HABIT-CHANGE

adaptive management for protected areas

HABIT-CHANGE

Literature review

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1. Introduction

With this report we provide a literature review for all project partners in the Habit-Change Project as a knowledge-basis that will help finding and using the necessary information for the preparation of many different outputs. This literature review can also be used by the management authorities from investigation areas (and other protected areas) to enhance their knowledge regarding climate change impacts and adaptation options.

In the application form of the Habit-Change Project this output is described as an analysis of literature concerning climate change related problems on habitats in protected areas and an analysis of relevant national legislation, informal management guidelines and management plans. With the support of all project partners and investigation areas we collected relevant sources and tried to relate them to different chapters of this report, though some publications contain information on different subjects which made the allocation difficult.

Because of the huge number of publications on climate change and climate change impacts this review cannot claim to cover all information available. If one enters the words “climate change nature conservation” into Google, it responds with 7.080.000 results. And even in Google Scholar, that only lists scientific articles the search for “climate change nature conservation” leads to 765.000 findings. We tried to focus on information that is most topical and that is closest to the topics of the Habit-Change Project. It seems necessary to monitor available databases for more up to date information that might be published during the time span of this project. Future publications concerning climate-change related topics will be distributed via internal communication structures like the Zotero database of the Habit-Change Project.

The following figure gives an overview of the structure and content of this literature review.

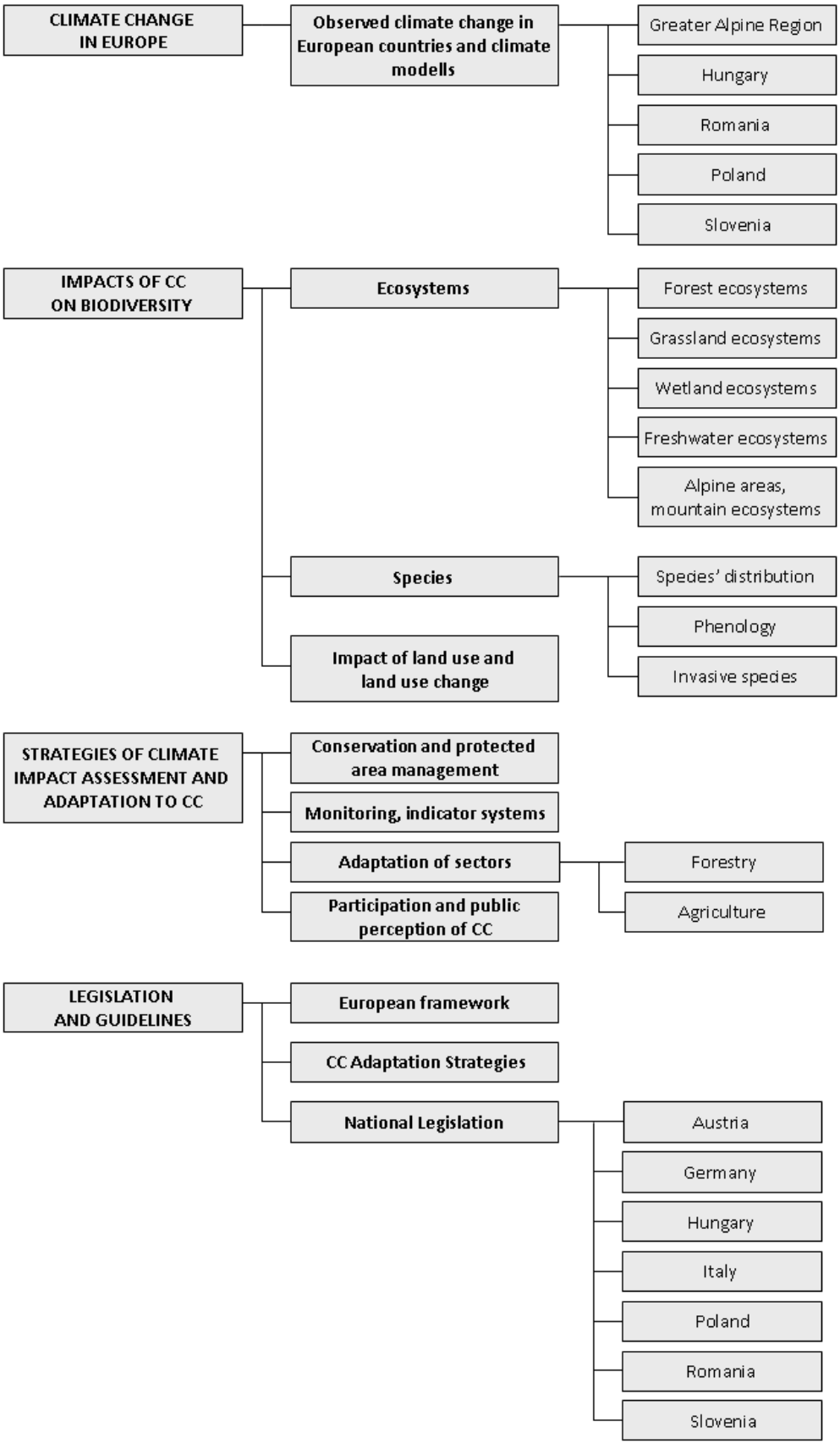

Figure 1: Structure and content of the literature review

(Source: TUB (PP 6))

