Biodiversity in time of climate change : management or wilderness ?

New challenges for the alpine protected areas

2010 International Year of Biodiversity

alparc


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Editorial

As we all know, 2010 is the International Year of Biodiversity. The occasion has been marked by the inclusion of the special logo on the websites of many organisations, conferences of all kinds, wide media coverage and a general, though not always appropriate, public debate.

For protected areas and parks, preserving biodiversity has always been a key driver. Maintaining biodiversity is a goal against which to measure the effectiveness of protected areas, and demonstrate how these are essential to safeguard the different ecosystems within their far-reaching geographical network. Down the years, especially in Alpine regions, the concept of safeguarding and preserving species threatened by extinction for whatever reason, has undergone a sea change in the wake of "field" experience in protected areas. The exclusive objective of protecting an individual species - for example, the Edelweiss - has given way to an understanding that whole biotopes must be safeguarded. This is especially true for ecosystems that are home to fast dwindling species like amphibians and birds of prey on account of ever-encroaching farmland. This broader view has in turn led to the concept of habitat safeguard as reflected by the EU Nature 2000 Directive.

It is an approach that unfortunately is still struggling to gain a foothold in many areas. It is, however, the only way to ensure effective safeguard of biodiversity in its wider sense, not least because it is rooted in the concept of a widespread, interconnected network that stretches beyond the local dimension, which, experience has shown, produces disappointing results.

Who better than the Parks and the different forms of regional protected areas to guarantee the dissemination of scientific research and application of know-how among the various local or macro-regional administrative bodies in the Alps, Carpathians or other regions of Europe, and perhaps one day, even beyond ? Sharing the findings of field surveys conducted using common assessment criteria is key to long-term monitoring of the situation. This in turn is the only way to manage the possible widespread effects caused by external factors such as climate change. Alparc and its members have for years operated on this principle. It is key to disseminating interpartner collaboration. It has also proved extremely useful in spreading environmental-management best practices in contrast to other communication channels like conferences whose findings often remain a dead letter.

If the 2010 International Year of Biodiversity succeeds in further raising environmental awareness among all components of society and triggering a resolve to undertake concerted action to safeguard the environment, then all the declarations and events will not, as often in the past, have been in vain.

Ettore Sartori - Vice President of ALPARC


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SUMMARY

INSTRUCTIONS FOR USE...

« How to manage at the best biodiversity facing the new global phenomena (climate change etc.) and with a restricted budget ? Is it always necessary to manage nature ? If yes, how can it be managed in the most effective way? What should be the priorities ? What criteria should be followed ? Who decides on these criteria ? »

These are the core questions this brochure is trying to answer.

The goals of this brochure are to contribute to and participate in the debate on biodiversity and climate change in a wider and more critical way. Last but not least, it shall contribute to share ex¬periences in the field of biodiversity protection and management of wild fauna in the Alpine area.

The brochure is divided into 4 main sections :

a) scientific research : 4 scientific articles aim to highlight the big questions and the new problems linked with climate changes and the management of biodiversity in Alpine protected areas. In this part of the brochure, you will find a general introduction by Mateja Pirc on the interdependence of climate change and biodiversity. Oliver Schweiger illustrates here the consequences of climate change at species and community level and the opportunities for their conservation. Kurt Bollmann's proposal is using grouse as a model species to study the impacts of climate and land use change on Alpine ecosystems and tries to answer the following question : "How can the Alpine network of protected areas contribute to grouse conservation under scenarios of climate change ?". Finally, Christophe Randin, Pascal Vittoz, Robin Engler and Antoine Guisan study past and future developments linked to climate change in plant populations in the Alps.

b) interview with... : thanks to 3 interviews with managers of protected areas, we were able to collect a certain number of experiences and highlight what the current issues are for mana¬gers facing these new problems. In the Adamello Natural Park (Andrea Mustoni) « efforts to protect nature are aimed primarily at raising awareness among visitors to the Park and in this way trying to make their presence sustainable ». In Prealpi Giulie natural Park (Stefano Santi) « the main cause of biodiversity loss seems to be the gradual closing of open spaces, such as meadows or pastures, due to people abandoning farming and breeding acti¬vities, and the consequent growth of woodlands in these areas ». In Berchtesgaden National Park (Michael Vogel) « Priority measures are long-term climate monitoring and analysis of climate change impacts on the hydrological balance in this area. »

c) zoom on... : 3 protected areas share their practical experiences in the management and monitoring of the wilderness: in Triglav National Park they tried management without human intervention, in Ecrins National Park they developed a new method to map native plant species and in the Dürrenstein Wilderness Area they created a protected area to conserve the remaining old-growth forest which spans over more than 400 ha.

d) tools : this part of the brochure aims to help you to take action personally in favor of the preservation of biodiversity (for example by using Alparc's awareness raising exhibition "Return of wilderness" in your protected area) and to have more information about climate change and biodiversity in the Alpine arc (Alpine resources).


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More biodiversity for better climate - the interdependence of climate change and biodiversity

[Mateja Pirc, CIPRA International Im Bretscha 22, FL-9494 Schaan,
mateja.pirc@cipra.org - www.cipra.org/cc.alps]

The Intergovernmental Panel on Climate Change (IPCC), set up in 1988 by the United Nations Environment Programme and the World Meteorological Organization, has the task to assess the risks of global warming on the basis of scientific principles. Various emission scenarios drafted by the IPCC show some possible developments of climate in the future. Based on each scenario (from complete cessation of greenhouse gas emissions to "business as usual") a global temperature increase ranging between 1.1 and 6.4°C is expected by the end of the century. From a global perspective, we must therefore count on an average increase of 3-4°C by 2100.
The most recent studies even suspect a significantly higher warming. As to local developments, it turns out that climate warming will be particularly marked in the Alps. The increase is almost twice as much compared to the global trend). In the history of the earth, climate has always changed, and nature in its wake. However, the speed and size of the current climate warming are extraordinarily high and are thus divergent from previous climate changes.

Changes in climate conditions are ref ected on species and ecosystems. Due to climate change, distribution areas move along climate zones, height and moisture gradients. If there is an average global warming of 3°C in the next 100 years, a horizontal shift of around 600 km from the south to the north or a vertical shift of around 600 meters in height will be expected in the northern hemisphere. Experts assume that some species cannot manage such migrations with respect to the speed of the current climate change. Most woods expand at a speed of around 100 km in 100 years, many Alpine species grow 50 meters further up in 100 years and some grass species in the Alps reposition themselves by a mere 4 metres in 100 years (www.gloria.ac.at). In addition to this spatial shift, it is expected that species will change their genes, aspect or behaviour. Reactions of biodiversity to climate change will be very different and are hard to foresee at the moment.

Climate change will produce winners and losers among plant and wildlife species. Mountain areas are particularly sensitive and will incur the highest losses in biodiversity. Species and ecosystems in mountain areas, especially in the higher areas of the Alps, are often durable and have special requirements and no chance of escaping (as per above). The way f ora changes as a consequence of climate change has been examined by international projects such as GLORIA (Global Observation Research Initia-


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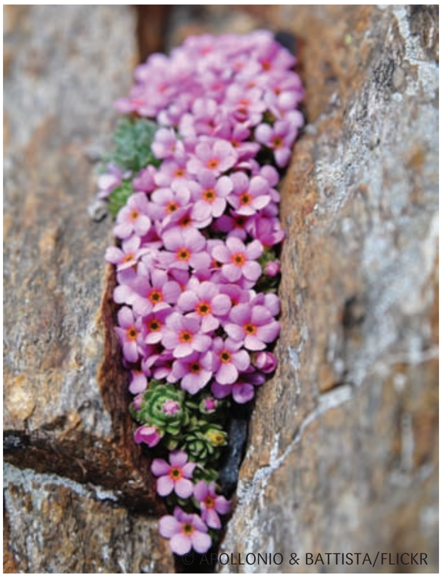
tive in Alpine environments). GLORIA is a project for the establishment of a worldwide network in which long-term data on plants and temperature are gathered, in order to estimate future trends in species' variety and temperature. According to GLORIA, it has already been determined that some plant species have moved around 15 meters higher.

The "Flora Alpina" features 4491 plant species in the Alps, 501 of which are endemic. Therefore the Alps are the richest f oral region in Central Europe. At the same time, they are most strongly impacted by climate change. According to current models, 45% of the Alpine plant species are threatened with extinction by 2100. Because of global warming, also well-known animal species such as the Alpine ibex, the snow grouse and the mountain hare will experience far worse living conditions in the Alps.



Picture 1
Extreme high altitude species, *like Androsace alpina*, according to the results of the research project Gloria are already displaying a retreat today.

If, in the near future, there is no expansion and connection between currently existing protected areas, and if the variety of species outside these areas is not protected, a large number of species from certain regions will disappear or even be globally threatened with extinction.

Climate change also affects ecosystems : for the last 150 years, glaciers have been retreating in the Alps (according to Bund Naturschutz Bayern : 52% in surface area and 60% of the mass). This endangers, for example, the f ow of Alpine rivers. Low water levels and further hydrological changes lead to serious changes in the ecosystems of watercourses. Fish species in the head waters are increasingly endangered. OcCC/ProClim (2007) predicts that by 2050 watercourses in the Swiss Alps will have warmed by 2°C compared to 1990. This means that the habitats of cold water fish may shrink by 20-25%. Also the situation of meadows and wetlands and their ecosystems changes along with that of rivers.

Climate change requires quick action since ecosystems are slow to react. Scientific bases are sufficient, there is no reason to wait any longer to take actions for protecting biodiversity.

Protection of biodiversity means climate protection

Against the backdrop of climate change, the role of ecosystems with high biodiversity is more significant than ever in the past, since they react more f exibly and dynamically to climate changes and, as reducers of organic carbon, they can improve the balance of greenhouse gases. As a consequence, high biodiversity can contribute at the same time to climate protection. Growing marshland and forests can store carbon dioxide (CO_2), and an agriculture compatible with nature releases essentially less CO_2 than intensive agriculture.

Renaturation and reactivation of rivers, meadows and wetlands as well as the improvement of the hydrologic balance of the landscape can soften the negative consequence of increased rainfall extremes also for people. The forest has always offered protection from natural hazards such as landslides, landslips and high waters. With climate change these dangers increase, so that well-functioning protection forests become increasingly significant.

Picture 2
The wetting of degraded swamps provides a significant contribution to climate protection and generates synergies such as the protection of biodiversity.

Adapting to the shift of climate zones

Climate change can have unpredictable and surprising effects on individual species and ecosystems because of the complex ecological interactions. Distribution areas move clearly along climate areas, as well as height or moisture gradients. Different strategies of networking of habitats from global to local level must make these shifts possible as biodiversity has been already experiencing changes due to climate change.

Against this background, the concepts of classic nature protection are no longer sufficient, since, up to now, it has focused on protected areas as "Islands" for the conservation of biologic variety. Future-oriented nature protection must strive for a functional networking of large and small protected areas and complex habitats, while a complexity of biotopes is protected or even created.

Landscape elements such as corridors or stepping stones, which can support the networking of habitats, play a decisive role in the protection of biodiversity. It is recommended that large connection areas be created instead of narrow corridors, since migration paths can change according to the various species. If conditions inside the protected areas are no longer appropriate, UNESCO in its "Man and Biosphere" Programme recommends the creation of buffer zones, which can accept migrating populations. For this strategy to work, the buffer area must be sufficiently large.

Based on local situations, measures in various sectors are necessary in order to improve the ecological networking of protected areas and complex habitats with the goal to protect biodiversity. Alongside nature protection, significant fields of action are for example agriculture, forestry, hunting, tourism, spatial planning, transport, water management and environmental education (see Kohler and Heinrichs, 2009 : Catalogue of measures on www.alpine-ecological-network.org).

In addition to measures in protected areas, land users outside protected areas should be offered incentives for judicious use. This increases the chance for species to find adequate conditions extensively and to move their habitats in response to climate change.

Protected areas can only contribute in the long term to the conservation of biodiversity if they are configured in such a way that the consequences of climate change as well as of "Global Change" in the widest sense are sufficiently taken into consideration. In nature protection institutions there are accumulated needs, when strategies are sketched, nature protection plans are newly drafted or management tasks are defined for protected areas. Even though it is not yet possible to foresee all the consequences of climate change, the data base is good enough to act now in a prescient manner.

Large buffer areas which surround large protected areas could be able to absorb future changes. However, in large parts of Europe, protected areas are on the one hand too small, and on the other hand their surroundings are too much utilized by man. New protected areas should also be established in low traffic and non-fragmented spaces. Static protection of individual species is, however, an obsolete concept.

Picture 3

In order to link living areas, it is necessary to overcome various barriers : alongside the ecological and legal obstacles, also the barriers between the various sectors and in the minds of people.

Picture 4

Renewable energies on the test bench : measures are taken in the name of climate protection which can damage the natural balance and biodiversity.
The Kölnbrein dam in the valley Malta/A

Climate change : a challenge for biodiversity

Not only does climate change have an impact on species and ecosystems, but also climate measures in the various fields of activity. Conf icts between climate protection and the conservation of biodiversity exist above all in the field of renewable energies. The boom of biogenous fuels and the connected increase in areas that are used for the cultivation of energy plants, must be assessed as particularly critical, first of all with respect to the hunger issue — in particular in southern countries. The rocketing expansion of areas also has negative consequences on biodiversity : intensification of agricultural production, loss of green areas and the expansion of cultivated areas. Biogenous fuels deserve support only if they are not in competition with the production of food and when they can be produced in an ecologically sustainable way. Corresponding certification systems on the basis of life cycle assessments are currently being developed.

Also, a possible increase in electricity production from water power can have significant consequences for the ecosystems affected if, because of this, residual water quantities are further reduced or hitherto near-natural watercourses are dismantled. Furthermore, the production of wind energy represents an ecological conf ict, since pumped storage hydro power stations must be constructed in order to store the electricity from wind power stations which is not constantly available.

Since high water events become more frequent as a consequence of climate change, more extensive adaptation measures are necessary. If hydraulic engineering measures are taken, which considerably change the natural water f ow (straightening, riparian control structures, channeling projects), there are conf icts with the protection of the ecosystems of the watercourses. For a sustainable high water protection – particularly as regards climate changes – restraint spaces must be preserved and the necessary space along rivers must be ensured which also has a positive effects on biodiversity.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Climate change – novel communities, altered interactions, affected ecosystem services

[**Oliver Schweiger** - **Helmholtz Centre for Environmental Research – UFZ, Theodor-Lieser-Strasse 4, 06120 Halle, Germany - oliver.schweiger@ufz.de**]

Background

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."

This is a very clear statement in the last report of the Intergovernmental Panel on Climate Change (IPCC, 2007) where it is elaborated that increased anthropogenic greenhouse gas emissions are mainly responsible for drastic changes in global climate. Global surface temperature, for instance, increased by 0.74 ± 0.18 °C during the 20th century and future climate model projections indicate that temperature is likely to rise further 1.1 to 6.4 °C during the 21st century (***Fig. 1***). It is noteworthy that these

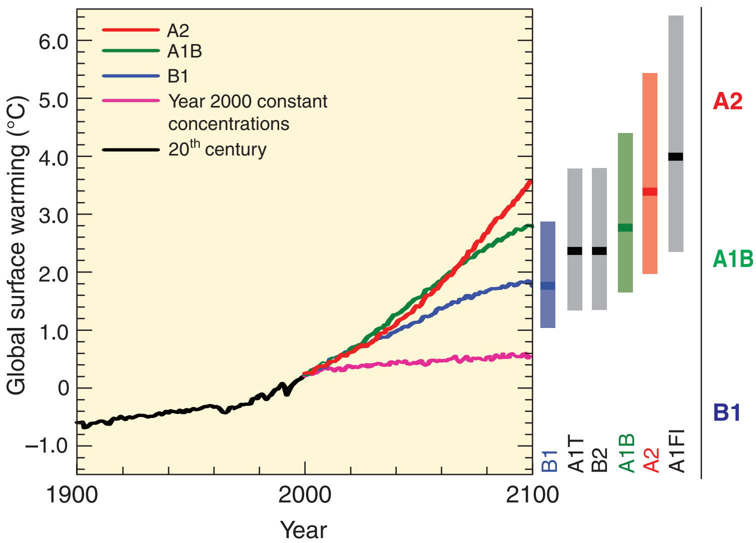

Figure 1
Observed global temperature anomalies for the last century and projected anomalies for the next century according to several greenhouse gas emission scenarios.

Picture 1-2
(1) glacier blanc point A 1995

(2) glacier blanc point A 2009

projections are not meant as predictions, they rather inform about the range of different possible futures based on different developments of driving forces such as policy, demography, socio-economy, and technological change. Consequently, the projected changes range from relatively moderate (1.1 °C temperature increase) to quite drastic (6.4 °C increase).

The observed and projected changes in climate are not evenly distributed across the globe but differ regionally. Europe, for instance, has warmed more than the global average (by 1.0 °C) and some changes are particularly significant in the Alps, especially in winter. Here for instance, the annual surface temperature increased by 2.0 °C during the last century, nearly threefold more than the global increase, and regional climate models project a further increase between 2.6 and 3.9 °C until the end of the 21st century (EEA, 2009). Such regional models further indicate that the annual number of frost days and the amount and duration of snow and ice cover will decrease much more than in the rest of Europe leading to a corresponding prolongation of the growing season (Jylhä et al., 2008) and an altitudinal shift of the tree line (Hickler et al., 2009).

