpine Space Programme 2014 to 2020 offers a funding priority, which for the first time is solely dedicated to improving governance structures. The goal is to motivate all Action Groups to suggest concrete measures to improve governance aspects within their thematic field. In this context, the Bavarian State Ministry for the Environment and Consumer Protection and the Institute of the Republic of Slovenia for Nature Conservation will lead Action Group 7 'Ecological connectivity' and prepare a set of relevant measures covering a period of 3 years from 2017 to 2019.

Protecting the rich natural and cultural heritage of the Alps is of huge significance to the socio-economic stability and development in the Alps. This is reflected in different objectives of the Macro-Regional Strategy: it supports the idea of a competitive economy that can successfully combine prosperity, energy efficiency, a high quality of life and traditional values. Among others, the 'Recharge Green' project is an example of an Alpine Space project that has explored such potentials in the Alps. But careful consideration of future welfare impacts occasioned by spatial developments in the region still require cautious assessments to avoid exacerbating some of the problems the macro-strategy is meant to curb (According to the EC's Action Plan [2015] document, problems and challenges facing the Alps could be summarised as: low population density; high vulnerability to climate change and biodiversity loss; a high degree of seasonality; and an ageing population).

Welfare impacts could occur in various forms such as landscape changes that favour economic development but diminish the leisure or scenic value of the Alps; loss of local artisans due to direct competition with modern industries for access to raw materials; traditional or cultural practises like mountain farming being no longer sustainable due to improved network access structures, for example roads, as well as loss of their valuable sensitive ecosystems safeguarding function (Schmitt [2010] reported that in many Alpine regions, mountain farming plays a key role in safeguarding living and working space as well as the sensitive ecosystems). It is important to note, however, that in some cases, welfare impacts may not be entirely avoidable and would instead require adequate planning to accommodate their eventual occurrence.

EUSALP further addresses the challenges of combating climate change and sustainable natural resource use by advocating for more committed collective actions. Such collaborations broaden the scope of tackling climate change repercussions beyond spatio-temporal impacts to include trans-border transferred impacts.

Moreover, EUSALP includes within its boundaries (which are larger than the perimeter of the AC and the ASP) all metropolitan areas around the Alps. This inclusive approach reflects the fact that intensive exchange and interaction take place between those areas and the Alpine areas in terms of energy flows, tourism and leisure activities, transport, settlement policy and cultural exchange. The valorisation of the socio-economic aspects and ecosystem services of a well-functioning ecological network will help to create strong incentives to drive sustainability and conservation actions. TEEB (2013) presents very convincing views for economic perspectives on biodiversity and natural resource conservation and sets out useful guidelines for valuing ecosystem services and aiding policy decision-making processes. The Nordic Countries study by Ketunen et al (2010) is a useful case study that used TEEB tools.

To conclude, the EUSALP holds a considerable potential to initiate measures that are favourable to ecological connectivity, nature and landscape protection and sustainable development in general by providing an institutionalised basis for interdisciplinary co-operation and exchange. Together with the Alpine Convention, which identified the cross-cutting theme of 'Green economy' for the most recent Report on the Status of the Alps, EUSALP represents a strong political framework for focusing on further valorisation of the Alps' natural resources and striving to improve future natural resource conservation efforts.

5.2. Financing the ecological continuum – funding options and strategic project development

// Marianne BADURA //
// Dorothea PALENBERG //
// Onyebuchi CHIGBO //
blue! advancing european projects GbR – consulting&engineering, Munich, Germany

Ecological connectivity represents a cross-cutting topic that interfaces with all relevant regional policy aspects such as mobility, tourism and leisure, urban and rural development, business and agriculture as well as nature conservation. Furthermore, planning and implementation of ecological connectivity requires policy adjustment on different governance levels that ideally engage in a converged multilevel governance approach. Beyond this, the establishment of connectivity requires different implementation patterns for different species. Identifying funding options for such a multidimensional and complex topic requires evaluation of the overall goal from the different perspectives and channelling a pipeline of compliant proposals toward a unified umbrella strategy.

The following text will therefore not focus on a "one size fits all" funding scheme but will rather outline a strategy to constructively connect the offers of the various EU funding instruments with aspects of ecological connectivity.

The European Commission in July 2015, with the launch of EUSALP (EU Commission 2015a and b), gives appropriate guidance, stating various available funding instruments for implementing the programme and respective action plan. Currently, Macro-Regional Strategies are not designed to be financed through their own financing programme but rather by using the existing EU funding schemes.

Generally speaking, two different approaches can be followed when developing a funding proposal for ecological connectivity:

- → **Option 1:** Narrow: focusing on one of the relevant aspects such as agriculture, traffic, light, noise, and more and developing a concrete proposal that is attached to a selected territory.
- → **Option 2:** Comprehensive: remaining more general and implementing governance strategies, but on a cooperative policy level that represents instead an overarching approach.

In both cases, the guiding principle for a successful implementation is negotiation and compromise between different stakeholders. Therefore, the financing of the ecological continuum requires funding instruments that allow cooperative approaches, bringing together different administrative levels, different sectoral policies and/or partners from different countries that all participate in developing the territory concerned.

When identifying suitable funding instruments, it should be emphasised that the implementation of the ecological continuum is highly territorial. Consequently, funding instruments have to be identified where territory matters. From a more general perspective, appropriate research regarding non-territorial funding options contributes constructively as well, but is reflected more in preparation than implementation.

It should be emphasised that ecological continuity is not to be financed based on a single funding source, but instead from a well-coordinated project pipeline integrating different thematic aspects and their respective funding sources. Here, bringing together the appropriate actors within custom-fit funding schemes is crucial to successful and ongoing progress. It is essential to organise the work of application and project management in a well-coordinated system of political drivers and an interdisciplinary set of thematic contributors. In this context, the EUSALP and its action group(s) appear to be an appropriate framework for coordination at the policy level as well as developing and overseeing a project pipeline and coordinating thematic contributors.

Another requirement is to identify the player(s) within each territorial entity who are best equipped to take responsibility for initiating or coordinating a strategic approach in developing a series of complementary projects on ecological connectivity. There are different options, the most inspiring one being a territorial administration that takes the lead for integrating different sectors and stakeholder groups in a region or another territorial entity. Another option would be that protected area administrations in the respective regions act as facilitators and organise cooperation and involvement of stakeholders, as has been tested in the former ETC project ECONNECT from 2008 to 2011 (Künzl *et al.* 2011) (*www.econnectproject.eu*).

In addition, the geographical scope of possible funding sources must be taken into account. For example, Interreg A (cross-border) programmes offer a relatively wide and flexible thematic menu, while focusing on a defined cross-border area. Interreg B projects with a comparably wider geographic scope might thus be suitable to integrate relevant actors in a transnational system.

As an example, two territorial funding instruments for the funding period 2014 to 2020 that would allow the implementation of both formerly mentioned options (narrow and wide) have been selected and will be briefly described.

5.2.1 Interreg as an option for cross-border and transnational cooperation

Interreg stands for "Inter Regions" and represents a family of more than 60 funding instruments that support cooperative cross-border or transnational approaches on a wide range of regional development themes (EU Commission 2013). Since the establishment of the EU funding instrument "Interreg" more than 20 years ago, the relevance of European Territorial Cooperation (ETC) between European regions have increased significantly, and the budget as well as the use of this funding instrument for cooperative policies has been continuously increasing as well. Interreg is purely funded out of the Structural Funds. The programme allows funding of broad spatial planning approaches as well as focused thematic cooperation. Although public as well as private partners are eligible, regional authorities and cities remain the main target groups. The potential of Interreg projects can be significant. As an example, the Interreg III B CADSES Project "Carpathian Project" has successfully financed the implementation of several protocols of the Carpathian Convention.

5.2.2 LIFE: innovative demonstration projects in the field of biodiversity and nature conservation

When focusing on the environmental aspects, the EU funding instrument LIFE (EU Commission 2014) has represented an instrument for the successful funding of innovative demonstration projects for more than 20 years. These projects should represent illustrations and best practices for the implementation of the EU's environmental policies including the biodiversity strategy and Natura 2000. Considering that LIFE is a demonstration tool for EU wide applicable solutions, the programme allows for non-cooperative project approaches as well. For example, activities in Natura 2000 areas or projects that target selective species or a broader approach to biodiversity management with a single project beneficiary (or only few partners) are eligible as well.

> **Policy support and commitment** *are crucial factors for successful projects: The existence of EUSALP as an overarching policy strategy triggers and supports favourable developments in the context of project development support.*

As a regional example, the Free State of Bavaria has developed a small funding programme that supports the development of transnational Interreg projects as such (Bayer. StMFLH 2015). This instrument is of course open for the development of projects relevant for the EUSALP as well. From a broader governance perspective, the openness of authorities to developing cooperative projects is fostered through political commitment on regional and national levels. This can be clearly seen as opportunity for vitalising the implementation work of the EUSALP with concrete project activities.

Also in this context, a more detailed assessment of the design of the funding programmes offers new options. As an example, the transnational Interreg funding programme for the Alpine Space offers additional opportunities for governance institutions to build up cooperative and coordinative capacities on a transnational level (Priority 4).

Regarding the development of concrete project options on the ground, the multitude of funding options is thus rooted in the complex, cooperative and cross-sectoral approach that is required in the implementation of ecological continua. One the one hand, an extensive thematic menu of possible themes with different foci is possible. On the other hand, the analysis of the funding options through EU programmes offers a wide range of options depending on their specific thematic pattern. In this context, a strategic approach to project planning is relevant to fully exploit these options and identify suitable thematic matches.

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5.3 EU initiatives on Green Infrastructure and the role of the Alpine region: Towards an 'Alpgreen Infrastructure'

// Julie RAYNAL //
European Commission, Directorate-General for the Environment
Unit B2 – Biodiversity, Brussels, Belgium

In 2013 the European Commission adopted a Green Infrastructure Strategy,'to promote the deployment of green infrastructure in the EU in urban and rural areas'. This represents a key step in implementing the EU 2020 Biodiversity Strategy, specifically its Target 2, which requires that, 'by 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 percent of degraded ecosystems'.

The Alpine region features an outstandingly rich biodiversity, which is also well reflected in the high number of protected areas. However, the co-existence of protected areas on the one hand and intensively used territories on the other hand contributes to increasing fragmentation. This poses a big threat to Alpine biodiversity and prevents essential ecological processes from taking place. Green Infrastructure can provide a strategic framework for a more integrated and sustainable approach to Alpine landscape development.

Green Infrastructure (GI) is a strategically planned network of natural and semi-natural areas including other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates (urban) green spaces (or blue spaces if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in both rural and urban settings. These networks of green elements provide economic benefits, deliver local services, improve quality of life, support a green economy, contribute to social cohesion, protect biodiversity and safeguard key ecosystem services such as water purification, air quality, recreation, climate mitigation and adaption. In other words, Green Infrastructure harnesses the creative, protective, supportive and adaptive forces of nature in a cost-efficient way.

GI can substantially contribute to reducing the carbon footprint of transport and energy provision, mitigating the negative effects of land uptake and fragmentation and boosting opportunities to better integrate land use, ecosystem and biodiversity concerns into policy and planning throughout the Alpine region.

GI can also boost disaster resilience and risk management. Climate change and infrastructure development make disaster-prone areas more vulnerable to natural catastrophes, such as floods, landslides, avalanches and forest fires, which can occur frequently in the Alpine region. The impacts of such events can often be reduced using GI solutions such as functional flood plains, riparian woodland, and protection of forests in mountainous areas.

The management of land devoted to agriculture and forestry has a major impact on the condition of the EU's natural capital. The Common Agricultural Policy (CAP) and rural development provide instruments and measures to encourage GI and to enhance areas with a high nature value in the countryside. Because implementing GI approaches requires an integrated view of ecosystem services, it encourages a balanced approach that emphasises the multifunctional nature of rural areas, including those in mountainous regions such as the Alps. Green Infrastructure will therefore foster a more coherent approach to decision-making in relation to integrating ecological and sustainability concerns into spatial planning in the rural and urban landscape.

With a view to maximising the delivery of ecosystems services to citizens and to protecting biodiversity in both rural and urban settings, Green Infrastructure should therefore be integrated systematically into territorial development and spatial planning across the EU. The EU Natura 2000 network, which is at the core of Europe's Green Infrastructure, hosts a vast amount of Europe's natural and cultural heritage. The further development of Green Infrastructure is vital in promoting the conservation, restoration and sustainable use of Europe's cultural and natural heritage.

Many geographical features, such as mountain ranges (ex: the Alps or the Pyrenees), river basins and forests, or traditional migration routes for wildlife, go beyond national boundaries and are part of the EU's shared natural and cultural heritage and identity. Their management calls for coordinated, cooperative actions and a pan-European vision. To date, large-scale infrastructure initiatives have been devoted to transport, energy and ICT (Information and Communication Technology). Developing an equivalent instrument for GI in Europe, a so-called TEN-G (echoing what has been done on trans-European networks in grey infrastructure sectors), would contribute significantly to insuring the resilience and vitality of some of Europe's most iconic ecosystems, with subsequent social and economic benefits. Recent calls from the Council of the European Union, from the European Parliament, and from the EU Committee of the Regions, reiterate their support for the Commission to generate a proposal for a TEN-G in 2017.

Against this backdrop, the Alpine region has great potential to act as a living laboratory. The region could be used to develop and implement initiatives relating to Green Infrastructure and to what could be a TEN-G for Europe. These endeavours could include improvement of ecological connectivity between protected and non-protected areas, as well as that between the Alpine core and peri-Alpine areas. In this regard it is important that the activities developed by the Platform Ecological Network of the Alpine Convention and by the Action Group 7 set up under the EU Strategy for the Alpine Region (EUSALP) "to develop ecological connectivity for the whole Alpine region" contribute in order to fully realise this potential.

Example of a specific connectivity measure: fish ladder near Olten in the Canton of Solothurn (Switzerland).

5.4 Alpine connectivity – A green island?

// Guido PLASSMANN //
Alpine Network of Protected Areas ALPARC, Chambéry, France

// Maja RAPP //
Swiss National Park, Zernez, Switzerland

// Rudolf HALLER //
Swiss National Park, Zernez, Switzerland

Map 14 gives an overview of the current status of connectivity in the Alps according to an analysis using the JECAMI tool coupled with expert knowledge. The extrapolation for the Alps shows an image where large inner Alpine areas are still well connected, while outer-Alpine surroundings are largely affected by fragmentation hindering the migration of species to and from the Alps.

5.4.1 The aim of the map

The intention of the map is to illustrate the Alpine situation as a whole in a very general way. Local situations and regional contexts are not considered and need to be evaluated in a more precise way by local visits and territorial analyses. Nevertheless, the picture is interesting and reveals a lot about the Alpine situation of connectivity confirming that, beside some very fragmented inner Alpine valleys, the main barriers to connectivity are those surrounding the Alps, and these create real obstacles for an exchange with the extra-Alpine regions.

The map illustrates the ecological connectivity potential, the barriers and possible wildlife corridors by taking into account the land use, expert-knowledge about barriers and the technical JECAMI analysis based on scientific and statistic indicators.

5.4.2 The approach of the map

In order to evaluate the coherence of activities within the type of landscape according to principles of sustainability, a classification scheme of land use data has been implemented. Corine Land Cover data available for the whole of Central Europe was classified according to impact on the natural environment.

Three reference scales were considered for three classifications:

1. The Cost Surface Classification of the Southeastern Ecological Framework (Carr *et al.* 2002)

2. Mean Species Abundance relative to land cover/land-use of Cross-roads of Planet Earth's Life-Project (ten Brink et al. 2006)

3. Habitat Protection and Spatial Planning (Kias 1990)

This classification method was developed in an earlier project called "The Continuum Suitability Index" (CSI), a model approach of ecological connectivity across the Alps that was carried out under the Interreg IV B project ECONNECT in 2010 for the indicator land use. Table 8 shows the classification scheme.

Additionally, the major motorways of central Europe have been overlaid. European data of traffic volume was available for visualisation of main traffic arteries across the Alps (UNECE, 2005). Unfortunately, traffic census data from Italy was missing, so that motorways are mapped with a constant line width for this country.

Data Source

Land use: Corine Land Cover European seamless 100 metres raster database (Version 18.5), European Environment Agency
Roads: United Nations – Economic Commission for Europe, Census of Motor Traffic 2005

To further highlight the importance and impact of dense demographic features, a second map (map 15) illustrates quite clearly the situation of Alpine demography within the context of ecological connectivity.

Table 8: Corine Land Cover nomenclature classification

	Land Cover Class	Classification (0–100)
1.1.1.	Continuous urban fabric	0
1.1.2.	Discontinuous urban fabric	0
1.2.1.	Industrial or commercial units	0
1.2.2.	Road and rail networks and associated land	40
1.2.3.	Port areas	5
1.2.4.	Airports	5
1.3.1.	Mineral extraction sites	0
1.3.2.	Dump sites	0
1.3.3.	Construction sites	0
1.4.1.	Green urban areas	40
1.4.2.	Sport and leisure facilities	0
2.1.1.	Non-irrigated arable land	10
2.1.2.	Permanently irrigated land	5
2.1.3.	Rice fields	10
2.2.1.	Vineyards	10
2.2.2.	Fruit trees and berry plantations	20
2.2.3.	Olive groves	20
2.3.1.	Pastures	50
2.4.1.	Annual crops associated with permanent crops	10
2.4.2.	Complex cultivation patterns	10
2.4.3.	Land principally occupied by agriculture, with significant areas of natural vegetation	50
2.4.4.	Agro-forestry areas	70
3.1.1.	Broad-leaved forest	60
3.1.2.	Coniferous forest	60
3.1.3.	Mixed forest	60
3.2.1.	Natural grasslands	70
3.2.2.	Moors and heathland	100
3.2.3.	Sclerophyllous vegetation	60
3.2.4.	Transitional woodland-shrub	60
3.3.1.	Beaches, dunes, sands	60
3.3.2.	Bare rock	100
3.3.3.	Sparsely vegetated areas	100
3.3.4.	Burnt areas	100
3.3.5.	Glaciers and perpetual snow	100
4.1.1.	Inland marshes	100
4.1.2.	Peat bogs	100
4.2.1.	Salt marshes	100
4.2.2.	Salines	100
4.2.3.	Intertidal flats	100
5.1.1.	Water courses	60
5.1.2.	Water bodies	60
5.2.1.	Coastal lagoons	100
5.2.2.	Estuaries	100
5.2.3.	Sea and ocean	100

Source: ALPARC Alpine Protected Areas database, January 2016. ALPARC makes no claim of exhaustivity.

5.4.3 The interpretation of the maps

The maps illustrating both the importance of the land use impact and that of the main transit and transport axes on ecological connectivity clearly demonstrate that the most important challenges are not within but outside of the Alps. Indeed, only the most populated and fragmented inner Alpine valleys have an impact on connectivity comparable to that of the very important barriers in areas surrounding the Alps.

This statement leads to the acknowledgement that the future challenges to Alpine biodiversity have to be evaluated, at least partially, in regions outside of the Alpine space proper. It is not realistic to regard the Alps as an autonomous functioning entity when considering its biodiversity.

The conservation of the enormous diversity of life within the Alps as well of fauna and flora depends largely on the management of those areas on the outer edge of the Alpine range that are economically intensively used. Of greatest concern here are the large flood plains of important European rivers like the Po, the Rhône and finally the Rhine and the whole riverine system of the Danube.

The important peripheral Alpine cities such as Marseille, Lyon, Torino, Milano, Geneva, Zurich, Munich, Venice, Ljubljana, Graz and Vienna have a significant impact on ecological fragmentation through their relative dispersal of human settlements, their con-urbanisation and satellite towns needing transport and energy infrastructure, as well as via their large footprints of economic activities (industry, commercial areas and more).

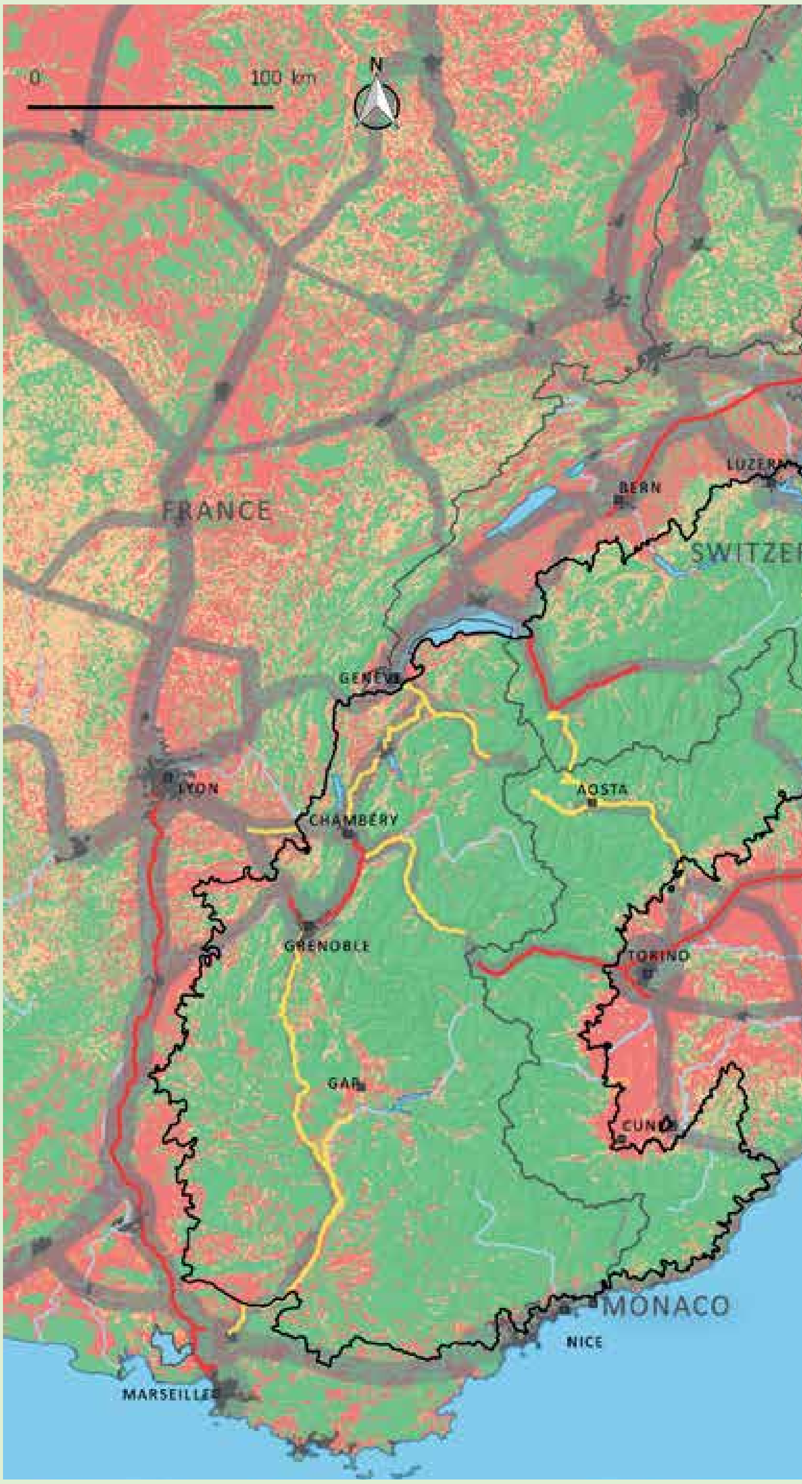
The population density layer in map 15 shows this fact in a very impressive way: the Alpine surroundings are like a continuous belt of towns with some more or less important hot-spots of settlements (see map 15).