1.1. Objectives

The overarching objective of this literature review is to provide an overview on relevant literature about climate-change related subjects. That includes literature about already observed and projected changes of climate, literature about impacts of a changing climate on different sectors like agriculture, forestry or nature conservation and literature on specific impacts on habitats and species in protected areas.

The objectives of the review of scientific literature about climate-change related subjects are

- to give an overview about the state of research and discussions in national and international scientific communities, with focus on habitat types and on specific impacts of climate change in different countries
- to provide a basis for information exchange between participating countries about existing experiences and research results on impacts of climate change on habitats
- to identify subjects and habitats of common interest on which further research may focus

Therefore this literature review provides information about habitat types that are already well investigated, which climate-change effects are considered relevant and what kind of measures for adaptation in protected areas are already discussed. It compiles information on climate-change related problems existing in protected areas and shows, what problems are already visible or are expected in the future and which differences exist in different countries. With the content of this review we want to make sure those actions and outputs of the Habit-Change Project cover all relevant problems currently discussed in science and literature.

Beside the review of scientific publications and policy papers it is an additional objective to compile information about the relevant national legislation, informal management guidelines and management plans.

The objectives of the review of national legislation and management guidelines are

- to identify the legal basis for the management of protected areas for further analysis and
- to identify national and federal management guidelines to protected areas for later integration of climate-change aspects.

The information about existing management plans for the participating investigation areas is not included in this literature review but will be presented in output 3.3.1 that is due in September 2011. This report contains data about the legal framework for the management of protected areas which might have to be revised in order to allow adaptation measures inside the protected areas. With the information about national and federal laws, rules and guidelines which are

a) important for the management of protected areas and/or

b) deal with impacts of climate change on natural environment and could be used as a basis for mitigation and adaptation measures.

The sources gathered in chapter 5 “Legislation and guidelines concerning climate change and nature conservation“ provide basic information for the adaptation and revision of legislation in order to integrate climate change and adaptation requirements into the legal framework. This information is an important basis for the preparation of several outputs in work package 6. The legal framework will be analysed later if climate change and the need for mitigation and adaption are already addressed in these laws. The information about national legislation and management guidelines was provided by different project partners from the participation countries.

1.2. Relevance for other work packages and outputs of the Habit-Change Project

The literature review is the knowledge-basis for outputs in action 3.1, 3.2, 3.3, 3.4 and for several outputs in work package 5 and 6. The scientific information about the impacts of climate change on habitats and species is an important basis for the spatial decision support system (SDSS) that is planned in action 5.1. The information about adaptation needs and options is the basis for the climate-change adapted management plans (CAMPs) in action 5.3 as well for the SDSS.

The first compilation of relevant national legislation will be needed for output 6.2.2 that will develop recommendations for application and CC adaptation of laws and guidelines on national and EU-level.

1.3. Method

To collect relevant information we designed a questionnaire that was sent to all project partners. In the questionnaire we asked for publications or links to publications that focus on climate-change related subjects. To get an overview on the state of research in different participating countries of the Habit-Change Project, we asked for country-specific literature. Detailed bibliographic information was collected for every resource. Because some literature is only available in national language, we also asked for a translation of the title and if possible of an abstract as well. As additional information and instead of an abstract up to 10 keywords were asked for in order to characterize the content.

With the questionnaire we also asked for information about national legislation and management guidelines. Project partners were asked to assign the relevant legislation to the following categories:

- legal basis for protected areas
- property laws that protect rights of landowners, users and stakeholders
- forestry legislation relevant for the management of protected areas
- agricultural legislation relevant for the management of protected areas
- water legislation relevant for the management of protected areas
- nature conservation legislation relevant for the management of protected areas
- other relevant legislation e. g. laws addressing climate change, mitigation and adaption

Even though a large share of information provided by our project partners is available in English, there are some publications only available in national languages. They were included in the review because they are of great value for the managing authorities of protected areas in the respective participating countries. If literature is only available in national language you will find information about the language in brackets, for example for articles in Romanian language you find [Romanian] at the end of the bibliographical information.

In a second step the information received from project partners was completed with additional literature we searched for in online data-bases. We put a focus on literature that is easily assessable via internet and that is published in English, so all project partners can make use of it. For literature that can be downloaded from the internet we added the hyperlink. Especially with journal articles we included the abstract in the review. This was not possible for all articles but it will make it easier to decide whether certain resources really contain the expected information.