Yet, climate is globally controlled but it acts locally and the wild species are adapted in their behaviour and physiology to these local conditions. In fact, there is an ongoing debate whether abiotic conditions such as climate or biotic conditions such as interacting species limit the performance and distribution of particular species (Davis et al., 1998 ; Pearson & Dawson, 2003). The prevailing view is that climate limits distributions at cool, higher latitude/altitude range margins, while warm, lower latitude/altitude margins are determined by biotic interactions (Brown et al., 1996). However, studies on butterf ies support the viewpoint that climate and land use are likely the major driving factors for butterf ies (Quinn et al., 1998 ; Merrill et al., 2008). Nevertheless, even when a species is largely limited by biotic interactions, it is not necessarily unaffected by climate change since these changes may act either directly, when large enough, or indirectly via reactions of the interacting species (see below).

The effects of climate change on single species are likely accompanied by consequences for all levels of biodiversity ranging from the genetic level to single species to communities to ecosystems. This is of particular importance since biodiversity, besides being realised as a value on its own, is now acknowledged to provide indispensible ecosystem services for human well being (Diaz et al., 2005) and can be regarded as "our collective life insurance policy" as noted by the High-Level Meeting of the United Nations General Assembly in 2010. Consequently, halting the loss of biodiversity is a key international priority, enshrined in the UN Convention of Biological Diversity (CBD) and EU policy ; and, as increasingly realised, biodiversity and the climate change crises are inextricably linked.

Consequences of climate change at the species level

Changing Phenologies

Single species can be affected in many ways by climate change. Among the well documented cases are changes in the timing of species occurrence and activities. In a recent literature review Parmesan (2006) provides an overview on the many studies that deal with such changes in species' phenologies. Here she reports that earlier spring and later fall lead to a lengthening of the growing season by 10.8 days (six in spring, 4.8 in autumn) from 1959–1993 in Europe. These changes are mirrored by phenological changes of many species and an average advancement of spring events by 2.3 days per decade is reported but the variability of these advancements among different species groups is noteworthy. Amphibian breeding, for instance, advanced by 1-3 weeks in England as a potential consequence of the fact that their reproduction is closely linked to both nighttime and daytime temperatures. Birds have been shown to lay their eggs by an average of 8.8 days earlier in the UK. Butterf ies are closely linked


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Picture
The Plaine Morte glacier/CH - 2009

to climate and thus the first appearance of most of the species in the UK and in Spain happens to be increasingly advanced.

In European alpine regions, where climate change leads to a particularly prolonged vegetation period, such changes in species' phenologies will be most pronounced. Here the productivity of many species is tightly linked to both warmer conditions and prolonged vegetation period and will be increased accordingly (Theurillat & Guisan, 2001). Modelling studies indicate that managed grasslands in the Swiss Alps will increase their productivity when temperature rises by 2 °C, but different management styles (e.g., grazing vs. cutting) as well as regional differences should be taken into account. For subalpine mires, warming may increase the growth rate of peat mosses (e.g., Sphagnum capillifolium) as shown by Gerdol (1998), if there is no drawdown of the water table, for instance due to a decrease of precipitation or an increase of evapotranspiration

Similarly, the growth rate of alpine tree species is affected by climate warming and has increased significantly since the middle of the 19th century for instance in the French Alps . However, the responses of the trees can differ among the species and with different altitudes. Modelling studies indicate that an increase of 2-3 °C can affect growth of larch (Larix decidua) and Scots pine (Pinus sylvestris) in different ways (Keller et al., 1997). Larch will increase its growth rate with increasing temperature only at its upper distribution, while it may not react at a lower, subalpine elevation because temperature here is less of a limiting factor. On the other hand, Scots pine will reduce its growth rate with increasing temperature but only at its lower Mediterranean distribution as a consequence of water limitation.

Distributional shifts

Another well documented response of species to changing climates is a shift in their ranges. A large number of species have already shifted their northern range boundaries polewards averaging 6.1 km per decade (Parmesan & Yohe, 2003). However, in her recent literature review Parmesan (2006) also reports on some variations of these expansions among different species and species groups. UK birds, for instance, showed both expansions and contractions, but the average was a mean northward shift of 9.5

km per decade over a 20-year period. For butterf ies and moths (Lepidoptera) some 30% to 75%, depending on the study, of their northern boundary sections had expanded north. Nonmigratory European butterf ies shifted their ranges between 35-240 km during the last century, and UK butterf ies expanded their northern ranges at average 10 km per decade over a 30-year period. Dragonf ies and damself ies (Odonata) show a mean northward shift of 2.5 km per decade over a 35-year period.

According to these differences in range expansion, and also indicated by other studies, it is evident that many species may not be able to track climate change at their northern range boundaries sufficiently. Moreover, they will lag behind northwards shifts in temperature. For instance, changes the composition of bird communities in France correspond to a 91 km northward shift for the period of 1989-2006, while during the same period temperature increase corresponds to a 273 km northward shift in temperature (Devictor et al., 2008). This discrepancy between the rapid increase of temperature and the slower response of the species is a consequence of several circumstances.

Firstly, simple dispersal limitations may impede the colonisation of newly suitable areas. This may particularly apply to many plant species as inferred, e.g., from recent estimates of postglacial tree migration rates less than 1 km per decade (Svenning & Skov, 2007), but also to many other species groups such as reptiles and amphibians (migration rates less than 2 km per generation ; Smith & Green, 2005), or land snails (migration rates less than 1 km per generation ; Schweiger et al., 2004).

Picture 3
Pararge aegeria

Secondly, dispersal is inevitably linked to habitat availability and landscape structure. In the UK most butterf y species are expected to have benefited from recent climate warming (Warren et al., 2001) while it was shown that most species actually declined in abundance and range size as a consequence of simultaneously changing landscape characteristics such as habitat availability and landscape structure (Warren et al., 2001 ; Hill et al., 2002). Since habitat loss and fragmentation at smaller scales and geographical barriers at larger scales impede the ability of species to reach new climatically suitable areas, dispersal characteristics are of great relevance (Hewitt, 2000 ; Clark et al., 2003). Northern expansion rates of the speckled wood butterf y (*Pararge aegeria* ; ***picture 3***), for instance, were 42%-45% slower in an area that had 24% less woodland, the preferred breeding habitat.

Thirdly, interacting species may affect colonisation of and establishment in new climatically suitable areas for a particular species. When a species colonises new areas, it may escape potentially harmful species interactions which have restricted the species' performance in its original area («enemy release» ; Keane & Crawley, 2002), or the species may constitute a combination of traits that are novel and potentially harmful to

the organisms in the new area («novel weapons» ; Callaway &Ridenour, 2004). In such cases, colonisation success and performance of the new species would be increased, and under particular circumstances such a species could transform from a weak competitor at home to a strong competitor in the new area. On the other hand, a new species might also experience new detrimental conditions of competition, herbivory, predation, parasitism, etc., in the new areas; or it may simply miss essential resources (see below). However, it still remains hard to predict the circumstances under which a species will benefit from or be suppressed by the new conditions in the new areas.

While much is known about recent changes at northern range margins, the situation at the southern margins is less well documented. Nevertheless, this is particularly important since quite different mechanisms are acting at these ‘trailing edges’. While at the northern margins expansion to the north and all related issues such as dispersal capacity, colonisation ability, or competitive strength are important, issues related to ecological plasticity, adaptability, or ecological buffering are important for questions of persistence under changed climatic conditions at the southern range margins.

However, whether climate is the driving factor at southern range margins is still under debate. The prevailing view is that climate limits distributions predominantly at cool, higher latitude range margins, while warm, lower latitude margins are majorly determined by biotic interactions (Brown et al., 1996). However, studies on butterf ies support the viewpoint that climate can be one of the major driving factors acting at the entire range (Quinn et al., 1998 ; Merrill et al., 2008). Although the southern range margins seem to be more stable than the northern ones, several species already met the expectation that also southern range margins should move northwards (Parmesan et al., 1999).

All these latitudinal shift of species ranges are mirrored by altitudinal shifts in mountainous areas. Here many organisms have already shifted both their lower (warm) and upper (cool) margins upwards with an average of 6.1 m per decade (Parmesan & Yohe, 2003). But again, the variability of these changes varies significantly among different species and is related to processes that determine performance at the individual and population level. In Spain for instance, the lower elevational limits of 16 species of butterf y have risen an average of 7.0 m per decade over a 30-year period, concurrent with a 1.3°C rise in mean annual temperatures (Wilson et al., 2005). In contrast, plants in the European Alps have shifted their ranges only 1-4 m upwards per decade (Walther et al., 2002).

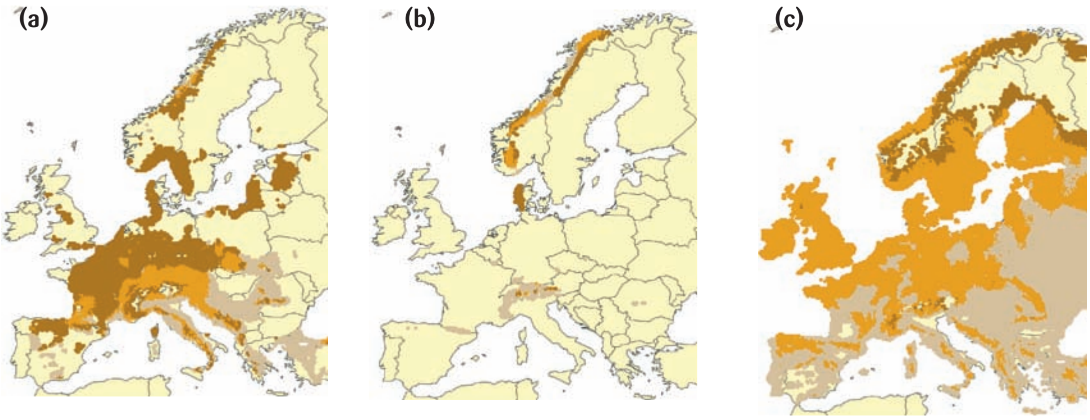
Local extinction

One problem of climate change, which particularly applies to mountainous regions, is local extinction. For those species whose populations have already been driven extinct at their lower latitudinal or altitudinal range boundaries, some are unable to expand northwards due to geographic barriers or upwards due to obvious orographic barriers. Such species have suffered absolute reductions in range size. For 16 mountain-restricted butterf ies in Spain warming has already reduced their habitat by one third in just 30 years (Wilson et al., 2005). Similar effects have been reported for other mountaintop species, such as pikas in the western United States (Beever et al., 2003), many cloud-forest-dependent amphibians in Costa Rica (Pounds et al., 1999), or the Apollo butterf y in France (Descimon et al., 2006). Such local extinctions accompanied by a severe reduction in range size will put those species at greater risk of regional or even global extinction in the near future.

Projections of future species distributions

To get an overall impression of the consequences of climate change, it is not only important to document and analyse recent distributional changes but also to asses potential changes in the future. Therefore, the climatic niche of a species can be modelled with respect to its current distribution and the climatic variables that determine its range (Heikkinen et al., 2006). Once these models have been developed, they can be used to project suitable climatic conditions into the future (Pearson & Dawson, 2003). Usually, these future projections are based on different climate change scenarios such as those from the IPCC (SRES) or from other sources such as the EU-funded ALARM project (Settele et al., 2005). Such models have been used to provide first estimates of the magnitude and direction of the potential distributional changes for plants (Huntley et al., 1995 ; Thuiller et al., 2005 ; Pompe et al., 2008), birds (Virkkala et al., 2008), butterf ies (Settele et al., 2008), amphibians and reptiles (Araújo et al., 2006), and mammals (Levinsky et al., 2007).

All these modelling approaches generally agree that most species will expand northwards, retract southwards and at average move upwards in the mountains. Further, they agree that the strength of the specific responses highly depends on the assumed future scenario with the general message that a future world with drastically reduced greenhouse gas emissions must be the ultimate goal. Further, although some species are projected to potentially benefit from climate change, most are projected to suffer from reduced range sizes. For instance, 70%-80% of the European butterf ies are modelled to reduce their ranges according to three different climate change scenarios for



Source Settele et al. 2008

Figure 2

Projected changes in climatically suitable areas for an intermediate change scenario (IPCC A2) for 2080.

(a) The tufted marbled skipper (*Carcharodus flocciferus*) is projected to largely increase its climatically suitable areas.

(b) The marbled ringlet (*Erebia montana*), a mountain species, is projected to virtually disappear.

(c) The red admiral (*Vanessa atalanta*), a very common and broadly distributed species, is also projected to lose large areas. Grey colours indicate lost, formally suitable areas; orange colours indicate suitable areas both in the past and in the future; brown areas indicate projected suitable areas under changing climates.

2080 (Settele et al., 2008). This study shows that under an extreme scenario of climate change (4.1°C temperature increase, IPCC A1FI) and the assumption of no dispersal, 24% of the species lose more than 95% of their present climatic niche and 78% lose more than 50%. Under an intermediate scenario (3.1°C increase, IPCC, A2), 9% lose more than 95% of their climatic niche and 66% lose more than 50%. While under a best case scenario (2.4°C increase, IPCC B1), only 3% lose more than 95% of their climatic niche and 48% lose more than 50%. The importance of dispersal is also highlighted by this study. It was shown that only 6% of the European butterf y species will reduce their ranges by 95% under the most severe change scenario when unlimited dispersal is assumed, while this number is significantly increased to 24% of species that will lose 95% of their ranges when they are assumed not to move at all.

The way how species will react to climate change largely depends on the position and breadth of the climatic niche of the species and the corresponding geographical position and the size of the species range. For instance, butterf ies dwelling in warm areas of Europe and tolerant to large variations in moisture conditions are projected to suffer less or even profit from global change, e.g. the tufted marbled skipper (*Carcharodus flocciferus*, ***Fig.2a***), while species restricted to cool, northern or Alpine areas will suffer most, e.g. the marbled ringlet (*Erebia montana*, ***Fig.2b***). Interestingly, even very common and broadly distributed species such as the red admiral (*Vanessa atalanta*, ***Fig.2c***) are not immune and may face severely reduced ranges in the future (Settele et al., 2008).

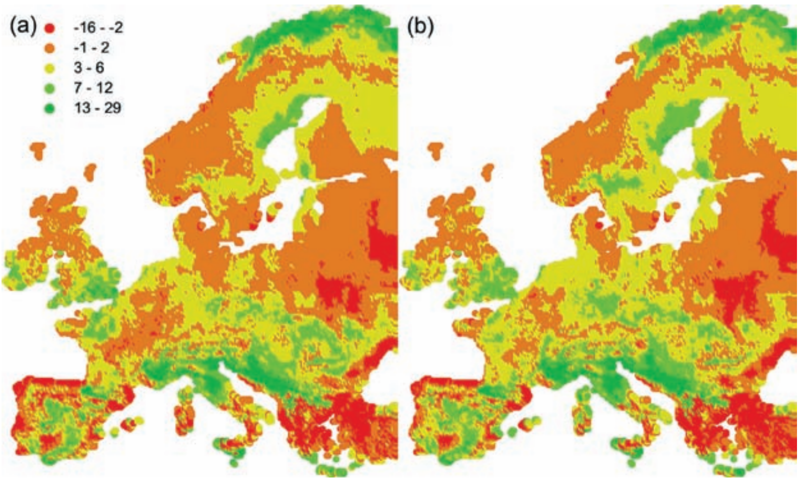


Figure 3

Projected changes in reptile species richness for minimum future climate change (IPCC B1; a), and maximum change (IPCC A1; b) under the assumption of full dispersal.

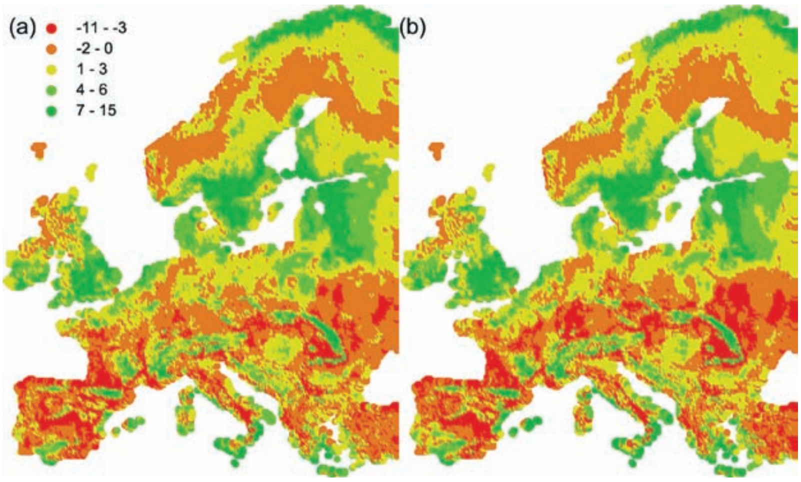


Figure 4

Projected changes in amphibian species richness for minimum future climate change (IPCC B1; a), and maximum change (IPCC A1; b) under the assumption of full dispersal.

Consequences of climate change at the community level

Species richness

Distributional changes and alterations of range size as a consequence of changing climates can be transformed into changes in species richness. Since most species are modelled to have reduced range sizes in the future, it is projected that average regional species richness will decrease accordingly. For instance, European plant species richness will be reduced by 27%-42% at average per 50 x 50 km^2 grid cell (Thuiller et al., 2005). However, these changes will considerably vary regionally. In most projections, northern parts of Europe will likely profit from increased temperatures in terms of species richness as well as some parts of the Alpine regions (e.g. Settele et al., 2008). On the other hand, large parts in Central and Southern Europe are likely to lose many species (e.g. Araújo et al., 2006 ; ***Figs 3,4***).

