Chapter 1

Management Strategies to Adapt Alpine Space Forests to Climate Change Risks – An Introduction to the Manfred Project

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1. Introduction

The challenges posed by climate change for forests in the Alpine Space are considerable. Climatologists have identified mountains as types of ecosystems that are facing an above-average warming trend. However, it is not entirely clear why mountains are warming up quicker than other landscapes, and whether the the past trend will continue in the future [1]. The currently expected warming is at least 3 to 4°C in the next century and thus far above the warming that is considered to be controlable by mankind [2, 3]. Despite the uncertainty of the future development several consequences of climate change on mountains are well understood. The duration of snow cover is expected to decrease, the water discharge regime will be altered, and the frequency of rock falls may increase, the distribution of plant species will change, and invasive species, such as pests and pathogens, will change the environmental setting of forestry. Trees are especially vulnerable when they are growing at the margins or even outside of their natural range [4, 5].

The human demands on the utilisation of mountain forests are manifold. A harmonized approach is required for the settlement of conflicting demands on land management [6, 7]. When maintaining the concept of a multi-purpose forestry the provision of ecosystem services need to be harmonized solutions from both demand and supplier side. Concepts for forest management may be insufficient when they are focused solely on timber production. An increasingly demanding society asks for biodiversity and scenic beauty, and is heavily dependent on the provision of drinking water and the protective function of mountain forests, even in regions far away from mountains [8, 9].

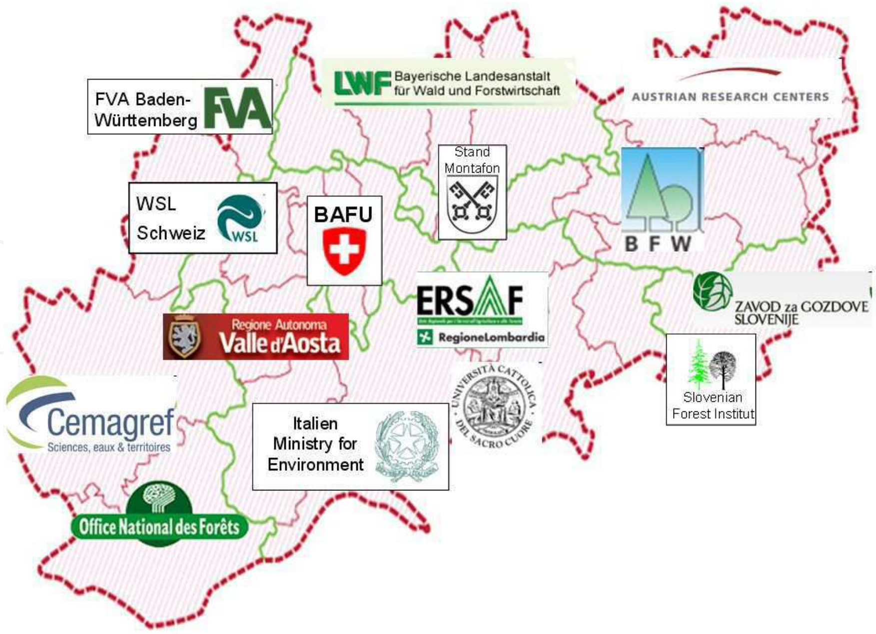

Figure 1. Geographical distribution of the partner institutions of the Interreg project "MANFRED - Management strategies to adapt Alpine Space forests to climate change risks".

The forests have a dual function within climate change. They are contributing to the *mitigation* of climate change, and their *adaptation* to climate change effects ensures their sustainable development under future site conditions. When the conservation of the huge carbon stock of forests in the Alpine Space is on the agenda, it is necessary to enhance the resilience of forests. Many forests, particularly in mountains, are going to benefit from climate change effects in the near future. Their productivity is currently limited by the duration of the growing season, which is expected to be elongated in the future. However, climate change is expected to manifest itself in many ways and the increase in the temperature is only one aspect. The rising CO_2 level affects the growth rate as well and altered temporal patterns of drought, mortality, and disturbances are to be taken into account. Moreover, the nitrogen supply has been increasing in the last decades and may in some regions exceed the demand of forests [10, 11]. Superimposed on these effects are potentially adverse effects such as extreme meteorological events, ecosystem disturbances, air pollution, and an increasing pressure from pests and pathogens on forests.

The Interreg project "MANFRED - Management strategies to adapt Alpine Space forests to climate change risks" is a collaboration between numerous institutions, comprising researchers, stakeholders, and forest practitioners who are engaged in the Alps (Figure 1). The intention of MANFRED is creating a mutual understanding of the recognized challenges due to global change, and elaborating guidelines for forest management in a joint effort.