Some of the literature that was provided by project partners of the Habit-Change Project is available through the Zotero database. If literature in this review is available via Zotero we added a note behind the bibliographical information. Please notice that not all literature from Zotero was integrated into this review. Therefore we advise all project partners to search the literature database in Zotero for additional information.

Differing from former plans to structure the literature review by participating countries of the Habit-Change Project, we decided to choose a structure that assigns the sources to different topics. That way it will be easier to search the review for literature dealing with a certain topic. Please consider that most articles and publications do not focus on one subject only. We tried to identify the main content in order to locate the publication in the fitting chapter of this report. If you're looking for information on a certain subject it might be useful to search other chapters of this report for relevant content, too.

2. Climate Change in Europe

- Bates, B.C., Kundzewicz, Z.W., Wu, S., and Palutikof, J. P. (Eds.). (2008) **Climate Change and Water.** Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva.
  Available for download at: http://ec.europa.eu/environment/water/adaptation/index_en.htm

- EEA (European Environment Agency) 2008: **Impacts of Europe's changing climate.** EEA Briefing, ISSN 1830-2246.

- EEA (European Environment Agency) 2008: **Impacts of Europe's changing climate - 2008 indicator-based assessment.** EEA Report No 4/2008. European Environment Agency, Copenhagen.
  Available for download at: http://www.eea.europa.eu/publications/eea_report_2008_4

- Kundzewicz Z., Radziejewski M. and Pińskwar I. (2006). **Precipitation extremes in the changing climate in Europe.** Climate Research 31: 51–58.
  ABSTRACT: Several episodes of extreme precipitation or extreme lack of precipitation (and high temperature) leading to dramatic and high-impact floods and droughts have occurred in Europe in recent years. Climate scenarios suggest that problems of too little or too much water may become more severe in the future. Using data from the Hadley Centre's HadRM3 model, this paper analyzes future changes in the characteristics of intense precipitation (mean daily precipitation amounts and number of days with intense precipitation in a year) and the duration of dry (also dry and hot) spells over the European continent, comparing the time periods of 1961–1990 and 2070–2099. The potential for intense precipitation is likely to increase in the warmer climate of the future, contributing to the growth of flood hazard in areas where inundations are typically triggered by heavy rain. The projected number of days with intense precipitation and the maximum daily precipitation are likely to increase over much of Europe, especially in the central and northern parts. According to projections, 'dry and hot' extremes may become more severe for most of Europe. The areas already affected by water stress in the present climate (e.g. southern Europe) are expected to experience even more severe conditions.
  Keywords: Precipitation, Intense precipitation, Floods, Droughts, Climate projections

- Liszewska M. (editor), 2004, **Potential Climate Changes and Sustainable Water Management**. Publ. Inst. Geophys. Pol. Acad. Sc., E-4, 377, 92 pp.

- Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, C.H.C., and Oppenheimer, M., et al. (2007). **Assessing key vulnerabilities and the risk from climate change.** *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 779-810.

2.1. Observed climate change in European countries or regions and climate models

- EEA 2010: **The European environment — state and outlook 2010: synthesis.** European Environment Agency, Copenhagen.

  SOER 2010 provides a set of assessments of the current state of Europe's environment, its likely future state, what is being done and what could be done to improve it, how global megatrends might affect future trends and more. It includes 13 Europe-wide thematic assessments of key environmental themes from which some are listed below. All reports are Available for download at: http://www.eea.europa.eu/soer

  Understanding Climate Change — SOER 2010 thematic assessment.

  Average global air and ocean temperatures are rising, leading to the melting of snow and ice and rising global mean sea level. Ocean acidification results from higher CO2 concentrations. With unabated greenhouse gas emissions, climate change could lead to an increasing risk of irreversible shifts in the climate system with potentially serious consequences. Temperature rises of more than 1.5–2 °C above pre-industrial levels are likely to cause major societal and environmental disruptions in many regions. The atmospheric CO2 concentration needs to be stabilised at 350–400 parts per million (ppm) in order to have a 50 % chance of limiting global mean temperature increase to 2 °C above pre-industrial levels (according to the IPCC in 2007, and confirmed by later scientific insights).

  Mitigating Climate Change — SOER 2010 thematic assessment.

  The EU emitted close to 5 billion tonnes (Gt) of CO2-equivalent emissions in 2008. It contributes today around 12 % of annual global anthropogenic direct greenhouse gas emissions. The EU is making good progress towards achieving its emission reduction targets. A rapid, sustained and effective transition to a low carbon economy is necessary to mitigate climate change and to meet global greenhouse gas emission targets.

  Adapting to Climate Change — SOER 2010 thematic assessment.