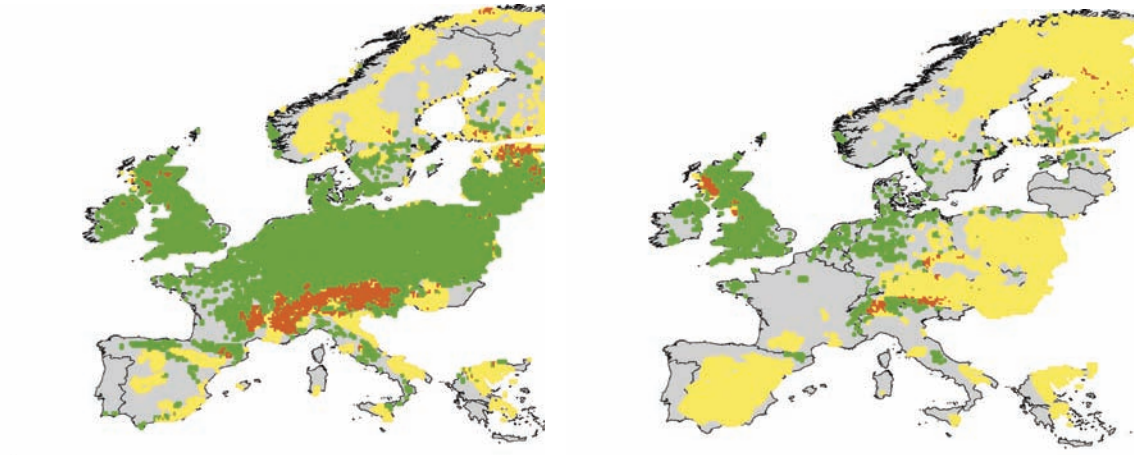
Community composition

Every single species can be expected to react in an individualistic manner to climate change and thus no species will be affected by changing climates in the very same way as other species. Moreover, the individualistic responses depend on the species-specific traits that uniquely identify a species' ecological niche. According to these traits species responses might be similar but not necessarily the same. Yet, biotic communities will not react to climate change as a whole in a uniform manner because the single species represent the units of change. Consequently, all the effects of species-specific local extinctions, colonisations of new areas, and changes in phenology will ultimately lead to the generation of novel biotic communities. These novel communities may be characterised by a lack of potentially co-evolved interactions but also by the potential of new interactions.

Under climate change there is great scope for disrupted species interactions. In current local communities, there are quite many mechanisms that lead to species interactions which all can be disrupted such as spatial and temporal synchronicity of occurrence (Parmesan, 2006 ; Hegland et al., 2009), or morphological and physiological interdependencies (Bond, 1994 ; Corbet, 2000).

Temporal mismatches are increasingly well documented for species interactions in general (Parmesan, 2006) and for plant-insect interactions in particular (Visser &

Both, 2005 ; Both et al., 2009). Under climate warming, both f owering periods (Fitter & Fitter, 2002) and insect f ight times may initiate earlier (Roy & Sparks, 2000) but plant and insect phenology may respond to different environmental cues and thus may not respond equally to climate change. For instance, the egg hatch of the winter moth (Operophtera brumata) has advanced more than the bud burst date of its larval food plant the pedunculate oak (Quercus robur) over the past two decades (Visser & Both, 2005 ; Both et al., 2009). Such a desynchronisation between larval egg hatch and the phenology of a vital resource can lead to severe consequences in the overall fitness of a species (van Asch & Visser, 2007). Temporal mismatches were also observed for pollinator species and their preferred forage plants on the Iberian Peninsula (Gordo & Sanz, 2005). The occurrence of the honey bee (Apis mellifera) changed from about 10



Source Schweiger et al. 2008 - © Ecological Society of America

Figure 5

Mismatch in the overlap of the climatically suitable areas of Titania's fritillary (Boloria titania) and its larval host plant the common bistort (Polygonum bistorta) for current (a) and future conditions for a most severe change scenario (IPCC A1FI) for 2080. Green colours indicate climatically suitable areas of the plant; yellow colours indicate climatically suitable areas of the butterf y; orange colours indicate the overlap of both (climatically suitable for both the butterf y and the host plant).

days later than the f owering of crucial host plants to about 25 days earlier during the last 30 years. Also the phenology of the small white (Pieris rapae) advanced more than that of his hosts from about 5 days later to 15 days earlier.

Climate change can also affect co-occurrences of interacting species in space. This will be of particular concern when the climatic niches of interacting species are quite different and the overlap of them is rather limited. In such cases it is likely that these species will react to different climatic variables or at different thresholds of the same climatic variables in a different manner (Schweiger et al., 2008). A modelling study on the effects of future climate change on the Titania's fritillary (*Boloria titania*) and its larval host plant the common bistort (*Polygonum bistorta*) showed that the overlap of their climatic niches will be considerably reduced under future climate change scenarios (Schweiger et al., 2008 ; ***Fig. 5***). Such local disruptions of rather basic trophic interactions may well apply to other more complex interactions such as pollination, competition, or parasitism.

Climate change may also affect morphological and physiological matching of interacting species. For instance, successful pollination of a particular plant is often determined by the appropriateness of pollinator morphological characteristics, e.g. tongue length, while a particular pollinator can forage profitably only on plants that offer adequate and accessible rewards, e.g. pollen or nectar (Corbet, 2000). When climate changes the functional composition of local pollinator communities, such morphological matchings might be disrupted. On the other hand, the quality of the vital resources might change under climate change. For instance, the adequacy and accessibility of nectar reward may change considerably with changing temperature and water supply (Willmer & Corbet, 1981). Even when the amounts of long-term average temperature increases might not affect nectar quality much, the increasing number of extreme events such as heat waves and droughts can easily reduce the quantity and quality of the nectar. Such changes can severely affect pollinator performance and behaviour which in turn might also lead to a negative feedback on overall pollination service.

Climate change will also generate new interactions in novel communities when species come into contact to other, to date unfamiliar species (Schweiger et al., 2010). This can happen in a more natural way when species shift their ranges or change their phenologies, but also when direct human activities lead to the introduction and establishment of totally new alien species (Richardson et al., 2000 ; Pyšek et al., 2004). In this context, climate change might directly inf uence the likelihood of alien species being introduced into a territory, or indirect effects might occur as some ecosystems become less resistant to alien species (Walther et al., 2009). In extreme cases, climate-driven invasions could lead to completely transformed ecosystems where alien species dominate. Such changes are particularly obvious at higher latitudes and altitudes, where growing and reproductive period are prolonged or where previous thermal constraints are released with climate warming. For instance, the range of the pine processionary moth (*Thaumetopoea pityocampa*) is no longer limited by temperature (night air temperature < 0° C and temperature inside the larval nest < 9° C) in many regions, enabling the species to expand its existing range into new sometimes disconnected areas (Robinet et al., 2007). Alien plants have also benefited from milder winter conditions which enabled, e.g., the palm Trachycarpus fortunei to establish fertile populations in the wild in the past few decades (Walther et al., 2007).

The consequences of climate-mediated biological invasions are far-reaching and more controversial than those of past invasions not affected by climate change. For example, milder winters changed the climatic conditions of deciduous forests in a way that facilitates evergreen broad-leaved species (Berger et al., 2007). As a consequen-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ce, resident species can become increasingly poorly adapted to the local environment, which will then provide opportunities for newcomers that are better adapted and more competitive. This could lead to the establishment of mixed communities, such as a new assemblage of evergreen broad-leaved plants growing in former deciduous broad-leaved forests, e.g., at the southern foot of the European Alps (Walther, 2000).

However, controversial effects can occur by both types of new species in novel communities (i.e. alien and simple range shifting species). In addition to the often discussed negative effects of alien species, there are potentially positive ones, too. Increasingly mismatches of vital species interactions, for instance, can be buffered by novel species when they substitute the role and function of species that are lost due to climate change (see below).

Potential buffer mechanisms

Rapid evolution

One potential buffer against the detrimental effects of climate change is the intrinsic potential of species to adapt to changing environmental conditions. This is especially important for populations at the trailing edge of a species' range and even more when a species can not track changing climates fast enough at its leading edge. In cases like these the only chance to survive is adaptation to changing conditions. However, current and predicted climate changes are expected to be rapid, therefore necessitating equally fast evolutionary adaptations. Rapid evolution has been increasingly acknowledged as an ecological process acting at relevant time scales (Thompson, 1998; Parmesan, 2006). Thompson (1998) reported on interspecific specialists interactions that coevolved over only a few decades implying that ecologically significant evolutionary responses can accompany both climate change and the generation of novel communities. However, there is little experimental or theoretical support that a particular species will be able sufficiently to evolve the necessary climatic tolerances (Parmesan, 2006). The current understanding is that evolution will rather complement and modulate than replace projected ecological changes.

Such microevolutionary processes must not be restricted to adaptation to novel climates but can also act via adaptation to novel resources which then allow a species to colonise newly suitable but otherwise hostile areas. A prominent example is a shift of larval feeding host plants. At their northern range margins, the larvae of the European brown argus butterf y (Aricia agestis) were to date restricted to feed only on the plant genus Helianthemum. A recent host shift enabled the butterf y to additionally utilise Geranium species which grow much farther north than the Helianthemum species. This local diet evolution promoted further expansion to northern areas where the original host, Helianthemum, was absent and thus enabled this species to move ahead of changing climates (Thomas et al., 2001). However, there are limits to such rapid changes, e.g. due to constraints imposed by phylogenetic histories, and consequent similarities or differences in potential defence mechanisms, of the involved species. Thus, shifts to alternative resources may be restricted to a small subset of the available resources (Thompson, 1998).

Ecosystem plasticity

Another mechanism that potentially buffers the effects of climate change on ecosystem functioning is given by the fact that the intrinsic structures of ecosystems tend to be highly flexible and dynamic. In addition, often high levels of functional redundancies among different species might insure the sustainability of basic functions within ecosystems even under drastically changed climates and corresponding novel communities. Plant-pollinator interactions, for instance, are often structured in a way that a core set of generalist species play key roles while specialist species entirely rely on the generalists (Jordano et al., 2003 ; Petanidou & Potts, 2006). The generalist species are often less vulnerable to environmental change, and thus they can partly sustain network structure under altered environmental conditions. These network structural properties are suggested to confer robustness to loss of species and interactions due to the high level of redundancy and flexibility within the systems (Memmott et al., 2004 ; Fortuna & Bascompte, 2006).

Another insurance mechanism would be the often high level of plasticity of ecosystems with respect to species composition and interaction identity. Many interaction networks are not static, but who interacts with whom is highly variable through time (Schweiger et al., 2010). In this context, novel species can play an important role when they substitute relevant ecosystem functions of declining or disappearing species. For instance, generalist alien pollinators often integrate into native plant-pollinator networks and they can improve pollination services to native plant species (Goulson, 2003).


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Similar to alien pollinators, enthomophilous alien plants are readily integrated into native plant-pollinator networks (Memmott & Waser, 2002 ; Lopezaraiza-Mikel et al., 2007; Stout, 2007), and might thus be considered as additional resources for pollinators that might potentially compensate temporal or spatial mismatching. Alien plants that produce showy and rewarding f owers decrease the dependence of native pollinators on potentially suffering native plants and could make an invaded area able to sustain larger pollinator populations. However, such buffering capacities of entire interaction networks are not unlimited and the robust structure of the networks may not suffice and the system might reach a tipping point and collapse under severe pressures when multiple environmental threats are involved (Memmott et al., 2004 ; Fortuna & Bascompte, 2006; Schweiger et al., 2010).

Opportunities for conservation

The general effects of global climate change seem unstoppable, although they depend in their severity largely on the way we design our future and the corresponding emission of greenhouse gases. Nevertheless, there are several options for conservation management to adapt and mitigate to climate change. Since the effects of climate change are quite context specific, potential management options can be designed to meet the specific requirements.

The main issue at the leading edge of species concerns the colonisation of new areas to sufficiently track changing climates. Thus, every action that enables a species to make use of its full dispersal capacity is highly recommended. Further the active translocation of species to newly suitable areas that lay by far outside the species' dispersal capacity might be considered. However, such an approach still needs a serious discussion and a proper risk analysis.

The main issue at the trailing edge concerns the maintenance of local populations as long as possible to provide or increase the possibility of adaptation to the novel climates. Here active habitat management is one of the most promising approaches. If a high level of environmental heterogeneity is ensured in a way that a large variability in micro-climates is generated, many species can then avoid harmful climatic conditions by actively choosing the adequate micro-climates.

Further, a general high level of biodiversity is desirable to benefit from system-intrinsic buffer mechanisms. Species rich communities generally exhibit high levels of functional redundancy and f exibility. Thus, they provide a greater insurance against a loss of crucial ecosystem functions when single species decline or go extinct in the course of climate change.

In this context, also the general perception of alien species should be critically reassessed. A rash prejudgment of alien species as being generally bad might be overly simplified. Indeed, there are many cases where particular alien species are reported to have negative effects on ecosystems. On the other hand, there are also obvious beneficial effects when alien species replace otherwise lost resources or functions particularly under changing climates. Thus, a proper assessment of the pros and cons of alien species is necessary which can then help to guide management decisions. ●

Picture
Rumex developing around an artificial lake intended to water the cattle / *Vanoise National Park / F*

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Climate or land use change : what affects alpine grouse species more ?

[Kurt Bollmann, Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland, kurt.bollman@wsl.ch]

The polar bear (*Ursus maritimus*) and yellow-bellied marmot (*Marmota flaviventris*) are actually the best known species that are affected by climate change contrarily. While the flagship of arctic ecosystems suffers from the loss of habitat and accessibility to prey, the North American marmot gains from earlier emergence from hibernation and weaning of young, themselves resulting in a longer growing season and larger body masses in autumn. The resulting reduction in adult mortality has triggered an abrupt increase in population size during the last thirty years. These examples obviously demonstrate that cold-adapted organisms like grouse species can be affected reciprocally by climate change.

Bioclimatic envelope models only predict one part of the future

Minimising negative impacts on species diversity requires effective conservation strategies that anticipate species' responses to climate change and enhance their opportunities to adapt to future environmental conditions. Protected areas and national parks have the disadvantage that they are static conservation instruments following a surrogate approach by using present conditions to conserve future situations. To-date, the predicted shifts of species' distribution ranges under the assumption of climate change is heavily dominated by the outcome of bioclimatic envelope models. Although these models may highlight the general magnitude of climate change on biodiversity, range distribution and species' relative extinction risks, bioclimatic envelop models have several shortcomings. They make several simplifications and de-couple the impact of climate change on the target species from other ecological changes. These include processes that inf uence habitat suitability or vegetation growth and relate them to changes in human land use resulting from climate-dependent socio-economic factors. The combined impact of these changes can result in loss, gain or fragmentation of habitats for different species.

Vegetation composition and structure determine habitat suitability of most terrestrial animals and remarkably inf uence land use by humans. The increasing greenhouse gas emissions and temperatures are expected to change vegetation characteristics over most of the world' regions and benefit woody and herbaceous plants differently. Thus, complex interactions of the numerous elements of an ecosystem make predictions about the impact of climate change on particular species very difficult. Only dynamic models of species' potential range shifts that incorporate habitat processes, demographic characteristics and dispersal potential as well as human responses in land use could make more realistic predictions for future situations.

As long as we lack such models we have to refer to the results of single studies, estimate their significance for our conservation targets and predict the relative importance for a particular ecosystem, protected area or reserve.

Grouse as model species to study impacts of climate and land use change on alpine ecosystems

In the Alps, negative effects of climate change are mainly predicted for habitat specialists of subalpine and alpine ecosystems. There, four grouse species occur along the ecological gradient from semi-open cultural landscapes to high alpine tundra. The grouse are appropriate model organisms to study the direct and indirect impacts of climate change on f agships of Alpine biodiversity. The hazel grouse (*Bonasa bonasia*) and capercaillie (*Tetrao urogallus*) inhabit mixed-deciduous and coniferous forests of the high montane and subalpine zone, while the rock ptarmigan (*Lagopus mutus*) occurs in the Alpine tundra where the growth of trees is ecologically inhibited. The black grouse (*Tetrao tetrix*), a so-called edge-species, prefers the ecotone between mountain forests and the adjacent dwarft-shrub and grassland vegetation. Although all four grouse species show morphological characteristics of cold-adapted organisms, I do not expect all of them to become threatened due to climate change during the next 50-100 years. The main reason for this preliminary conclusion is that the relative impact of climate and land use change and their interaction will affect the viability of the Alpine grouse species differently.

To-date, the two forest grouse species capercaillie and hazel grouse are classified with higher extinctions risks than black grouse and rock ptarmigan if we compare the


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red lists of the European countries with Alpine territories. Capercaillie and hazel grouse are classified as threatened in six of seven national red lists, black grouse in four and rock ptarmigan in three. Thus, the integral threats for grouse species decrease in Alpine habitats from lower to higher elevations. Differences in the type and intensity of human land use along the altitudinal gradient during the last 150 years have caused this characteristics. Human-inducted changes in structural and vegetation composition have inf uenced habitat suitability of mountain forests more than of Alpine pastures and tundra, the main habitats of black grouse and rock ptarmigan respectively. The abundance of semi-open forests that are rich in structure and ground vegetation with ericaceous shrubs decreased significantly during the last century and affected capercaillie and hazel grouse populations negatively.