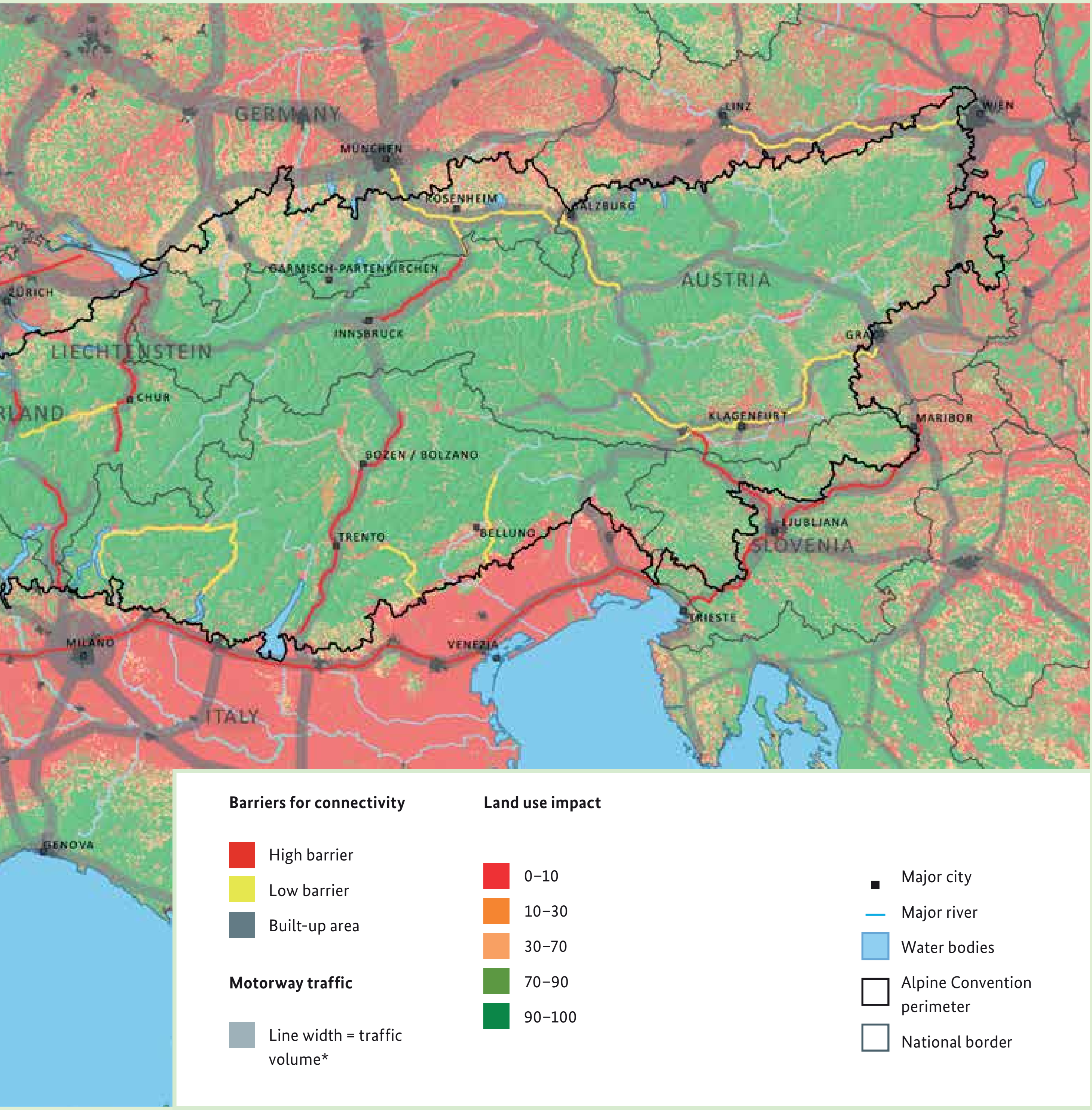
This impact combined with an intensive land-use in the respective valleys, as shown on the map (red surfaces of land-use impact), sometimes leads to complete fragmentation of the space, creating barriers of highest importance for wildlife migration.

It is evident that those extra-Alpine areas with such important urban areas and activities are generating high transport flows, of both people and merchandise, as well as of energy (high tension lines for example). The high volume traffic lines providing connectivity for human populations are creating barriers to the ecological connectivity needed for wildlife migration. In this respect, the Alps seem to be more and more isolated from their surrounding regions..

Even if Alpine connectivity still seems to be functioning in large parts of the Alps, this connectivity increasingly resembles a tenuous thread loosely linking a series of habitats, as connections to the surrounding European landscapes and mainly neighbouring massifs like the Jura, the Central Massif, the Apennines and the Carpathians are more and more disrupted. In any case, Alpine biodiversity will not survive in the long term if it is completely isolated from the outside, inaccessible for any kind of gene exchange. The growing disconnection in very large parts of the Alpine surroundings needs to be addressed through adapted measures. Especially the west (Rhone valley – France), the south (Po plain – Italy) and the east (axis Trieste – Ljubljana – Maribor) face major barriers. The northern part of the Alps seems more open to connectivity with its surroundings.

Map 14: Land use and ecological connectivity





Source: ALPARC work on barriers and connectivity potentials; United Nations – Economic Commission for Europe, Census of Motor Traffic 2005; Eurostat, EFGS for the population grid information; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: *unique line width for Italian motorways. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

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The inner Alpine situation is different: all important communities are situated in the large Alpine valleys such as the Isere valley (France), the Aosta valley (Italy), the Valais (Switzerland), the valley of Adda and Oglio (Italy), the valley of Adige (Italy), the valley of the Rhine (Switzerland-Austria-Liechtenstein), the valley of the Inn (Austria) and the basin of Klagenfurt to mention only the most important. In these valleys, barriers (red colour) are sometimes important due to infrastructure and settlement and in some cases to high traffic.

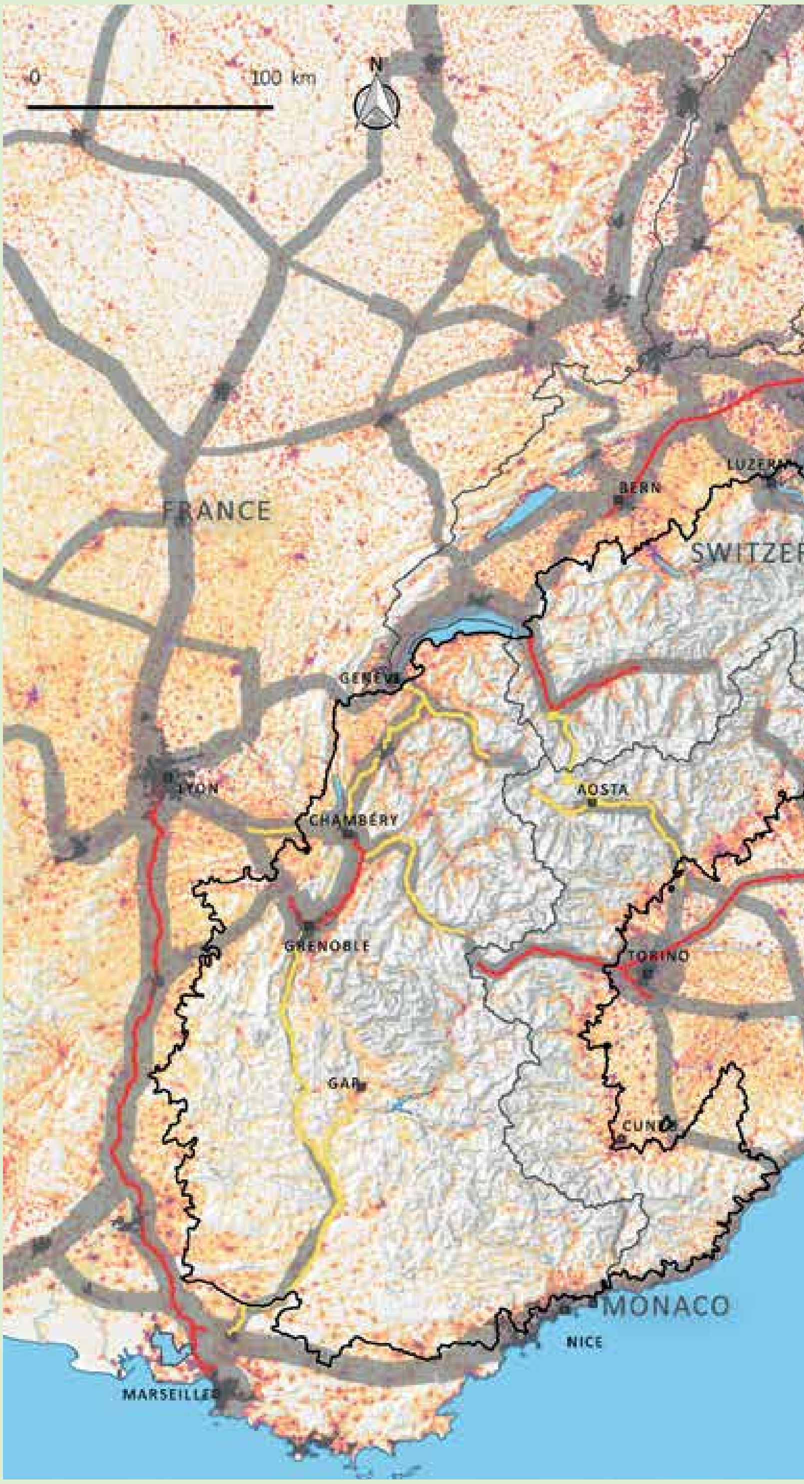
Nevertheless, they are never as significant as those involved in the outer Alpine fragmentation as mentioned above. All barriers of lower impact (yellow colour) are within the Alps (excluding the highway from Munich to Salzburg), while all barriers of high importance (red colour) are either surrounding the Alps or linked mostly to the Alpine periphery area.

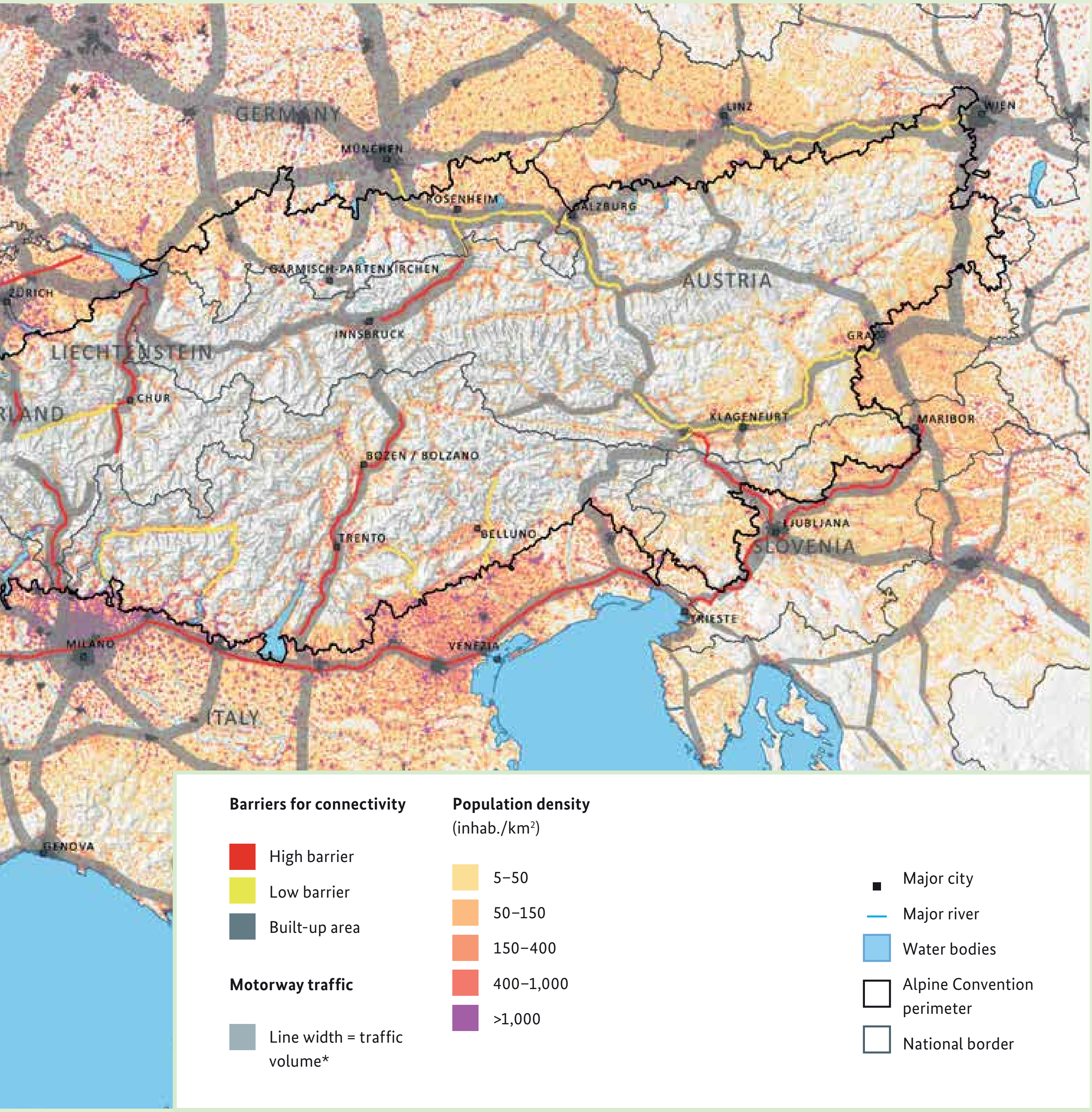
In some inner Alpine situations the fragmentation may be important, in contrast to the statement above, such as in the Isere valley, the Rhine valley and the Adige valley. In all three cases the problem results from a combination of several factors such as high traffic of persons and merchandises, important settlement with all the economic activities linked, intensive agriculture, canalisation of riverine systems, monocultures (often fruits protected by nets and more), and of course heavy infrastructure, such as highways and railways protected by fences and energy lines. As important as these phenomena may be, they are located in a punctuated fashion and do not present a continuous belt like the fragmentation that encircles the Alpine arch.

For almost all Alpine regions it is true that wildlife corridors may be in conflict with more or less important barriers within the Alps. However, the larger obstacle to connectivity exists at the periphery where links to and from the Alps are negatively impacted.

Maps 14 and 15, combining on a very large scale the connectivity potential, the importance of barriers, demography, wildlife corridors and the land use impact, provide a synthesis of inner and outer Alpine ecological connectivity. For this reason, they are one of the major results of this publication. The maps will be completed with other elements and analysed in a more detailed way in the next chapter allowing the elaboration of scenarios of Alpine ecological connectivity for the coming decades.

Map 15: Population density and ecological connectivity





Source: ALPARC work on barriers and connectivity potentials; United Nations – Economic Commission for Europe, Census of Motor Traffic 2005; Eurostat, EFGS for the population grid information; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: * unique line width for Italian motorways. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

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5.5 The future of Alpine biodiversity – Potential scenarios for Alpine ecological connectivity in 2030

// Guido PLASSMANN //
// Yann KOHLER //
Alpine Network of Protected Areas ALPARC, Chambéry, France

// Marianne BADURA //
blue! advancing european projects GbR – consulting&engineering, Munich, Germany

// Chris WALZER //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Ecology and Evolution, University of Veterinary Medicine, Vienna, Austria

Ecological connectivity is one of the main challenges in the conservation of global biodiversity. Nevertheless, the topic is less prominent than climate change even though both are directly linked to one another. Decisions need to be taken today if Alpine connectivity is to be significantly improved and all the more so if the Alps are to provide a future model of ecological connectivity.

As described in a chapter (2.4), the Alps are characterised from an ecological connectivity point of view by three main landscape situations (patches):

1. Areas with a very high degree of fragmentation. **Ecological Intervention Areas (1)** (see map 16, page 192)
2. Areas with persistently functional connectivity and with non-fragmented patches. **Ecological Conservation Areas (2)** (see map 18, page 198)
3. Areas with a high potential for connectivity with larger, more or less natural non-fragmented patches. **Ecological Potential Areas (3)** (see map 21, page 208)

1. These areas are mainly characterised by intensively used inner Alpine valleys at lower altitudes. Here specific and individual approaches are needed to solve highly specific problems and issues in order to make the area more permeable.

The Danube Floodplains – An ecological corridor connecting bio-regions and forming green infrastructure between Vienna and Bratislava and by that between the Alps and the Carpathians.

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Recommendation to act: specific ad hoc measures to improve ecological connectivity (active focused approach)

2. These areas are characterised by sparse infrastructure, dispersed settlements and large natural areas at mid-altitude. Here connectivity should be conserved by adequate legislation.
   Recommendation to act: targeted large-scale conservation policy (passive diffuse approach)

3. Areas characterised by the presence of numerous non-fragmented natural patches like protected areas, Natura 2000 sites, biotopes and intact natural habitats at all altitudes.
   Recommendation to act: spatial planning policy aimed at creating future larger scale non-fragmented areas (active diffuse approach)

On the basis of this categorisation and the general "recommendations to act", it is necessary to develop potential scenarios of the future ecological connectivity in the Alps in order to frame a vision for the Alps and implement management decisions. These scenarios must reflect policies, their outcomes and long-term impacts, as well as connectivity measures on the ground (for example corridors), while considering management measures and awareness raising of stakeholders and the wider public. Besides these factors that can be actively managed and implemented, a number of "passive" factors, unavoidable in dynamic multi-use landscapes, must be considered when generating scenarios.

For each of the three types of landscape situations, which we label SACA (Strategic Alpine Connectivity Areas), we analyse several factors highly likely to influence the future evolution of these areas. Concerning the "active" factors, the following will be taken in to consideration:

→ Nature protection policy
→ Social demographic effects (active migration)
→ Regional economic development (for example industrial siting)
→ Tourism
→ Spatial planning
→ Agriculture and forestry
→ Governance processes
→ Alpine social and cultural framework

We assume that these factors can be more or less directed and influenced by various policy and legislative measures.

Additional and primarily dynamic factors that cannot be directly steered by policies but are nevertheless an integral part of the landscapes will impact the targeted goals delineated by active policies (factors). These uncontrollable factors are more or less consistent across all three types of SACA. For this reason, we treat them only once for all three categories within the first landscape type. The following factors are considered:

→ Global climate change and natural hazards
→ Development of demography (natural evolution, birth rates, mortality)
→ Global economic development and change
→ International touristic trends
→ EU policies (planning, transport…)
→ EU agriculture policy
→ Political changes
→ General social trends

The capacity of the European Union to implement specific policies for varying situations and geographical contexts such as the Alps is a particularly important issue. This capacity should be considered an active factor when specific and target-orientated policies for the Alps are generated in the different sectors mentioned in the following tables. On the other hand, it can be considered an uncontrollable factor when the Alpine Space must support generalized EU policies not taking into consideration Alpine specifics. In this context the Macro-regional Strategy and its targets and implementations are of utmost interest.

A detailed analysis for each Alpine country or region is beyond the scope of this publication, and only general tendencies are described, presuming that they may occur more or less in the same fashion throughout the Alpine regions. A far more detailed study would be necessary in order to tackle biodiversity and ecological connectivity issues with a regional resolution while considering the entire Alpine arch.

5.5.1 Connectivity scenarios for the densely populated inner Alpine Valleys – Ecological Intervention Areas

These spaces are the areas most exposed to fragmentation and conflicts concerning land use. In Table 9 we give an overview of the main factors that will influence ecological connectivity in the coming decades. The green colour denotes an essentially positive development, while yellow represents a relatively stable/neutral development and the red signifies a problematic progression concerning ecological connectivity.

Table 9: Main factors influencing ecological connectivity in Ecological Intervention Areas in the coming decades – Active factors

	Active factors	Development and trends in the next decades	Impacts for the area in 2030
1	**Nature protection policy**	■ Implementation of already existing EU and national nature protection policy and reinforcement of nature protection in the densely populated sites	■ Improvement in the permeability of the landscape
		■ Punctuated ad-hoc measures to allow species migration	■ Improvement for some species, no broadening of or improvement in protection of the last remaining habitats
		■ No specific measures or new legal intervention to insure species protection and interlinked habitat conservation or at least migration corridors	■ Increased habitat fragmentation, loss of the last existing intact habitats in the Alpine valleys, valleys as major barriers for migration between mountain massifs
2	**Social demographic effects**	■ Balanced urbanisation and reduction of spread of rural area settlement	■ The issue of fragmentation is taken into consideration in spatial development policies and pressure on habitats and ecosystems is reduced by awareness raising of the population
		■ Growth in alpine valleys but concentrated in periphery urban Alpine areas, further rural exodus from structurally weak areas	■ The fragmentation of the densely populated inner Alpine valleys continues, but the rural areas are less affected
		■ Demographic sprawl around urban areas and increased population density in Alpine valleys	■ Higher fragmentation due to dispersed settlements and urban sprawl in Alpine valleys
3	**Economic development, industries**	■ Well-structured and locally concentrated development of sustainable economic activities and infrastructure	■ Major fragmentation will be limited to the urban hot-spots in the most important Alpine valleys and along the important transport routes
		■ Increased, large scale concentration of economic infrastructure in Alpine valleys and around mid-sized towns	■ Diffuse threats of fragmentation at low altitudes but limited to the largest valleys
		■ Uncontrolled industrial and commercial development in Alpine valleys	■ Increase of barriers and fragmentation in the valleys of the entire Alpine arch
4	**Tourism**	■ Conversion to green sustainable tourism	■ Reduction of fragmentation thus far caused by classical forms of tourism such as: important infrastructure for activities, individual transport, land consuming leisure activities
		■ Mass tourism potential decreased due to climate change and the emergence of novel nature-oriented sustainable tourism practices	■ Balanced and environmentally friendly touristic infrastructure, integration of lower altitude regions in Alpine tourism
		■ Increased concentration of summer and winter tourism in increasingly fragile environments with tendencies to consider the Alps solely as an outdoor activities playground	■ Lower areas and Alpine valleys more or less excluded from this type of touristic development in the Alps

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

	Active factors	Development and trends in the next decades	Impacts for the area in 2030
5	**Spatial Planning**	■ Nature and environmental protection issues are generally and in a legally binding way included in spatial planning procedures	■ Fragmentation of Alpine valleys is a topic of regional spatial planning and additional fragmentation is avoided
		■ Nature and environmental protection issues require specific impact studies to be considered in spatial planning	■ Worst case scenarios of fragmentation can be avoided
		■ Nature and environmental protection issues disregarded in spatial planning procedures	■ Uncoordinated and uncontrolled settlement and land use policy. No guarantee that spatial planners and politicians consider ecological connectivity issues
6	**Agriculture and forestry**	■ Defragmentation is a requirement for intensive agriculture and forestry in Alpine valleys and integrated into management and subsidy policies	■ The situation of the most intensively used Alpine valleys improves in respect to ecological connectivity
		■ Less intensive agriculture is promoted	■ A higher share of extensive agriculture provides additional options for species migration through Alpine valleys
		■ No change of land use, no consideration of ecological connectivity in the densely populated inner Alpine valleys	■ Increased habitat fragmentation and biodiversity loss due to intensive agriculture, augmented by transport and energy infrastructures; genetic exchange between population patches impossible. Abandonment of traditional agricultural land use in higher altitudes with reforestation of open spaces
7	**Governance processes**	■ Civil society and nature protection stakeholders participate in political decisions concerning their living space	■ A genuine understanding and integration of ecological connectivity will be achieved in all local policies and legislation
		■ Governance processes are limited to representatives of stakeholder groups	■ Integration of connectivity in areas with decisive land use conflicts like the inner Alpine valleys will be limited
		■ No special development of governance measures in respect to the protection of biodiversity and ecological connectivity	■ Very little probability that the issue will be integrated into local policies and legislation
8	**Alpine social and cultural framework**	■ New sustainable model of economic and ecological development precipitated and preferred by Alpine inhabitants	■ The situation of connectivity and biodiversity conservation in the inner Alpine valleys greatly improved by 2030
		■ Stronger valorisation of natural values on a local level	■ Better integration of natural values in local land-use decisions – local stakeholders empowered
		■ Global economic crises and enhancing further economic growth and consum-erism is the first and foremost concern of Alpine inhabitants	■ Small chance for any consideration of ecological connectivity and biodiversity conservation issues.