  Climate change is happening and will continue to have far-reaching consequences for human and natural systems. Impacts and vulnerabilities differ considerably across regions, territories and economic sectors in Europe. Strategies to adapt to climate change are necessary to manage impacts even if global temperature stays below a 2 °C increase above the pre-industrial level. The EU adaptation framework aims at developing a comprehensive strategy by 2013, to be supported by a clearinghouse for sharing and maintaining information on climate change impacts, vulnerability and adaptation.

  Biodiversity — SOER 2010 thematic assessment.

  Biodiversity — the variety of ecosystems, species and genes — is essential to human wellbeing, delivering services that sustain our economies and societies. Its huge importance makes biodiversity loss all the more troubling. European species are threatened with extinction and overexploitation. Natural habitats continue to be lost and fragmented, and degraded by pollution and climate change. Despite actions taken and progress made, these threats continue to impact biodiversity in Europe. The new global and EU targets to halt and reverse biodiversity loss by 2020 are ambitious but achieving them will require better policy implementation, coordination across sectors, ecosystem management approaches and a wider understanding of biodiversity's value.

- Hirschi, M., Seneviratne, S., Alxeandrov, V., Boberg, F., Boroneant, C., Christensen, O., Formayer, H., Orlowsky, B., Stepanek, P. 2010: **Observational evidence for soil-moisture impact on hot extremes in southeastern Europe.** Nature Geoscience online, 12/2010. DOI: 10.1038/NGEO1032

  ABSTRACT: Climate change is expected to affect not only the means of climatic variables, but also their variability and extremes such as heat waves. In particular, modelling studies have postulated a possible impact of soil-moisture deficit and drought on hot extremes. Such effects could be responsible for impending changes in the occurrence of heat waves in Europe. Here we analyse observational indices based on measurements at 275 meteorological stations in central and south-eastern Europe, and on publicly available gridded observations. We find a relationship between soil-moisture deficit, as expressed by the standardized precipitation index, and summer hot extremes in south-eastern Europe. This relationship is stronger for the high end of the distribution of temperature extremes. We compare our results with simulations of current climate models and find that the models correctly represent the soil-moisture impacts on temperature extremes in south-eastern Europe, but overestimate them in central Europe. Given the memory associated with soil moisture storage, our findings may help with climate-change adaptation measures, such as early-warning and prediction tools for extreme heat waves.

- Szwed M., Graczyk D., 2005, **Heat waves in the changing climate, based on HadRM3-PRECIS results**, Geophysical Research Abstracts, vol. 7, 03121, 2005.

2.1.1. Greater Alpine Region

- Auer, I., Böhm, R., Jurkovic, A., et al., 2006: **HISTALP – Historical Instrumental Climatological Surface Time Series of the Greater Alpine Region.** Int. J. Climatol. 27: 17-46. [ZOTERO>CC]

  ABSTRACT: This paper describes the HISTALP database, consisting of monthly homogenised records of temperature, pressure, precipitation, sunshine and cloudiness for the 'Greater Alpine Region' (GAR, 4–19 °E, 43–49 °N, 0–3500m asl). The longest temperature and air pressure series extend back to 1760, precipitation to 1800, cloudiness to the 1840s and sunshine to the 1880s. A systematic QC procedure has been applied to the series and a high number of inhomogeneities (more than 2500) and outliers (more than 5000) have been detected and removed. The 557 HISTALP series are kept in different data modes: original and homogenised, gap-filled and outlier corrected station mode series, grid-1 series (anomaly fields at 1° × 1°, lat × long) and Coarse Resolution Subregional (CRS) mean series according to an EOF-based regionalisation. The leading climate variability features within the GAR are discussed through selected examples and a concluding linear trend analysis for 100, 50 and 25-year subperiods for the four horizontal and two altitudinal CRSs. Among the key findings of the trend analysis is the parallel centennial decrease/increase of both temperature and air pressure in the 19th/20th century. The 20th century increase (+1.2 °C/+1.1 hPa for annual GAR-means) evolved stepwise with a first peak near 1950 and the second increase (1.3 °C/0.6hPa per 25 years) starting in the 1970s. […] This, further developed via some atmospheric statics and thermodynamics, allows the creation of 'barometric temperature series' without use of the measures of temperature. They support the measured temperature trends in the region. Precipitation shows the most significant regional and seasonal differences with, e.g., remarkable opposite 20th century evolution for NW (9% increase) versus SE (9% decrease). Other long- and short-term features are discussed and indicate the promising potential of the new database for further analyses and applications.