Currently, there are evidences that climate change may reverse the differences in the integral threat between grouse species of mountain forests and alpine grassland/tundra. The predicted increase in wind storms and summer droughts will directly or indirectly affect habitat suitability of hazel grouse and capercaillie positively. Forests that are inf uenced by wind storms and bark beetle calamities show a better light regime and higher structural heterogeneity than homogeneous even-aged forests that do not provide suitable grouse habitat. On the other hand, the more recent dynamics in forest expansion in the southern and northern Pre-Alps due to land use abandonment is expected to affect the habitat of black grouse negatively. Studies show that the vegetation of plenty of former extensively cultivated alps within the forest belt (e.g. Maiensäss) will develop to forest during the next decades. In addition, ridges of lower mountains where the natural tree line ecotone has been forced down-slope for centuries by tree cutting and forest pasturing will also undergo a vegetation succession towards forest. Thus, black grouse in poorly developed, peripheral and lower mountain areas is expected to loose considerable habitat during the next decades independent of the direct effects of climate change. The rock ptarmigan in contrast, is least affected by land use changes. Locally, negative impacts by more frequent recreational activities will occur, but such developments have rarely negative consequences at the large scale. In contrast, the specialist of alpine tundra habitats is more exposed to physiological limitations of climate change than the other grouse species. Climate envelope models predict a drastic reduction of the distribution range of this species for the ongoing century. But, we also have to consider that the rock ptarmigan's persistence under les favourable climatic conditions is unknown at the moment.

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Indirect threats by seasonal asymmetry between climate and breeding ecology

A seasonal asymmetry in regional climate change that negatively affects the weather conditions for breeding of black grouse has been shown in Finland. The study gave support for the mismatch hypothesis. Like in the yellow-bellied marmot, warmer temperatures in spring triggered advanced breeding and hatching in several populations studied since 1987. Because the preferable weather conditions for the development of newly hatched grouse did not advance simultaneously, seasonal asymmetric climate change between spring and summer negatively affected the breeding success of black grouse in Finland. This caused the intrinsic rate of increase to decrease and the studied populations to severely decline during the last 4-5 decades. Such a pattern has not been shown for Alpine grouse species yet. We can not predict if a seasonal mismatch between spring and summer weather under climate change scenarios might negatively inf uence female breeding conditions, insect abundance during chick rearing or chick survival per se, and thus override positive effects deriving from summer droughts or habitat conservation measures.

Another factor that is difficult to predict is the rate of timber harvest due to an increasing energy demand by humans. Unlike many conservationists, I expect a positive impact of higher harvest rates in the Alps because standing stock in most regions has reached a historical maximum at the end of the last century. This development has deteriorated the habitat suitability of specialists of open forests like hazel grouse and capercaillie. If we want to generate a synergy between timber use and habitat suitability in the near future, several ecological outcomes of contemporary grouse research have to be considered while harvesting.

To conclude, I expect different and reciprocal impacts of climate and land use change for the four grouse species of the Alps (***Table 1***). Hazel grouse and capercaillie should profit from future developments caused by natural changes and forest management, black grouse is expected to loose habitat particularly in the peripheral and lower mountain regions. Integral predictions for rock ptarmigan are hard to make because we do not know the physiological plasticity and adaptive potential of the species under climate change. In general, changes in species' abundance and occupied area will be more pronounced in the Pre-Alps than in the Alps where I do not expect an extinction of any of the four grouse species due to climate and/or land use change during the next 100 years.

By combining all the mentioned drivers of grouse species distribution and abundance in the Alps I conclude that land use change will affect them more than climate change will do – at least in the subalpine zone. ●

Table 1
Expected impact of climate and land use change on the Alpine grouse species and predicted integral impact on their viability during the next 50-100 years.

Climate change / land use change causes	**Environmental characteristics**	**Hazel grouse**	**Capercaillie**	**Black grouse**	**Rock ptarmigan**
↗	Annual temperature and precipitation	–/+	–/+	–/+	–
↗	Natural disturbance (e.g. wind storm, drought, insect calamity)	+++	++	+	+
↗	Forest area	+	++	-	o
↘	Area of Alpine pastures	o	o	--	-
↗	Human disturbance	(-)	-	-	-
Predicted integral viability		++	+	--	-

↗ increase in ...; ↘ decrease in ...; – – – strong negative impact; – – considerable negative impact; – low negative impact; o neutral impact; + low positive impact; ++ considerable positive impact; +++ strong positive impact; –/+ impact depends on the seasonal pattern.

How can the Alpine network of protected areas contribute to grouse conservation under scenarios of climate change ?

- **Increase the surface of protected areas : large conservation areas provide space for population fluctuations and habitat heterogeneity that can buffer or compensate negative consequences of future developments.**
- **Increase connectivity between core areas of grouse distribution by managing habitats in the matrix. Current reserves alone can not guarantee the regional survival of Alpine grouse species because they do not provide enough habitat for viable populations.**
- **Conserve the genetic diversity and support gene flow by a network of protected areas over the entire range of grouse distribution. This precautionary principle distributes the potential negative impact of future developments over different biogeographic regions and protected areas.**
- **In general, protected areas that implement habitat management measures have a higher conservation potential than total reserves because directed measures can support the resilience of the ecosystem under scenarios of climate change.**
- **Adopt habitat management measures area-wide and improve the suitability of grouse habitats. Higher habitat suitability reduces mortality in general.**

PAST AND FUTURE DEVELOPMENTS IN PLANT POPULATIONS IN THE ALPS LINKED TO CLIMATE CHANGE

[Christophe Randin[1] - christophe.randin@unibas.ch, Pascal Vittoz[2] - pascal.vittoz@unil.ch, Robin Engler[2] - robin.engler@unil.ch and Antoine Guisan[2] - antoine.guisan@unil.ch]

Set up in 2002, the Spatial Ecology (ECOSPAT) group at the University of Lausanne (http://www.unil.ch/ecospat) has been studying how climate change influences developments in plant populations in the Swiss Alps. The research has focussed on two separate issues : using permanent observation plots, Dr Pascal Vittoz has been studying observed changes in plant populations, whilst Professor Antoine Guisan is developing forecasting models to predict the changes that might occur during the 21st century.

THE PERMANENT.PLOT.CH PROJECT

In 2003, Dr Pascal Vittoz (Vittoz & Guisan 2003) set up the PERMANENT.PLOT.CH project to create a centralised database containing information about permanent plots used to study plants in Switzerland (clearly marked areas of ground used to carry out regular surveys over a period of time). The project's primary aim is to create a record of this valuable historical data and ensure that it is available for researchers to use in studying past and future plant life developments in Switzerland.

The information has been used to study the impact of climate change to date. The researchers initially examined changes in plant diversity on different peaks in the alpine zone and above the snow line (2800 - 3400 m; ***Fig. 1a***) during the 20th century (Vittoz et al. 2008; Vittoz et al. 2009a). The results showed an average increase of 86% in the variety of plant life found on the summits between 1900 and 2000, which confirmed previous findings (see for example Grabherr et al. 1994 and Walther et al. 2005). However, the research also revealed that the majority of new species came from lower zones, thereby proving that the warmer climate is conducive to species migrating upwards. What is more, the species that had colonised a range of new summits tended to have seeds with appendages designed to facilitate effective wind dispersal (silky hairs or narrow wings).

1 Institute of Botany, Schönbeinstrasse 6, 4056 Basel, Switzerland
2 Department of Ecology and Evolution, Lausanne University, Biophore Building, 1015 Lausanne, Switzerland

Figure 1a-1b
(a) Piz Languard, a peak above the snow line (3262 m) for which we have detailed records dating back to 1905
(b) Botanical survey in subalpine grassland (Vallon de Nant)

As human activities have put a lot of pressure on low and mid-altitude areas, there is limited information available on the impact of climate change on meadow plants below the tree line. Most of the grassy areas surveyed in the past have seen dramatic changes in terms of usage and management. Nevertheless, we have been able to use two sets of data for subalpine meadows (Vittoz et al. 2009b) : permanent plots have been monitored since 1954 in the Bernese Alps (Schynige Platte) and plant populations have been surveyed since 1970 in the Vaud Alps (Vallon de Nant ; ***Fig. 1b***). When analysing the data, we have tried to distinguish between climate-related changes and those linked to land management.

At both sites, our analysis has shown that the changes were much less significant than those previously recorded at higher elevation. What is more, most of the developments observed in the plant cover were probably caused by changes in land management. At the first site, grazing had been replaced by mowing, which favoured some species over others (for example, grazing animals did not feed on poisonous plants but these did not survive mowing). The second location was grazed by goats in the past – in their absence, taller and denser grasses have gained ground which in turn means that some small alpine species are no longer able to compete. However, global warming does also seem to have inf uenced the vegetation. At Schynige Platte, a hemiparasite from the premontane to subalpine zones (*Rhinanthus alectorolophus*) has replaced a hemiparasite from the alpine zone (*Euphrasia minima*), whilst some species in the Vallon de Nant have thrived in the absence of the goats and are now found at unusually high altitudes for the region.

These studies, along with others carried out in the Alps, have demonstrated that climate change has already had a significant inf uence on plant life, with species migrating towards the summits, although the effects are currently much more modest at lower altitudes. However, we cannot draw any firm conclusions as yet about vegetation below the tree line as there is not sufficient research data.

Tools for predicting future species distribution

Statistical models known as predictive distribution models can be used to forecast potential current and future species distribution (Guisan & Zimmermann 2000). These models identify links between the observed presence and absence of species and environmental factors such as climate, topography, substrates and land use (***Fig. 2***). By modifying the climatic variables to allow for different scenarios and socio-economic projections (IPCC 2007), the models can forecast potential future species distributions and thereby assess how climate change might affect biodiversity.

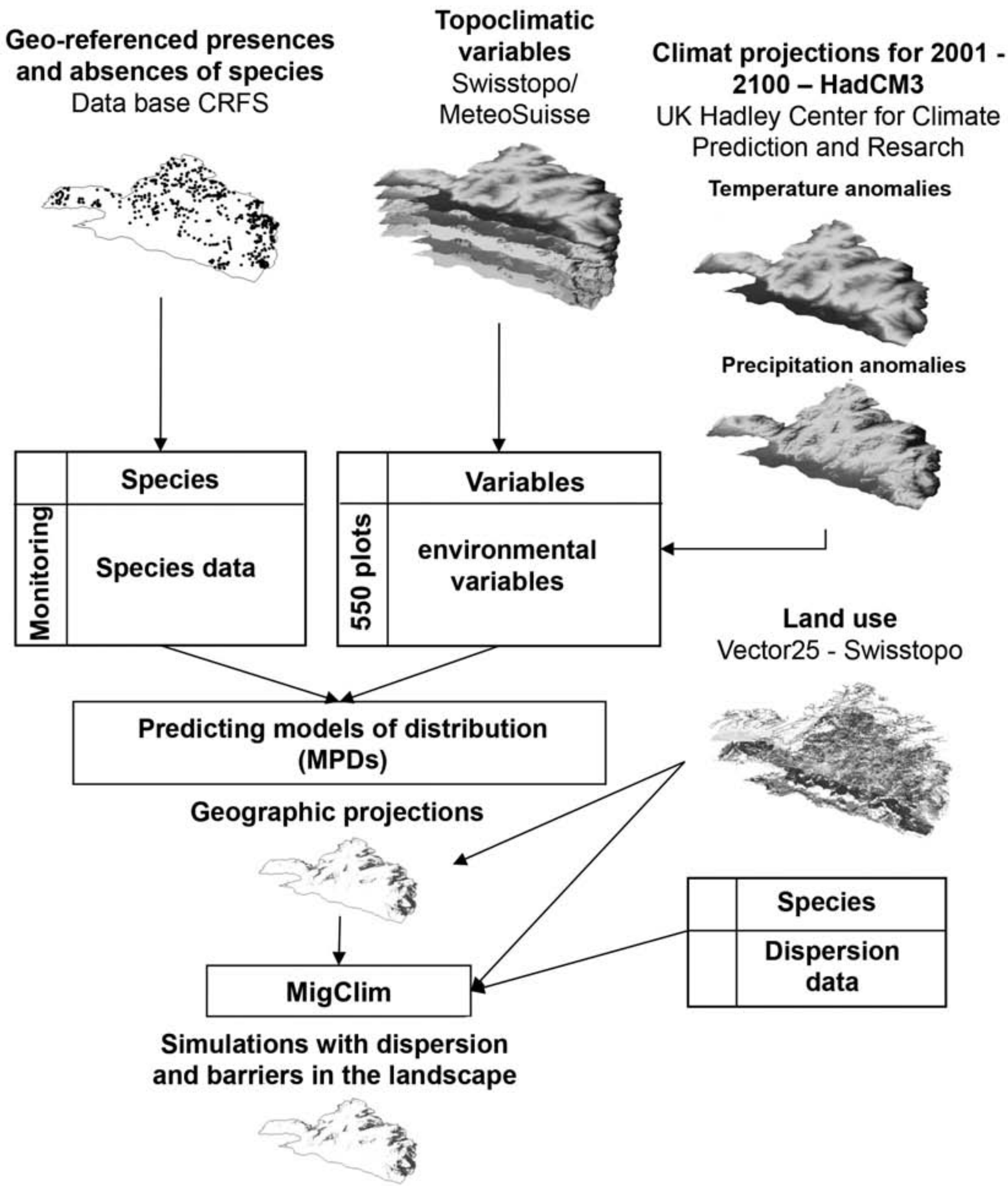

Figure 2
Conceptual model showing the different stages of predictive distribution modelling and the cell-based MigClim simulation tool.

Large-scale studies using coarse-resolution models (16 x 16 km plots in the Alps) have predicted that up to 60% of species could disappear from sites in the European mountain range by the end of the 21st century (Thuiller et al. 2005). However, these large-scale models are not really appropriate for the complex topography of the Alps. Using higher-resolution models (25 x 25 m), we have evaluated the impact of climate change at the end of the 21st century in terms of the distribution of 78 plant species in two regions of the Swiss Alps (Swiss Prealps and Zermatt region; Randin et al. 2009a). As these higher-resolution models are better able to ref ect the microhabitats that allow plants to survive in localised areas, the findings are far less pessimistic, although still worrying, suggesting that between 26% and 43% of these 78 species could disappear from the Swiss Prealps as opposed to none in the Zermatt area. However, many plant species will be far less widely distributed in future, particularly in the Swiss Prealps (38-45% will lose coverage compared with 24-25% in the Zermatt area). These results indicate that species in mountain regions with a wide range of altitudes will have a better chance of surviving as they will be able to migrate more easily to higher elevation sites.

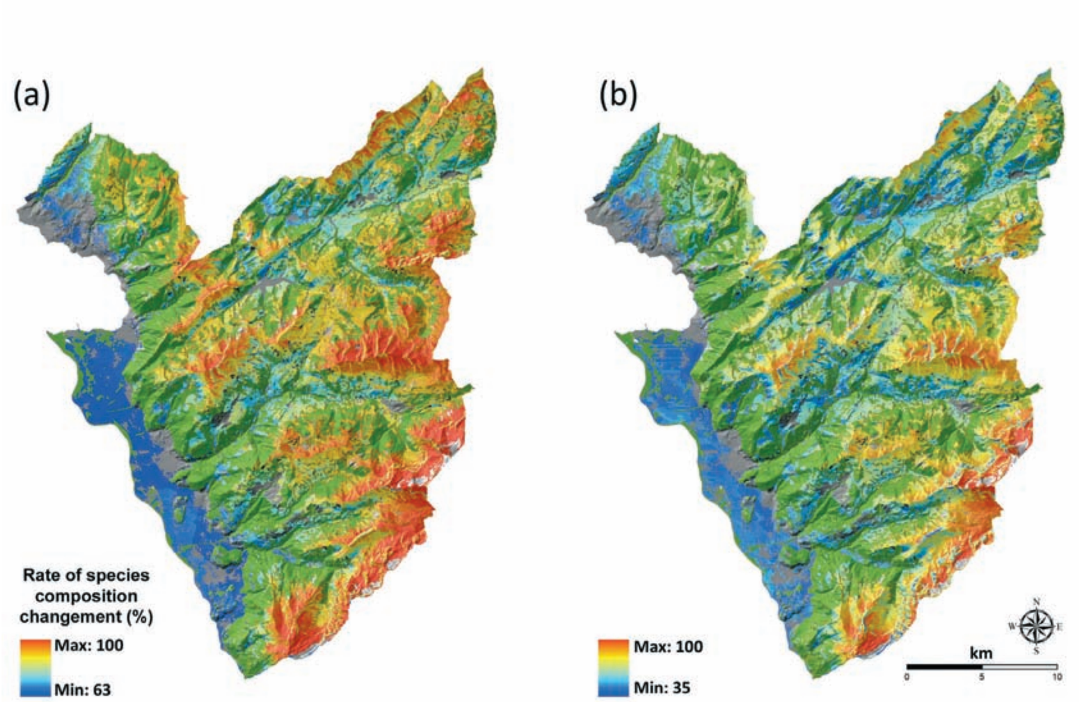

Figure 3a-3b
Predicted rate of species composition change (%)"at the end of the 21st century for (a) IPCC scenario A1FI and (b) scenario B1. The forested zones (shown in green) and land which is not suitable for plants (in grey) have not been included in the projections. The rate of change of composition is calculated for each cell in the landscape (25 x 25 m) using the following formula : T = 100 x (No. of species lost + No. of new species) / (Predicted no. of species now + No. of new species).