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

Table 10: Main factors influencing ecological connectivity in Ecological Intervention Areas (and others) in the coming decades – Uncontrollable factors

	Uncontrollable factors common to all three types of areas (SACA categories 1 – 3)	Development and trends in the next decades	Consequences for the area in 2030
1	**Global climate change and natural hazards**	■ (green) Increased impacts noted in the Alps, increased awareness, issues are considered and integrated into nature protection policies	■ (green) Increased proactive land use management and use-constrains enhancing efficient and adapted nature protection while mitigating global change
		■ (yellow) Impact studies implemented, delayed action while results are pending	■ (yellow) Awareness raised, but actions for ecological connectivity will probably be too late
		■ (red) Global change not sufficiently considered and implemented in long term policies and legislation	■ (red) Global change and increasing natural hazard impacts will severely limit the development of efficient policies for permeable landscapes
2	**Demographic development**	■ (green) Stable demographic development in the different types of areas	■ (green) Possibility of ad-hoc wildlife corridors in Alpine valleys, less pressure in ecological potential areas
		■ (yellow) Increasing population due to concentration movements in some of the areas' categories, especially in the inner Alpine valleys	■ (yellow) Densely inhabited valleys lead to more ground speculation and less chances for land use for defragmentation; in the other area categories, the increasing population may increase local pressure on biodiversity
		■ (red) Dispersal of population especially within inner Alpine valleys and in a lower measure within other area categories due to demographic increase in regions with population concentrations	■ (red) Inner Alpine valleys are more and more inhabited and dense settlement leads to even more fragmentation by stronger and less well-planned urbanisation
3	**Global developments on varying economic scales**	■ (green) Change of paradigm in EU transport and competition policy with external costs included in transport prices reducing transports of goods within and through the Alps complemented by season adapted consumption and more	■ (green) Increased chance that road infrastructure and transport barriers remain limited (no realistic scenario)
		■ (yellow) Alpine specific economic development taking into account specific opportunities and needs of the space within a global context	■ (yellow) Alpine interests and ecological constrains integrated into economic processes and embedded in global policies avoiding excessive land consumption
		■ (red) Further globalisation of the economy independent of local situation and constraints, no internalization of external costs in transport prices	■ (red) Higher concentration of economic infrastructure in the largest Alpine valleys, reduced permeability of the landscape and riverine systems. Additional areas could be impacted by the further development of the tertiary sector, especially because of the attractiveness of the landscapes and recreation possibilities

■ (green) denotes an essentially positive development
■ (yellow) represents a relatively stable/neutral development
■ (red) signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

	Uncontrollable factors common to all three types of areas (SACA categories 1 – 3)	Development and trends in the next decades	Consequences for the area in 2030
4	**International tourism trends**	■ Stable trend to local, sustainable nature oriented tourism	■ The situation of connectivity and biodiversity conservation improved by 2030
		■ Trends to more public transport for tourism. Diversification of touristic offers in all four seasons. Reduction of the effects of mass tourism formally reduced to short intensive time periods in summer and winter	■ Alpine valleys less impacted by the seasonal intensification of tourist traffic. Although the other area categories could be impacted by increased traffic to touristic destinations
		■ Globalisation of international tourism and trends towards “disneyfication” of the natural environment for tourism	■ Some densely populated valleys, primarily the main transport hubs (airports, train stations, highways), are favoured as tourist destinations in the sense of a regional centre for outdoor activities; higher altitudes may be used more intensively for winter tourism; increasing fragmentation for some species for example by cables, cable transport and ski slopes
5	**EU policies (planning, transport…)**	■ EU policies systematically promote biodiversity and ecological connectivity and requires impact studies for all infrastructure projects with a special view to ecological connectivity	■ The connectivity issue is mainly a concern for the Alpine valleys in an European perspective, general support is provided; policies are accorded to this issue, other areas are less concerned by this factor
		■ EU policies integrate and consider ecological connectivity in various sectoral policies	■ If implemented in all sectors, all categories of spaces will benefit through less fragmented areas, not a very realistic scenario
		■ No consideration of ecological connectivity in sectoral policies	■ Fragmentation in inner Alpine valleys will be significantly increased
6	**EU agriculture policy (Common Agricultural Policy – CAP)**	■ EU agricultural policy actively promotes sustainable and regionalised Alpine agriculture based on organic and extensive farming	■ A more permeable landscape matrix especially within the inner Alpine valleys will be possible; easier to create more and larger non-fragmented areas even in categories 2 and 3
		■ EU policy partially supports a more extensive agricultural approach in some areas	■ Local solutions could facilitate a more permeable landscape especially in the inner Alpine valleys and ecological conservation areas
		■ EU policy doesn’t consider regional specificities and constraints CAP does not further support ecological and mountain farming	■ No changes in the ecological connectivity in the inner Alpine valleys; difficulties in implementing active measures in other areas (2-3) and for biodiversity conservation in still intact areas

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

	Uncontrollable factors common to all three types of areas (SACA categories 1 – 3)	Development and trends in the next decades	Consequences for the area in 2030
7	**Political changes**	■ National and regional policies understand, value and integrate the protection of ecosystems and functional connectivity. The added values of ecological connectivity and ecosystem services for a Green Economy widely recognised by all economic actors	■ The inner Alpine valleys are part of this policy and with a proactive approach large and well-connected areas could be created in the Alps for all SACA categories (1-3). As the economic added value of functional ecosystems is recognised, all sectors promote activities in favour of them
		■ National and regional policies mainly focus on protected areas only to maintain biodiversity	■ Connectivity in inner Alpine valleys will be very limited, and the establishment of new large non-fragmented areas by linking protected areas via stepping stones or special measures becomes more difficult
		■ No special policies for nature and habitat protection	■ No positive development by 2030 for connectivity and transalpine migration, especially in the most intensively used valleys of the Alps
8	**General social trends**	■ European population is more aware of the values of nature and biodiversity protection and understands global processes more clearly	■ Improvements on a local and regional level such as Alpine valleys and regions; local populations take responsibility for environmental issues through improved governance processes
		■ The Alps are fashionable and popular for their beauty and nature-related leisure and recreation possibilities	■ Nature protection becomes an important European issue in order to conserve the "playground's" natural quality
		■ Society generally pays less attention to nature related issues	■ The risk of an even higher fragmentation and biodiversity loss is important

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

How to achieve positive developments

While it is possible to develop numerous scenarios of how the future will look, it is important to be cognisant of the fact that these are merely hypotheses, which may be more or less realistic. Our primary focus is first and foremost: how best to enhance ecological connectivity for biodiversity conservation. In these authors' view, this is especially important in the densely populated valleys where the pressure on ecological connectivity and biodiversity is the highest. Today there is little time or room left to advance biodiversity conservation and ecological connectivity. Actions must primarily concentrate on influencing factors as delineated above in order to achieve positive outcomes.

Needs of the next years

The highest pressure on ecosystems and habitats is in areas with the greatest land use conflicts. Such areas are naturally found at lower altitudes. The densely populated inner Alpine valleys represent some of the most significant problem areas for ecological connectivity.

On the one hand, an intensive analysis of the connectivity situation in the respective valleys is necessary in order to define and conserve remaining potentially permeable areas. On the other hand, active planning and implementation of further measures to improve landscape permeability and maintain or restore key habitats are crucial in maintaining a minimum of (genetic) exchange across valley floors and in allowing movements of flora and fauna. These processes must be framed by robust nature protection policies specifically adapted for these valleys. These regionalised and detailed policies must reach far beyond the established general nature protection acts of the individual countries with their low spatial resolution.

Furthermore, these processes must be firmly integrated into the respective urban and spatial planning concepts. Coherent landscape planning is just as important as concentrated and land-sparing economic activities. Externally driven developments such as a rapid market globalisation can, if ignored in the planning process, strongly and negatively impact local efforts to conserve biodiversity and ecological connectivity. Intensive agricultural practices and widespread monoculture deserts need to be mitigated by efficient landscape defragmentation measures. The promotion of public regional transport, especially to and from tourist destinations in the concerned valleys, can further enhance ecological connectivity in these intensively utilised valleys.

A new economic model based on regionally adapted industries and economic activities for the Alpine valleys combined with a participative governance approach in regional planning processes could constitute the mainstay for a more balanced development of Alpine valleys. Today several industries based primarily on energy availability in the Alpine valleys still persist, but these currently have only scant justification for their presence in these fragile inner Alpine sites (for example the French Maurienne and Romanche valleys).

Finally, the often uncontrollable and unpredictable dynamic factors emanating from political and general social trends strongly influence the way that societies perceive and deal with nature and especially with such technical aspects as connectivity. A better general understanding of eco-systematic approaches is necessary for both society and European policy makers.

Actions and measures employed

Concrete measures must be undertaken in these Alpine valleys within the next years if connectivity is to be maintained. Measures can exist on different levels and scales and can face varying degrees of difficulty. They should also be implemented in the most efficient way. A profound knowledge of the local situation is necessary, and this can be achieved through a variety of means including: spatial analysis (for example JECAMI), site visits and stakeholder and expert interactions to verify results. Specific steps and measures are as follows:

1. **Analysis of the existing barriers**
   The actual barriers in the area need to be defined in order to determine concrete measures to overcome these obstacles.

2. **Definition of remaining permeable landscape patches and interlinked habitats**
   Spatial analysis and observed species migration can delineate specific persisting wildlife corridors.

3. **Identification of movement needs of species**
   Permeability measures in the densely populated inner Alpine valleys need to be modified along the lines of specific species needs by adapting and enriching urban planning with biodiversity fostering measures. The goal of maintaining a generally permeable landscape matrix is largely unrealistic in this category of SACA. As a minimum requirement, the movement and genetic exchange for threatened or important local species must be ensured.

Example of measure:
Measures for seasonal amphibian migration: Most amphibians in Central Europe undertake various migrations during their lives, including the seasonal spring migrations to their spawning grounds. They invariably encounter numerous barriers that they must overcome, especially the dense transport network where millions of amphibians are killed by vehicles every year. There are many measures which could be taken to protect amphibians during migration and to help reduce the barrier effects; these include warning signs for drivers; mobile seasonal fences for amphibians; substitute spawning grounds; temporary road closures; and permanent protection systems (amphibian tunnels), and more.

4. **Measures for green infrastructure**
   Construction measures to allow the movement of species are often among the last tools employed in areas that are no longer permeable. They should be well-placed and targeted towards enabling specific species passage. It is important to note that continued movement on both sides of the actual barrier must be enabled.

Example of measure:
Corridors for small animals: Underpasses for small animals are pipes made from concrete or steel that are incorporated into the road-body crossways or at angles as crossing aids for small mammals, amphibians, reptiles and invertebrates. Conduits obstruct animals' free access to the road and lead them to the underpasses. An uninterrupted link between the conduits and the

underpasses is essential. The conduits should run parallel to the road and should, if possible, be supplemented with guide structures placed at right angles to the tunnel openings. These crossing aids for amphibians and small animals should be incorporated at an early stage during road building and should be ready for operation before traffic is permitted to use the road. Retrofitting of these systems is rarely possible due to the high costs involved. The advantage of these permanent protection systems is that they work all year round and require very little management.

5. **Measures in landscape planning in a long term perspective**
   The question of connectivity needs to be integrated in to all urban and landscape planning policies, legislation and documents. A binding and robust legal framework is required or if one already exists, it needs to be implemented.

Example of measure:
Taking account of the elements of ecological networks in planning tools (land-use plans, landscape development strategies and more): The consideration of central elements of a biotope network in spatial planning is extremely important for the long-term and sustainable creation of a biotope network. This is the only way to ensure long-term connectivity. Planning must, however, be flexible enough to take account of the dynamic character of the biotope network. Depending on the type and significance of the elements, they should be taken into account in the design of different tools and at different levels (at the local level, areas for a small-scale network; at the regional level, key migration corridors and solutions for major conflict points). There are already a number of examples in existence, notably in Switzerland with the creation of the REN in guidance planning (Richtplanung), in Germany with the legally binding integration of a landscape plan

Informational sign explaining restoration measures taken along the river Coisetan in order to improve ecological connectivity in this area located in the corridor between the two mountain massifs Bauges and Belledonne in Savoy (France).

into the municipal planning or in France, where individual municipalities have incorporated elements of the local biotope network in their land-use planning.

6. **Awareness-raising of stakeholder and politicians**
   All relevant stakeholders and decision makers need to be part of the process. They need to be informed about possible ad-hoc measures and should participate in the definition of a local long-term strategy for ecological connectivity. Local populations should be an integral part of this strategy. Individuals can contribute towards connectivity in theses spaces, especially within private grounds.

Example of measure:
Information campaigns in towns and municipalities: Settlements are among those areas that contribute to the fragmentation of the landscape and whose further development may contribute to a decline in habitat quality. However, it may be possible to mitigate these detrimental effects with measures in gardens and green and blue spaces of towns and villages. Restricting further land utilisation for building purposes can increase the permeability of the areas. Habitats can be created and made more environmentally compatible, for example limiting the use of pesticides and herbicides. By initiating information campaigns and providing brochures along with building permits, the public can be encouraged to adopt these measures. Possible measures could include: creation of near-natural hedges from local timber, permeability of fencing around properties, "insect hotels", bee forage and more.

Biodiversity connectivity 2030

If individuals and populations can be made aware that the inner Alpine valleys have special needs for connectivity and that connectivity should be considered from now on in all urban and infrastructure plans and projects, there is potential to maintain a minimum of connectivity for 2030. Municipalities play a key role in this vision. Empowering municipalities to implement strategic biodiversity conservation and ecological connectivity measures can contribute significantly towards sustainable solutions.

Municipalities own and manage major parts of the Alpine territory. Their land-use decisions affect biodiversity, the quality of ecosystems and the connections between them. In some circumstances, connectivity measures that are implemented by municipalities lack a long-term vision and are not integrated into regional connectivity strategies. In addition, decisions taken by municipalities are often influenced by short-term reflections and political considerations (greenAlps, political recommendations, 2014).

The role of the municipalities in biodiversity conservation needs to be strengthened, and more harmonisation in managing of territories has to be requested from them. This could happen through "biotope network plans" on the local scale, since targeted and functional measures are important for effective biotope networking. An area-wide biotope network plan is essential if the right measures are to be implemented in the right way and in the right place. At the level of the local authority, priority areas for the biotope network must be included in the appropriate and legally binding planning documents. This permits the land use interests of the various sectors to be weighed at the same time. Ecological interests and development potential for the residential and economic area need not necessarily conflict.

Evaluation of the most realistic scenarios

The following ten inner-Alpine valleys are probably the most impacted by the lack of permeability of their environment and landscapes: the Isere valley (France) between Albertville and Grenoble; the lower aspects of the Rhone valley (Valais, Switzerland); the marginal Alpine valley between the Swiss Jura and the Swiss Alps (between Bern and Zurich, Switzerland); parts of the central aspects of the Aosta valley (Italy); the lower Rhine valley between Sargans and Bregenz (Switzerland, Austria); the Inn valley between Innsbruck and Kufstein; the Eissach (Isarco) and Etsch (Adige) valley between Brixen and Trento (Italy); the Ticino valley between Como and Lugano (Italy/Switzerland); parts of the Klagenfurt basin (Austria) and the Salzach valley between Salzburg and Bischofshofen (Austria).

For these regions it is very probable that a certain concentration of activities will endure and that impacts leading to even more fragmentation will persist. It is also probable, that green infrastructure measures will take place more often and that the legal framework will be strengthened in order to maintain a minimum of connectivity. Nevertheless, it is not realistic to think that the situation can be greatly improved with the restoration of a permeable landscape matrix as an option.

The Map 16 indicates the geographical localisation of the most important fragmented inner Alpine valleys.

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Conclusion

Presently, several inner Alpine valleys have almost no ecological connectivity with their surroundings. Through the implementation of specific measures and investments for biodiversity conservation and efforts from the local population to ensure a minimum of connectivity, these areas could still provide baseline ecological functionality. These areas along the Alpine valleys should not increase too much in size, and economic activities should be strictly limited in space.

5.5.2 Connectivity scenarios for areas retaining well-functioning connectivity – Ecological Conservation Areas

Areas with well-functioning ecological connectivity still exist in the Alps. These are mainly situated in rural and decentralised parts of the Alps. Conservation depends on their recognition as important patches of intact Alpine ecosystems. Pressure on these areas is increasing through the development of new infrastructure, increased land use through new forms of economic activities and/or changes in the social and cultural context of rural zones.

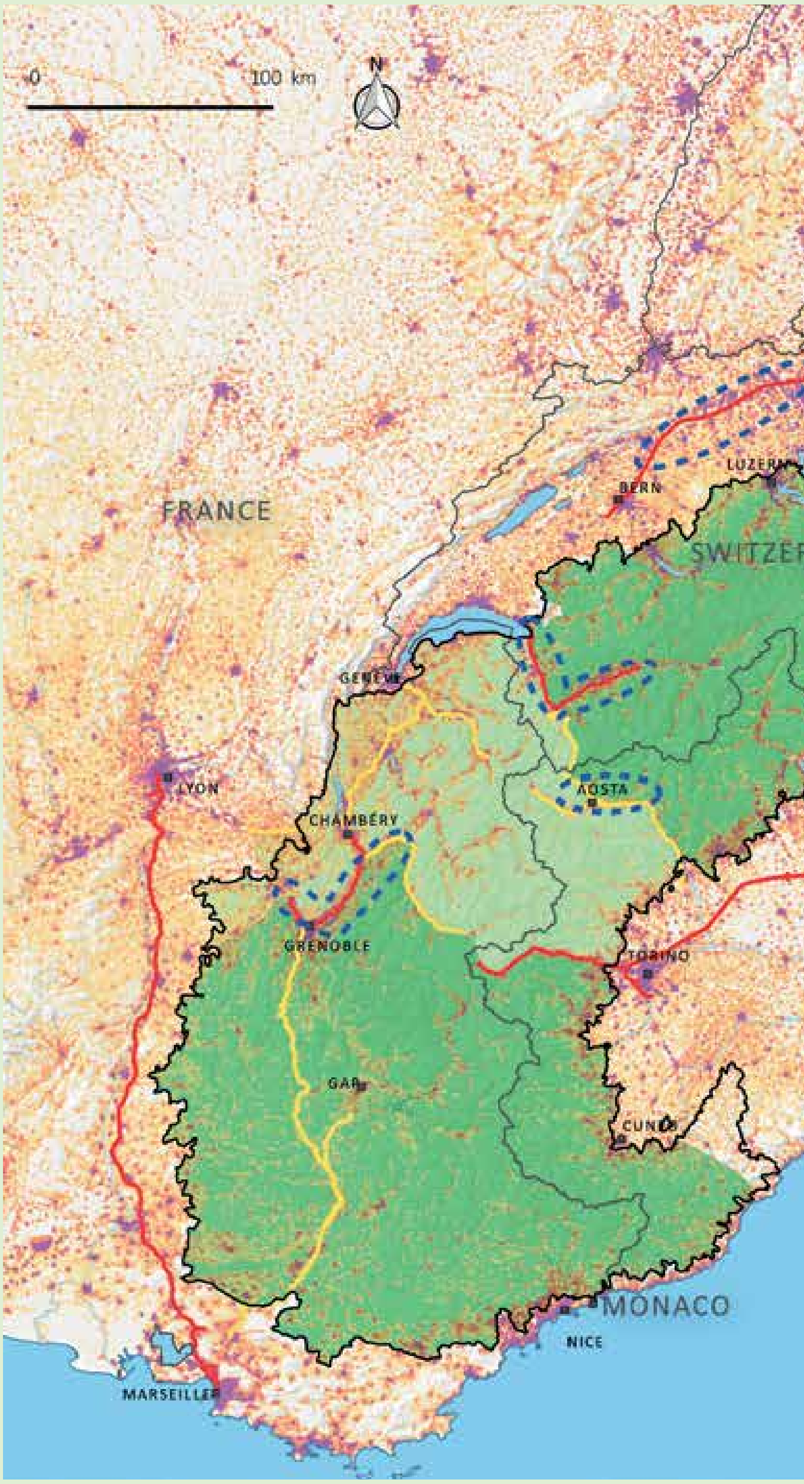
How to achieve positive developments

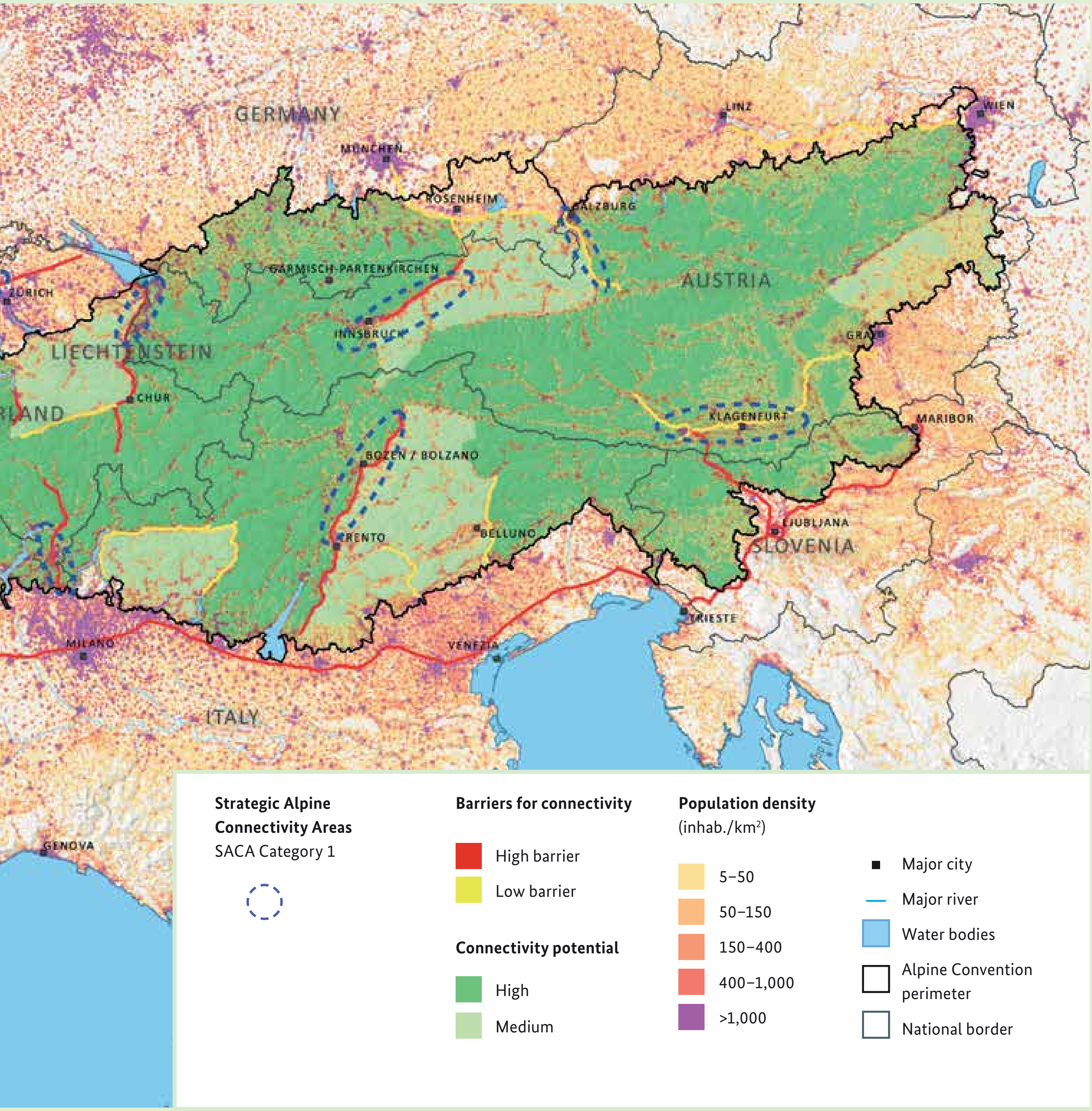
These categories of areas are still very prevalent in the Alpine space, but they are continuously being encroached upon, both spatially and in respect to their functionality. There is still time to act and to react to these slow and often hidden degrading developments.

Needs for the next years

The types of ecological conservation areas within the complete Alpine space is essential in order to develop specific strategies and adaptive implementation measures. The scale of these areas may be very different but is not necessarily correlated with the ecological value of such patches (for example small well-linked habitats may be very precious for some endemic species of Alpine flora or invertebrates, while large scale connected habitats of non-fragmented ecosystems are crucial for larger mammals such as red deer or lynx). The definition of ecological conservation areas depends on a multitude of factors, but a very general approach is to conserve large areas with an intact permeable landscape matrix. Strong conservation policies

Map 16: Strategic Alpine Connectivity Area (SACA) Category 1 – Ecological intervention areas





Source: ALPARC work on barriers and connectivity potential; Eurostat, EFGS for the population grid information; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

Table 11: Main factors influencing ecological connectivity in Ecological Conservation Areas in the coming decades – Active factors

	Active factors	Development and trends in the next decades	Impacts for the area in 2030
1	**Nature Protection Policy**	■ A well thought-out, custom-tailored conservation concept is applied to such areas in order to conserve their well-connected habitats	■ A high probability exists to conserve these intact areas
		■ No change in actual conservation policy	■ A high risk of alteration of these areas is probable, as present protection and conservation policies and legislation are not sufficient or not well-applied for the large scale conservation of these areas, since specific connectivity measures are mostly missing
		■ More space is given to new infrastructure and energy projects	■ Alteration and destruction of the last intact and functioning large scale connected habitats is very probable
2	**Social effects of demographic development**	■ Low, stable or rural exodus	■ No impact, no change in the situation
		■ Mid-level immigration due to attractiveness of landscapes close to urban centres	■ Most of the intact habitats are not impacted by this situation, only in conjunction with increased interest in leisure activities such as Alpine skiing, mountain biking, …
		■ High immigration especially into intact still functioning inter-connected habitats	■ Will impact the remnant well-connected areas with new infrastructure and settlements, high level of activities due to the attractiveness of landscapes and their leisure and recreation potential
3	**Economic development, industries**	■ No additional industrial infrastructure in rural Alpine areas	■ No impact on these intact well-functioning connectivity areas
		■ Limited new economic activities in areas with still intact natural spaces	■ Locally connectivity potentially disrupted if infrastructure fragments habitats
		■ New infrastructure and increased activities in rural and mountainous areas due to the attractiveness of the landscapes	■ Impact on several habitat connections and larger connected ecosystems
4	**Tourism**	■ Development of green tourism close to protected areas and adapted visitor management to preserve certain areas	■ Protection of still functioning ecologically linked habitats
		■ Limited development of tourism infrastructure on already existing sites	■ Separation of the Alps into ecologically precious patches and anthropogenically transformed patches
		■ Further 'disneyfication' of the Alps, increased space use and infrastructure deployment, ski stations in higher and more fragile regions due to global climate change	■ Threat for many regions in the Alps including intact sites with well-functioning ecosystems and ecological connectivity

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

	Active factors	Development and trends in the next decades	Impacts for the area in 2030
5	**Spatial Planning**	■ Spatial planning fully integrates ecological connectivity as a main feature in rural areas and an integral part of regional policies based on a robust legal framework	■ Spatial planning is an important tool in conservation policies in these areas and especially in the mid-altitudinal levels of the Alps where many category 2 SACAs are situated
		■ Spatial planning considers ecological connectivity but is not systematically implemented subsequent to impact assessments	■ Without implementation of compensation and mitigation measures from impact assessments, the risk of altering these areas persists
		■ No consideration of ecological connectivity in spatial planning	■ Areas with well-functioning connectivity are exposed to massive impacts by various infrastructure projects (mainly tourism, urban sprawl at mid-altitudinal levels)
6	**Agriculture and forestry**	■ Alpine specific agriculture and sustainable forestry are implemented and economically valorised, specific conservation areas are identified and preserved (also by non-use if necessary)	■ High chance of conserving ecological connectivity conservation areas
		■ Agriculture and forestry are Alpine specific and sustainable but lack concrete measures within connectivity areas	■ Impacts to these areas are limited but cannot be excluded
		■ Agriculture and forestry are impacted by unsustainable global economic discounting, while ignoring Alpine specific valorisation and constraints	■ High probability of degradation of ecological connectivity conservation areas
7	**Governance processes**	■ Local governance takes on the responsibility for the conservation of these areas	■ The identification and valorisation of these areas by the local populations enables long time conservation
		■ The ecological conservation areas are managed and protected by regional or -state authorities	■ A legal framework exists but the lack of local initiative and interest threatens the good management of these areas
		■ Policies and legislation are in place for the conservation of these areas but no local governance process has been initiated and identification is low	■ Without concrete measures and the involvement of local stakeholders in conservation measures these areas are highly threatened by alteration
8	**Alpine social and cultural framework**	■ The population of rural and decentralised areas in the Alps maintain and develop a profound understanding and identification with spaces of high natural value	■ Local population takes over responsibility for such areas and supports their conservation
		■ The social and cultural context will lose its consistency and lifestyle is more and more adapted to urban areas losing its link to the natural environment and processes	■ The understanding of the need of conservation may still exist but concrete measures and real local initiative is no longer ensured due to loss of management know-how
		■ The social and cultural context is lost while the economic situation worsens with local interests deferring conservation needs	■ Ecological conservation areas will be exposed to alteration due to a lack in understanding and valorisation

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

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for such areas are necessary, and need to be harmonised between the individual Alpine countries. The Alpine Convention constitutes a framework for such a coordinated approach, and the results from several EU-funded projects and analyses concerning ecological connectivity enable an initial knowledge-based procedure for the entire Alps. Another important aspect is that the selected areas must be well allocated in their spatial distribution in order to cover all important habitats and altitudinal levels. Conservation areas situated only at higher altitudes in the Alps are not sufficient and inherently lead to fragmentation at lower altitudes.