  Keywords: multiple climate database, homogeneity, instrumental period, greater alpine region, gridded data sets, climate variability

- Böhm, R., 2008: **Climate reconstruction of the instrumental period – problems and solutions for the greater Alpine region.** (Klimarekonstruktion in der instrumentellen Periode – Probleme und Lösungen für den Großraum Alpen.) In: Klimawandel in Österreich – die letzten 20.000 Jahre…und ein Blick voraus. Reihe Alpine Space – Man and Environment 6, Innsbruck University Press. 145-164. [German]

  ABSTRACT: Two recent activities of the climate variability working group at the Austrian weather service (ZAMG) are chosen to demonstrate the extraordinary potential of the instrumental record existing in the greater Alpine region and to highlight the risks arising with the uncritical use of original instrumental climate information. First we deal with the correction of a systematic warm bias found in the early instrumental summer temperatures prior the 1860s. This exercise is a successful step towards real climate information with a reduced share of yet undetected or not yet removable non-climatic information (random noise but also systematic biases). The second example describes a yet not successfully solved problem: the homogenization of daily or subdaily climate series. This matter is particularly urgent as the ongoing discussion on the change of extreme events in frequency and/or intensity needs proper data, which are presently not available. Here some regionally limited attempts are shown and discussed.

- Matulla, C., 2009: **Das Klima der nächsten 100 Jahre.** In: Klimawandel in Österreich – die letzten 20.000 Jahre…und ein Blick voraus. [German] Reihe Alpine Space – Man and Environment 6, Innsbruck University Press. 165-180. [ZOTERO>CC]

- Nagy, L., Pauli, H., Gottfried, M., Grabherr, G., 2010: **Climate Change Impacts on the Future Extent of the Alpine Climate Zone.** Settele et al. (eds.). Atlas of Biodiversity Risk, Pensoft Publishers, Sofia (EU FP-6 Integrated Project ALARM). [ZOTERO>CC]

2.1.2. Hungary

- Bartholy, J., Pongrácz, R, Gelbó, Gy. 2007: **Regional climate change expected in Hungary for 2007-2010.**

  ABSTRACT: Expected climate change estimations for the Carpathian basin and especially, Hungary, are summarized for the 2071-2100 period on the basis of the results from the project PRUDENCE. Different regional climate models (RCMs) used 50 km as the horizontal spatial resolution, and evaluated the A2 and B2 global emission scenarios. Results suggest that in case of temperature, a warming trend is evident in the Carpathian basin. The largest warming is expected in summer. The expected change of annual total precipitation is not significant. However, significantly large and opposite trends are expected in different seasons. Seasonal precipitation amount is very likely to increase in winter, while it is expected to decrease in summer, which implies that the annual distribution of precipitation is expected to be restructured. The wettest summer season may become the driest (especially in case of A2 scenario), and the driest winter is expected to be the wettest by the end of the 21st century. It is evident that all these climate processes affect agricultural activity and disaster management strategy. In order to prepare for the changing climate conditions, results of this regional climate change analysis may serve as basic information.

  Keywords: Regional climate change, temperature, precipitation, Carpathian basin, regional climate model

- Mika, J., 2006: Globális klímaváltozás, magyarországi sajátosságok. (**Global climate change and its characteristics to Hungary**) pp. 397-408 In: Fekete, G. – Varga, Z. (editors) (2006) Magyarország

tájainak növényzete és állatvilága. (Vegetation and fauna of Hungary) MTA Társadalomkutató Központ, Budapest pp.460

- Mika, J., 2007: **Climate change in Hungary: trends, impacts and vulnerabilities.** Presentation. Available for download at: http://web.ceu.hu/envsci/climate2007/JanosMika.CCHungary.pdf
  Keywords: Hungary, Climate change, regional modell, temperature, precipitation

2.1.3. Danube-Carpathian Region, Romania

- Busuioc, A., Dumitrescu, A., Soare, E. and Orzan, A., 2007: **Summer anomalies in 2007 in the context of extremely hot and dry summers in Romania.**
  ABSTRACT: Summer 2007 was among the hottest summers in Romania over the entire observational period 1901-2007. This paper presents a detailed analysis of the surface air temperature and precipitation anomalies recorded during the summer 2007 in comparison with the corresponding values of the first three hottest summers recorded in Romania, in order to understand the mechanisms controlling these events and, more generally, the summer temperature variability in Romania. In order to reach this objective, the time series of the mean air temperature and total precipitation for two observational periods were analyzed: a longer period for 14 stations (1901-2007) and a shorter one (1961-2007) for a complete higher spatial density data set (94 stations for temperature and 104 for precipitation). Non-parametric tests (Mann-Kendall and Pettitt) and empirical orthogonal function analysis were used as statistical tools to identify the main temporal characteristics of regional climate variability (trends and shifts). It was found that, in terms of spatial average over the country, the summer 2007 was similar with that of 1946, considered so far the hottest one over the period 1901-2006. In order to understand the large-scale mechanisms responsible for these extreme events, the corresponding anomalies of the possible dynamic factors (sea level pressure and geopotential heights at 500 hPa) and thermodynamic factors (specific humidity and temperature at 850 hPa), from the NCEP reanalysis for the period 1961-2007, were analyzed. The obtained results showed that a persistent anticyclonic structure over Romania, associated with very large positive temperature anomalies at 850 hPa, were the main reasons of the very hot summers in Romania. When these large-scale anomalies were additionally associated with a persistent dry air mass at 850 hPa, prolonged and intense droughts were recorded in Romania. A strong agreement between the temporal variability of the summer temperature anomalies in Romania and upper large-scale geopotential and temperature anomalies over the period 1961-2007 was found as well. The signal extracted from the sea level pressure field was not so significant for the analyzed summer extreme events in Romania.