Another limiting factor in projects to simulate the potential impact of climate change on plant distribution is that they tend not to include data on seed dispersal. Most studies either assume unlimited dispersal or no dispersal. Yet, depending on the speed of climate change, the fragmentation of the landscape, and each species' capacity for seed dispersal, these assumptions either exaggerate or massively underestimate the changes in plant distribution, and consequently considerably increase the level of uncertainly associated with the projections.

In order to reduce these uncertainties, we have developed the MigClim model (***Fig. 2*** ; Engler & Guisan 2009), which is able to simulate seed dispersal within the future distribution projections. The model also includes parameters such as landscape fragmentation and the time that elapses between two generations. Using the MigClim simulation model for 287 species found in the Swiss Prealps (Engler et al. 2009), we found that when including dispersal and depending on the selected scenario, between 30% and 70% of the species could lose up to 90% of their current potential surface coverage by the end of the 21st century. Taking the most pessimistic IPCC forecast (A1FI, 7.6°C increase in 2100), between 63% and 100% of the species in each plot (25 x 25 m) would be replaced by new species (***Fig. 3a*** : rate of change in species composition). Land above the tree line would be more affected, with all the summits studied likely to have an almost completely new set of species. Consequently the majority of alpine plants could have disappeared by 2100. Under the most optimistic IPCC scenario (+3.9°C in 2100), the forecasts are slightly different : mid-altitude summits would see fewer changes in the variety of species (***Fig. 3b***). However, the higher peaks would still experience massive changes. As these models include species dispersal, this is a significant finding in terms of biodiversity. The models also allow us to estimate when the first wave of extinctions will occur. In the region under examination, plants could begin to become extinct from 2040 onwards in the most extreme scenario, or around 2090 in the most optimistic scenario.

In order to further improve the quality of the projections obtained from the predictive models, other key factors such as inter-specific / biotic interactions, geomorphology and land use could also be incorporated (Randin et al. 2009b ; Randin et al. 2009c). Some land-use categories may actually function as facilitators or inhibit the movements of other species within mountain ecosystems (Randin et al. 2009b ; Randin et al. 2009c). Unfortunately it is very difficult to obtain information about these variables from high-resolution maps covering large areas. ●

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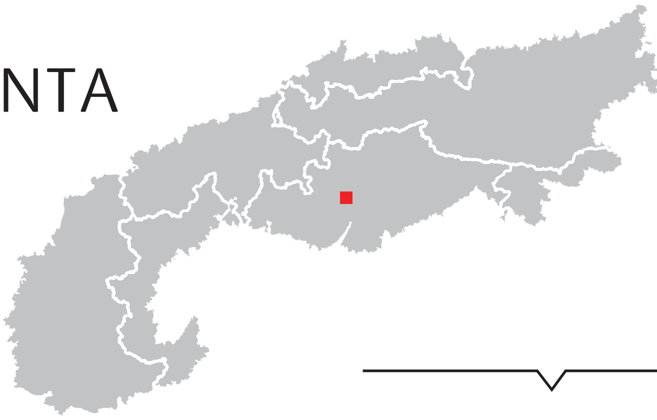
INTERVIEW WITH...

ADAMELLO BRENTA NATURAL PARK



[ANDREA MUSTONI - WILDLIFE MANAGER
ANDREA.MUSTONI@PROVINCIA.TN.IT]

What do you think is currently the main threat to the environment in the protected area where you work ?

I think the main threats are tourism and the consequent anthropization of the area. We should also bear in mind that the area of the Adamello Brenta Natural Park is very fortunate as the environment is still markedly natural and the ecosystem still presents most of its original specific features.

Its being a mountainous area and therefore difficult to exploit in the way that happened with the nearby wealthy Po Valley probably contributed significantly to the safeguarding of the environment in this "lucky" area. The Park, however, has changed remarkably lately due to the environmental changes caused by man and the local economy, which is now based mainly on tourism. We have witnessed how the "need for nature" has grown in the past few years in our society and people increasingly decide to spend their leisure time in contact with nature : woods, meadows and all those areas that evoke a feeling of peace and quiet. It is therefore easy to understand why the main problem for the mountains of Trentino is the increased exploitation of local resources by the local authorities in order to meet the needs of tourists. The beauty of the mountains of Trentino is therefore also our main concern.

What solutions have you introduced to try and tackle the situation you have just described ?

Unfortunately, we are not magicians and do not have a magic wand. In a situation like this it is not easy to find solutions that can truly reverse the economic and social trend I have just described. Our efforts to protect nature are aimed primarily at raising awareness among visitors to the Park and in this way trying to make their presence sustainable. The management policy we have adopted is focused more on raising awareness than imposing rules, which, although necessary, are rarely successful.

That is why, rather than banning entry to particularly "precious" areas or not allowing specific outdoor activities, we are currently trying to "channel the f ows" in an attempt to foster a sustainable use of the mountains and promoting practices that are most compatible with nature conservation.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What new challenges will you be facing with regard to biodiversity loss and climate change ?

Nobody can deny that, in addition to the social changes underway, our environment is also experiencing climate change, which also raises serious conservation issues.

More specifically, it has been noticed that some animal species have changed their «life habits», or even shown clear signs of suffering, by reducing their home range and the size of their populations.

Examples are the capercaillie, whose home range in the Park can now be found at higher altitudes, and the ptarmigan, a glacial relic, which more than any other species is suffering as a result of climate change and has now become extinct in most of its ancient home range. Besides these clear examples, we also believe that the effects of climate change might be involving other less visible, but still tremendously important, components of the ecosystem. We might therefore say that, in an Alpine area such as that of the Park and of Trentino in general, climate change dependent factors may be playing a pivotal part in biodiversity loss, together with the environmental changes that accompany socio-economic development. It is therefore difficult to envisage how a single protected area can take the necessary action to tackle climate change and its effect on the environment.

As a result, the strategy we are currently adopting is that of protecting "large creatures" as well as the smallest ones, starting with their habitats, and trying to prevent excessive environmental deterioration and fragmentation due to the tourist policies implemented in the mountain area. The strategies implemented in the Park are aimed at achieving these goals as a foundation, with the further aim of promoting scientific research and introducing educational and communication activities in order to raise awareness among mountain users.

«More specifically, it has been noticed that some animal species have changed their «life habits», or even shown clear signs of suffering, by reducing their home range and the size of their populations.»

Moreover, given the importance of protecting biodiversity, it is extremely important to introduce environmental monitoring activities to assess the status of animal and plant species and in this way provide useful information on where to focus our efforts.

What problems are being created by these new processes and which of these do you have to face in the everyday management of your protected area ?

A question we are asking ourselves more and more is : «How do we find the funds needed to introduce the management strategies we want ?» Even in a time of economic and financial crisis like the one we are facing now, the economic resources needed to solve the problems mentioned are definitely not substantial, sometimes seeming inadequate to achieve our goals.

Another doubt we have is whether we are too focused on abstract issues and the «theory of environmental conservation» and as a result forget that sometimes we can act directly on animal populations, albeit only in those rare cases when it is right to do so. This is a legitimate doubt, bearing in mind that the Adamello Brenta Natural Park has traditionally favoured a practical approach, as in the case of the ambitious project for the reintroduction of the brown bear, in which we were closely involved. This was because the brown bear is a symbol of environmental and biodiversity conservation.

ALPARC © Marian FILIPEK

Are you developing new areas of collaboration ?

Due to the problems I have just mentioned, we believe that it is fundamental that all of the bodies involved in nature conservation "close ranks" and help each other. This is why the Alpine Network of Protected Areas is so important, as are all the initiatives aimed at developing useful synergies to reduce management costs and carry out more significant actions. We should however also duly consider the difficulties resulting from the immense differences that exist between the various protected areas, whose economic and organisational features are often very different from one another. This tricky problem can often make cooperation very difficult, and in some cases even hamper the outcome of the initiatives proposed. Other channels that can foster cooperation are undoubtedly the economic resources arriving from the European Union, especially LIFE projects, in which we have often participated in the past, sometimes directly promoting them. ●

Picture
Massif of the alpine Garden of Lautaret in front of the glaciers of the Meije (2006)/FR


Parc national de la Vanoise © Damien HEMERAY

INTERVIEW WITH...

PREALPI GIULIE NATURAL PARK

[STEFANO SANTI - DIRECTOR
STEFANO.SANTI@PARCOPREALPIGIULIE.IT]

What are the new challenges you are facing with regard to biodiversity loss and climate change in your protected area ?

At the moment, the main cause of biodiversity loss seems to be the gradual closing of open spaces, such as meadows or pastures, due to people abandoning farming and breeding activities, and the consequent growth of woodlands in these areas.
That is why we are trying to take action to stop this phenomenon. Our lack of financial resources makes this rather complicated however.
By means of a specific project called "Climaparks", financed with funds coming from the Italy-Slovenia Cooperation Objective, we will try to assess whether and how climate change is affecting our protected area.

What solutions have you tried to implement to tackle the situation you have described ?

a. Census of meadows and pastures in the Park.
b. A few focused activities to re-open meadows and pastures in newly-formed woodlands, also through specific funding from the upland authority association.
c. Promotion of traditional farming activities and local products.
d. Implementation of the "Climaparks" project, with the detection of bioindicators to monitor climate change, the setting up of a photovoltaic system, the experimentation of sustainable mobility modes of entering the protected area.

What do you think is currently the main threat to the environment in the protected area where you work ?

The main threat is the cut in funding carried out in 2010, which will probably become even more serious in the years to come, together with a lack of «political» attention on the part of non-local authorities.

Other threats are the disappearance of open areas and energy production projects, which are not compatible with the existence of the Park itself.

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What problems are created by these new processes, and which of these do you have to tackle in the everyday management of your protected area ?

The main problems are :

- continuous search for visibility and lobbying activities so as to raise awareness among the non-local "political" authorities and gain support for the Park, which should be included as an active part of local development policies ;
- lack of resources to implement far-reaching projects and in some cases even for the everyday running of the protected area ;
- impossibility to carry out effective awareness-raising activities for subjects involved in the development of the area and, more specifically, the remaining farmers. ●

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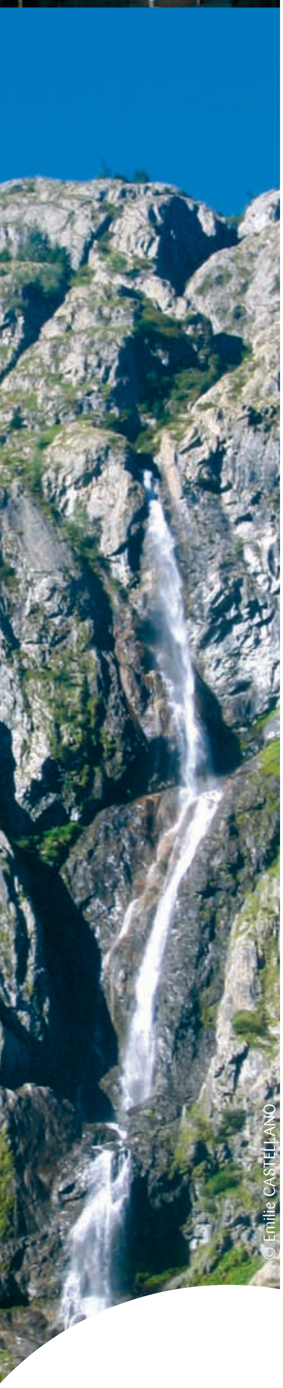
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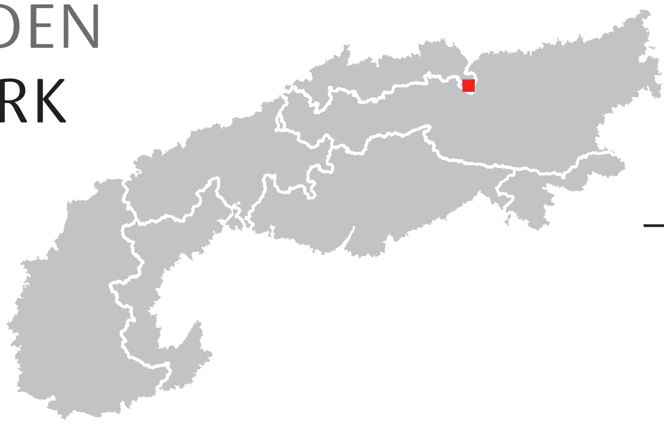
INTERVIEW WITH... BERCHTESGADEN NATIONAL PARK

[MICHAEL VOGEL - DIRECTOR

MICHAEL.VOGEL@NPV-BGD.BAYERN.DE]



What are the main problems and issues that you are faced with in your protected area, concerning biodiversity loss and/or climate change ?

A National Park's motto is to 'let nature remain nature'. Yet management implies active dealing with and intervening in natural processes. How can these contradictory concepts fit together and why are they necessary ? History plays a significant part here because Berchtesgaden National Park is located entirely in the densely populated area known as 'Central Europe'. Accordingly, its natural resources have been utilized for centuries. In the past the natural ecosystems of the National Park's area have been undergoing major changes mainly due to agriculture and forestry; at present nearly 1.5 million people use the area for their recreation. At the same time the National Park is a top ranking nature reserve with high biodiversity values.

The National Park management therefore strives to identify potential conf icts of usage and, if possible, to resolve or, at least, to ease them. One important tool is the zonation concept : in the core area no human and / or management activities are taking place whereas traditional and nature adapted land use forms as well as visitor management are concentrating in the management zone.

Successful solutions to new challenges arising from climate change and ongoing biodiversity loss can only be developed on the basis of sufficient research and documentation on the ecosystems' cycles. Moreover, the distribution of plant and animal species and the impact of different land use forms are important aspects.

Which part of your protected area is most influenced by the land use changes ?

In Berchtesgaden National Park forests are the habitats which are underlying most changes as has been shown in the interpretation of colorinfrared photographs. Main reasons for the high dynamic in these habitats are natural events like wind- and snow break, bark beetle, and avalanches. Up to now no major changes can be observed in the remaining land use types within the National Park as e.g. mountain pasturing.

ALPARC © Kurt WAGNER

« Let nature remain nature »

What are the current questions, which are raised to your management team, by these new situations?

In the management zone of the Park current forest transformation measures (change of species composition of forests, planting of beech and fir) are adapted to the changes expected to be linked with climate change. The most important question in this context is : What kind of forest communities (species composition) we will and we must develop ?

Concerning the core zone of the Park main aspects of management and research are :

- The creation of a monitoring system (e.g. MONAP, GLORIA) to register changes that can not be detected through the interpretation of aerial photos.
- Special research projects to gain more knowledge on permafrost, species composition, and species interactions (e.g. food chains, prey predator systems, plant – pollinator interaction).

Generally, an important research question in Berchtesgaden National Park is the long-term investigation of global climate change impacts on

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alpine ecosystems. Priority measures are long-term climate monitoring and analysis of climate change impacts on the hydrological balance in this area. The underlying reason is to ensure the water supply of pastures and cottages and the surrounding communities. Since the foundation of the National Park, a network of 39 automatic and mechanical weather stations has been established to provide long-time series of climate parameters.

Another aspect of growing importance for the National Park management are functional relations between the protected area and the adjacent region : Several interactions are existent, like e.g. the migration of species between the National Park and its surroundings. In order to reach success -ful biodiversity conservation in the National Park ecological connections have to be maintained and developed across the whole landscape. The establishment of a regional ecological network and the role of protected areas in this process are an important question currently being examined in the course of several alpine-wide initiatives which are supported by Berchtesgaden National Park.

Which innovative solutions you developed in order to face these new problems ?

One important tool to develop solutions to upcoming challenges is a management plan considering possible consequences of climate change. It has to take into account the zonation concept and its differing objectives. In the management zone the most challenging task is the implementation of forest transformation measures (e.g. changes on species composition of forests).

Changes in species and ecosystem behaviour and / or reactions are important in the core area. Besides, the further development of existing usages (e.g. concerning water supply) has to be observed against the background of climate change.

« Long term environmental observation (monitoring) plays a significant role, especially in view of the noticeable climatic changes. »

In Berchtesgaden the National Park Plan serves as a binding guideline for future management measures. It was created in 2001 and identifies measures to be taken over the following 10 years. Currently, the evaluation process of the National Park Plan has been started and will be continued over the next years. In this process climate change has to be considered as one important aspect.

Have you developed new cooperation, dealing with these situations ?

Yes, of course! We need to work together! The Alpine Network of Protected Areas allows for an intensive exchange between alpine national parks, nature reserves, biosphere reserves, tranquility zones and many other kinds of protection, and also with organizations and institutions of nature protection, local actors, population and scientists.

Moreover Berchtesgaden National Park is involved in numerous national and international projects, as e.g. cc.Habitalp project, ECONNECT project, Continuum Initiative, Climate Change and Protected Areas project. Some of the Park's projects' are run solely by the National Park, whereas others are coordinated as partnership projects with universities, ministerial departments, other conservation areas etc.

Long term environmental observation (monitoring) plays a significant role, especially in view of the noticeable climatic changes.

Where do you find (if you find) technical, financial and other support, needed to cope with these new challenges/problems ?

In order to cope with new upcoming challenges a close transnational cooperation and communication is crucial. It is provided by several current alpine initiatives like e.g. Think-tank Continuum Project, ISCAR protected area working group, and working groups in the frame of the Alpine Network of Protected Areas.

Existing partnerships are very valuable as the long-term experience shows that you have to count at least with a 5 years time, to bring an idea into practice. These poor prospects are unfortunately the reality. ●


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ZOOM ON...