Efforts of responding to climate change are embedded in a particular political setting. There are many processes, conventions on different geographical scales, from regional to international policies. The political framework is described in one module of the project [12]

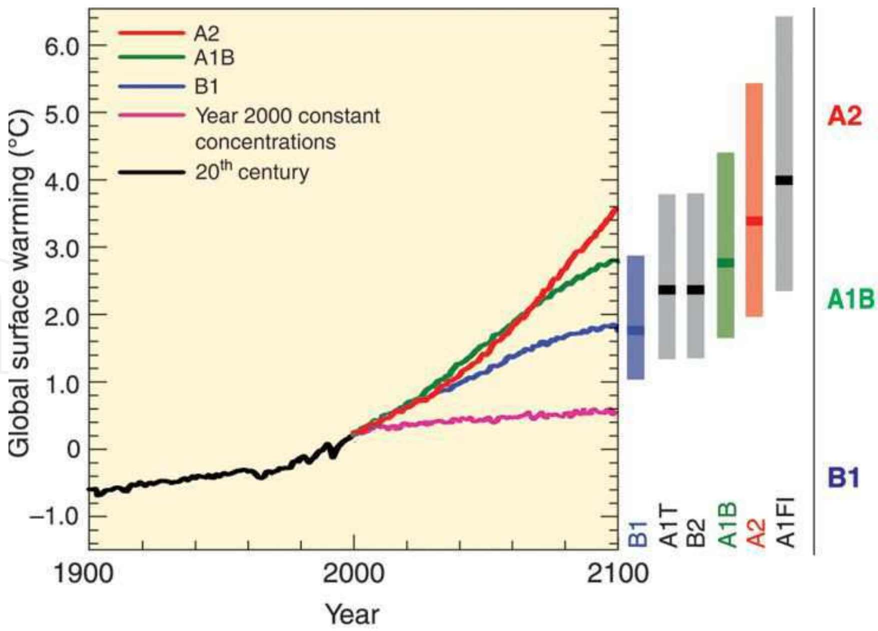

Figure 2. Scenarios of the global surface warming according to different emission rates of greenhouse gases; Source: IPCC Climate Change 2007: Synthesis Report Fig. 3-2.

2. Biotic and abiotic drivers call for an adaptation of forest management

The Fourth Assessment Report of the IPCC has provided global scenarios for the warming trend under different emission scenarios (Figure 2). In the Fifth Assessment Report even more comprehensive scenarios are developed that do not only include changes in radiative forcings, but also the implications of various responses of mankind in terms of technology, mitigation, and adaptation [13].The IPCC uses several climate models. They are yielding widely different results, and come in a rough spatial resolution. In order to include the differences between the models, often ensembles of simulation results are used. For a regionally valid estimate on the expected climate change, the large-scale scenarios need to be regionalized.

The climate scenarios give allow to interpretations, which tree species can best cope with future conditions. Trees will either go extinct, or migrate to sites where their requirements are fulfilled, or adapt to climate change. The extent of climate change and the expected future distribution of trees has been assessed in two comprehensive modules of the Manfred project [14, 15]. The analysis included the prediction of the potential occurrence of a large number of tree species by different statistical models and several climate scenarios. For the unique effort field data from national forest inventories of countries within the Alpine Space were made available by the participating institutions (Figure 1).

The successful regeneration of trees depends to a large extent on the average climatic conditions. However, extreme events can reset the success of tree seedlings. Extreme events come in many manifestations. Despite the uncertainty of the future climate there is sufficient evidence that they will be more common in the future [16]. The IPCC has even published a special report on extreme events [17]. Particularly harmful situations for tree seedlings are created by frosts in late spring and early summer, and by elongated drought events. Other types of extreme events are forest fires, that are triggered by increasingly dry conditions. Due to the history of active fire suppression the fire risk does not receive the full attention in the Alps. Nevertheless, future climate conditions may well call for an improved alerting system for the prevention of devastating forest fires [18]. These topics are covered in several chapters in this book [19, 20]. The knowledge of the past is instrumental when learning lessons for the future. One of the outcomes of the Manfred project is an online-database of documented effects of extreme events in the Alpine Space [21]. It is our true hope that the database can be kept alive beyond the lifetime of the research project.

A particularly difficult issue is the topic whether storm damages are becoming more problematic in the Alpine Space. There is sufficient evidence that European forests have been hit by a series of major storms in only a few years [22–25]. However, it is scientifically not established whether this trend of damages continues or even attenuates in the future, or whether the devasting storms where only a coincidence. Judging extreme events only by the local effects is clearly insufficient. It requires the geophysical expertise to evaluate whether a particular event is caused by global changes of the disturbance regime or whether it is caused by severe local conditions with a low probability. To further complicate the case it has been shown that the recorded damages due to storms are not only driven by climate change. Instead, the practised form of forest management such as the maturing of increasingly dense forests has created types of forest stands that are quite vulnerable to storm damages [26]. In Germany an exceptional dataset on a storm event has been collected. The findings could not be extended to the entire Alpine Space due to the relevance of regional factors for the vulnerability of storms. The regionally valid results are elaborated for a particular region [27, 28].