- Central European University, 2008: **Impacts of and Adaptation to Climate Change in the Danube-Carpathian Region** (Overview study commissioned by the WWF Danube-Carpathian Programme). Budapest: Dept. of Environmental Sciences and Policy Central European University.
  Keywords: Danube-Carpathian region, CC impact, CC policies, Adaptation

- Cuculeanu, V., Marica, A. and Simota, C., 1999: **Climate change impact on agricultural crops and adaptation options in Romania**. – Climate Research 12: 153-160.
  ABSTRACT: The aim of this paper is to assess the potential effects of climate change on development, grain yield, and water balance for the main agricultural crops at 5 typical sites located in one of the most vulnerable zones of Romania. In addition, the paper evaluates possible adaptation measures of crop management to future climate changes. The vulnerability assessments focused on winter wheat and maize crops due to the particular importance of these crops in the cultivated areas and the

difference in the genetic type of these crops reflected in their distinct physiological responses to CO2 concentration level (winter wheat is a C3 crop, while maize is a C4 crop). Outputs from 2 equilibrium 2 ´ CO2 general circulation models were used to develop climate change scenarios. CERES simulation models, linked with a seasonal analysis program included in the dedicated software DSSAT v3.0, were run for 30 yr with baseline climate and climate change scenarios. The results of crop simulations under climate change scenarios indicated that winter wheat benefits from the interaction of double CO2 concentrations and higher temperatures, while irrigated maize in southern Romania shows negative responses to climate change. The adverse impact of climate change on the maize crop can be lessened by using a longer maturing hybrid, sowing in the last week of April, applying a plant density of 5 plants m–2, and increasing fertilization levels.
Keywords: Romania, Winter wheat, Maize, Baseline, GCM outputs, Carbon dioxide, Models, Adaptation option

- Cuculeanu, V., Tuinea, P. and Balteanu, D. 2002: **Climate change impacts in Romania: Vulnerability and adaptation options**. GeoJournal 57: 203-209
  ABSTRACT: Using the output from five climate model experiments (four equilibrium GCMs and one transient GCM) for a double carbon dioxide atmospheric concentration, the climate change scenarios in Romania for a time slice up to 2075 were constructed. These scenarios were used to assess the climate change impacts on different resource sectors: agricultural crops, forests, and water resources. The vulnerability of each sector and specific adaptation options were then analysed.
  Keywords: agricultural crops, climate change, forests, impact, water resources, Romania

- Ghioca, M. 2006: **Using GIS on climate changes assessment.** – Geographia technical 1: 73-78. [Romanian]
  ABSTRACT: Global regional climate model results are analyzed regarding the assessment of climatic changes in Romania. A downscaling model is used to construct climate change scenarios for Romania area, using the parameters provided by PRUDENCE Project (temperature, precipitation, runoff) on 2071-2100 period.

- Ghioca, M., 2008: **The physical assessment of climate impact on hydrological extreme events**. PhD thesis – resume, University of Bucharest, Faculty of Physics.
  ABSTRACT: The present thesis analyzes the impact of climate changes from the past until the present and based on this period describe a prediction for the year 2071-2100 on extreme hydrological events in Romania. As a study case it was pointed out a deficit area from the hydrographic view, which is Jiu River basin.
  It is approaching three distinct study directions:
  -A climatic diagnosis for the last 50 years in Romania, especially Jiu River, using hydro-meteorological assessment indices,
  -Developing of a debit-duration-frequency model for minim and average river flowing in order to calculate (hypothesize) hydrological information for other basins that are not systematically measured,
  -Inter-comparison of the climatic models for Romania in order to estimate the water resources for the next 50 years.