These ecological conservation areas can still be found in many parts of the Alps. Regions that are not fragmented by extensive infrastructure, important settlements, increased economic or industrial activities have more of these areas. Today it is important to create or implement existing legal frameworks to conserve these areas and to protect them from new threats.

Actions and measures employed

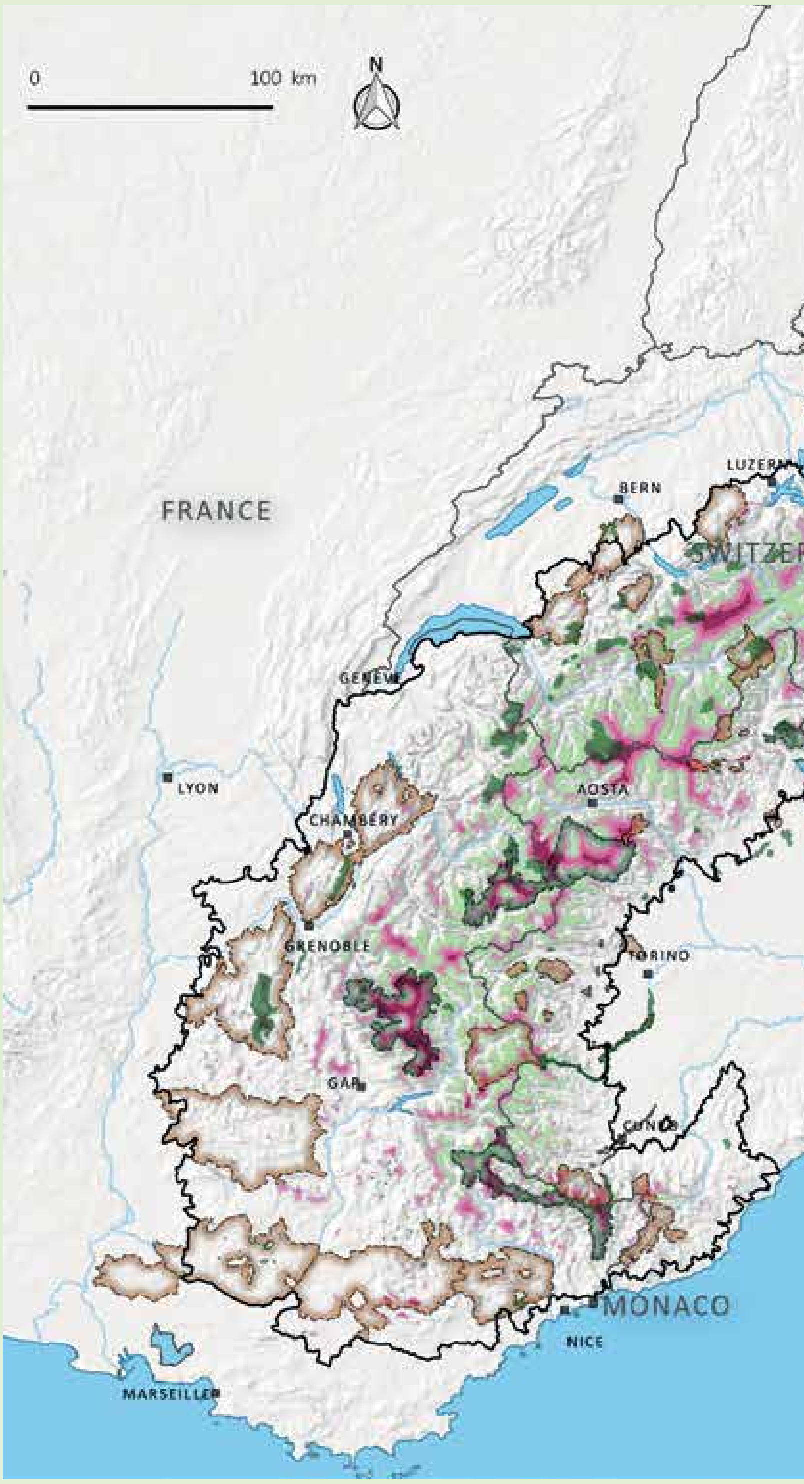
Concrete and coordinated action involving all relevant stakeholders should take place in order to proceed towards an efficient conservation strategy for these still well functioning areas.

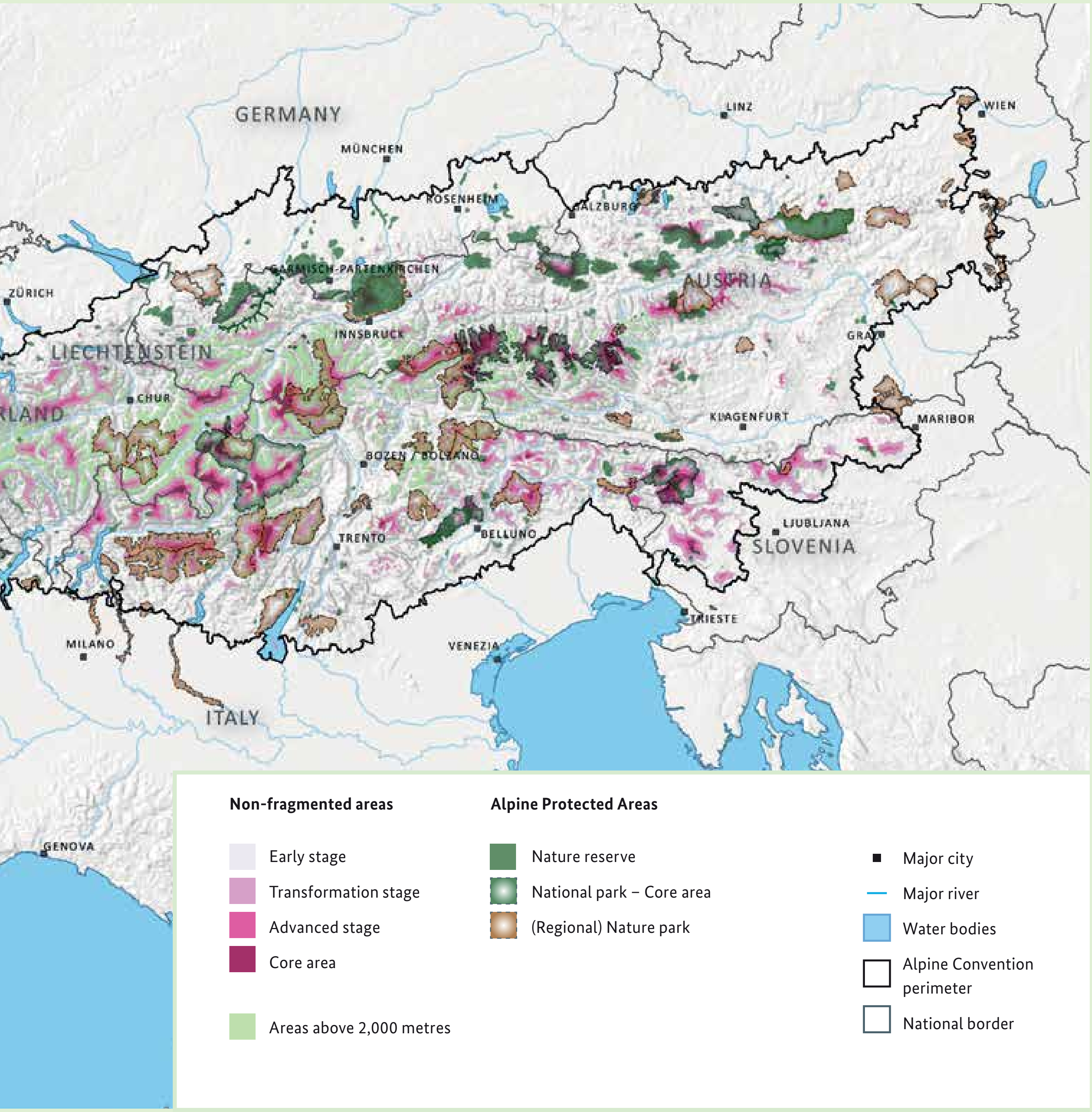
1. **Identification of the locations of well-functioning ecological connectivity areas**
   Indicators such as the demographic index of an area, surface area, habitat types, length of barriers, and edge density (vegetation) should allow identification and classification of the areas to be conserved by specifically adapted legislation and measures (see as well the indicators of the JECAMI tool, description in chapter 4.4). Map 17 shows that large areas are presently not fragmented. However, it also shows that many of these areas are in existing protected areas and/or at altitudes over 2,000 metres. This indicates that the role of these areas for Alpine connectivity is limited.

2. **Verification in situ**
   The identified sites must be visited, and an in-depth local evaluation involving experts and local stakeholder is crucial.

Example of measure:
Guided tours and information events: For the implementation of measures and thus the realisation of

Map 17: Non-fragmented areas and altitudinal level





Source: ALPARC, WWF, ISCAR, CIPRA for-non-fragmented areas; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

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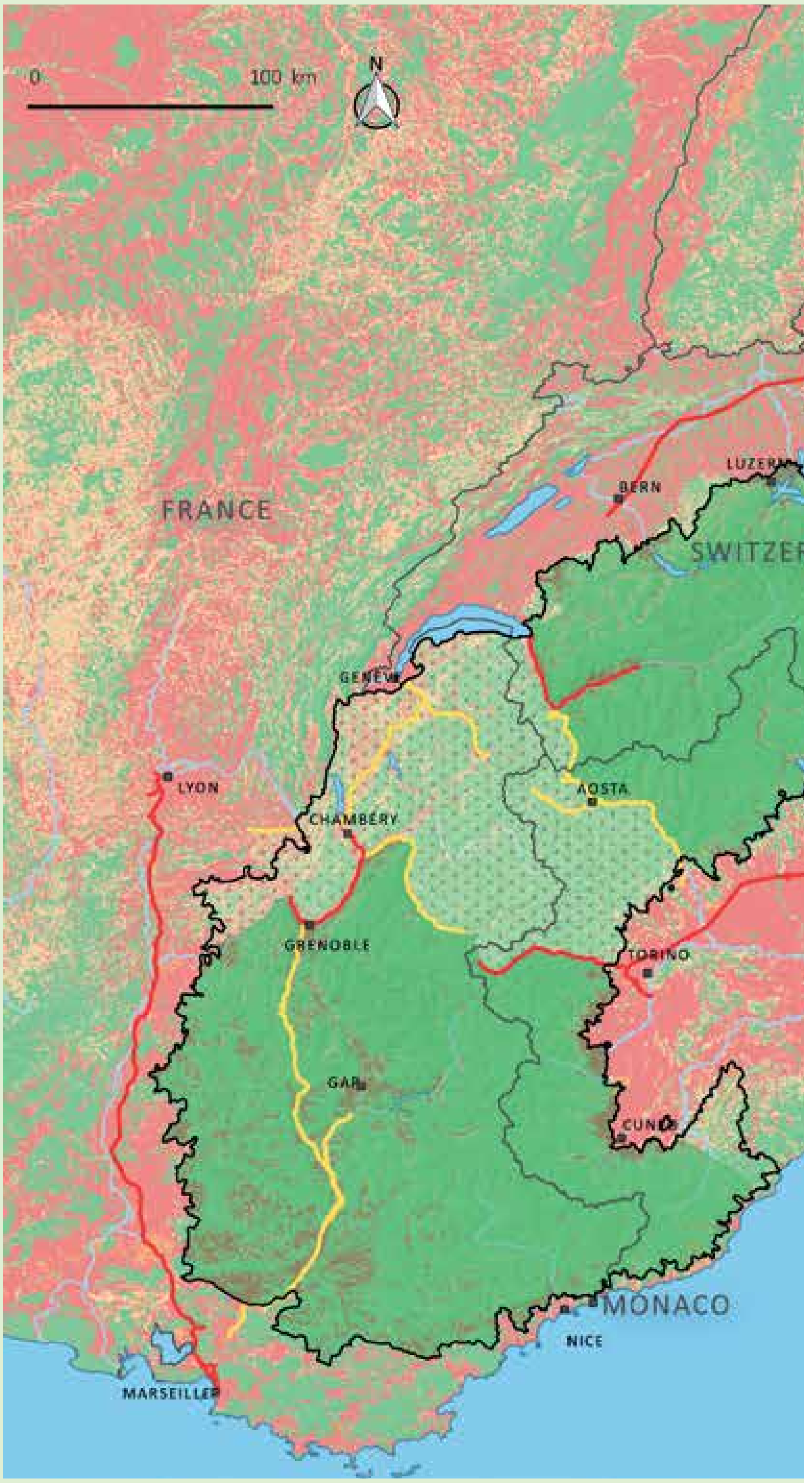
biotope network projects at the local level, spatial and landscape planners and municipal administrations have a role to play as key actors alongside the nature conservation organisations, which are often the driving forces behind biotope network projects. Local information events and guided tours with bi-directional exchange (to collect local knowledge) are a good way of informing these actors (as well as other stakeholders such as farmers, hunters and more) about the issue of biotope networks, and ecological connectivity and ways of realising them in practice. In order to ensure the success of these initiatives, it is important to prepare summary documentation (for example a manual with decision-making aids) and to present the benefits and value-addition that such projects can generate at a local level (for example multifunctionality of corridors, which are significant not only in ecological terms but also perform key social functions as spaces for leisure and recreation as well as economic functions, for example through the sustainable and non intensive management of roadside grass verges).

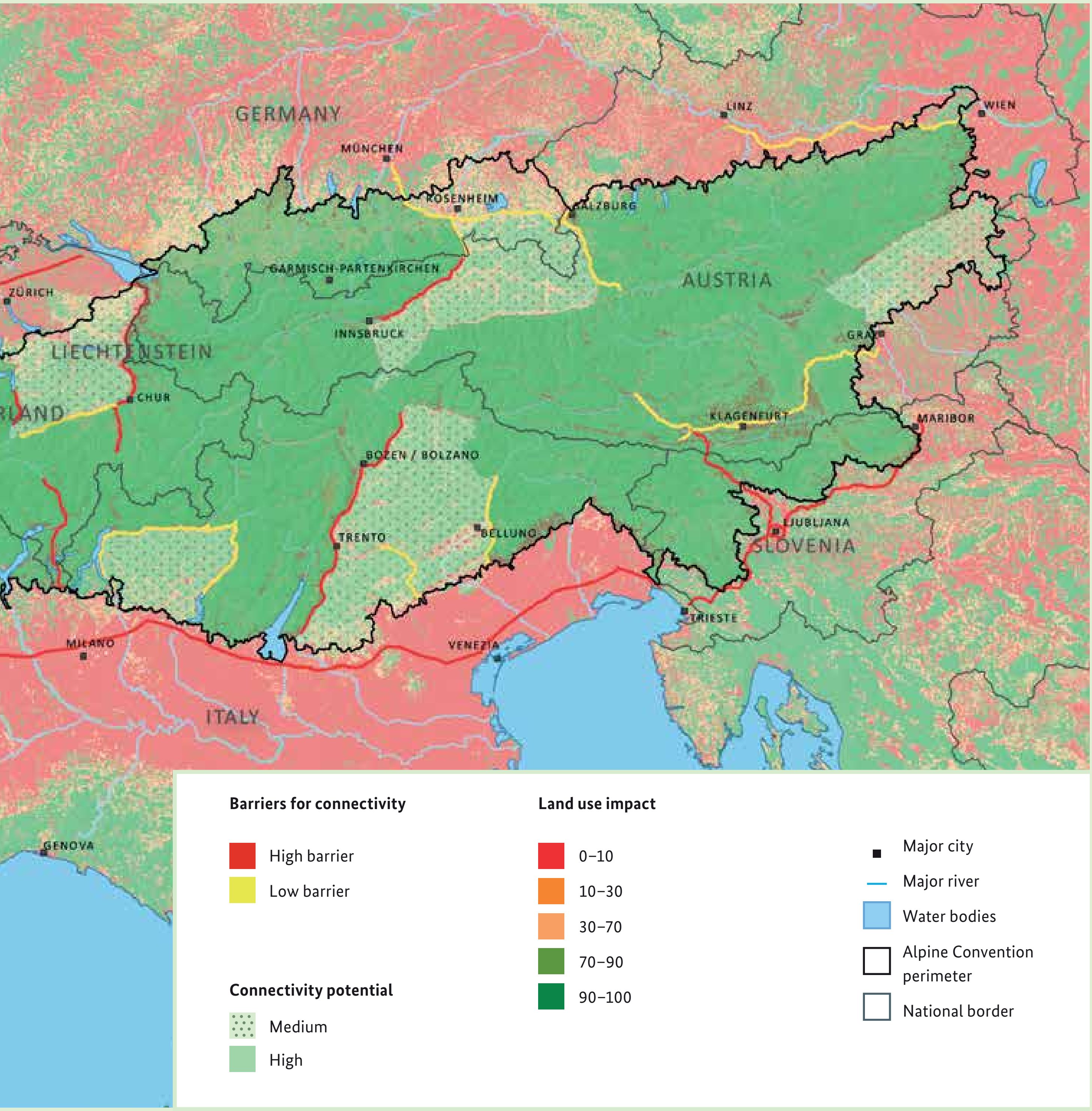
3. **Possible threats for the future needs to be identified**
   The impacts of current or future activities need to be analysed. A scenario of the future development of the area must be considered in order to define mitigation measures and legal frameworks as needed to prevent impacts from these threats.

4. **Local stakeholders need to be involved**
   Successful long-term conservation of these areas must integrate local stakeholders during the planning process and when implementing tools and measures. The political and social acceptance of the employed measures and land use constraints are vital to the final success of the strategy.

Example of measure:
Agreements on environmentally compatible practice of sports with sportspersons and associations: Many of the sports carried out in the natural environment can cause major disturbance and even the destruction of habitats. Mountain biking, paragliding, canoeing and climbing are just a few examples. In order to guarantee that sports are practised in a more environmentally compatible manner, agreements for sensitive areas can be reached with sports groups and associations. One example is the climbing strategy adopted by the German Alpine Association (DAV). Many rocky crags and rock faces provide refuge for rare and protected species of flora and fauna. To ensure that these unique biotopes are not

Map 18: Strategic Alpine Connectivity Area (SACA) Category 2 – Ecological conservation areas





Source: ALPARC work on barriers and connectivity potentials; Corine Land Cover European seamless 100 metre raster database (Version 18.5), European Environment Agency for land use impact on connectivity; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

damaged by climbers, strategies for environmentally compatible climbing are both useful and necessary. The package of measures adopted by the DAV on eco-friendly climbing involves working with public authorities and nature conservation organisations to develop climbing strategies. The DAV relies on a wide variety of solutions to identify, at a micro level, those areas where environmentally compatible climbing is possible and those where no climbing should take place in the interests of nature conservation. Uniform marking of crags, temporary closure of crags (or sections of them), and local wardens with responsibility for crags are just some of the key elements of these strategies.

5. **Restoration measures if necessary**
   In some cases it may be necessary to proceed locally with restoration measures to improve or to recreate connectivity. Such measures can include amongst others, restoration of rivers, restoration of open fields, and increasing the visibility of power lines.

Example of measure:
Management and maintenance of flowing waters: Near-natural flowing water systems are important connecting elements that make a substantial contribution to reducing fragmentation. In many cases, however, the space and financial resources required for the comprehensive revitalisation of obstructed rivers are not available. Nonetheless, upgrading can be achieved with near-natural, differentiated management concepts, which can be integrated into the legally prescribed management work along water bodies (flood protection). As part of this process, a holistic view should be taken of the embankments, riparian zones and water bodies, and adjacent green spaces (biotope network) should also be included. Appropriate maintenance measures include management of meadows and woodland (bank stabilisation), and regeneration in the areas of erosion. An individual management plan should be produced for each water body, clearly defining the development goals.

Biodiversity connectivity 2030

At a European level, goals for biodiversity were set for 2010 and missed, which makes a success in achieving the newly formulated goals for the Alps and the 2030 decade even more urgent. The challenge for 2030 consists in conserving, at all altitudinal levels, the numerous intact well-functioning areas with high ecological connectivity potential. Concrete measures and policies need to be implemented in the short term to achieve this goal. Connectivity measures on a local scale must be site and species specific.

One of such measures could be the restoration of wetlands. Wetland habitats are especially species-rich and are a dominant feature of the natural landscape structure in the Alpine region and the pre-Alps. Wetlands also provide a habitat for numerous rare and highly endangered species (for example the Azure Hawker [*Aeshna caerulea*]) and are therefore important elements of a biotope network. Wetland restoration measures can bring about an improvement in the hydrological regime of degraded wetlands and generally enhance habitat quality. Peat growth resumes in the rewetted areas, allowing an increase in typical wetland species. This also improves the function of wetlands as CO_2 sinks as water is stored, supporting the avoidance of and adaptation to climate change. Wetland restoration can include restoring natural structure by blocking drainage ditches, restoring natural function by changing land-use, and management measures such as the removal of tree and shrub cover.

Evaluation of the most realistic scenario

Map 18 shows large parts of the Alps that are still quite well connected (dark green) especially in comparison to the regions surrounding the Alps. Nevertheless, Alpine valleys systematically impact connectivity through human activities and infrastructure even if this not always immediately visible. Protected areas, at least those with a strong protection status, for the most part are situated at an average altitude above 1,500 metres, which limits potential connectivity. By implementing a coherent conservation policy and locally adapted measures to prevent additional fragmentation, there is a good chance to conserve connectivity in these areas for the next generations.

Conclusion

The Alps are still in a very favourable position to determine the future of a large number of ecologically well-connected areas. It is up to the current generation to ensure that this heritage still exists tomorrow. Active awareness-raising strategies directed towards local populations and stakeholders, valorisation and a coherent legal framework are needed to make the long-term conservation of these areas a reality.

5.5.3. Connectivity scenarios for areas with a high potential of connectivity – Ecological Potential Areas

The Alps still have a high number of large non-fragmented spaces, but these are mostly not sufficiently valorised. Indeed numerous protected areas, Natura 2000 sites and other precious biotopes and natural spaces are isolated from each other. With an active approach in identifying links and measures to create even larger non-fragmented spaces, the Alps could become one of the model regions of Europe for a functioning sustainable biodiversity conservation strategy.

How to achieve positive developments

Numerous protected areas and Natura 2000 sites as well as biotopes and other precious natural spaces have a high potential for connectivity. These areas are mostly situated in decentralised areas of the Alps. They are under less pressure than areas close to important urban centres and constitute important non-fragmented areas for biodiversity conservation and ecological connectivity between the different protected areas and biotopes.

Needs in the coming years

It will be crucial to make sure that nature protection policies in protected areas are not weakened during the next years due to ever-increasing economic pressure. Tendencies toward such a development can already be observed today. This is sometimes due to impacts and pressures and due to uncontrollable external factors (passive factors) such as those induced by climate change for example extension of ski resorts to higher altitudinal levels, often into fragile natural habitats, in order to provide skiing opportunities for the next decades.

The southern parts of the French Alps still shelter a number of large spaces showing a low degree of fragmentation.

Furthermore, the political legitimisation for the conservation or creation of protected areas increasingly employs arguments based on ecosystem services and economic benefit. These developments are in contradiction to the concept and philosophy of an intrinsic value of nature, which was painstakingly built up during the last decades, but remains fragile.

Beside technical and scientific procedures and measures in place, it is probably this aspect that is the most important to consider during the next years: ensuring that nature protection is valued as the essential basis of all human life.

Today the opportunity to save or to restore the last large Alpine connectivity areas through a coherent policy establishing links between important habitats, protected areas and more still exists, but a common vision on how to achieve this goal is needed (see next article). This is a unique chance that the "Alpine decision makers" need to implement now.

Actions and measures employed

To achieve these "Potential connectivity areas" it is necessary to act now. The following crucial steps can ensure the creation and protection of these large connected areas and could showcase the Alps as a role model in modern nature protection.