Biotic threats to forests are also triggered by global change. Climatic change clearly modifies the potential habitat of insects and pathogens. Warmer winters and longer growing seasons enable insects extending their natural occurrence into regions where they have not been encountered before, and to develop more generations in regions where they are already present. Infamous examples are the gradation of mountain pine beetles in the Canadian forests with unfavorable effects on the Canadian greenhouse-gas emission budget and the increased virulence of fungi [29, 30]. The second aspect of global change is the increase in international, even global, commerce. Unintentionally, pests and pathogens are distributed globally. Sometimes, these invaders encounter at least temporarily favorable conditions and can cause havoc on resident tree species [31–33]. – Within the Manfred project the propagation of potentially problematic pests and pathogens was analyzed [34]. In addition, a transnational web-based alerting system was created. The intention is providing sufficient information that regionally arising entomological challenges are identified early on so that sufficient time for appropriate counter measures is available. In recognition of the limited experience of local foresters with emerging pests and pathogens the online information is supported with a handbook specifically designed for field use in order to offer instantenously available information on indicators of pest and pathogen propagations.

Air pollution research has a long tradition in Central Europe. Although the attention has shifted towards other topics, ozone damages to forests are still problematic [35–37]. The emission of oxidating precursors favors the formation of ozone and high rates of incoming solar radiation are potentially a problem in mountain forests, especially in the southern part of the Alps the risk of increasing ozone damages is increasing. The topic is covered within the Manfred project in focused research effort [38–40].

3. Forest engineering approaches – Adaptive forest management

Eco-engineering methods are invoked when the protective function of forests is jeopardized. Climate change can affect forests in many ways so that they are more vulnerable to rockfall, avalanches, and landslides. This is a serious threat, given that the protection function is by far the most important ecosystem service of mountain forests [41]. For the development of appropriate counter measures the potential threat to these ecosystem services needs to be mapped and evaluated. Efficient methods are described and applied [42, 43]. The developed methods meet the challenge of being easily applicable in order to be useful even when extensive data are not available.

Another engineering approach is the utilization of the genetic adaptive capacity of trees. Many species are successfully growing on a wide geographical range and it is left to the expertise of forest geneticists to identify the most useful provenances. With the knowledge of the anticipated future site conditions it is possible to establish new forests. The full use of existing long-term provenance trials that have been established globally as an adaptive measure is pursued since a long time and promising populations have been identified for several tree species [44, 45]. Within the Manfred project such provenance trials have been evaluated for *Picea abies* [46, 47]. It has been shown that the potential productivity of forests can be greatly increased when chosing the appropriate provenance. Including these informations on the genetic amplitude of tree species can help to mitigate climate-induced productivity losses and can reduce the risk for the chosen tree species in their lifetime of presumably accentuated changes in the local climatic conditions.

A straightforward engineering tool is the use of simulation models for forest growth. These models are popular because forest management decisions can be instantenously tested. In traditional forest growth models the focus is usually on the temporal trend of the stem volume as dependent on different silvicultural practices. For a more comprehensive evaluation of different forest treatments a growth model has been combined with a soil carbon model. Hence, it is possible to extend the evaluation from timber production to the carbon sequestration potential of forests [48].

In four transnational case study regions, comprising 6 countries and 15 partners of the consortium, an analysis of land use, land-use change, and the demand and supply of ecosystem services was assessed. Local authorities and forest owners played an important role in these projects in recognition that their experience harbors a wealth of information, and yields valuable observations on early indicators of climate change effects. The study sites were chosen such that diverse situations for practical forestry are covered, such as regions with a peculiar threat of biotic and abiotic damages of forests, regions were the protective function of forests may suffer from climate change effects, and regions with a high risk of adverse effects of air pollution [40, 43, 49–51]. The different aspects should give a broad overview on the challenges for forestry under future conditions and the proposed solutions are intended to provide a range of strategies serving as reference for other regions as well.

The final chapter develops strategies for adaptive forest management, based on the experiences derived from the case study areas and based on previous concepts [52–58]. The concepts are intended to build bridges between research and practical forest management. The trans-national collaboration ensures that regional experiences are brought to the attention of a wider community. The suggested strategies of adaptive forest management are conceptually not necessarily new. Like in earlier periods were forests were under pressure due to acidic precipitation and elevated rates of nitrogen deposition, the concepts aim at increasing the stability of the forests in order to distribute potential risks within a forest stand among different tree species and cohorts of age groups. The suggested measures are rather conservative with hindsight to the high uncertainty of the future climatic conditions. Nevertheless, we want to emphasize that the suggested concepts only can be successfully implemented when damages of forests due to high population densities of ungulates are kept at an acceptable level. Presently, damages caused by deer are inhibiting the establishment of species-rich forest ecosystems.

In recognition of the limited distribution of textbooks among forest practitioners, additional avenues for education and dissemination were followed. The generated experience has been distributed in guidelines and handbooks, and was brought forward in roundtables with different stakeholder groups. It was recognized that forests in the Alpine Space always have to be seen in the context of the regional land-use system, embedded in agriculture and recreational demands for the landscape. There is no generally valid concept of forest management. Driven by land-management policies, forestry is an integral part of the green economy where land owners have both a lot freedom and responsibility for the general public in their management decisions. The increasing demand for renewable energy will have an impact on the form of silviculture. Nevertheless, forests are satisfying many needs of humans for goods and services in a sustainable way, and are also safeguarding the conservation of habitats for plants and animals.

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