- Lungu, M., 2008: **Resources and climatic risks in Dobrogea.** PhD thesis - resume, University of Bucharest, Faculty of Geography.
  Keywords: climate, Romania, climatic risks

- **Report on influences of regional and global climatic changes on Dobrogea** (Romania) Researches and data acquisitions regarding the climatic factors evolution at regional and local level [Romanian]
  CONTENT: Climate changes at regional and local level – causes, effects and historical events, data, determinant factors knowledge of climate changes and effects in Dobrogea

- Stavros, D., 2007: **Climate Change and Built Environment in Romania.** Paper presented to the 46th ECCE meeting, Athens, 19-20 October.
  Keywords: CC impact, Romania, legal framework, political framework

- United Nations Environment Programme 2007: **Carpathian Environment Outlook.** Geneva: 236 p. ISBN 978-92-807-2870-5
  ABSTRACT: The "Carpathians Environment Outlook" (KEO) project was initiated in early 2004 by UNEP's Division of Early Warning and Assessment (DEWA)/GRID-Geneva and the Regional Office for Europe (ROE). The KEO report is a sub-regional examination and synthesis of the environmental situation in the greater Carpathian region that includes parts of seven countries (the Czech Republic, Hungary, Poland, Romania, Serbia and Montenegro, the Slovak Republic and Ukraine). KEO is being carried out in a "bottom-up", collaborative and consultative style, similar to its parent products, UNEP's Global Environment Outlook (GEO) assessments at the global level.
  Keywords: Carpathian mountains, Romania

2.1.4. Poland

- Dąbrowski, M., Marszelewski, W., and Skowron, R., 2004: **The trends and dependencies between air and water temperatures in lakes in northern Poland from 1961–2000.** Hydrology and Earth System Sciences 8: 79–87.
  ABSTRACT: Over 40 years, from 1961–2000, daily mean values of surface lake water temperatures at 0.4 m depth in six lakes in northern Poland were recorded with nearby mean daily air temperatures at 2 m. Air temperatures increased on average from 0.020 to 0.025°C year–1 while lake-water temperatures varied more but increased by 0.005 to 0.028°C year-1. For shorter periods (for instance, for 10 days) the pattern of trend directions and values was more complex, depending on the morphometric and trophic conditions of the lakes. It has been concluded that changes in lake water temperatures during climate warming may be documented by studies of lakes located relatively closely together (up to 300 kilometres).
  Keywords: physical limnology, climate changes, lake water, temperature

- Liszewska, M., and Osuch, M., 1997: **Assessment of the impact of global climate change simulated by the ECHAM1/LSG general circulation model onto hydrological regime of three Polish catchments**. Acta Geophys. Pol. 45, 363-386
  A semi-empirical approach to the statistical climate inversion problem was applied. The Polish surface air temperature and precipitation were related to the large scale circulation over Central Europe represented by mean sea level pressure, geopotential height of 500 hPa and 500/1000 hPa thickness, by means of canonical correlation analysis. The results of verification of the method for an observed independent data subset are presented. The procedure was then applied to the output of the three runs of the ECHAM1/LSG model: control and two perturbed integrations. Results are discussed. Also, the hydrologic assessment of the responses of three Polish catchments to climate change is presented. In order to evaluate the water balance elements CLIRUN3 watershed model was used.

- Liszewska M., Osuch M., 1998: **Regional climate scenarios and their applications,** Geographia Polonica, vol.71, 39-56.
  In the first part of the paper various approaches to the formulation of regional climate scenarios are described. In the second part an example of a climate scenario for Poland based on results from the ECHAM/LSG general circulation transient model is presented. Two perturbed runs of the model are considered: A - "buisiness as usual" and D - "accelerated policies". The hydrological regime of Polish catchments in changed climate conditions is evaluated using CLIRUN 31 watershed model. Results are discussed.

- Liszewska M., 2000: **Examples of reconstructions of Polish climate by GCMs and projections for future**, Images and reconstructions of Weather and Climate over the Last Millennium, Cracow, 20-22.09.2000. Scientific Works of the Jagiellonian University, Geography,107, p.365-372.
  Great efforts have been made to develop climate modelling. The most sophisticated tools to simulate the behaviour of the ocean and atmosphere over time are general circulation models. The new centre IPCC DDC has been recently established to coordinate the distribution of data resulting from many climate simulation experiments provided by the world climate centres. The paper contains analysis of simulations for Poland.

- Liszewska M., Osuch M., 2000: **Analysis of results of global climate models for Central Europe and Poland.** Geographia Polonica, vol.73, no.2, 49-63.
  The paper presents an evaluation of climate simulations by the ocean and atmosphere general circulation models from the IPCC DDC for two regions: the Central European area and Poland. The comparisons have concerned air surface temperature, precipitation and wind speed. Control runs of the models for the period 1960-1989 and the results of the „Greenhouse Gas plus Sulphate" experiment for the next century 2000-2099 have been analysed. Re-analysed observed data have been used as the reference distributions for climate parameters.