Identify potential connectivity areas
Several potential areas in the Alps already exist and can facilitate large-scale territories with a low fragmentation index. These areas need to be identified through adapted tools (JECAMI), expert knowledge and site visits involving all the relevant stakeholders. As in other SACA categories it is especially important to involve areas at all altitudinal levels. Map 19 shows protected areas and NATURA 2000 sites at all altitudinal levels as important elements for connectivity, often overlapped but also able to create links between each other. Map 20 shows that most of the defined

Table 12: Main factors influencing ecological connectivity in Ecological Potential Areas in the coming decades – Active factors

	Active factors	Development and trends in the next decades	Impacts for the area in 2030
1	**Nature Protection Policy**	■ Legal framework provides competences to protected areas to act beyond their territory. Strategies developed to link non-fragmented spaces to large territorial patches for the survival of wildlife in the Alps	■ Possibility to develop larger areas of non-fragmented habitats in order to maintain biodiversity for the next generations (ecological potential areas)
		■ Legal framework provides mediation and expertise functions to protected area managers outside of their territory	■ Limited possibility to achieve some contractual based links with special measures between two or more areas of non-fragmented habitats
		■ No change according to current legislation	■ Without a legal framework and more competences for the protected area managers or other (public) actors taking over a proactive part in connectivity conservation, the establishment of large Alpine non-fragmented areas does not seem realistic
2	**Social effects of demographic development**	■ No important change to the current situation	■ No impact or positive impact for the establishment of larger connected areas
		■ Polarisation of demographic migrations to different Alpine areas	■ May in some situations hinder the linkage between valuable natural spaces
		■ General increase of the Alpine population even in rural areas	■ A significant increase of the Alpine population in rural areas will make the establishment of large connected areas more difficult due to increased land-use conflicts and needs as well as increased infrastructure development (roads, energy, transports…)
3	**Economic development, industries**	■ Areas with sustainable land use activities, protected areas or Natura 2000 sites at all altitudinal levels	■ High potential for the creation of large ecological connectivity areas (ecological potential areas)
		■ Some concentrated economic development areas	■ Limited impacts on connectivity
		■ New industrial or intensive economic activities	■ Low probability of using the potential of connectivity in areas impacted by new industrial or economic development
4	**Tourism**	■ Potential connectivity areas are free from heavy infrastructure such as ski resorts and access roads to touristic sites	■ Good opportunity to link large non fragmented areas
		■ Very moderate touristic development based on the sustainable access to nature	■ The establishment of large areas with interconnected and non-fragmented habitats may be more difficult locally
		■ New touristic sites are developed in these areas with potential for connectivity	■ Limits the establishment of large connectivity areas

■ denotes an essentially positive development
■ represents a relatively stable/neutral development
■ signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

	Active factors	Development and trends in the next decades	Impacts for the area in 2030
5	**Spatial Planning**	🟩 Spatial planning integrates the need for the creation of such areas; if possible in a transboundary context	🟩 High probability to create new areas which are not fragmented by heavy infra-structure, energy or transport systems
		🟨 Land use conflicts in lower areas exclude the creation of large scale connected areas	🟨 Negotiations and special solutions for the valleys separating spaces which should be linked have to be found
		🟥 Spatial planning does not consider conserving these areas	🟥 Land use conflicts and diverging interests hinder the establishment of large con-nectivity areas
6	**Agriculture and forestry**	🟩 No intensive agriculture or forestry in low and mid-altitudes, pastures based on extensive grassland farming	🟩 No obstacle to the enhancement of eco-logical connectivity by large connected areas with high ecological value
		🟨 Specific agro-environmental and forestry measures are part of the CAP and can be concluded with local farmers and foresters.	🟨 Continuous negotiations necessary to maintain large connected areas probably by compensation measures
		🟥 Intensive use of agriculture and forestry at all altitudes	🟥 Real obstacle to the creation of connec-tivity potential areas
7	**Governance processes**	🟩 Local population and all relevant eco-nomic stakeholders and NGOs are in-volved in ecological projects and have a good understanding and identification with the need for ecological connectivity	🟩 This is the main factor for successful implementation of connectivity potential areas
		🟨 Population and stakeholders are informed and can express opinions but cannot participate in decision processes	🟨 Probably difficult to mobilise the public opinion in a sustainable way in favour of ecological connectivity
		🟥 No specific governance process	🟥 High risk of numerous legal conflicts, extensive and long procedures risking compromise in the implementation of connectivity potential areas
8	**Alpine social and cultural framework**	🟩 Strong identification of the Alpine popu-lation with their natural environment; strong will to conserve their natural heritage for the future generations	🟩 Excellent base for the improvement of conservation of biodiversity and the creation of high value connected areas
		🟨 Alpine demographic evolution leads to more and more urbanisation and con-centration and decreased identification with natural values	🟨 Important to "reconnect" people with their environment if ecological projects are to be successful
		🟥 Urbanisation and demographic develop-ment leads to a "banalisation" of the Alpine space in the mind of the resident population	🟥 Without a strong identification with the natural and cultural values of the Alps by the population, biodiversity conservation and connectivity will be difficult to imple-ment

🟩 denotes an essentially positive development
🟨 represents a relatively stable/neutral development
🟥 signifies a problematic progression concerning ecological connectivity

Source: Guido Plassmann, 2016

Natura 2000 sites are higher than 1,500 metres, which means that their role as linking elements is is limited, as connectivity is especially needed at lower altitudes, where most land-use conflicts are observed.

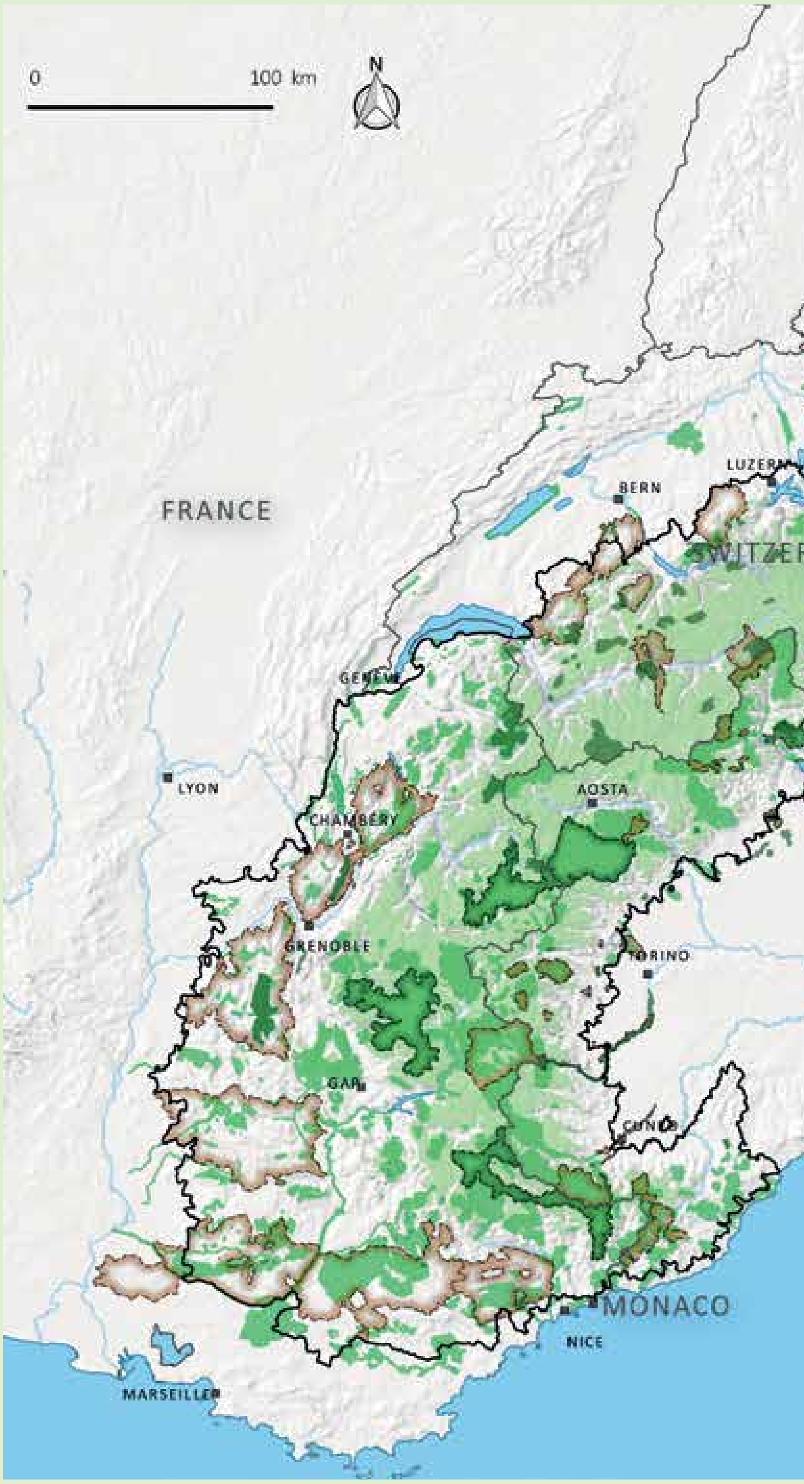
1. **Identify land use practices and potential links between concerned areas**
   More intensively used valleys often interrupt connections between areas whose value would be enhanced by linkage or intermediary spaces such pastures or touristic areas extending from the valley to the middle altitudinal level. The identification of possible links (or corridors) is essential to evaluate the possibility for establishment of larger connected areas. Similarly it is crucial to evaluate the compatibility of their land-use with the goal of connectivity or wildlife corridors.

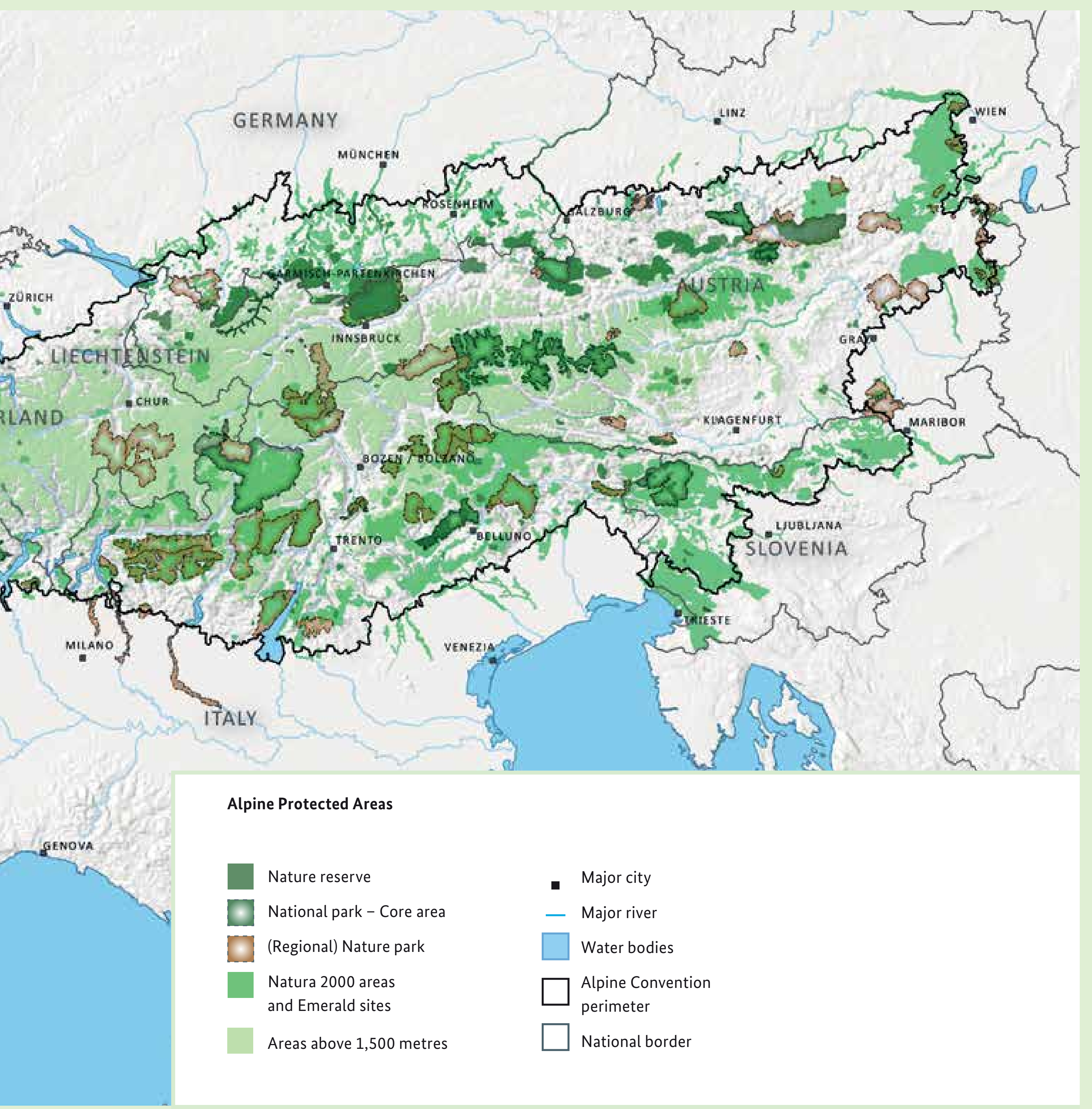
Example of measure:
Maintenance and restoration of traditional irrigation systems: As early as the Middle Ages, complex irrigation systems were created in various Alpine regions with low precipitation, in order to bring water from the mountains to the farmed areas in the valleys, often some distance away. These artificial water transportation systems, frequently many kilometres in length (for example the "suonen" channels in Valais, Switzerland, the "acquedotti" in Val di Non (Trentino/Italy) and the "waale" in South Tyrol) are important landscape features with great significance for various associated habitats (lines of trees, mosaics of wet, semi-dry and dry sites). The conservation, restoration and maintenance of these elements are supported on a project basis or through the payment of maintenance premiums.

2. **Determine land ownership**
   An essential factor is, of course, land ownership of concerned spaces. Negotiations need to be conducted in most cases, and compensation measures need to be proposed. New models of land pooling (for example from compensation measures) in municipalities or at regional level should be taken into consideration. Exceptions are some state owned territories.

Example of measure:
Connectivity measures with support from church-owned land: The churches are important owners of land and farmland that are also suitable for the creation of a network of interlinked biotopes, and they can thus serve as an important partner in the planning of biotope network measures. If the church backs the

Map 19: Alpine Protected Areas, Natura 2000/ Emerald sites and altitudinal level





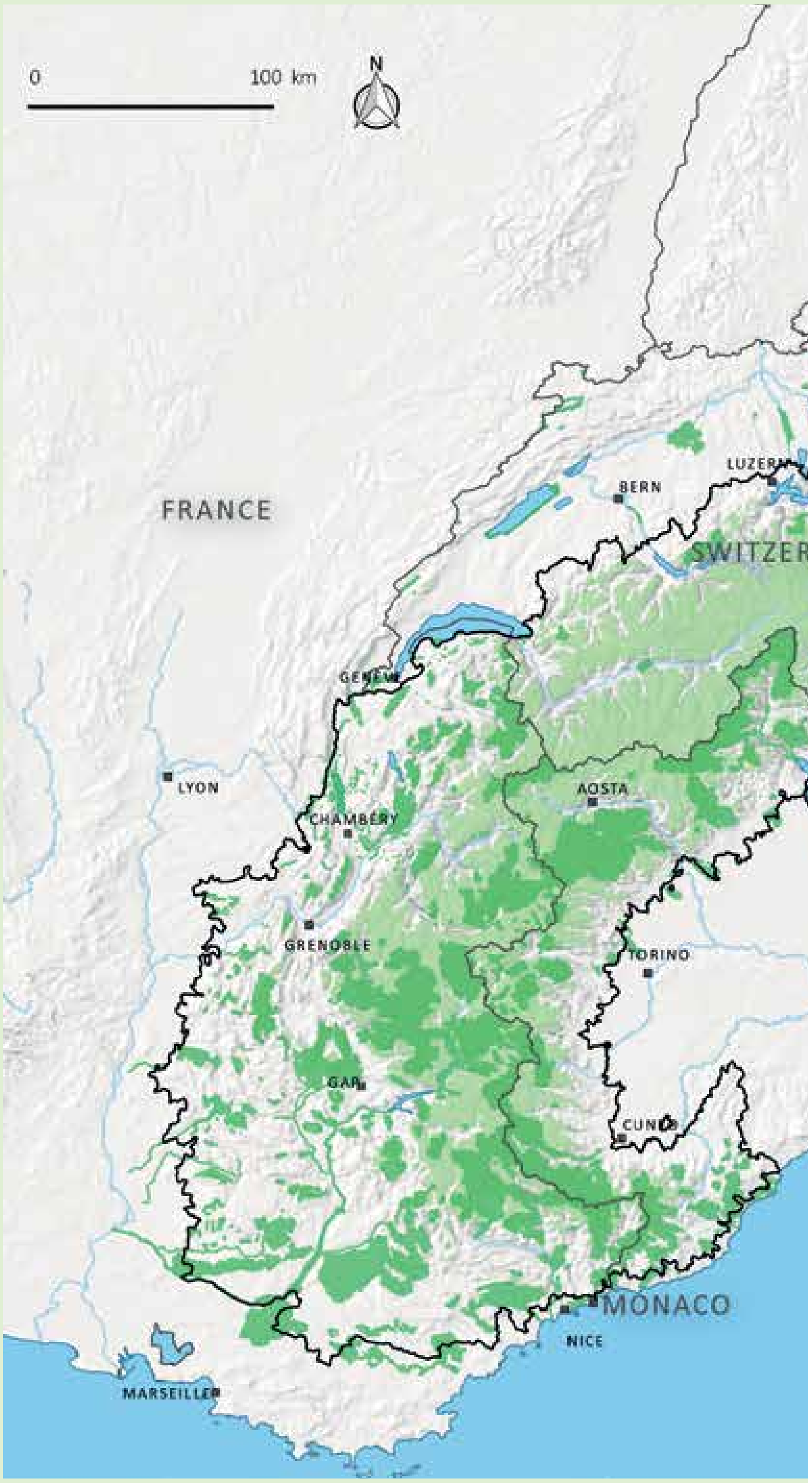
Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); European Environment Agency for land use impact on connectivity; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: This map makes no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

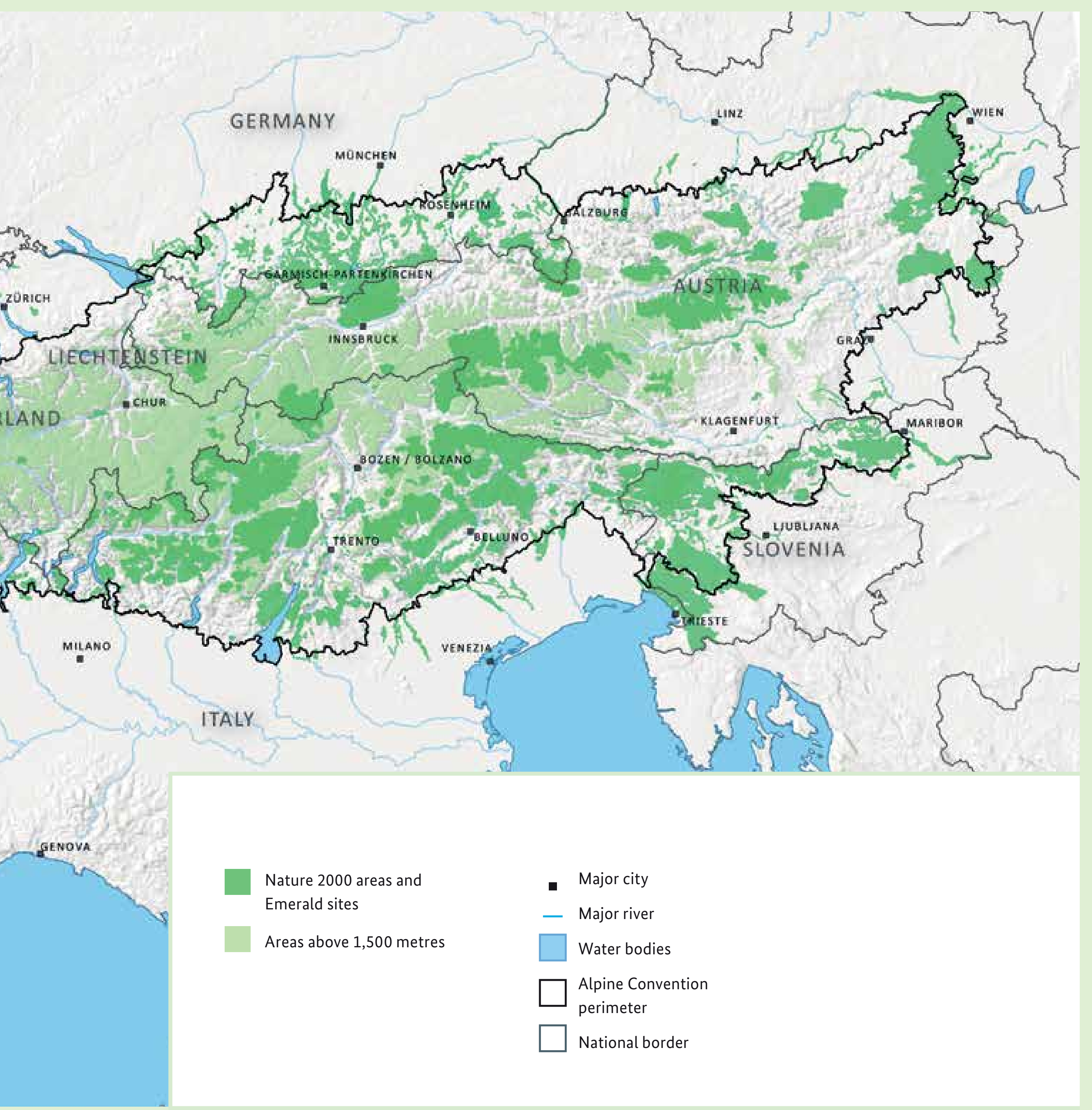
development of a biotope network and works actively to ensure that appropriate measures are implemented on its property, the tenants can also be sensitised to the importance of the biotope network, and the tenancies are then linked to the implementation of relevant measures. In order to increase acceptance of the biotope network and plan appropriate measures, the planning process should involve as many different stakeholders as possible (besides church workers, this should include nature conservation experts, local community representatives, farmers and more). Appropriate public relations work can be used to encourage similar initiatives in other regions.

3. **Analyse the possibilities and links for potential areas**
   Different measures and methods lead to the creation of potential connectivity areas. This includes the creation of corridors for wildlife migration, special methods of agriculture and forestry that allow species migration during the most important seasons, the creation of "stepping stones" (small adapted habitats) where species can "make a break", feeling safe and secure during their migrations, or last but not least the extension of existing protected areas. The implementation of all these measures is primarily a question of their social, economic and political acceptance. Every situation is specific and needs people who take care as well as adapted tools, procedures and solutions. Common to all is that every case needs political negotiation and ultimately buy-in.

Example of measure:
Planting of individual trees or tree groups: Individual trees and small tree groups are a key element of the landscape and have high ecological significance. They provide habitats and refuge for many different animal species and are therefore valuable stepping-stones in the biotope network. They also enrich the appearance of the landscape (for example by visually enhancing large areas of farmland) and increase its recreational value (for example by providing shade for seating areas). Due to their cultural and historical value as well (for example as symbols of peace, or where they had a role in the execution of justice), individual trees have landscape significance. Old trees in particular should be preserved in farmland; one reason being that their cavities provide particularly valuable micro-habitats. The planting of new trees should also be supported. Trees with a trunk circumference of at least 12 to

Map 20: Natura 2000 and Emerald sites above 1,500 metres





Source: European Environment Agency for Natura 2000 areas and Emerald sites; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: This map makes no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

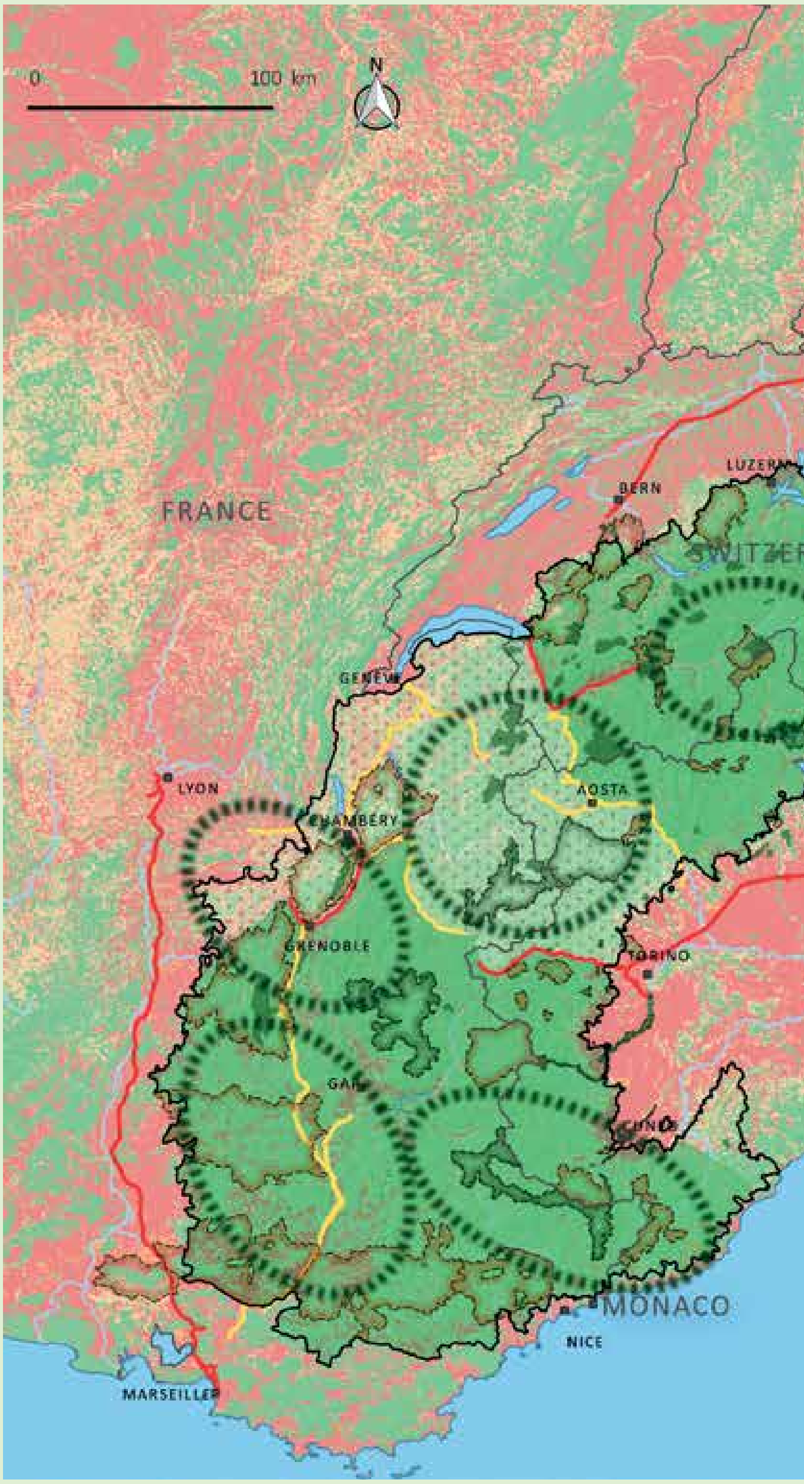
14 centimetres should be planted, and should be well-adapted to the chosen site.