WILDERNESS - A CHALLENGE AND TEST OF THE MANAGEMENT OF NATURE WITHOUT HUMAN INTERVENTION - a case of the Triglav National Park

[Martin Šolar, Director - martin.solar@tnp.gov.si - www.tnp.si/national_park/]

What do we understand under wilderness ? Are we attracted or repelled by it ? In nature conservation, the notion of wilderness is understood as management of (protected) areas of nature which are left to natural processes without any intervention from man. The primary purpose and understanding of wilderness emphasizes protection and management of extensive natural and nature-protected areas which are kept free from human intervention. Do such areas – nature-protected and left to develop by natural processes – still exist in Europe ? If we interpreted wilderness in the narrow sense of the word as truly untouched areas of nature, such sites would be hard to find in Europe, the only exceptions being Scandinavia and the mountains of the Alps. However, as recently wilderness has also come to equal protected areas of nature without any human intervention where the nature is left to undisturbed natural processes, we can say that there are still wilderness areas in Europe.

Over the last decade Europe has realized that its existing protected areas (parks) and Natura 2000 sites form an exceptional ecological network which, however, requires extensive investment to maintain its conservation status. On the other hand, the circumstances governing the new Europe, which joins more and more countries, have proven beyond doubt that there exist parts of nature which managed to retain their exceptionally high conservation status unassisted. Further maintenance and upkeep of this situation does not require investment in terms of human intervention but rather a conscious decision that certain parts of nature are to be left to develop by undisturbed natural processes; and therefore, generate nature protection value added – wilderness areas – also for Europe.

The new understanding of wilderness as a model of management without human intervention works towards two clear objectives : protection and conservation of integral natural ecosystems and enhancement of natural processes in these ecosystems. Natural ecosystems may form a rounded whole that can function without any 'help' from humans.

Throughout the human history a number of extremely novel ideas sprang up, many of them becoming reality and as such the basis for the progress of mankind. The wilderness initiative may become a milestone in the nature conservation movement, policy and work and can ensure existence of the Earth for the future generations.

What about the Triglav National Park ?

It was at the beginning of the 1990's when the TNP Management Authority became aware that its original management practice and park protection regime were not aligned with the contemporary nature protection objectives and were not in accordance with the international (largely IUCN) management standards. In 1993 the TNP Management Authority prepared a concept of gradual implementation of IUCN's management standards with emphasis on the elimination of use, i.e. human intervention in the best preserved natural areas within the Park. Over the last 15 years, we have gradually formed an area without human intervention where the wilderness criteria are met and of which we are all very proud. The new TNP Act extracts the first protective zone measu-

ring slightly more than 31 000 ha where all use is prohibitted and human intervention is reduced to spatially limited operations to maintain the existing mountain trails and huts.

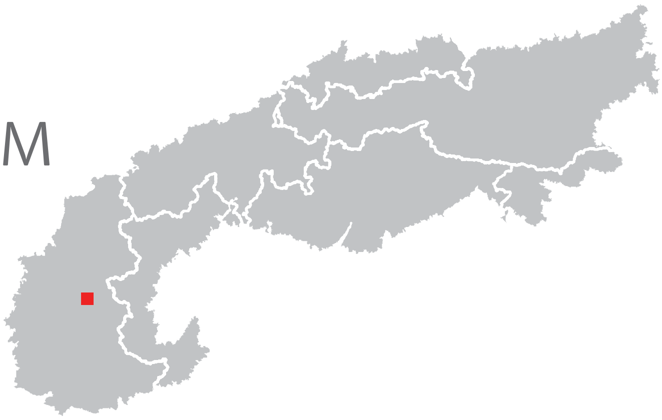
Legal background and zoning without proper content of the "non-intervention principle" is useless. Parallel to designing new zones, the protection regime and measures were created. And what have we achieved ? In the first protection zone which we can also declare as a "non-intervention" or wilderness zone there are some specific regulations as follows :

- hunting is forbidden,
- there is no forestry – tree felling is prohibited except when and to the amount required for maintenance of the existing trail network,
- there is no agriculture and unregulated grazing, the only exception being occasional very extensive pasturing use,
- fishing is forbidden,
- no energy use,
- no sand removal,
- no settlements and no new constructions, rare exceptions limited to pastures and constructions intended for environmental recovery near mountain huts,
- air transport above the core zone of the TNP is explicitly prohibited (not merely on account of noise),
- visitation, recreation and events are limited, and further limitation options are given through the instruments of the management plan,
- in certain aspects, mountaineering is also limited – construction of new mountain huts and trails is prohibited.

What do we expect ? An area left entirely to natural development is an ideal nature's lab where the development of ecosystems and inter-species relations can be examined ; regular monitoring and surveys are carried out to check and prove that nature can be left to its our resources. Last but not least, status monitoring in non-intervention areas can be crucial to studying and understanding the effects of climate change.

ZOOM ON...

BOTANY : FROM SURVEYS TO MONITORING



[Pierre Salomez, Botanist at Ecrins National Park , info@ecrins-parcnational.fr - www.ecrins-parcnational.fr]

When carrying out surveys, the Ecrins National Park wardens use a handheld computer to map native plant species. Nowadays, the emphasis is on showing changes in the geographical distribution of a species, rather than simply recording where it is found.

Much like with the traditional binoculars and walkie-talkies, handheld computers are gradually becoming standard issue for Ecrins National Park wardens. The pocket-sized devices are currently used to monitor the 169 indigenous plant species.

The portable device and the «f ora» software have been designed by the Ecrins National Park in conjunction with software developer Caminéo. The equipment is being tested in all seven sectors of the Park this summer. It contains all the relevant IGN maps (1/25000) and aerial photographs of the Ecrins (1/5000).

The warden maps the location of each species, but also marks zones in which it is not found at present. The aim is to identify how each species behaves (density, dispersal, etc.) in response to recent changes (climate, changes in grazing, etc.).

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The Park hopes to extend its use of the tool to other wildlife monitoring activities and other protected areas are also interested in using the device.

The Alpine National Botanical Conservatory (Conservatoire botanique national alpin – CBNA) is also involved in the Ecrins National Park's new project and has made the devices available to its network of partners for use in research and plant conservation.

From surveys to monitoring

In just under two hundred years, almost all of the f owering plants and ferns found in the Ecrins massif have been catalogued. We now know that the Ecrins National Park is home to around 1,800 species, 120 of which (6.7%) have protected status at regional, national or European level.

Pictures

Two species endemic to the Dauphiné region :

On the left : *Berardia subacaulis*, one of the first plants to be catalogued, recorded by Dominique Villars in 1779.

On the right : *Cotoneaster raboutensis* – the last plant entry in the catalogue produced by Flink, Fryer, Hylmö, Garraud and Zeller in 1998.

Botanists nowadays have two mutually-beneficial priorities :

- to expand the catalogue to include non-f owering plants (mosses), lichens, and fungi and
- to develop their understanding of the links between f owering plants and their physical (climate, substrate) and biological environment (interaction with other plants, animals and humans).

The Ecrins National Park is primarily interested in the second point.

This new approach to monitoring is much easier now that wardens in the field can use the handheld computers which are linked to the main database of plants found in the National Park.


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Part of the Flora Protection Network

In 2008, the Alpine National Botanical Conservatory (CNBA) brought together conservation organisations that were active in its catchment area, which covers seven French départements (01 - Ain, 04 - Alpes de Haute Provence, 05 - Hautes Alpes, 26 - Drôme, 38 - Isère, 73 Savoie and 74 - Haute Savoie).

Plant conservation in such a large area is only feasible if supported by strong, long-term partnerships with all of the organisations involved in the different elements of conservation : protected area managers, university researchers, conservation groups, amateur botanists, and so on.

Members of the network have a number of shared aims :

1. To create links between researchers, scientific experts and managers,
2. To link up, standardise and revitalise plant monitoring and conservation activities in the French Alps and the Ain,
3. To promote the creation of joint biogeographical projects focussed on information and conservation management in relation to native alpine species and environments identified by the network,
4. To encourage joint activities and to raise awareness among stakeholders in the region.

This approach has already resulted in a joint list of priority species for conservation (closed list), the definition of standard protocols for species monitoring and evolution summaries for certain species.

The Ecrins National Park has developed the device for field surveys in close cooperation with the Alpine National Botanical Conservatory (CNBA). The CNBA also provides handheld devices to all its network partners for use in monitoring plant life in the Alps and the Ain.

Technology used for field surveys

The information recorded in the Ecrins using the portable device will be included in the main database on plants in the Ecrins National Park (1,800 species).

The database also contains a wealth of historical data (bibliography), information from surveys conducted by National Park wardens (paper records covering over 35 years) and information submitted by partners, particularly the Alpine National Botanical Conservatory. Users can also search for data from previous surveys on distribution, phenology, disturbances, land use, etc.

Avoiding methodological inconsistencies

For the time being, the computer is only used for indigenous plants monitored in the Ecrins mountains. The closed list is available as a drop-down menu : «This way we can avoid current fashions affecting the species and sites surveyed.


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The GPS and aerial photographs (1/5000) that are integrated in the tool allow us to be much more accurate about the geographical location,» explains Pierre Salomez, the National Park botanist who has been monitoring the software rollout.

«In the past, apart from counting individual plants (when there were not many to start with), the botanical surveys suffered from the lack of quantifiable data. The new tool allows us to estimate the size of the area and plant density.

Above all, we want to keep a record of the size of the survey areas in which there are no plants. It is only by recording the absence of the species we are looking for that we can then identify new populations of that species. »

Out in the field, the device contains all known historical information about the location of a native species : was it present before, who found it, and when, etc. The user can then enter data immediately, providing :

- the correct plant name,
- the precise location on the map and on the aerial photo with (or even without) the assistance of the GPS
- and can mark areas that contain no specimens.

How does it work ?

Monitoring certain native species allows observers to find answers to unsolved questions and to corroborate theories about climate change and land management.

How long can an arctic-alpine species survive the current global warming ?

Case study
Two-colour sedge
(*Carex bicolor*)


© Parc national des Écrins - Marc CORAIL

A colourful herbaceous plant found in the Alps and around the Artic Circle

Habitat in the Ecrins-Dauphiné region : on the banks of cold streams on limestone substrates in the alpine zone

Will global warming affect dry environments ?

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A small tree found in the western Mediterranean (Morocco, Spain, Dauphiné).

Habitat in the Ecrins-Dauphiné region : around 1000 m above sea level (700-1300 m) in sunny rocky positions

Are managed planted forests compatible with preserving biodiversity in mountain woodland ?

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Case study

Lady's slipper orchid (*Cypripedium calceolus*)

Rhizomatous herbaceous plant of Europe and Asia, found in continental climates

Habitat in the Ecrins-Dauphiné region : montane woodland on limestone substrates

Is it possible to graze sheep in old hay meadows in spring and summer and maintain plant diversity ?

© Dessin Pierre Emmanuel DEQUEST

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Case study

Alpine sea holly (*Eryngium alpinum*)

Colourful herbaceous plant found only in the Alps.

Habitat in the Ecrins-Dauphiné region : Tall-herb grassland, hay meadows in the subalpine and montane zones.●

For more informations :

Scientific contacts : Pierre Salomez, Cédric Dentant, Richard Bonet
Technical contacts : Julien Guilloux, Gil Deluermoz, Camille Monchicourt
Parc national des Écrins - domaine de Charance - F-05000 Gap

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Case study

Surveying with a handheld computer : searching for two-colour sedge near Lake Goléon (Briançonnais).

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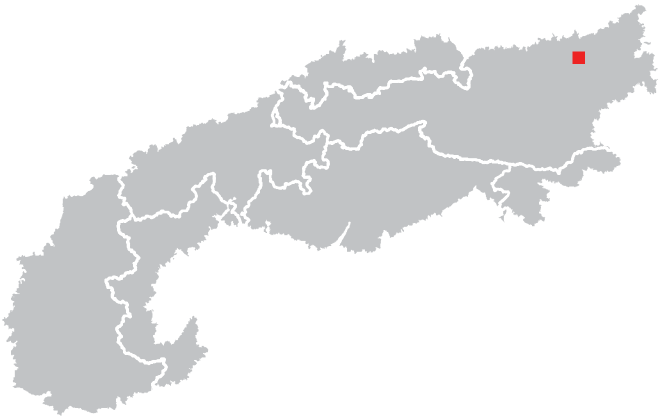
ZOOM ON...

DÜRRENSTEIN WILDERNESS AREA : ITS CONTRIBUTION TO BIODIVERSITY



[Reinhard Pekny and Christoph Leditznig - christoph.leditznig@wildnisgebiet.at - www.wildnisgebiet.at]

The Dürrenstein Wilderness Area is a protected forest area of international importance. Located in the south-west of Lower Austria, the area includes Rothwald, the largest old-growth forest in Austria. The protected area was created to conserve the remaining old-growth forest which extends over more than 400 ha. Adjoining land was decommissioned and classified as IUCN Category Ia and Ib, thereby creating a 2,400 ha area which enjoys maximum protection. Efforts are currently underway to extend the protected area.

Unlike many other categories of protected area, conservation is the top priority here, taking precedence over all other considerations. In future, the mountain woodlands of spruces, firs and beech will be left untouched while the formerly managed woodland will be left to Nature, although it will never qualify as old-growth forest in human timescales. The most important conservation measure is non-interference : removing all trace of human inf uence wherever possible.

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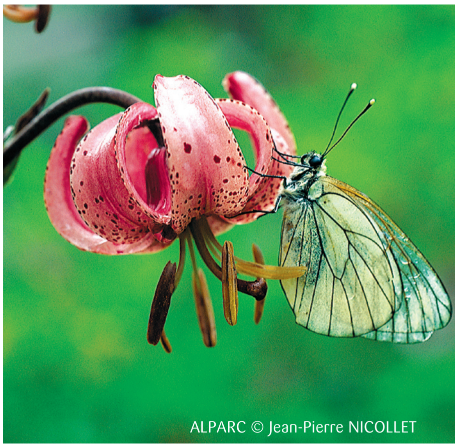
The Dürrenstein Wilderness Area in central Europe contains a unique mountain old-growth forest habitat. The ecosystem in the protected area is home to a wide range of organisms that have either become very rare or disappeared completely from other regions. We still know very little about many of these life forms and our understanding of their role in the ecosystem is patchy, even after over 150 years of extensive research. In recent years, the emphasis of research has shifted away from silviculture and botany to focus more on ecological systems. At the same time, extremely potent processes have caused massive disruption in our forests.

In addition to natural events such as powerful storms and avalanches, unusual f uctuations and marked changes in temperature ranges have had an impact on many organisms. Bark beetles have caused problems in Dürrenstein and other protected areas. As any measures to tackle the beetle problem would run counter to the wilderness area's conservation aims, the pest has traditionally been left to its own devices, with some surprising results – populations have even died out in certain areas. However, with frequent storms, extreme spring temperatures and a pronounced rise in maximum summer temperatures, all linked to climate change, some populations have spread and multiplied – notably the eight-toothed spruce bark beetle – which is not consistent with past trends. The result has been a marked drop in the number of spruce trees, a lynchpin of this climax forest community, with losses affecting nature reserve and ancient woodland alike. This has naturally had repercussions for the surrounding area and created problems for the protected area itself.

We are as yet unable to predict the consequences of a massive reduction in the proportion of spruce trees in terms of the ecosystem and biodiversity. If the current trend continues at the same rate, the proportion of spruce trees, particularly mature specimens, will plummet. That would have a knock-on effect for all organisms associated with spruces, especially organisms that are dependent on large dimensioned timber or specific to spruce trees. Our findings to date suggest that there have been no comparable changes in the local old-growth forest in the period since the reforestation after the last Ice Age, 10,000 to 12,000 years ago. The diversity and stability of the neighbouring woodlands was repeatedly reduced and blighted by extensive human activity. However, the core protected area itself was spared these encroachments. We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are now faced with a situation that we are unable to change. The fact that one main tree species and one secondary species are declining and could even disappear has serious implications for the ecosystem. If this is the current tangible effect of a complex combination of factors, how much harder will it be to quantify the consequences for a wider range of organisms ? At the same time, however, we are unable to predict the scale of the change that will be triggered by the massive increase in dead wood within the «live» woodland and greater quantities of light reaching the forest f oor – biodiversity may even increase.

Climate change will alter the range of species, and indeed has already done so to some extent. It is impossible to determine whether biodiversity will be reduced or increased by the predicted temperature rises. Obviously we do not welcome the changes associated with global warming, even though the primary aim of a wilderness area must always be to protect natural processes. It would undoubtedly be better if we were able to slow or halt these processes, because whatever the outcome may be, the pace of change is far too rapid. A relatively small protected area can do little to alleviate the effects of climate change. However it is good to see that untouched areas tend to be able to cope, if not well, then at least better, with these changes than managed woodlands. In the midst of the current tough situation, the wilderness area is still seen as a haven for many endangered species and biocoenoses and also serves as a genetic reservoir. In recent years, we have noticed that many xylobiontic species from the old-growth forest are now moving into other parts of the wilderness area.

So, the Dürrenstein Wilderness Area and all similar protected areas are crucial in these tough ecological times, as they tend to be more stable and provide protection for ecosystems that are rare or no longer found elsewhere. Nature and environmental conservation should not focus solely on these few outstanding areas, but equally should not allow their value to be eclipsed by current global issues.

In its PR and educational work, the Dürrenstein Wilderness Area seeks to demonstrate how mankind’s activities around the world are affecting the last unspoiled ancient woodland in Austria. Hopefully this will inspire our audiences to rethink the demands they place on our environment.