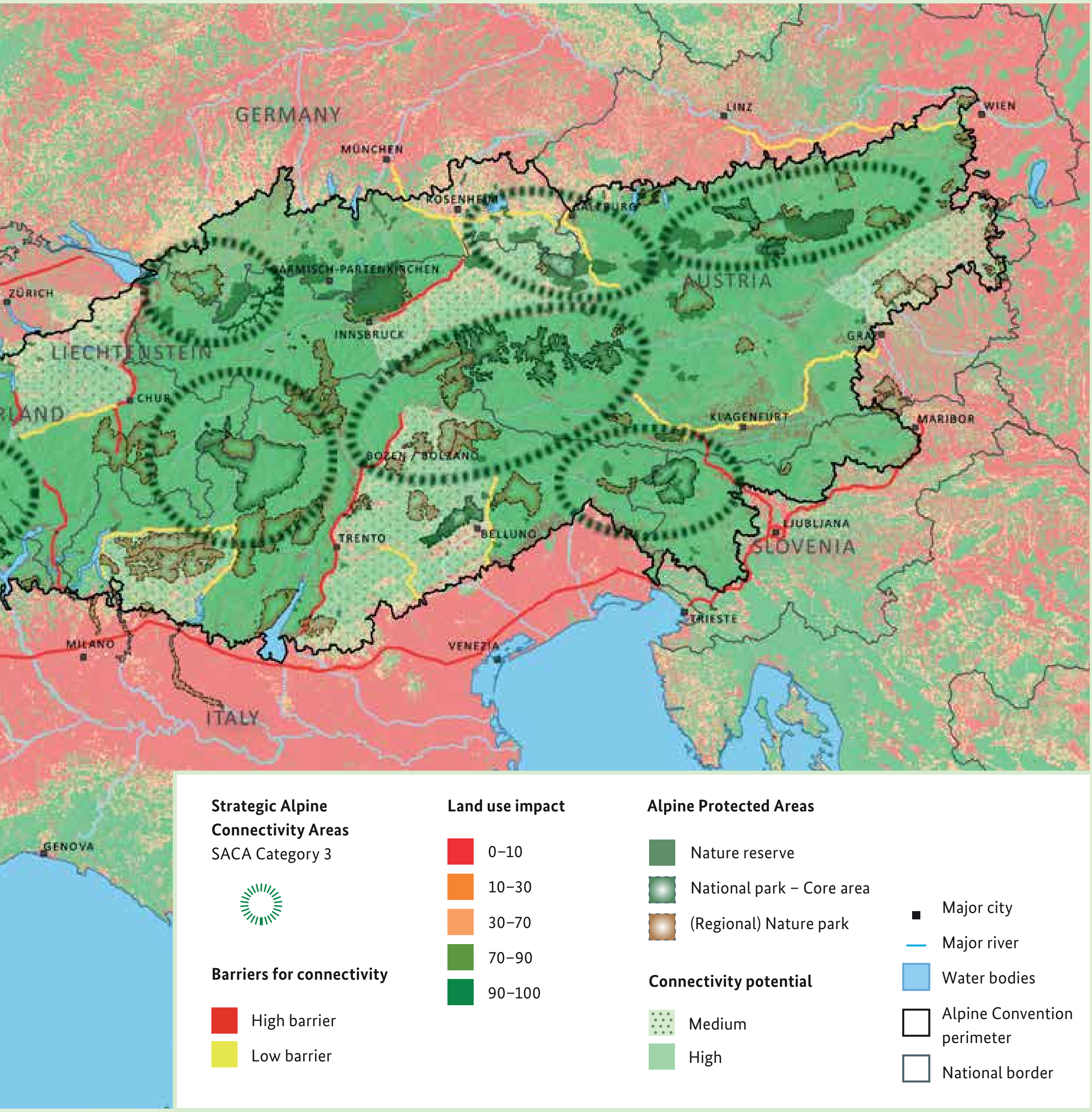
4. **Involve local stakeholders in long term management and monitoring**
   In light of the previous statements, it is evident that all relevant local stakeholders and decision makers need to be involved from the onset. To learn about intentions of connectivity or "another" land use from external sources will alienate local stakeholders and engender mistrust in every project. Local stakeholders are also needed for the long term monitoring of the success of connectivity measures.

Example of measure:
Volunteer programmes: Some providers offer various target groups (for example families, companies, schools and private individuals) the opportunity to undertake voluntary work in the ecological sphere (for example in woodlands). Participants thus make an active contribution to forest, climate and species protection while gaining a very intensive experience of the ecosystem at the same time. The purpose of the volunteering is to improve habitat quality at specific project sites. Relevant programmes also inform the volunteers about connections within the various habitats and make a contribution to sensitisation and awareness-raising. Focusing measures on the creation of a biotope network is an option in this context. Cooperation through current "corporate social responsibility" initiatives also helps to raise environmental awareness and increase knowledge of the importance of connectivity measures in an up-to-date way while drawing attention to the problems arising in this context.

5. **Involve all relevant political levels**
   From the very beginning on, the different political levels need to be involved. This may concern mainly ministries on the national level, regional authorities competent for protected area management and local level administrations for the management of nature reserves for example according to the legal framework of the different Alpine countries. An important partner for the issue of connectivity is the Alpine Convention. Its legal framework has the level of an international treaty, and the protocols, if ratified, are binding (in all Alpine countries except Switzerland). The creation of ecological connectivity is clearly laid-down in one of the articles of the Convention (article 12 of the Nature Protection Protocol).

Map 21: Strategic Alpine Connectivity Area (SACA)
Category 3 – Ecological potential areas





Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine protected areas (> 100 hectare); ALPARC work on barriers and connectivity potentials; Corine Land Cover European seamless 100 metre raster database (Version 18.5), European Environment Agency for land use impact on connectivity; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: This map makes no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

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Example of measure:
Preparation of Natura 2000 management plans: Natura 2000 is the EU-wide network of protected areas intended to preserve the endangered habitats and species in the EU. It comprises the protected areas defined in Council Directive 2009/147/EC (former Directive 79/409/EEC), on the conservation of wild birds (Birds Directive) and in Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive), and aims to build a coherent ecological network. Binding provisions apply to the implementation of Natura 2000, including a requirement to produce management plans defining mandatory conservation measures for the area in question. The plans consist of a basic part and a section containing relevant measures, which describes which species and habitat types contribute to the specific ecological value of the area and the conservation objectives that this creates for the area concerned. This generates an obligation to maintain and where appropriate develop connecting features of the landscape with a view to improving the ecological coherence of the Natura 2000 network (Articles 3 and 10). Member states are also required to take measures to improve the connectivity of the Natura 2000 areas outside these areas themselves (Article 10).

6. **Generate "publicity" for successful models**
   Functioning examples of connectivity should be used to make "publicity"; it is the most likely way to convince stakeholders, individuals and populations that "things can work" without massive land use or personal freedom constraints. The use of "witnesses" is interesting in this context and can accelerate processes for the establishment of more Alpine connectivity.

Biodiversity connectivity 2030

The challenge for 2030 consists in the creation of large-scale connectivity areas as main pillars of Alpine biodiversity. This 'designation' definitely needs to occur in the coming years. On a political level, the situation would rapidly enable the necessary processes (including cooperation between Alpine Convention and EUSALP). The possibilities of selecting potential areas in the Alps are numerous; the objective to create several large scale connectivity areas in all Alpine countries is not utopic. A certain number of such areas can be identified very quickly.

Evaluation of the most realistic scenario

The creation of these potential areas depends on political will more than on physical possibilities and opportunities. It is realistic that 2030 will see the creation of several such areas if concepts are convincing and if the negotiation process with local stakeholders and decision makers in each of the areas is successful. These areas would be part of Europeans Green Infrastructure. The legal statuses may be varied; compensation measures may be needed. In the most opportune cases, these areas should become property of the state or region managing them.

Map 21 indicates potential connectivity areas that should be analysed for feasibility. A tight cooperation with the Alpine Convention is recommended.

5.5.4 Conclusion statement

The perception of biodiversity's intrinsic value as a good in and of itself, as something that should be protected for its own sake and not just for its utility to humans leads some to reject the ideas that an ecosystem services approach could be the key to protection biodiversity (greenAlps, 2014).

Even if the intrinsic value of nature is beyond any doubt, such an ecosystem service approach could allow acceleration of the process of creating large connected areas by increasing financial resources in order to implement measures including compensation payments for the abandonment of some land use practices in favour of habitat and species protection.

5.5.5 The macro-regional context

As Map 14 shows, the most important barriers for the Alps are those surrounding them. The real challenges are the outer Alpine barriers. This is particularly true in the plains around the Alps. The plains of the Po River (Italy) and the Rhône River (France) are fragmented mainly by their important infrastructures, monocultures (agriculture) and traffic (links to and from the Alps or skirting the mountain massif). Important migration routes are cut by these barriers (see article 5.4).

The current European Macro-Regional process and strategy for the Alpine Space (EUSALP), which was initiated some years ago, provides a real opportunity to improve the situation of fragmentation around the

Alps. A special "Action Group" (Action Group 7) is presently dealing with this issue and attempting to develop strategies for all Alpine countries to attain a more permeable landscape matrix in and around the mountain massif. These actions will insure movements to and from the Alps. Particular attention is given by the Action Group to the surrounding metropolitan areas and their Green Infrastructure concepts to spatially intersect with Alpine ecosystems and territories.

Together with the Platform Ecological Network of the Alpine Convention there is an institutional and political acknowledgement of the importance of the topic. Both official groups are cooperating and will ensure a coherent approach between inner Alpine connectivity strategies and those within the entire Macro-Region. At a political level, ecological connectivity today is recognised as a major pillar of biodiversity conservation. This provides opportunities to use this momentum to stimulate decisive further steps towards achieving the described goals for biodiversity conservation until 2030.

It seems crucial that the macro-regional context is considered systematically when analysing ecological connectivity in the direction of large connected areas within the Alps. Similarly all large connected inner-Alpine areas (potential connectivity areas) must take the spatial links to habitats and ecosystems surrounding the Alps into account.

5.5.6 Recommendations for future biodiversity and connectivity policy

The following recommendations are given in light of the described scenarios:

- Ecological connectivity is a long-term project and one important pillar of nature protection.
- Policies and measures need to be adapted to different kinds of areas (ecological intervention areas, ecological conservation areas, ecological potential areas) in order to be efficient and feasible.
- It is important that all current nature protection policies and especially those strategies related to ecological connectivity anticipate and integrate future economic developments. This includes amongst others transport and infrastructure development, new technologies, industrial production and their potential location. Furthermore it is essential to adopt a long-term perspective that also

The provision of clean water is an important ecosystem service of Alpine areas. An ecosystem service approach could be one way to increase financial resources to finance the implementation of ecological connectivity measures.

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incorporates social and cultural evolutions in civil society.

- Every Alpine country must ensure the scientific knowledge basis for habitat and species protection by performing systematic assessments and monitoring activities. The results must feed into a transnational knowledge data repository.
- Analyses concerning the efficiency of measures for ecological connectivity and their spatial localisation help to rapidly reach the goal of a permeable landscape matrix for the Alps.
- Simulation tools allow the definition of potential areas of connectivity, but nevertheless site visits and ground truthing remain crucial for reliable outcomes.
- Stakeholder and decision makers must be involved in the entire process from the onset.
- The work with Pilot Regions is a fundamental key to success. Pilot Regions play the role of models and are references for an Alps-wide connectivity policy.
- Highlighting the possible benefits of ecological connectivity measures in the frame of green economy will improve acceptance by stakeholders.
- Every measure in favour of ecological connectivity needs to be integrated into a clearly communicated and transparent strategy of connectivity projects or planning in order to guarantee maximum effectiveness and support from local stakeholders.
- Ecological connectivity is a transdisciplinary topic that can facilitate the discussion with stakeholders and allow them to address various subjects like climate change, sustainable production and consumption, governance, and more.
- In a mountain massif like the Alps, an international approach to this topic and close transboundary cooperation is essential for success.
- Exchange mechanisms of existing instruments should be intensively employed and enforced in order to concentrate manpower, means and funds to implement projects and measures.
- The Alps cannot be considered without their surroundings. In the context of biodiversity conservation, the Alps are not an isolated functioning landscape. The highest fragmentation actually occurs around the Alps. Measures to mitigate the progression towards an isolated “Alps-Island” situation in a sea of hyper-developed anthropogenic lands must be actively pursued.

Example of a specific connectivity measure: overpath for the hazel dormouse (Muscardinus avellanarius) in Switzerland.

The described scenarios may be more or less realistic, but they indicate possible trends and allow for the timely reflection and subsequent adaption of policies so long as the decision makers act in a prompt and proactive way.

5.6 Conclusions and recommendations: Steps to undertake until 2030 – The Alpine Ecological Vision 2030

// Chris WALZER //
Conservation Medicine Unit, Research Institute of Wildlife Ecology, Department of Integrative Ecology and Evolution, University of Veterinary Medicine, Vienna, Austria

// Guido PLASSMANN //
// Yann KOHLER //
Alpine Network of Protected Areas ALPARC, Chambéry, France

// Marianne BADURA //
blue! advancing european projects GbR – consulting&engineering, Munich, Germany

Understanding, containing and mitigating the threats to Alpine biodiversity, ecological connectivity and the provision of ecosystem services are international imperatives. They necessitate a common and cohesive reaction to the emerging threats with the efficient dissemination of knowledge and methodologies across sectoral and disciplinary boundaries. The Alps are most probably the wealthiest mountain range in the world, and they offer examples and efforts that can provide a model for other mountain ranges and their surrounding environments. Here we delineate a number of future steps that appear indispensable when addressing these threats.

5.6.1 Develop an integrated, trans-sectoral landscape vision for the Alps

Alpine landscapes are highly diverse, featuring a multitude of ecosystems and providing habitats for many different species. Human settlements, infrastructure and activities are increasingly fragmenting Alpine landscapes, especially in valleys and at mid-altitude. This fragmentation is contributing towards a loss of natural habitats and the connections between them, resulting in a gradual degradation of ecosystems and a loss of biodiversity and ecological function. Since ecological connectivity is of key importance for ecosystem function, which in turn is the basis for human wellbeing, integrated landscape-level planning is essential at a national, provincial and local government level.

Planning processes must be based on sound and systematic scientific information concerning ecosystems and species with assessments carried out in every country of the Alpine arch. These planning processes must assimilate and integrate the conservation of biodiversity and the protection and enhancement of ecological connectivity as priority concerns. Valuing biodiversity, connectivity and ecosystem services should be given the same priority as economic growth in regional planning processes. Currently, while there are numerous individual, localised measures, no overall guiding and accepted future vision for strategic landscape planning in the Alps exists.

These authors recommend that policy makers from Alpine Space countries participate in a process of developing a common, guiding, integrated, trans-sectoral landscape vision for the Alps in 2030 and beyond. This vision should be based on existing biodiversity policies and strategies, both at the EU level and at a national and provincial level, but it must be supplemented with concrete operational action plans that will guide future ground-level implementation.

5.6.2 Migrate from practices that require compensation for environmental damage to the valuation of and payment for ecosystem services

The rich biodiversity and ecological functions of the diverse ecosystems found in the Alps are the basis for the wellbeing of the individuals and populations living in the region and beyond. Also termed ecosystem services, many of these functions are currently taken for granted or insufficiently appreciated and valued. Marked efforts have been made in the past decades to determine the total economic value of ecosystems, including use and non-use values.

The concept of paying for ecosystem services has recently become a point of discussion in both academic and policy circles. At the interface between science and policy, the 2012 study on the Economics of Ecosystems and Biodiversity (TEEB) provided an impetus for European countries to assess the value of their ecosystem services. Several such assessments are currently underway. However, the principal focus within the EU and its member states is on economic growth, even within the realm of a "green" economy. The value of ecosystem services, and especially their value to future generations, tends to be grossly discounted. This leads to compensation for damages resulting from economic activities that disregard the inherent scarcity of the resource: "natural area".

These authors recommend exploring and subsequently implementing ecosystem services (ESS)-based approaches to provide a new impetus for trans-sectoral collaboration. We recommend the approach be further explored through ground-truthed assessments and valuations of ecosystems and their services, with the clear long-term goal of protecting and improving ecological connectivity. Initiatives in this field should by default be cross- sectoral and include stakeholders from diverse interest groups. Furthermore, in order to be successfully implemented, ecosystem services-based approaches must be an integral part of economic policy, development and trading while engendering benefits for local stakeholders (for example landowners). It is essential to clearly understand that the ESS approach can only depict and value a fraction of the benefits we incur from the environment. Therefore ESS can only constitute the initial basis for a holistic valuation process that necessarily incorporates additional welfare values. A case-in-point is the ongoing evaluation of the LIFE programme at the behest of the EU Commission, which does not sufficiently consider and value other welfare benefits from intact environments.

5.6.3 Ensure trans-sectoral implementation of ecological connectivity measures

Connecting areas between intact wildlife habitats are composed of a matrix of land-cover types in a multi-use landscape. These include agricultural lands, patches occupied by industrial complexes or settlements, and those with no special protection status or defined use. Key sectors that have an interest in and potential impact on the functioning of ecosystems (environment, agriculture, forestry, fisheries, energy, transport, construction, tourism and spatial/land-use planning) often have conflicting goals. The objectives of stakeholders from these areas do not usually include the improvement of ecological connectivity and may actually be opposed to it. Settlement areas, for example, are focused on the quality of the living space for inhabitants.

However, housing projects built in key areas for ecological connectivity will disturb or obstruct the movement of animals and plants. Representatives of sectors other than nature conservation are regularly unaware of the importance of ecological connectivity in protecting and maintaining biodiversity. They are not aware of the fact that their decisions will potentially either support or obstruct the movement of flora and fauna. Yet potential synergies between these sectors and the nature conservation sector exist and should be further exploited. The implementation of ecological connectivity measures requires understanding and support from the representatives of these diverse sectors.

These authors recommend that environmental conservationists, practitioners and scientists "translate" the concept of ecological connectivity into a language that can be understood by other sectors. Some work has previously been carried out at a global level and could be adapted to the Alpine context. The benefits obtained from functioning ecosystems are an important aspect in communication relating to ecological connectivity. In order to achieve this goal, additional manpower is needed at all administrative levels.

This could mean that nature protection departments or new 'biodiversity task forces' must be enabled and politically supported. These units must operate proactively beyond the present-day practice of merely commenting on environmental impacts and progress towards the sectoral integration of biodiversity conservation. An obvious link between these varied activities in disparate sectors is spatial planning. An integrated spatial planning process could guarantee that biodiversity and ecological connectivity do not fall victim to individual or specific sectoral interests.

5.6.4 Ensure project results are visible and given due consideration in EU policies and strategies

European cooperative projects and their results substantially contribute towards achieving European goals. They serve as laboratories for developing trans-sectoral and transnational solutions. In circumstances where the European Commission has defined concrete goals through directives or regulations, transnational projects often reflect what is at stake in a given thematic field and contribute towards a harmonised implementation of these goals. Valuation of these projects is more often than not difficult, as issues relating to nature and biodiversity conservation are inherently site-specific, and benefits from environmental conservation tend to accrue slowly over long timescales. Translating and transferring project results to the policy level is therefore challenging with many results not receiving the political attention and buy-in they deserve.

As has been pointed out previously, bridging and translating the gaps of knowledge between policy makers, research and conservation practitioners cannot be achieved with unidirectional platforms and approaches. While it has been previously suggested that new platforms of bidirectional knowledge dissemination must be developed, we strongly believe that it is more efficient to employ and if necessary adapt existing information platforms. Integrating scientifically trained and transdisciplinary and trans-sectorally cognisant persons that can translate science and ease the exchange of information would significantly enhance the effectiveness of such platforms.

While biodiversity losses continue, communication and public relations efforts to highlight the importance of biodiversity and ecological connectivity have lost momentum when compared to the efforts during the International Year of Biodiversity. The authors recommend that strategic communication and lobbying be markedly intensified in order to mainstream biodiversity conservation as the basis for life on earth to a similar degree as has been achieved with global climate change.

5.6.5 Empower municipalities to implement strategic biodiversity conservation and ecological connectivity measures

Municipalities own and manage major parts of the Alpine territory. Their land-use decisions affect biodiversity, the quality of ecosystems and the connections between them. Lacking a broad overview, connectivity measures implemented by individual municipalities are often not integrated into regional and supra-regional connectivity strategies. Additionally, decisions taken by municipalities are often driven by short-term gains and political considerations, such as upcoming elections. To these authors it appears judicious to strengthen and educate municipalities as small but decisive units for long-term biodiversity and ecological connectivity conservation. Municipalities need to develop a common legally binding strategic framework for biodiversity protection and ecological connectivity that is negotiated and agreed on at a regional level.

As political and administrative borders must not interrupt ecological connectivity, this process is especially important in border regions. Agreements between neighbouring countries and regions are required and spatial data needs to be harmonised. At a concrete implementation level, contractual measures and agreements with landowners are crucial. Larger territorial and national administrations should support communities in such efforts through special dedicated funding strategies.

5.6.6 Sanction protected area administrations to operate beyond the borders of protected areas

Ecological connectivity is a central, but very often a controversial issue in biodiversity protection. This is primarily due to the fact that it is directly based on concrete landscape planning and subsequently directly affects land use rights. Protected area administrations are charged with implementing measures to protect biodiversity and ecosystems within their respective parks. Their mission is centred on ensuring the best possible biodiversity conservation status for future generations. However, given current legal frameworks, their lack of authority to operate beyond defined park boundaries, compounded by the generally relatively small size of the protected areas in the Alps, makes it increasingly challenging for park managers to fulfil this task. The requisite genetic exchange for the long-term viability of the species living on these “conservation islands” in a sea of rapidly changing, multi-use landscapes can only be ensured by connecting parks to the surrounding landscapes, thereby preventing and reversing the fragmentation of natural spaces.

While some strategies for large and coherent ecological networks in the Alps and Europe have been elaborated and some isolated ad-hoc actions have been taken to remove barriers, such favourable and important local actions, while useful, are insufficient.

Today, existing protected areas and Natura 2000 sites represent an excellent opportunity in linking the remaining large, more or less unfragmented, areas of the Alps via a permeable landscape matrix. This process, as outlined in this publication, must be solidly based on integrated landscape planning and broad stakeholder involvement. While fundamental challenges remain, this approach would provide a realistic chance in sustainably protecting Alpine ecosystems over the long term. The close cooperation of protected area administrations with surrounding communities in explaining, negotiating and acting in favour of ecological connectivity to benefit all, could present an important co-opportunity.

On the one hand it would allow parks to fulfil their long-term mission, and on the other hand establishing an ecological Alpine network of natural areas would ensure the long-term provision of ecosystem services directly benefiting people living in and beyond the Alps. We recommend that provincial and municipal administrations create the legal foundation for implementing connectivity measures and grant park administrations the authority to actively engage with surrounding communities.

The sustainable management of biodiversity resources and other forms of ecosystem services clearly do not fit within sectoral and administrative boundaries. Today cooperative approaches that bridge the traditional sectoral silos are essential for efficient biodiversity conservation. Unfortunately, such boundaries and silos are still very prevalent. In the realm of sectoral silos, ecological connectivity and biodiversity conservation have only a very limited sphere of influence.

Cross-sectoral cooperation can only be effective if it takes place at a manageable scale at which all relevant partners can contribute towards achieving tangible results, and gained knowledge can be embedded into policies and operational plans. Experience has shown that regional actions that extend beyond administrative or national boundaries are the most promising scale for such new models of cooperation. These regional actions are self-defined by the local actors to suit their actual needs for successful implementation.

Examples of such regions are the officially nominated Pilot Regions of the Alpine Convention's Platform for Ecological Connectivity included within the ETC Alpine Space Projects ECONNECT, RechargeGreen and greenAlps, and also LEADER regions. The authors recommend that administrations from the local to national level ensure that such informal cooperation is underpinned by a long-term political buy-in and commitment. In order to gain fully from such successful regional actions, financial resources must be made available beyond the duration of individual short-term projects and over administrative boundaries.

5.6.7 Key statements of this publication

For the Alpine space, five central spatially related aspects are a basis for a green infrastructure of the Alps see in Table 13.

Table 13: Key statements for the implementation of green infrastructure in the Alps

Statement		Effect	Perspectives-Outlook
1	The main barriers are around the Alps and these reduce the positive effects of an alpine ecological network	The lack of connections to and from the Alps disturb the gene flow of wild species.	A close cooperation between the Alpine Convention, the Macro Regional Strategy and the Alpine countries is necessary.
2	Small scale solutions and model or Pilot Regions are important factors in realising ecological networks in the Alps	On a local scale, fragmentation can be reduced efficiently by specific and adapted measures while local stakeholders insure long term and sustainable implementation.	Pilot Regions can have a model function for other regions. The Alpine ecological network must be considered like a puzzle slowly becoming complete within the frame of the Alpine Convention and the macro regional space.
3	Protected areas and their communities are crucial actors in the establishment of an ecological network	Protected areas have competent and knowledgeable staff. These can contribute towards the regional management of biodiversity by participating in the establishment of an ecological network beyond their borders in cooperation with local communities.	Protected areas should be tasked with contributing towards ecological connectivity beyond their own territory. This also contributes to the conservation of biodiversity within the parks.
4	Air, aquatic, and terrestrial environments necessarily need to be considered when realising the ecological network	The different life spaces need to be considered with specific adapted measures. Mostly the terrestrial environment is the focus of measures, but the aquatic milieu and even the airspace can be highly fragmented.	In cooperation with competent stakeholders and experts measures have to been implemented to prevent a reduction of aquatic and aerial habitats. In this context, agreements with the energy providers are especially important.
5	A permeable landscape matrix is the central focus of the Alpine ecological network	Most crucial and of utmost importance is to guarantee that our landscapes remain permeable for wildlife. Where necessary, habitats need to be interlinked and stepping stones created.	The Alps still have numerous smaller, intact permeable landscapes, but conservation measures need to be taken to create larger non-fragmented areas. This process need to be integrated into all spatial planning policies of the Alpine countries.

Source: Dr. Guido Plassmann, Dr. Yann Kohler

5.6.8 Closing by viewing – Summarising priorities by mapping – An outlook

The two final maps of this publication (see map 22 [page 218] and map 23 [page 220]) propose a number of Alpine areas where concentrated action seems the most appropriate in the immediate future. It is evident that the maps are not exhaustive, but their primary objective is to stimulate and contribute to discussions regarding the primary sites in which to implement Alpine ecological connectivity measures.

Both maps have a double approach, highlighting areas with high "connectivity potential", where preservation measures should be insured, and areas with high "need for action" either because they are highly fragmented and have low permeability, or because they offer the possibility to act with reasonable investment for a significant result.

The first, map 22, was developed based on land use and demographic data as well as expert appraisal concerning the already introduced 3 types of landscape situations (SACA – Strategic Alpine Connectivity Areas):

1. Areas with a very high degree of fragmentation (Ecological Intervention Areas);
2. Areas with persistently functional connectivity and with non-fragmented patches (Ecological Conservation Areas);
3. Areas with a high potential for connectivity with larger, more or less natural non-fragmented patches (Ecological Potential Areas).

The second, map 23, is based on an analysis with the GIS tool JECAMI and shows action areas and hotspots calculated using the land use (LAN), population (POP) and environmental protection (ENV) indicators. Some priority action areas located along the major axis across the Alps were sketched on the map with black crosses. These priority action areas are all important Alpine valleys with high land use and major traffic routes, which are located between CSI (Continuum Suitability Index) hotspots. These priority action areas correspond to the SACA category 1, the Ecological intervention areas.

The valley of Chamonix-Mont-Blanc.

The maps identify connectivity hotspots in the south eastern and south western parts of the Alps, areas where this high potential of connectivity needs to be conserved by corresponding means (see also article 5.5). According to the results shown on both maps, active intervention should be concentrated on the edges of the Alpine Convention perimeter (SACA category 2). Based on the CSI calculations, such areas are clearly identified on the north-eastern edge of the Alps. In these areas activities described in article 5.5 for SACA category 2 needs to be implemented as a priority.

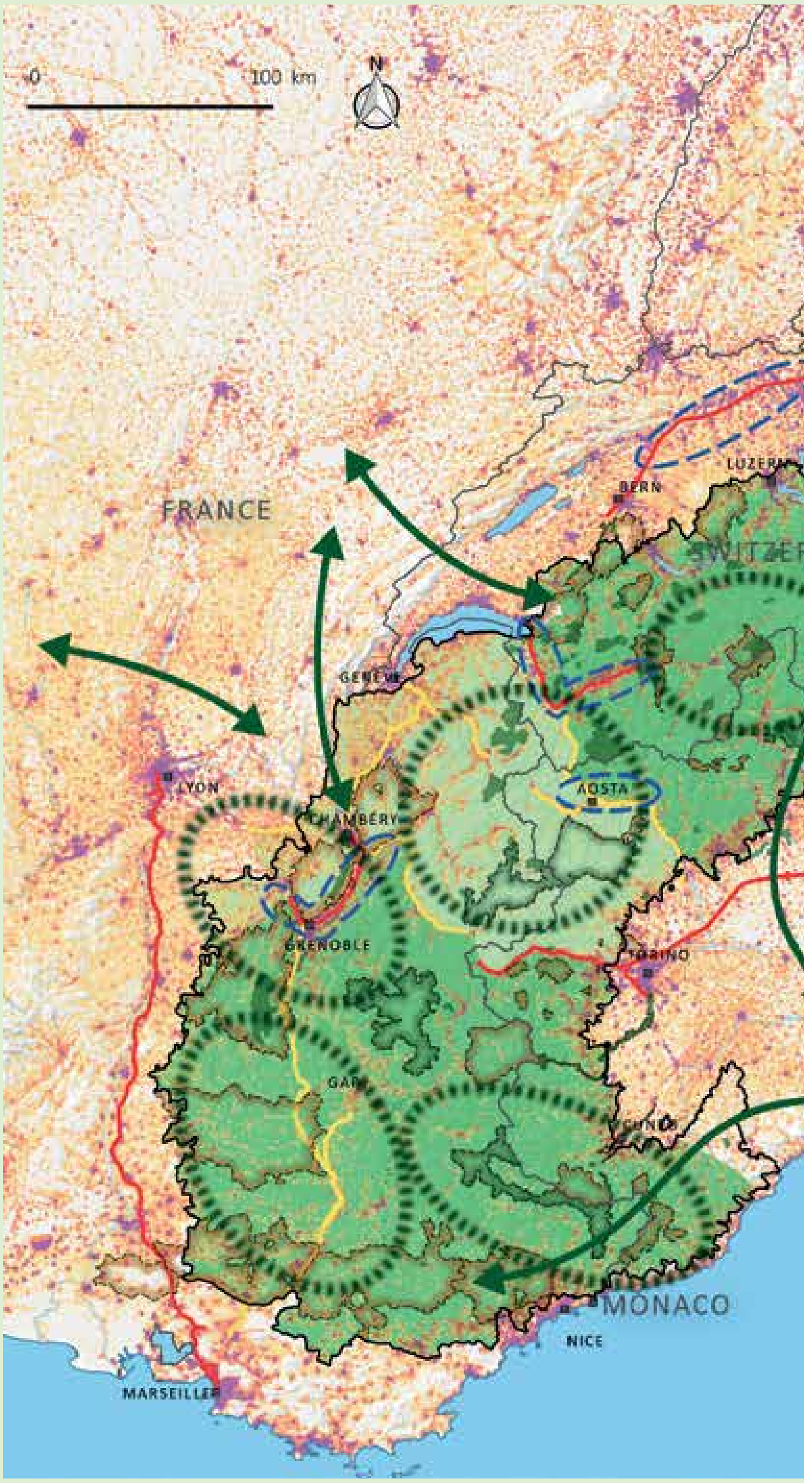
The expert knowledge reflected in the SACAs is confirmed by the GIS based JECAMI analysis, and both maps are complementary in this sense. Both highlight the most fragmented inner Alpine valleys, and both illuminate almost identical areas of high biodiversity potential. These are areas that should either be conserved through appropriate measures or be developed by active intervention creating larger non fragmented spaces. This double approach of expert knowledge and spatial analysis confirms the hypotheses of this publication and invites collaboration between concrete expertise and targeted policies and actions in order to conserve connectivity and thereby biodiversity beyond 2030 in the Alps and for the next generations.

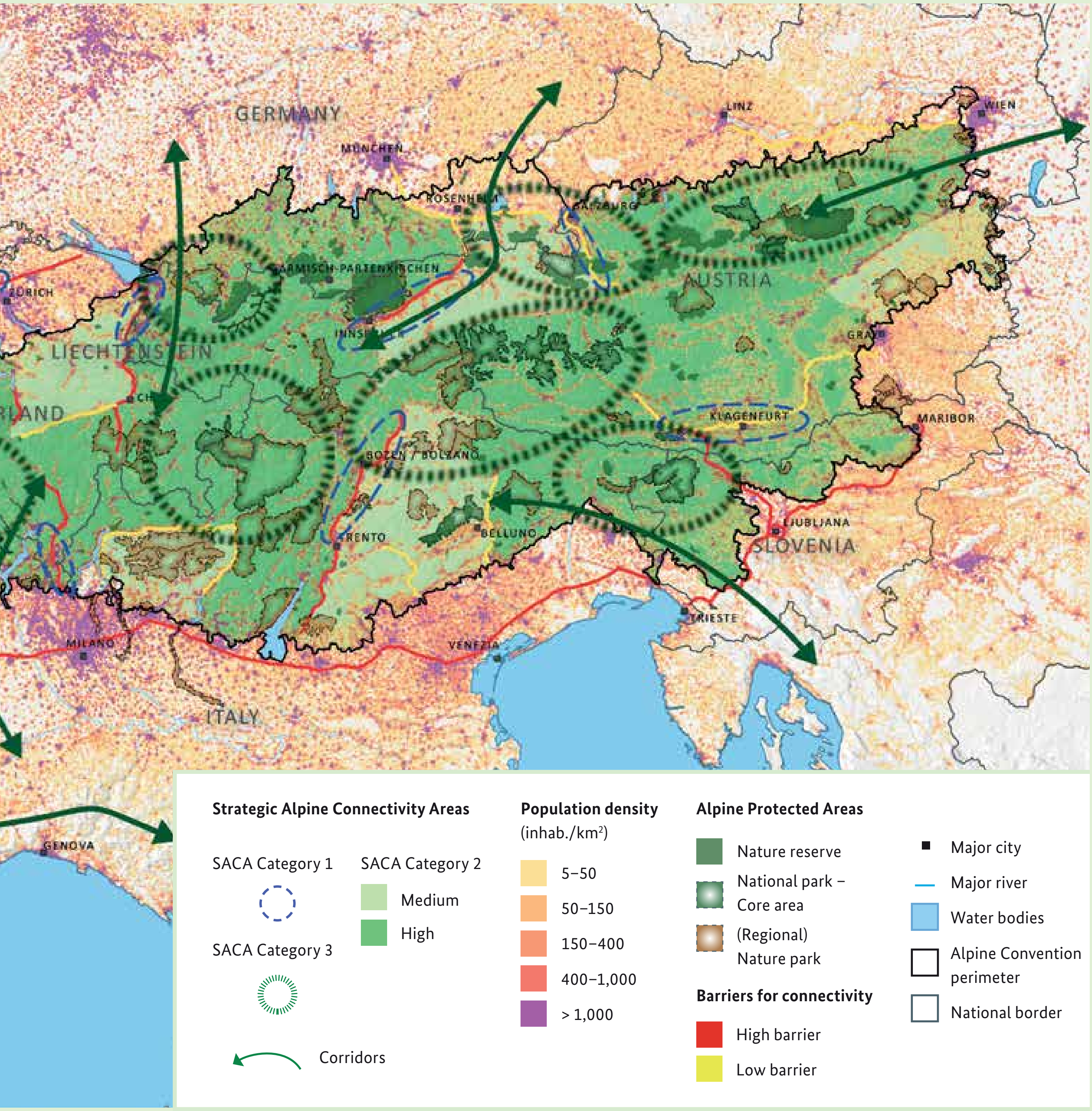
5.6.9 Final considerations

The gaps of knowledge in conserving and restoring connectivity emphasised in this publication make evident that these involve a highly dynamic and interconnected process rather than a simplistic and straightforward approach. It appears essential to reconcile the dynamic and complex nature of the problem with the problem solving approaches. Inadequate simplification

Landscape of the south western part of the Alps (here in the French department Alpes de Haute Provence), that has been identified as an areas with high potential for connectivity.

Map 22: Synthesis map of Alpine ecological connectivity





Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); ALPARC work on barriers and connectivity potentials; Eurostat, EFGS for the population grid information; Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (Original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: This map makes no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

of the interdependencies leads to results that are ultimately not relevant when informing policy. Furthermore, the work in the past two decades indicates that maintaining and restoring ecological connectivity and biodiversity conservation in the Alps is most likely a so-called "superwicked problem" implying the need for novel approaches in addressing this issue.

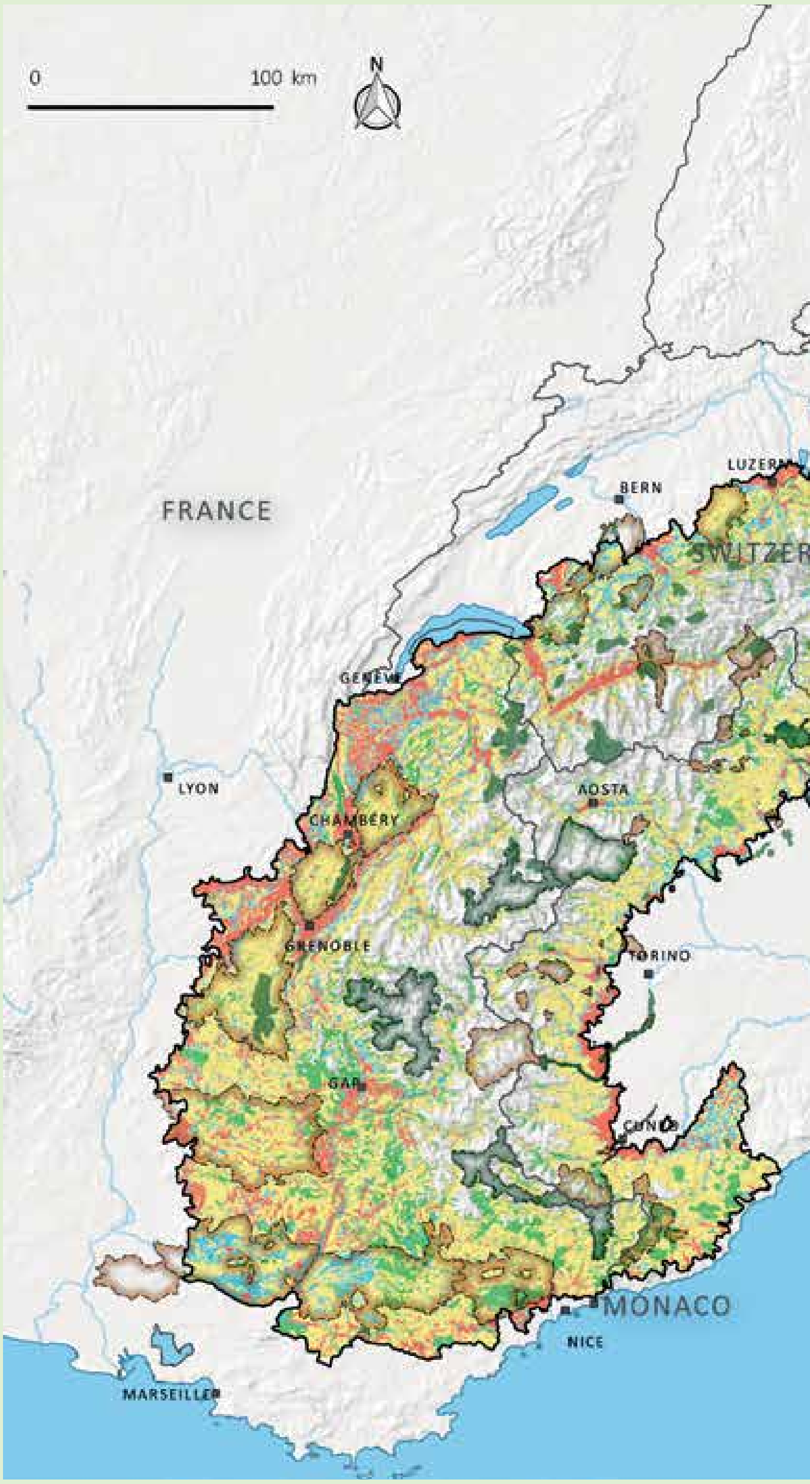
As has been previously suggested by others, we also feel strongly that the usual backward looking method of investigating the past and generating selective and singular predictions is only sufficient for "tame problems" but wholly inadequate for highly dynamic and interconnected environmental conservation problems. In order to address the complex issue of an Alpine ecological continuum, it appears necessary to apply a forward reasoning approach that identifies possible future scenarios and integrates uncertainties.

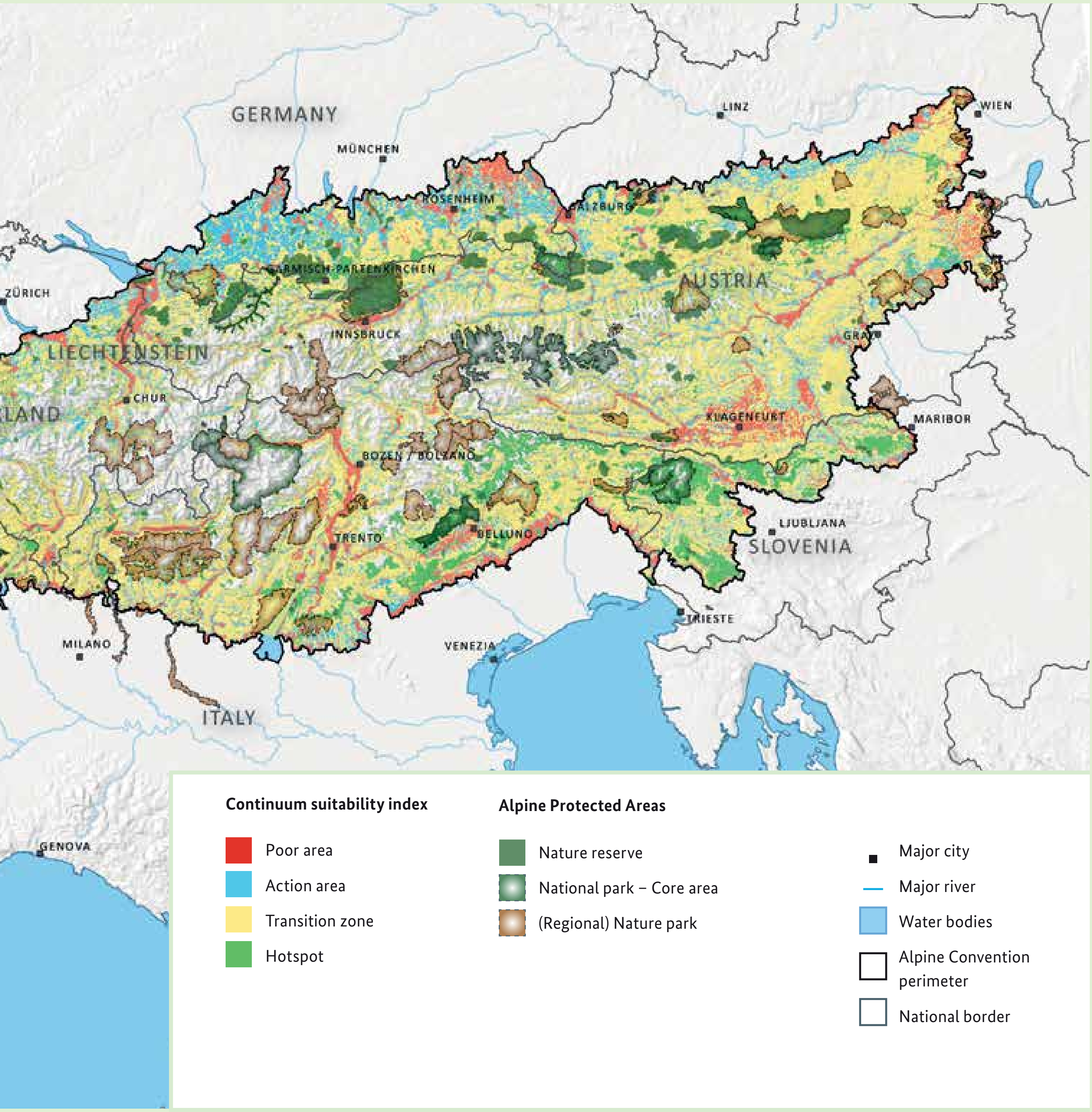
The work of the past decades also very clearly reflects the sectoral structure of society, governance and administration with respect to environmental problems in general. To overcome this, an integrative transdisciplinary and trans-sectoral approach is necessary. What appears to be missing in order to find a common starting point in addressing the problem of the Alpine ecological continuum is a common strategy or vision.

While total agreement among all actors in the search for a common denominator cannot be a realistic goal, a clear vision that expresses the joint aspirations of political leaders, administrations managers and individuals without blocking avenues for constructive debate and argument, to support and sustain connectivity conservation, may be an excellent starting point. In our view, ecological connectivity can constitute a common agreed starting point for trans-sectoral deliberations on biodiversity conservation. However, in order to not become overburdened by the complexity of the issue during the process, it appears essential to address the inherent complexity within a well-reflected and clearly delineated framework.

The spatially defined hypotheses of different Strategic Alpine Conservation Areas (SACA) outlined in this publication need to be verified on the ground and solutions must be effectively implemented through local and regional measures. In order for these efforts to be fruitful and lasting, it is crucial to invest further resources in concrete ground analyses and responses to ecological connectivity aiming to protect biodiversity for generations to come.

Map 23: Synthesis map based on Continuum Suitability Index (CSI) Analysis





Source: Data from different national and regional authorities and protected area managements for delimitations of Alpine Protected Areas (> 100 hectare); Analysis of the Swiss National Park for the continuum suitability index (below 1,800 metres); Permanent Secretariat of the Alpine Convention for the Alpine Convention perimeter; © Euro Geographics EuroGlobalMap opendata (Original product is freely available) for rivers, lakes, built-up areas and localities; European Environmental Agency/SRTM for the digital elevation model; © EuroGeographics for the administrative boundaries. **Note**: This map makes no claim to be exhaustive. **Design**: Dominik Cremer-Schulte, ALPARC-Alpine Network of Protected Areas.

Box 10: The Danube Habitat Corridor – Bridging biogeographic regions and protected areas

// Georg FRANK //
DANUBEPARKS – Danube River Network of Protected Areas, Donau-Auen National Park, Orth an der Donau, Austria

The Danube river – backbone for Europe´s biodiversity

The Danube river is a green lifeline for biodiversity. The large number of Natura 2000 sites is evidence of Europe´s commitment to preserve this natural heritage. While the Network of Danube Protected Areas conserves and manages the most valuable sites, habitat fragmentation limits efforts to preserve a cohesive ecosystem.

The EU Macro-Regional strategy (EU Strategy for the Danube Region, EUSDR) underlines the outstanding role of Danube protected sites, yet notes that they "often work in isolation". The EUSDR calls for transnational cooperation and the provision of "ecological connections that are essential for overall European environmental health".

Danube protected areas – key sites for ecological corridors

Nature does not recognise borders. Consequently, transnational cooperation in the field of nature conservation is crucial on the world´s most international river. In 2007, DANUBEPARKS, the Danube River Network of

Habitat fragmentation, is one of the main threats for Danube sturgeon, bringing them close to extinction.