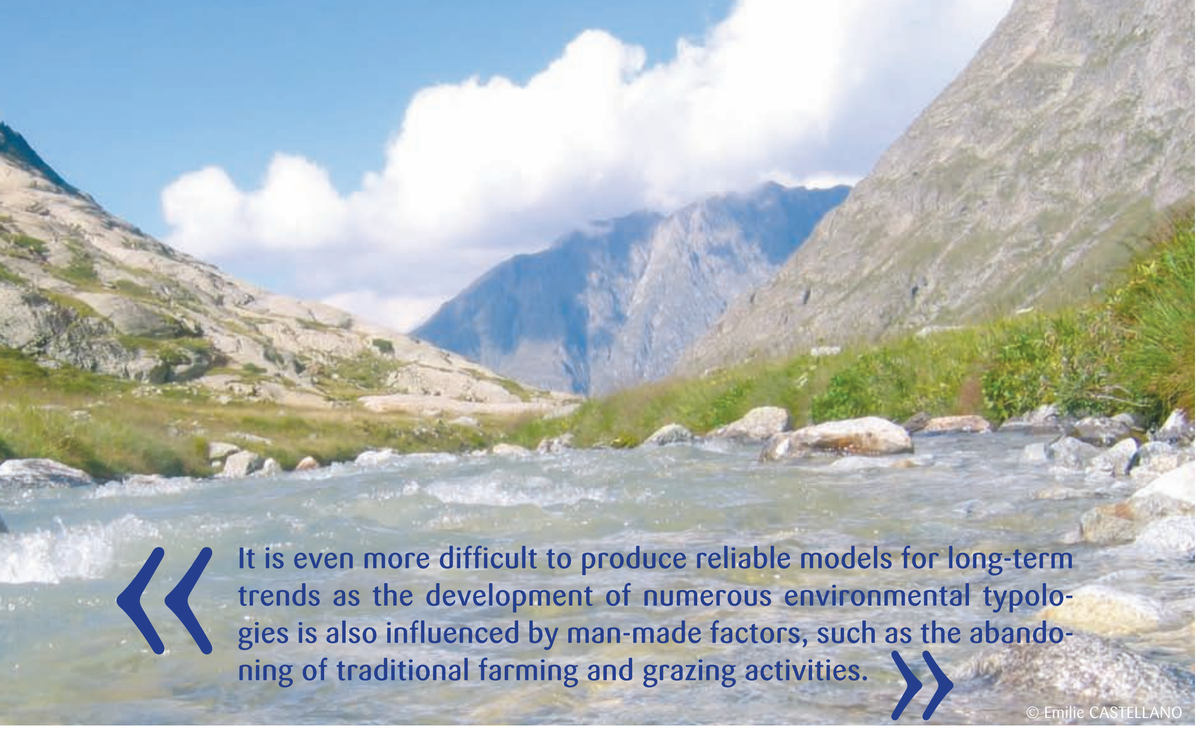
CONCLUSIONS THE ROLE OF PROTECTED AREAS

[Massimo Bocca- Member of the international steering committee of ALPARC and ISCAR-P, and Director of Mont Avic Natural Park
info@montavic.it , www.montavic.it]

The articles in this volume highlight the difficulty of analysing how rapid ongoing climate changes affect Alpine flora and fauna. Even more difficult is the production of reliable long-term models since many types of environment are influenced by other man-made factors such as the abandoning of traditional farming and grazing practices.

A number of specific issues need to be studied to preserve biodiversity :

- The effects of climate on the geographical areas at high altitudes and broad latitudes ;
- The effects of increasingly frequent extreme weather conditions on sensitive species and habitats ;
- The status of endemic species and, in general, of *taxa* with small home-ranges ;
- Alterations in the phenology of species sharing certain trophic features ;
- Variations in the relations between parasites, parasitoids, predators and their hosts ;
- Expansion of invasive alien species;
- Expansion or regression of specific environments mainly or exclusively on account of climate change;
- The dynamic of water body systems and their physical parameters.



« It is even more difficult to produce reliable models for long-term trends as the development of numerous environmental typologies is also influenced by man-made factors, such as the abandoning of traditional farming and grazing activities. »

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Only wide-ranging historical series will allow researchers to draw reliable conclusions on the interactions between climate and living beings. It is therefore extremely important to set up sustainable, long-term monitoring campaigns in undisturbed (wilderness) areas following standardized protocols.

Against this backdrop, the role played by protected areas is of paramount importance. Parks and nature reserves include a large number of practically virgin sites where the impact of global warming can be more readily studied. The sites can be used for focused scientific research projects while the personnel working there can carry out long-term monitoring activities. These areas can become experimental sites where the effect of environmental improvements and other active management strategies can be assessed.

Alparc coordinates the bodies managing the various protected areas and ensures the circulation of information on ongoing research programmes. It also carries out specific activities aimed at improving an ecological *continuum*, with consequent mitigation of some of the negative effects of climate change. Hopefully, in the immediate future various forms of collaboration will be started with protected areas in other mountain ranges of Central and Southern Europe with virtually no glaciers so as to compare the effects of a warmer climate on different environmental settings in the same geographical area.

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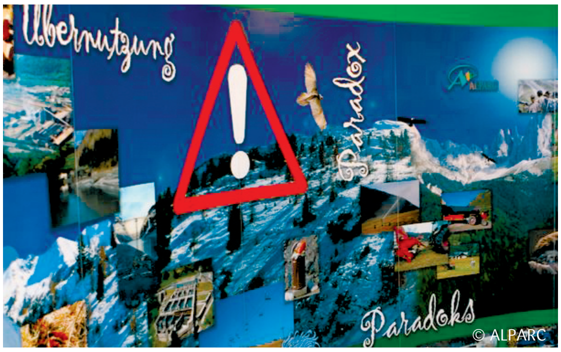

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A CONCRETE TOOL FOR AWARENESS RAISING :

"Return of Wilderness"

The Alpine protected areas and ALPARC have developed travelling exhibitions designed to move from park to park. These tools are at disposal for all alpine protected areas, and also for all interested organizations (museum, visitor centre, alpine city, NGO, association, etc.).

"Return of Wilderness" has been created in 2006 in the framework of ALPENCOM project, based on Interreg IIIB Alpine Space funding.

Covering the history of human specie and wilderness, the exhibition presents an evolving Alpine landscape, taking the visitor along a temporal trip. The spiral, a symbol of time advancement, is a shape, which the exhibition is based on, in order to guide you through different eras. Each spiral has its own kind of connection between the human being and the wilderness. Wildlife, which was dominant in the beginning, was later on, due to human activities, little by little repressed to islets, and in some areas already completely disappeared. Finally, in the end of the 20th century, it started its return, thanks to the first means of nature conservation and progressive creation of the Alpine Protected Areas. This 5 stage project finally finishes in our future: Are we ready to welcome the Wilderness coming back ? Will our behavior allow the Wilderness to come back and take its place in our life ?

The structure and content of the exhibition are very creative. Optional audio guide (available in 5 languages), tells the story of the relationship between wildlife and human beings. The texts of the banners are translated in 4 alpine languages (French, German, Italian, Slovenian) and English.

Don't hesitate to use this tool for awareness raising in your protected area awarness raising !
Contact us for more information at :

info@alparc.org (+33 4 79 26 55 00)
www.alparc.org/resources

Alpine resources

Alps and Biological Diversity :

1) Convention on Biological Diversity (CBD) : www.cbd.int

2) This page shows the hotspots of worldwide biodiversity. The richest and most threatened reservoirs of plant and animal life on earth are mentioned : www.biodiversityhotspots.org

3) The primary mission of the World Heritage Convention (WHC) is to identify and conserve the world's cultural and natural heritage : whc.unesco.org

4) A substantial dossier on biodiversity : www.greenfacts.org

5) A webpage dedicated entirely to biodiversity : biodiversite.medias-france.org

6) Large choice of interactive maps showing different biodiversity aspects of the world : stort.unep-wcmc.org

7) This page is a platform for information about the Clearing-House Mechanisms (CHM) in Germany : www.biodiv-chm.de

8) General information on biodiversity and activities of biodiversity protection in Switzerland : www.biodiversite.ch

9) An introduction to biodiversity research in France : www.gis-ifb.org

10) The website of the Centre for Biodiversity Conservation (CCB) at the University of Cagliari : www.ccb-sardegna.it

11) The Convention on Wetlands provides the framework for the conservation and wise use of wetlands and their resources : www.ramsar.org

12) The European Union's (EU) website on habitats and birds directive and the NATURA 2000 network : ec.europa.eu/environment

13) CIPRA International : http://www.cipra.org

14) Institute for Research and Further Education (EURAC) : www.eurac.edu

15) Laboratory of Alpine Ecology (LECA) : www-leca.ujf-grenoble.fr

16) The Research center on the Height Ecosystems (CREA) : www.crea.hautesavoie.net/crea

Alps and Climate Change :

1) Swiss Forum for Climate and Global Change. : www.proclim.ch

2) Swiss Advisory Body on Climate Change : www.occc.ch

3) The Austrian Climate Portal : www.accc.gv.at

4) German Advisory Council on Global Change (WBGU) : www.wbgu.de

5) The worldwide biggest archive on weather data : www.ncdc.noaa.gov

6) Website of climate related topics of the Swiss Federal Office for the Environment : www.bafu.admin.ch

7) Cipra International : www.alpsknowhow.cipra.org

8) Another website with very telling pictures showing the retreat on Alpine glaciers : www.gletscherarchiv.de

9) The Climate Portal of the Alpine Convention : www.alpconv.org

10) Latest climate news on the WWF website : www.worldwildlife.org/climate/

11) The International Scientific Committee on Research in the Alps (ISCAR) : www.iscar-alpineresearch.org

12) Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) : www.wsl.ch

Bibliography

Article p. 12 Oliver Schweiger - Climate change - novel communities, altered interactions, affected ecosystem services

Araújo, M. B., Thuiller, W., & Pearson, R. G. (2006) *Climate warming and the decline of amphibians and reptiles in Europe*. Journal of Biogeography 33, 1712-1728.

Beever, E. A., Brussard, P. E., & Berger, J. (2003) *Patterns of apparent extirpation among isolated populations of pikas (Ochotona princeps) in the Great Basin.* Journal of Mammalogy 84, 37-54.

Berger, S., Sohlke, G., Walther, G. R., & Pott, R. (2007) *Bioclimatic limits and range shifts of cold-hardy evergreen broad-leaved species at their northern distributional limit in Europe.* Phytocoenologia 37, 523-539.

Bond, W. J. (1994) *Do mutualisms matter - assessing the impact of pollinator and disperser disruption on plant extinction.* Philosophical Transactions of the Royal Society of London Series B-Biological Sciences 344, 83-90.

Both, C., van Asch, M., Bijlsma, R. G., van den Burg, A. B., & Visser, M. E. (2009) *Climate change and unequal phenological changes across four trophic levels : Constraints or adaptations ?* Journal of Animal Ecology 78, 73-83.

Brown, J. H., Stevens, G. C., & Kaufman, D. M. (1996) *The geographic range : size, shape, boundaries, and internal structure. Annual Review of Ecology and Systematics* 27, 597-623.

Callaway, R. M. & Ridenour, W. M. (2004) *Novel weapons : invasive success and the evolution of increased competitive ability.* Frontiers in Ecology and the Environment 2, 436-443.

Clark, J. S., Lewis, M., McLachlan, J. S., & HilleRisLambers, J. (2003) *Estimating population spread : What can we forecast and how well ?* Ecology 84, 1979-1988.

Corbet, S. A. (2000) *Conserving compartments in pollination webs.* Conservation Biology 14, 1229-1231.

Davis, A. J., Jenkinson, L. S., Lawton, J. H., Shorrocks, B., & Wood, S. (1998) *Making mistakes when predicting shifts in species range in response to global warming.* Nature 391, 783-786.

Descimon, H., Bachelard, P., Boitier, E., & Pierrat, V. (2006) *Decline and extinction of Parnassius apollo populations in France—continued.* Studies on the Ecology and Conservation of Butterf ies in Europe (ed. by E.Kühn, R.Feldmann, and J.Settele), Pensoft, Sofia, Moscow.

Devictor, V., Julliard, R., Couvet, D., & Jiguet, F. (2008) *Birds are tracking climate warming, but not fast enough.* Proceedings of the Royal Society B-Biological Sciences 275, 2743-2748.

Diaz, S., Tilman, D., Fragione, J., Chapin III, F. S., Dirzo, R., Kitzberger, T., Gemmill, B., Zobel, M., Vilá, M., Mitchell, C., Wilby, A., Daily, G. C., Galetti, M., Laurance, W. F., Pretty, J., Naylor, R., Power, A., Harvell, D., Pott, S. G., Kremen, C., Grinswold, T., Eardley, G., Ceallos, G., Lavorel, S., Orians, G., Pacala, S., & Supriatna, J. (2005) *Biodiversity regulation of ecosystem services. Millenium ecosystem assessment. Ecosystems and human well-being* pp. 297-329. World Resources Institute, Washington.

EEA (2009) *Regional climate change and adaptation – The Alps facing the challenge of changing water resources.* Report No 8/2009.

Fitter, A. H. & Fitter, R. S. R. (2002) *Rapid changes in flowering time in British plants.* Science 296, 1689-1691.

Fortuna, M. A. & Bascompte, J. (2006) *Habitat loss and the structure of plant-animal mutualistic networks. Ecology Letters* 9, 281-286.

Gerdol, R., Bonora, A., Marchesini, R., Gualandri, R., & Pancaldi, S. (1998) *Growth response of Sphagnum capillifolium to nighttime temperature and nutrient level : Mechanisms and implications for global change.* Arctic and Alpine Research 30, 388-395.

Gordo, O. & Sanz, J. J. (2005) *Phenology and climate change : A long-term study in a Mediterranean locality.* Oecologia 146, 484-495.

Goulson, D. (2003) *Effects of introduced bees on native ecosystems. Annual Review of Ecology Evolution and Systematics* 34, 1-26.

Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A. L., & Totland, O. (2009) *How does climate warming affect plant-pollinator interactions ?* Ecology Letters 12, 184-195.

Heikkinen, R. K., Luoto, M., Araújo, M. B., Virkkala, R., Thuiller, W., & Sykes, M. T. (2006) *Methods and uncertainties in bioclimatic envelope modelling under climate change.* Progress in Physical Geography 30, 751-777.

Hewitt, G. (2000) *The genetic legacy of the Quaternary ice ages.* Nature 405, 907-913.

Hickler, T., Fronzek, S., Araújo, M. B., Schweiger, O., Thuiller, W., & Sykes, M. (2009) A*n ecosystem-model-based estimate of changes in water availability differs from water proxies that are commonly used in species distribution models.* Global Ecology and Biogeography 18, 304-313.

Hill, J. K., Thomas, C. D., Fox, R., Telfer, M. G., Willis, S. G., Asher, J., & Huntley, B. (2002) *Responses of butterflies to twentieth century climate warming : implications for future ranges.* Proceedings of the Royal Society of London Series B-Biological Sciences 269, 2163-2171.

Huntley, B., Berry, P. M., Cramer, W., & McDonald, A. P. (1995) *Modelling present and potential future ranges of some European higher plants using climate response surfaces.* Journal of Biogeography 22, 967-1001.

IPCC (2007) *Summary for policymakers. Climate Change 2007 : The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (ed. by S.Solomon, D.Qin, M.Manning, Z.Chen, M.Marquis, K.B.Averyt, M.Tignor, and H.L.Miller), Cambridge University Press, Cambridge, New York.

Jordano, P., Bascompte, J., & Olesen, J. M. (2003) *Invariant properties in coevolutionary networks of plant-animal interactions*. Ecology Letters 6, 69-81.

Jylhä, K., Fronzek, S., Tuomenvirta, H., Carter, T. R., & Ruosteenoja, K. (2008) *Changes in frost, snow and Baltic sea ice by the end of the twenty-first century based on climate model projections for Europe. Climatic Change* 86, 441-462.

Keane, R. M. & Crawley, M. J. (2002) *Exotic plant invasions and the enemy release hypothesis. Trends in Ecology & Evolution* 17, 164-170.

Keller, T., Guiot, J., & Tessier, L. (1997) *Climatic effect of atmospheric CO2 doubling on radial tree growth in south eastern France.* Journal of Biogeography 24, 857-864.

Levinsky, I., Skov, F., Svenning, J. C., & Rahbek, C. (2007) *Potential impacts of climate change on the distributions and diversity patterns of European mammals.* Biodiversity and Conservation 16, 3803-3816.

Lopezaraiza-Mikel, M. E., Hayes, R. B., Whalley, M. R., & Memmott, J. (2007) *The impact of an alien plant on a native plant-pollinator network : an experimental approach.* Ecology Letters 10, 539-550.

Memmott, J. & Waser, N. M. (2002) *Integration of alien plants into a native flower-pollinator visitation web.* Proceedings of the Royal Society of London Series B-Biological Sciences 269, 2395-2399.

Memmott, J., Waser, N. M., & Price, M. V. (2004) *Tolerance of pollination networks to species extinctions.* Proceedings of the Royal Society B-Biological Sciences 271, 2605-2611.

Merrill, R. M., Gutierrez, D., Lewis, O. T., Gutierrez, J., Diez, S. B., & Wilson, R. J. (2008) *Combined effects of climate and biotic interactions on the elevational range of a phytophagous insect.* Journal of Animal Ecology 77, 145-155.

Parmesan, C. (2006) *Ecological and evolutionary responses to recent climate change. Annual Review of Ecology Evolution and Systematics* 37, 637-669.

Parmesan, C., Ryrholm, N., Stefanescu, C., Hill, J. K., Thomas, C. D., Descimon, H., Huntley, B., Kaila, L., Kullberg, J., Tammaru, T., Tennent, W. J., Thomas, J. A., & Warren, M. (1999) *Poleward shifts in geographical ranges of butterfly species associated with regional warming.* Nature 399, 579-583.

Parmesan, C. & Yohe, G. (2003) *A globally coherent fingerprint of climate change impacts across natural systems.* Nature 421, 37-42.

Pearson, R. G. & Dawson, T. P. (2003) *Predicting the impacts of climate change on the distribution of species : are bioclimate envelope models useful ?* Global Ecology and Biogeography 12, 361-371.

Petanidou, T. & Potts, S. G. (2006) *Mutual use of resources in Mediterranean plant-pollinator communities : how specialized are pollination webs ? Plant-pollinator interactions : from specialization to generalization* (ed. by N.M.Waser and J.Ollerton), pp. 220-244. University of Chicago Press, Chicago.

Pompe, S., Badeck, F.-W., Hanspach, J., Klotz, S., Thuiller, W., & Kühn, I. (2008) *Projecting impact on plant distributions under climate change - a case study from Germany.* Biology Letters in press, DOI : 10.1098/rsbl.2008.0231.

Pounds, J. A., Fogden, M. P. L., & Campbell, J. H. (1999) *Biological response to climate change on a tropical mountain.* Nature 398, 611-615.

Pyšek, P., Richardson, D. M., Rejmánek, M., Webster, G. L., Williamson, M., & Kirschner, J. (2004) *Alien plants in checklists and floras : Towards better communication between taxonomists and ecologists.* Taxon 53, 131-143.

Quinn, R. M., Gaston, K. J., & Roy, D. B. (1998) *Coincidence in the distribution of butterflies and their foodplants.* Ecography 21, 279-288.

Richardson, D. M., Pyšek, P., Rejmanek, M., Barbour, M. G., Panetta, F. D., & West, C. J. (2000) *Naturalization and invasion of alien plants : Concepts and definitions. Diversity and Distributions* 6, 93-107.

Robinet, C., Baier, P., Pennerstorfer, J., Schopf, A., & Roques, A. (2007) *Modelling the effects of climate change on the potential feeding activity of Thaumetopoea pityocampa* (Den. & Schiff.) (Lep., Notodontidae) in France. Global Ecology and Biogeography 16, 460-471.

Rolland, C., Petitcolas, V., & Michalet, R. (1998) *Changes in radial tree growth for Picea abies, Larix decidua, Pinus cembra and Pinus uncinata near the alpine timberline since 1750. Trees-Structure and Function* 13, 40-53.

Roy, D. B. & Sparks, T. H. (2000) *Phenology of British butterflies and climate change. Global Change Biology* 6, 407-416.

Schweiger, O., Biesmeijer, J. C., Bommarco, R., Hickler, T., Hulme, P. E., Klotz, S., Kühn, I., Moora, M., Nielsen, A., Ohlemüller, R., Petanidou, T., Potts, S. G., Pyšek, P., Stout, J. C., Sykes, M. T., Tscheulin, T., Vilá, M., Walther, G. R., Westphal, C., Winter, M., Zobel, M., & Settele, J. (2010) *Multiple stressors on biotic interactions : how climate change and alien species interact to affect pollination.* Biological Reviews in press.

Schweiger, O., Frenzel, M., & Durka, W. (2004) *Spatial genetic structure in a metapopulation of the land snail Cepaea nemoralis (Gastropoda : Helicidae).* Molecular Ecology 13, 3645-3655.

Schweiger, O., Settele, J., Kudrna, O., Klotz, S., & Kühn, I. (2008) *Climate change can cause spatial mismatch of trophically interacting species.* Ecology 89, 3472-3479.

Settele, J., Hammen, V., Hulme, P., Karlson, U., Klotz, S., Kotarac, M., Kunin, W., Marion, G., O'Connor, M., Petanidou, T., Peterson, K., Potts, S., Pritchard, H., Pyšek, P., Rounsevell, M., Spangenberg, J., Steffan-Dewenter, I., Sykes, M., Vighi, M., Zobel, M., & Kühn, I. (2005) *ALARM : Assessing LArge-scale environmental Risks for biodiversity with tested Methods.* Gaia-Ecological Perspectives for Science and Society 14, 69-72.

Settele, J., Kudrna, O., Harpke, A., Kühn, I., van Swaay, C., Verovnik, R., Warren, M., Wiemers, M., Hanspach, J., Hickler, T., Kühn, E., van Halder, I., Veling, K., Vleigenhart, A., Wynhoff, I., & Schweiger, O. (2008) *Climatic risk atlas of European butterflies.* BioRisk 1, 1-710.

Smith, M. A. & Green, D. M. (2005) *Dispersal and the metapopulation paradigm in amphibian ecology and conservation : are all amphibian populations metapopulations ?* Ecography 28, 110-128.

Stout, J. C. (2007) *Reproductive biology of the invasive exotic shrub, Rhododendron ponticum L. (Ericaceae).* Botanical Journal of the Linnean Society 155, 373-381.

Svenning, J. C. & Skov, F. (2007) *Could the tree diversity pattern in Europe be generated by postglacial dispersal limitation ?* Ecology Letters 10, 453-460.

Theurillat, J. P. & Guisan, A. (2001) *Potential impact of climate change on vegetation in the European Alps : A review.* Climatic Change 50, 77-109.

Thomas, C. D., Bodsworth, E. J., Wilson, R. J., Simmons, A. D., Davies, Z. G., Musche, M., & Conradt, L. (2001) *Ecological and evolutionary processes at expanding range margins.* Nature 411, 577-581.

Thompson, J. N. (1998) *Rapid evolution as an ecological process. Trends in Ecology & Evolution* 13, 329-332.

Thuiller, W., Lavorel, S., Araújo, M. B., Sykes, M. T., & Prentice, I. C. (2005) *Climate change threats to plant diversity in Europe. Proceedings of the National Academy of Sciences of the United States of America* 102, 8245-8250.

Van Asch, M. & Visser, M. E. (2007) *Phenology of forest caterpillars and their host trees : The importance of synchrony. Annual Review of Entomology* 52, 37-55.

Virkkala, R., Heikkinen, R. K., Leikola, N., & Luoto, M. (2008) *Projected large-scale range reductions of northern-boreal land bird species due to climate change.* Biological Conservation 141, 1343-1353.

Visser, M. E. & Both, C. (2005) *Shifts in phenology due to global climate change : The need for a yardstick.* Proceedings of the Royal Society B-Biological Sciences 272, 2561-2569.

Walther, G. R. (2000) *Climatic forcing on the dispersal of exotic species. Phytocoenologia* 30, 409-430.

Walther, G. R., Gritti, E. S., Berger, S., Hickler, T., Tang, Z. Y., & Sykes, M. T. (2007) *Palms tracking climate change. Global Ecology and Biogeography* 16, 801-809.

Walther, G. R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T. J. C., Fromentin, J. M., Hoegh-Guldberg, O., & Bairlein, F. (2002) *Ecological responses to recent climate change.* Nature 416, 389-395.

Walther, G. R., Roques, A., Hulme, P. E., Sykes, M. T., Pyšek, P., Kühn, I., Zobel, M., Bacher, S., Botta-Dukat, Z., Bugmann, H., Czucz, B., Dauber, J., Hickler, T., Jarosik, V., Kenis, M., Klotz, S., Minchin, D., Moora, M., Nentwig, W., Ott, J., Panov, V. E., Reineking, B., Robinet, C., Semenchenko, V., Solarz, W., Thuiller, W., Vilá, M., Vohland, K., & Settele, J. (2009) *Alien species in a warmer world : risks and opportunities. Trends in Ecology & Evolution* 24, 686-693.

Warren, M. S., Hill, J. K., Thomas, J. A., Asher, J., Fox, R., Huntley, B., Roy, D. B., Telfer, M. G., Jeffcoate, S., Harding, P., Jeffcoate, G., Willis, S. G., Greatorex-Davies, J. N., Moss, D., & Thomas, C. D. (2001) *Rapid responses of British butterflies to opposing forces of climate and habitat change.* Nature 414, 65-69.

Willmer, P. G. & Corbet, S. A. (1981) *Temporal and microclimatic partitioning of the floral resources of Justicia aurea amongst a concourse of pollen vectors and nectar robbers.* Oecologia 51, 67-78.

Wilson, R. J., Gutierrez, D., Gutierrez, J., Martinez, D., Agudo, R., & Monserrat, V. J. (2005) *Changes to the elevational limits and extent of species ranges associated with climate change.* Ecology Letters 8, 1138-1146.

Article p. 33 - Kurt Bollmann - Climate or land use change : what affects alpine grouse species more ?

Araújo M.B., Cabeza M., Thuiller W., Hannah L. & Williams P.H. (2004). *Would climate change drive species out of reserves ? An assessment of existing reserve-selection methods.* Global Change Biology, 10, 1618-1626.

Bollmann K., Graf R.F., Jacob G. & Thiel D. (2008). *Von der Forschung zur Auerhuhnförderung: eine Projektsynthese.* Der Ornithologische Beobachter, 105, 107-116.

Bollmann K., Graf R.F. & Suter W. (in press). *Quantitative predictions for patch occupancy of capercaillie in fragmented habitats.* Ecography.

Bugmann H., Zierl B. & Schumacher S. (2005). *Projecting the impacts of climate change on mountain forests and landscapes. In: Global change and mountain regions. An overview of current knowledge*, pp. 477-487, (eds. Huber U.M., Bugmann H.K.M. & Reasoner M.A.). Springer, Dordrecht.

EAA (2008). *Impacts of Europe's changing climate* – 2008 indicator-based assessment. EEA Report No 4/2008. European Communities, Copenhagen.

EEA (2009). *Regional climate change and adaptation – The Alps facing the challenge of changing water resources*. EEA Report No 8/2009. European Communities, Copenhagen.

Gehrig-Fasel J., Guisan A. & Zimmermann N.E. (2007). *Tree line shifts in the Swiss Alps: Climate change or land abandonment ?* Journal of Vegetation Science 18, 571-582.

Graf R.F., Bollmann K., Bugmann H. & Suter W. (2007). *Forest and landscape structure as predictors of capercaillie occurrence. Journal of Wildlife Management*, 71, 356-365.

Huntley B., Barnard P., Altwegg R., Chambers L., Coetzee B.W.T., Gibson L., Hockey P.A.R., Hole D.G., Midgley G.F., Underhill L.G. & Willis S.G. (2010). *Beyond bioclimatic envelopes: dynamic species' range and abundance modelling in the context of climatic change.* Ecography, 33, 621-626.

Huntley B., Green R.E., Collingham Y.C. & Willis S.G. (2007). *A climatic atlas of European breeding birds. Lynx Edicions*, Barcelona.

Keith D.A., Akçakaya H.R., Thuiller W., Midgley G.F., Pearson R.G., Phillips S.J., Regan H.M., Araújo M.B. & Rebelo T.G. (2008). *Predicting extinction risks under climate change: coupling stochastic population models with dynamic bioclimatic habitat models.* Biology Letters, 4, 560-563.

Laidre K.L., Stirling I., Lowry L.F., Wiig O., Heide-Jorgensen M.P. & Ferguson S.H. (2008). *Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change.* Ecological Applications, 18, S97-S125.

Ludwig G.X., Alatalo R.V., Helle P., Linden H., Lindstrom J. & Siitari H. (2006). *Short- and long-term population dynamical consequences of asymmetric climate change in black grouse. Proceedings of the Royal Society B* – Biological Sciences, 273, 2009-2016.

Ludwig T., Storch I. & Graf R.F. (2009). *Historic landscape change and habitat loss: the case of black grouse in Lower Saxony, Germany.* Landscape Ecology, 24, 533-546.

Moss R., Oswald J. & Baines D. (2001). *Climate change and breeding success: decline of the capercaillie in Scotland. Journal of Animal Ecology*, 70, 47-61.

Ozgul A., Childs D.Z., Oli M.K., Armitage K.B., Blumstein D.T., Olson L.E., Tuljapurkar S. & Coulson T. (2010). *Coupled dynamics of body mass and population growth in response to environmental change. Nature*, 466, 482-487.

Parmesan, C. (2006) *Ecological and evolutionary responses to recent climate change. Annual Review of Ecology* Evolution and Systematics 37, 637-669.

Pearson R.G. & Dawson T. P. (2003). *Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful ?* Global Ecology and Biogeography 12, 361-371.

Pressey R.L., Cabeza M., Watts M.E., Cowling R.M. & Wilson K.A. (2007). C*onservation planning in a changing world.* Trends in Ecology & Evolution, 22, 583-592.

Revermann R., Zbinden N., Schmid H. & Schröder B. (2007). *Habitatmodelle für das Alpenschneehuhn Lagopus muta helvetica in den Schweizer Alpen* – Skaleneffekte und mögliche Auswirkungen des Klimawandels. Vogelwarte, 45, 276-277.

Storch I. (1994). *Habitat and survival of capercaillie Tetrao urogallus nests and broods in the Bavarian Alps.* Biological Conservation 70, 237-243.

Storch I. (editor). (2000). *Grouse : Status Survey and Conservation Action Plan 2000-2004.* WPA/BirdLife/SSC Grouse Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK and the World Pheasant Association, Reading, UK

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Engler R. & Guisan A. (2009). *MIGCLIM : Predicting plant distribution and dispersal in a changing climate.* Diversity and Distributions, 15, 590-601.

Engler R., Randin C.F., Vittoz P., Czaka T., Beniston M., Zimmermann N.E. & Guisan A. (2009). *Predicting future distributions of mountain plants under climate change : does dispersal capacity matter ?* Ecography, 32, 34-45.

GIEC (2007). *Résumé à l'intention des décideurs. In : Changements climatiques 2007 : – Les éléments scientifiques - Contribution du Groupe de travail I au quatrième Rapport d'évaluation du Groupe d'experts intergouvernemental sur l'évolution du climat* (eds. Solomon S, Qin d, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M & Miller HL). Cambridge University Press Cambridge, 18.

Grabherr G., Gottfried M. & Pauli H. (1994). *Climate effects on mountain plants.* Nature, 369, 448.

Guisan A. & Zimmermann N.E. (2000). *Predictive habitat distribution models in ecology.* Ecological Modelling, 135, 147-186.

Randin C.F., Engler R., Normand S., Zappa M., Zimmermann N.E., Pearman P.B., Vittoz P., Thuiller W. & Guisan A. (2009a). *Climate change and plant distribution : local models predict high-elevation persistence.* Global Change Biology, 15, 1557-1569.

Randin C.F., Jaccard H., Vittoz P., Yoccoz N.G. & Guisan A. (2009b). *Land use improves spatial predictions of mountain plant abundance but not presence-absence.* Journal of Vegetation Science, 20, 996-1008.

Randin C.F., Vuissoz G., Liston G.E., Vittoz P. & Guisan A. (2009c). *Introduction of Snow and Geomorphic Disturbance Variables into Predictive Models of Alpine Plant Distribution in the Western Swiss Alps.* Arctic Antarctic and Alpine Research, 41, 347-361.

Thuiller W., Lavorel S., Araujo M.B., Sykes M.T. & Prentice I.C. (2005). *Climate change threats to plant diversity in Europe.* Proceedings of the National Academy of Sciences of the United States of America, 102, 8245-8250.

Vittoz P., Bodin J., Ungricht S., Burga C. & Walther G.R. (2008). *One century of vegetation change on Isla Persa, a nunatak in the Bernina massif in the Swiss Alps.* Journal of Vegetation Science, 19, 671-680.

Vittoz P., Dussex N., Wassef J. & Guisan A. (2009a). *Diaspore traits discriminate good from weak colonisers on high-elevation summits.* Basic and Applied Ecology, 10, 508-515.

Vittoz P. & Guisan A. (2003). *Le projet PERMANENT.PLOT.CH demande votre collaboration. Das Projekt PERMANENT.PLOT.CH bittet um Ihre Mithilfe*. Botanica Helvetica, 113, 105-110.

Vittoz P., Randin C., Dutoit A., Bonnet F. & Hegg O. (2009b). *Low impact of climate change on subalpine grasslands in the Swiss Northern Alps.* Global Change Biology, 15, 209-220.

Walther G.-R., Beißner S. & Burga C.A. (2005). *Trends in the upward shift of alpine plants*. Journal of Vegetation Science, 16, 541-548.

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Maison des parcs et de la montagne
256, rue de la République
F-73000 CHAMBERY
Tel. +33 . (0)4 79 26 55 00
Fax. +33 . (0)4 79 26 55 01
info@alparc.org   www.alparc.org

Director of publication : Guido PLASSMANN

Coordination and realization : Elena MASELLI

Editors/Contributors : Massimo BOCCA, Kurt BOLLMANN, Robin ENGLER, Antoine GUISAN, Yann KOHLER, Christoph LEDITZNIG, Elena MASELLI, Andrea MUSTONI, Reinhard PEKNY, Mateja PIRC, Christophe RANDIN, Pierre SALOMEZ, Stefano SANTI, Ettore SARTORI, Oliver SCHWEIGER, Martin ŠOLAR, Pascal VITTOZ, Michael VOGEL

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