Figure 25: Danube Protected Areas preserve the most valuable sites and build the backbone for the Danube Habitat Corridor

1 Danube Delta Biosphere Reserve,
2 Lower Prut Nature Reserve
3 Small Wetlands of Braila
4 Rusenski Lom Nature Park
5 Persina Nature Park
6 Iron Gates Natural Park
7 Kopački rit Nature Park
8 Gornje Podunavlje Special Nature Reserve
9 Duna-Dráva National Park
10 Duna-Ipoly National Park
11 Szigetköz Landscape Protection Area, Fertö-Hánsag National Park
12 Dunajské Luhy Protected Landscape Area
13 Záhorie Protected Landscape Area
14 Donau-Auen National Park
15 Wachau Protected Landscape Area
16 Narrow Valley of the Danube in Passau district
17 Donauauwald Neuburg-Ingolstadt

Source: DANUBEPARKS

Protected Areas was established, funded within the EU programme for European Territorial Cooperation for South-East Europe (ETC-SEE). Within ten years of co-operation, the partnership has enlarged to 17 partners (national parks, biosphere reserves, nature parks, nature reserves, protected landscape areas), covering the whole Danube stretch, including nearly all Danube countries (Romania, Moldova, Bulgaria, Serbia, Croatia, Hungary, Slovakia, Austria, Germany). Intense know-how transfer, sound strategies and tangible pilot actions in the field of habitat management, river restoration, conservation of flagship species and nature tourism contribute to strengthen the role of each individual protected area.

However, the amount of land designated as national conservation areas is relatively small, and the size of most Danube Protected Areas is generally too small to support self-sustaining wildlife populations. Therefore, actions to restore and preserve habitat connectivity are needed to raise the efficiency of protected areas as key sites of a Danube Habitat Corridor.

The Danube, providing blue and green infrastructure

The importance of longitudinal connectivity for rivers is well known and described. It impacts a variety of elements including sediment transport, ensuring rivers' functionality as migration corridors for aquatic organisms. Hydro-morphological alterations and hydropower dams (in particular on the upper Danube, as well as Gabcikovo and the Iron Gate dams) interrupt river connectivity and hinder the migration of numerous fish species upstream for spawning and downstream as juveniles. Despite considerable efforts under the Water Framework Directive, habitat fragmentation and degradation result in dramatic decrease in many fish populations. The Danube sturgeon, a flagship species for river continuity, illustrates this fatal impact and is close to extinction.

However, large rivers are more than eco-corridors for species in the waters of the Danube. The variety in floodplain and riparian ecosystems results in extremely rich bio-diversity. The Danube floodplains serve as home and breeding areas for more than 2,000 plant and 5,000 animal species.

The riparian zones of the Danube and its tributary rivers include a dense network of water bodies, wetlands and riparian forests, forming a backbone of biodiversity on a European scale. Even dry habitats are part of natural river eco-systems, due to hydro-morphological alterations, which are currently often isolated to small remnants in the floodplain areas. Furthermore, the Danube river is an important flyway particularly for waterfowl, waders and a wide variety of other water-related bird species, including core areas for resting and wintering.

The Danube Habitat Corridor, linking local habitat remnants and Europe´s macro-regions

Fragmentation is a major threat to European biodiversity and reduces the efficacy of conservation policies. On local and regional levels, the restoration and the further development of habitat connectivity along the Danube is designed to counteract fragmentation of single river stretches containing valuable habitat patches and Danube protected areas through improved habitat connectivity. On a meta-level, the Danube acts as an ecological corridor connecting biogeographic regions, large natural areas (for example Alps and Carpathians) and Macro-Regions.

Due to its south-east/north-west orientation, the Danube is an essential migration corridor. It spans 5 biogeographic regions, more than any other eco-corridor in Europe. Climate change influences the distribution of species, while developing and maintaining ecological corridors mitigates this effect and is highly relevant for the natural radiation of species particularly in such diverse regions.

Fostering ecological connectivity is a main focus of the cooperative work between ALPARC and DANUBEPARKS. The know-how transfer helps to raise the competence for the work on ecological networks within each Macro-Region.

Additionally, good practice projects like the Alpine-Carpathian Corridor stress the relevance of the Danube as a link between these bio-regions on the ground. With funding from the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, the strategic cooperation project *"Alps-Carpathians-Danube – together for European biodiversity. From protected areas to an European ecological continuum"* has been launched under the frame of the Alpine Convention: to exchange experiences in the field of ecological networks, to develop common strategies for habitat connectivity, and to plan and implement eco-corridor projects to further strengthen the Danube in its function as a link between the Alps and the Carpathians.

Ecological connectivity, a cross-sector approach

In floodplains, supply and demand of multiple Ecosystem Services is particularly high. In the past, up to 90 percent of riparian zones were lost due to flood protection measures, transport infrastructure, energy production and intensive land use. Restoring the ecosystems and their ecological connectivity increases the multifunctionality by enhancing supply of provisioning, cultural and other services.

Facing this river's multifunctionality, the implementation of Green Infrastructure along the Danube must seriously consider an integrative and cross-sector approach, including forestry, transport, energy and other sectors. Restoration and management of the Danube Habitat Corridor are within the focus of policy instruments in the Danube region and are a priority for the current work of the Danube Protected Areas´ Network.

The convergence of European regions and the dynamic economic and infrastructure development have placed increasing pressure on the natural treasures of the Danube. Concrete projects and initiatives, coupled with key partners from policy level, different sectors and Protected Area Networks from the Alps and Carpathians, are prepared for a step-by-step implementation in order to counteract ongoing fragmentation in one of Europe´s most dynamic and valuable regions.

Box 11: "Connecting Alpine actors" – A short profile of EUSALP AG 7 "Developing ecological connectivity in the entire EUSALP territory"

// Michaela KÜNZL //
Bavarian State Ministry of the Environment and Consumer Protection, Munich, Germany

// Tina TRAMPUŠ //
Institute of the Republic of Slovenia for Nature Conservation, Izola, Slovenia

The scientific community describes connectivity as "connectedness of processes". In its original sense, this term addresses ecological aspects. When interpreted in a broader sense, it might also be seen as a short vision statement of the EUSALP Action Group 7, as it aims for better coordination between national policies, across different sectors and in spatial terms. Due to its multidimensional character, improved connectivity calls for growth beyond the given institutional framework by more closely connecting actors and complementing Alpine connectivity governance approaches. Therefore EUSALP provides an innovative framework involving different policy fields across state borders and administrative levels.

Composed of representatives from Alpine states and regions as well as of advising members with different institutional backgrounds, the Action Group aims to establish a comprehensive macro-regional scheme in the Alpine Region, ensuring a broad, consistent and coordinated process. It endeavours to enhance Alpine ecological connectivity on a larger scale and to make the Alps a unified candidate for a Green Infrastructure (GI) of European-wide importance (TEN-G). This can be achieved by defining the concept of GI on a more regional level, reflecting links between the core area and the surroundings, between rural and urban areas, as well as through links with other mountain regions.

This inclusive approach will build on the rich knowledge and cooperation structures in the Alps. It will strive to capitalise on existing knowledge and enhance coherence of information. By sharing the concept of ecological connectivity with a wide range of sectors, the Action Group 7 will enter into a transdisciplinary dialogue with a view to developing strategic implementation concepts. An accompanying financial dialogue will help to identify specific needs for funding mechanisms and to make better use of appropriate financing options.

All in all, the EUSALP AG 7 can be understood as a strategic hub connecting various aspects of the topic in order to achieve a better coordination of actors and to subsequently contribute to a more integrated Alpine landscape development.

EUSALP AG 7 is in its first operational phase jointly lead by the Bavarian Ministry of the Environment and Consumer Protection (Michaela Künzl) and the Institute of the Republic of Slovenia for Nature Conservation (Tina Trampuš).

Epilogue: “Alpine Nature 2030” – Creating [ecological] connectivity for generations to come

// **Markus REITERER** //
Secretary General of the Alpine Convention

In 1866, Ernst Haeckel described the concept of ecology as “the study of the relationships of organisms with their environment”. Hence, from the outset “ecology” has been about interactions and connections. Or, as Barry Commoner, once put it: “The first law of ecology is that everything is related to everything else.” If that is so, talking about “ecological connectivity” seems somewhat tautological. Yet, 150 years after Haeckel’s defining statement, we are still struggling to better understand the underlying interactions, let alone maintain them in a way that we know (or believe to know) would be best for our planet and ourselves. We can deduce from that how infinitely more complex it is to try to re-establish interactions that have already been disrupted.

Today “ecological connectivity” is a crucial goal. If we just have a closer look at the Alpine region and some of its framework conditions:

1. the availability of habitable land is limited to roughly 1/5 of the entire territory;

2. never in history have the Alps been populated by more people than today: 14 million or 74,6 inhabitants per square kilometre make the Alps one of the most densely populated mountain regions of the world;

3. more than 100 Million tourists come every year to visit our region, and a tourism sector corresponding to this figure has been established over the years, creating substantial income, but also significant environmental (and social) impacts;

4. The Alps are also literally at the crossroads of some of the major trans-European transport axes, with around 200 million tonnes of goods carried across every year and a rail and road network density higher than the European average, in relation to the population;

5. The Alps are home to a vibrant economy, including industry, service providers, energy production, storage and transport as well as agriculture.

And still, the Alps are the second most important biodiversity hotspot of Europe. Yet, given the framework conditions, we can get an impression about the pressures our region is facing and the complexities we encounter, when we try to maintain or improve the links between the habitats, the relations and interactions that provide the very basis of our livelihoods.

The present volume put together by the German Presidency of the Alpine Convention and ALPARC provides an outstanding reference guide for the improvement of ecological connectivity in the Alps. Connectivity between protected areas is not a luxury: it is a necessity if we want to preserve healthy populations of the Alpine species, which – by the way – also include us humans. The Alpine fauna and flora is well-adapted to extreme conditions and often microclimates, hence the exceptional biodiversity. Climate change puts an additional strain on these specialists, which often have limited possibilities to migrate up or north to escape rising temperatures

The Alpine countries have committed in the Nature Protection and Landscape Conservation Protocol of the Alpine Convention to "preserving the indigenous animal and plant species with their specific diversity and in sufficient populations, particularly ensuring that they have sufficiently large habitats." As demonstrated in this publication, nature protection has already moved a long way from static reasoning, focused on islands of habitats, to dynamic approaches implemented in ecological networks. More research and monitoring are certainly needed, but an immediate need for action is already obvious. The recognition is there, that protected area managers need to work with each other and with stakeholders outside the protected areas, to set up ecological corridors or stepping stones linking the parks and reserves. The main challenge is probably more social than environmental: to make sure that nature keeps – or regains – its rightful space also in areas of intensive human use. This is why an important part of this publication has been devoted to participatory processes.

I see this challenge as an opportunity to establish sustainable land use in the Alps, with obvious benefits on the quality of life of their millions of inhabitants. Not only do healthy ecosystems provide services in terms of natural hazard protection, but also in terms of water supply, pest control and more. Ecological corridors are also green infrastructure with, often, a potential recreational and even economic function. They contribute to noise reduction and can offer relaxing commuting routes for cyclists and pedestrians.

Spatial planning is key, and needs to become to a larger extent a tool to balance the different interests at stake. Mainstreaming the need for ecological connectivity will be one of the main tasks of the Ecological Connectivity Platform of the Alpine Convention in the next years. In that respect, the Pilot Regions for Ecological Connectivity of the Alpine Convention are overcoming administrative borders and have a specific role to play to reinforce the Alpine-wide exchange of practical experience and to test innovative approaches. Also the macro regional strategy for the Alpine region EUSALP recognises the importance of the issue, having identified ecological connectivity as one of its nine priority fields of action; the corresponding Action Group will hopefully provide a functioning platform to intensify the cooperation on ecological connectivity between areas inside and outside the perimeter of the Alpine Convention. To look one step further still, the long-lasting cooperation between the Carpathian Convention and the Alpine Convention provides the frame to work further towards better maintaining or restoring the ecological link between both mountain ranges.

As formulated in one of the articles above, we have good ingredients and a basic recipe, and it is now up to us all to make sure the Alps remain a hospitable habitat for all living organisms now and in the future.

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Weblinks

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Chapter 5

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Weblinks

www.partizipation.at/173.html (Accessed 13 May 2016)

Footnotes

1 Eco-region strategy of WWF: The Alps are one of the 238 priority ecoregions in the world which are characterised by the "finest examples of a given major habitat type".

2 Integral nature reserves usually allow limited or no access for humans, scientists execpted. Some of these integral nature reserves are so difficult to access (topography) that a special interdiction is not necessary.

3 Ecological continuum means a permeable landscape matrix where habitats are not isolated by barriers but allowing their continuity at least partially.

4 See scoping according to §4 BauGB (Germany), based on Directive 85/337/EEC, with last review 2014/52/EU

5 High-ranking road network based on selected Tele Atlas and EuroGlobalMap data

6 www.lifemgn-serviziecosistemici.eu/IT/home/Pages/default.aspx

7 www.alpine-ecological-network.org/information-services/film-for-municipalities/film-for-municipalities?set_language=en

List of tables

List of figures

List of maps

Abbreviations

AGL	Action Group Leader
AKK	Alpine-Carpathian corridor
ALPARC	Alpine Network of Protected Areas
ASP	Alpine Space Programme
BfN	German Federal Agency for Nature Conservation (Germany)
BMLFUW	Federal Ministry of Agriculture, Forestry, Environment and Water Management (Austria)
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Germany)
BMVIT	Ministry for Transport, Innovation and Technology (Austria)
BNatSchG	Bundesnaturschutzgesetz
BOKU	University of Natural Resources and Life Sciences (Vienna)
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CICES	Common International Classification of Ecosystem Services
CIPRA	International Commission for the Protection of the Alps
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNDDGE	Grenelle Environment Forum National Sustainable Development Committee

CO_2	carbon dioxide
COH	Patch Cohesion
CSI	Continuum Suitability Index
DAV	German Alpine Association
DSS	Decision support system
EC	Ecological connectivity
ED	Edge Density
EN	Ecological network
ENV	Environmental Protection
ES	Ecosystem services
ESS	Ecological functions and ecosystem services
ETC	European Territorial Cooperation
ETH	Swiss Federal Institutes of Technology
EU	European Union
EUSALP	EU Macroregional Strategy for the Alpine Region
FAO	Food and Agriculture Organization of the United Nations
FEU	Functional Ecologic Unit
FFH	European Habitat Directive
FMP	Forest management plans
FOEN	(Swiss)Federal Office for the Environment
FRA	Fragmentation
FVA	forest research institute
GI	Green infrastructure
GIS	Geographical Information System
GPS	Global Positioning System
GWP	Generalwildwegeplan
ICT	Information and Communication Technology
IIASA	International Institute for Applied Systems Analysis
INF	Infrastructure
IRSNC	Institute of the Republic of Slovenia for Nature Conservation
ISCAR	International Scientific Committee on Research in the Alps
IUCN	International Union for Conservation of Nature
JECAMI	Joint Ecological Continuum Analysing and Mapping Initiative
LAN	Land Use
LAP	Land Use Planning
LEP	Bavarian State Development Plan
LPR	Land Stewardship Directives
MCC	Mercator Research Institute on Global Commons and Climate Change
MEA	Millennium Ecosystem Assessment
NGO	Non-governmental organizations
NPPG	Nature Park Prealpi Giulie
ÖBf	Austrian Federal Forests
OFT	Office fédéral des transports (Switzerland)
ONB	National Biodiversity Observatory
PA	Protected areas
PACA	Provence-Alpes-Côte d'Azur (French Region)
P.C.T.P.	Provincial Coordination Territorial Plan
PNR	Regional Nature Park
POP	Population
PTR	piano territoriale regionale
RE	Renewable energy
REN	Rete ecologica nazionale
SACA	Strategic Alpine Connectivity Area
SAEFL	Swiss National Forest Programme
SLF	Styrian federal state forests
SNA	Social Network Analysis
SNDD	National Sustainable Development Strategy
SRCE	Schéma régional de cohérence écologique (Regional ecological coherence scheme)
StMUV	Bavarian State Ministry of the Environment and Consumer Protection
TCM	Travel cost method
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
TNP	Triglav National Park
TOP	Altitude and Topography
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	World Commission on Environment and Development
WESP	Wildlife Ecological Spatial Planning
WWF	World Wide Fund For Nature

Main Authors

// Dr. Guido Plassmann //

Guido Plassmann has been studying, living and working since 1985 in the Alps (Bavarian and French Alps). His studies in Alpine geography and management of natural resources, economics and history gave him a solid appreciation for complex Alpine nature conservation processes. Developing, coordinating and leading the Alpine Network of Protected Areas (ALPARC) since 1995 expanded his experience with concrete issues and activities in all Alpine countries. For over 20 years, he has realised numerous projects dealing with management of protected areas, ecological connectivity, sustainable regional development and broad public communication in the Alps and Carpathians. He has also coordinated various international European projects and lead several European territorial cooperation projects within the Alpine space. Guido Plassmann is particularly interested in transdisciplinary and international approaches to develop solutions for a sustainable way and quality of life in the Alps and more generally in mountainous regions.

// Dr. Yann Kohler //

Yann Kohler has worked for the Alpine Network of Protected Areas (ALPARC) since 2004 on the topic of biodiversity conservation with a particular specialisation in aspects of ecological connectivity. In the context of various international projects like ECONNECT and greenAlps or "Life Belt Alps", he has gained an in depth knowledge of local, regional, national and international approaches to the implementation of ecological networks. He has coordinated the activities of the Platform "Ecological Network" of the Alpine Convention for the German and French Ministries of the Environment for several years and participates as an expert advisor to the EU Working Group "Green Infrastructure" and to the French expert pool on Green and Blue Infrastructure (TVB). The concept of ecological connectivity is for him an interesting and promising tool to develop global, coherent and multi-sectoral territorial projects integrating nature conservation aspects into broader spatial planning processes.

// Prof. Dr. Chris Walzer //

Chris Walzer is a veterinarian and university professor for conservation medicine with an internationally recognised expertise in working with wildlife, especially wild equids and carnivores, gained from combined years of work and research in Europe, Asia and Africa. He has a very diverse international research track record with some 400 + scientific publications to his name. Chris Walzer is sought as a consultant in wildlife matters by various organisations such as WWF, UNDP, World Bank, and several other GO's, NGOs and universities. Over the past decade he has successfully participated in numerous ecological connectivity projects such as INTERREG IVB Alpine Space projects: 'ECONNECT', 'recharge.green', 'green.Alps' and the "Impact of mining related infrastructure development on Mongolian Wild Ass in the Gobi" in Mongolia. Chris Walzer is a creative interdisciplinary idea initiator and problem solver; a critical and strategic conservationist dedicated to mainstreaming biodiversity conservation.

// Dipl. Ing. Marianne Badura //

Marianne Badura has been working as independent landscape architect and consultant since 1998. She has worked for many years in Central and Eastern European countries on Natura 2000 implementation and other environmental issues in the framework of the European Twinning Programme. Apart from these projects she has worked on many regional environmental projects in Bavaria. As landscape planner and GIS expert she has excellent knowledge in nature conservation and environmental protection issues. She has been involved in the transnational work on ecological connectivity in the Alps during different INTERREG IVB Alpine Space projects ('ECONNECT', 'recharge.green', 'green.Alps') as well as by the coordination of the Platform 'Ecological Network' of the Alpine Convention in 2012. Marianne Badura is particularly interested in developing cross-sectoral solutions with land users for the benefit of people and nature.

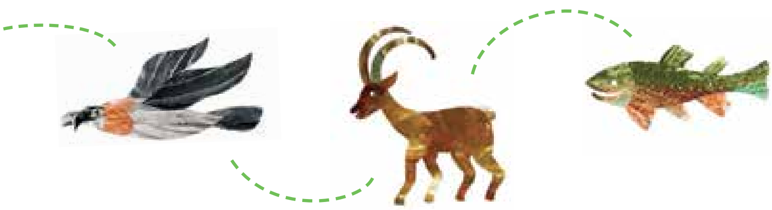
General Editing:

// Dr. PK Walzer //

PK Walzer is a clinically trained veterinarian with over twenty years of experience working with zoo and wild animals. Recently she has broadened her focus to include ecological connectivity and biodiversity, and she has participated in Alpine Space Program projects such as recharge.green. She has concentrated on writing and editing scientific texts with the goal of capturing relevant ideas, translating science-based knowledge into approachable documents, and informing policy-makers. PK Walzer is particularly interested in engendering awareness and identifying sustainable solutions by providing comprehensive, clear and concise coverage of environmental issues.

"Life needs connectivity"

Ecological connectivity is needed on land, under water and in the air to safeguard biodiversity for future generations.



Please use this link (Flashcode) for an illustration of barriers to ecological connectivity and the needs of the three species representing alpine nature & life:

"Three love stories"

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Page 12 (right): Joze-Mihelic, Triglav National Park, Slovenia
Page 13: NationalPark Gesäuse, Austria
Page 15: Yann Kohler, ALPARC
Page 16: Guido Plassmann, ALPARC
Page 23: Simon Cesar Forclaz, Nature Park Pfyn-Finges, Switzerland
Page 24: Hans Lozza, Swiss National Park, Switzerland
Page 29 (left): Swiss National Park, Switzerland
Page 29 (right): Swiss National Park, Switzerland
Page 30: Dan Briski, Triglav National Park, Slovenia
Page 32 (left): Frank Miramand, ASTERS, France
Page 32 (right): Brigitte Wolf, Landscape Park Binntal, Switzerland
Page 34 (left): ALPARC
Page 34 (right): ALPARC
Page 36: Guido Plassmann, ALPARC
Page 39: Guido Plassmann, ALPARC
Page 40: Yann Kohler, ALPARC
Page 42: Marie-Odile Guth
Page 46: Simon Cesar Forclaz, Nature Park Pfyn-Finges, Switzerland
Page 48 (left): Yann Kohler, ALPARC
Page 48 (right): Yann Kohler, ALPARC
Page 52: Guido Plassmann, ALPARC
Page 54: Franz Sieghartsleitner, National Park Kalkalpen, Austria
Page 56: Yann Kohler, ALPARC
Page 59: Yann Kohler, ALPARC
Page 60: Hans Lozza, Swiss National Park, Switzerland
Page 63: Dutoit, Nature Park Gruyère Pays-d'Enhaut, Switzerland
Page 64: Josef Hackhofer, Nature Parks South Tyrol, Italy
Page 66: Yann Kohler, ALPARC
Page 68: Archiv Abteilung Natur und Landschaft, Autonome Provinz Bozen, Südtirol, Italy
Page 74: Julien Heuret, ASTERS, France
Page 76: Brigitte Wolf, Landscape Park Binntal, Switzerland
Page 78: Erich Mayrhofer, National Park Kalkalpen, Austria
Page 80: Yann Kohler, ALPARC
Page 81: Andreas Holzinger, Steiermärkische Landesforste, Austria
Page 82: Carolin Scheiter, National Park Bechtesgarden, Germany
Page 83: National Park Berchtesgaden, Germany
Page 84 (left): Marie Stoeckel, ALPARC
Page 84 (right): Guido Plassmann, ALPARC
Page 87: Matthias Huss
Page 88: Marco di Lenardo, Nature Park Prealpi Giulie, Italy
Page 93: Marie Stoeckel, ALPARC
Page 94: ALPARC
Page 98: Conseil Général de l'Isère, France
Page 99: University of Innsbruck, Austria
Page 100: Brigitte Wolf, Landscape Park Binntal, Switzerland

Page 101: Umweltbundesamt Österreich, Austria
Page 102 (above left): MIREN
Page 102 (above center): MIREN
Page 102 (above right): MIREN
Page 102 (below left): MIREN
Page 102 (below center): MIREN
Page 102 (below right): MIREN
Page 103 (left): Research Institute of Wildlife Ecology, Vetmeduni, Vienna
Page 103 (right): Research Institute of Wildlife Ecology, Vetmeduni, Vienna
Page 105: Amt für Naturparke Südtirol, Italy
Page 106: Guido Plassmann, ALPARC
Page 109: Conseil Général de l'Isère, France
Page 114: Nature Park Gruyère Pays-d'Enhaut, Switzerland
Page 117: Anton Vorauer, Nature Park Kaunergrat, Austria
Page 120: Eric Le Bouteiller, Mercantour National Park, France
Page 122: Erich Mayrhofer, National Park Kalkalpen, Austria
Page 124 (above): Clemens Geitner
Page 124 (below A): Clemens Geitner
Page 124 (below B): Clemens Geitner
Page 124 (below C): Clemens Geitner
Page 124 (below D): Clemens Geitner
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Page 126 (right): Yann Kohler, ALPARC
Page 129: Yann Kohler, ALPARC
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Page 137: Sina Hölscher
Page 140: Guido Plassmann, ALPARC
Page 143: Yann Kohler, ALPARC
Page 145: Julien Heuret, ASTERS, France
Page 146: Yann Kohler, ALPARC
Page 151: ALPARC
Page 152: Yann Kohler, ALPARC
Page 154: Yann Kohler, ALPARC
Page 163: Fritz Reimoser
Page 164: Guido Plassmann, ALPARC
Page 166: Ales Zdesar, Triglav National Park, Slovenia
Page 168 (left): Yann Kohler, ALPARC
Page 168 (right): Hans Lozza, Swiss National Park, Switzerland
Page 175 (above): Yann Kohler, ALPARC
Page 175 (below): Yann Kohler, ALPARC
Page 182: Danubeparks
Page 190: Yann Kohler, ALPARC
Page 201: Yann Kohler, ALPARC
Page 211: Hans Lozza, Swiss National Park, Switzerland
Page 212 (above): Yann Kohler, ALPARC
Page 212 (below): Yann Kohler, ALPARC
Page 217: Marie Stoeckel, ALPARC
Page 218: Yann Kohler, ALPARC
Page 222: Danubeparks
Page 226: Marie Stoeckel, ALPARC
Page 248 (above): ALPARC
Page 248 (center): ALPARC
Page 248 (below): ALPARC
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