- Liszewska M., Osuch M., 2002: **Climate Changes in Central Europe Projected by General Circulation Models.** GeoJournal (Kluver Academic Publishers) vol. 57, no. 3, 155-163.
  The paper is based on recent climate simulations provided by the leading world climate centres and available through the Data Distribution Centre of the Intergovernmental Panel on Climate Change. Seven models have been considered. Three experiments: control, and two integrations for different greenhouse gases emission scenarios have been analysed. Assessments have been made for the European window defined as 5-40^{o}E, 40-60^{o}N. The paper presents selected results for the air surface temperature and precipitation. The intention of the authors was to show examples of analyses made specifically for the Central Europen region.

- Liszewska M., 2004: **Climate reconstructions and projections for Poland and Central Europe**, Publs. Inst. Geophys. Pol. Acad. Sc., E-4, 377, p. 19-24

- Somorowski C., Kaczmarek Z., 1998: **The influence of climate changes on demand for irrigation water in Poland.** Geographia polonica A. 1998, 71, 121-126.
  ABSTRACT: Possible future growth in Poland's demand for irrigation water is analysed in relation to possible climate change by comparing demand for 1951-1990, estimated on the basis of hydrometeorological data, with that for 1991-2050 determined on the basis of hydrometeorological variables (precipitation, potential evapotranspiration) accorded to a Global Circulation Model with a scenario of doubled CO2 content by the year 2080. The analysis was performed for the catchment of

the Warta and the Wieprz rivers, with areas of future irrigation determined in relation to possible technical and agronomic factors.

- Szwed M., Graczyk D., 2006: **Thermal seasons in Poland – the present and the future, based on HadRM3-PRECIS results.** Geophysical Research Abstracts, vol. 8, 05836, 2006.

- Szwed M., Graczyk D., 2007: **Thermal seasons in Poland – the present and the future, based on HadRM3-PRECIS results**. Global Change.

- Szwed M., Graczyk D., Pińskwar I., Kundzewicz Z. W., 2007: **Projections of climate extremes in Poland**. Geographia Polonica, 80 (2), 191-202.
  ABSTRACT: The climate change projections for Poland are consistent in foreseeing overall temperature increase in the coming decades. Precipitation is projected to decrease in summer (though this finding is not robust, being model-dependent) and to increase in winter. It is expected that the occurrence of climate extremes over Poland may change in the future, warmer climate. In this study, daily temperature and precipitation data from the Hadley Centre HadRM3- PRECIS regional model simulations (for the SRES A2 scenario in three model experiments) in Poland were used to study temperature and precipitation extremes defined according to the specification made in the Integrated Project entitled "Extreme meteorological and hydrological events". Climate extremes in the control period, 1961–1990, were compared with those in theprojection period, 2071–2100.
  Keywords: climate change, climate model, extremes, precipitation, temperature, Poland

- Ustrnul, Z., Czekierda, D., Wypych, A., 2010: **Extreme values of air temperature in Poland according to different atmospheric circulation classifications**. Physics and Chemistry of the Earth, Parts A/B/C, In Press, Corrected Proof, available online 14 January 2010
  ABSTRACT: The paper focuses on synoptic and climate analysis with the application of circulation types based on six classification schemes, both subjective and objective. The principal goal of the study was to determine circulation types with respect to the occurrence of extreme values of air temperature. A comparison between different available classifications was also performed. Maximum and minimum daily temperatures for the 56-year study period (1951–2006) were used in the analysis. The necessary data series were obtained from 61 weather stations, relatively well spaced across Poland. Each series was checked for homogeneity and evaluated. Detailed calculations were performed for the summer (June–August) and winter (December–February) seasons. Extreme values were selected with respect to probability distribution bases. The top and bottom 5% were used for further analysis. Calculations of extreme values for particular types and classifications were the main phase of analysis. All extreme temperature values were analyzed for each type. This enabled the creation of histograms presenting types producing the highest number of particular extremes. The study showed that circulation types with an anticyclonic ridge were the most important for extremely hot days in the summer, while extremely low temperatures in the winter were usually associated with anticyclonic types with an easterly airflow. A special effort was made to identify the classification scheme yielding the best accuracy in evaluating extremes.
  Keywords: Air temperature extremes, Circulation types, Subjective and objective classification, Poland

2.1.5. Slovenia

- Bergant, K., Kajfez-Bogataj, L., 2004: **Empirical downscaling method as a tool for development of regional climate change scenarios.** Acta agriculturae slovenica, vol. 83, no. 2, pp. 273-287. [Slovenian]

  ABSTRACT: The results of the simulations with general circulation models (GCM) are the basis for the future climate change and impact studies. In our case, the results of the simulations with five GCM (CSIRO/Mk2, CCC/CGCM2, UKMO/HadCM3, DOE-NCAR/PCM and MPI-DMI/ECHAM4-OPYC3), based on SRES A2 in B2 emission scenarios, were used. The mean monthly values were selected for the period 1951-2100. The results of GCM were projected to 5 locations in Slovenia (Ljubljana, Novo mesto, Murska Sobota, Ratece and Bilje) by using empirical downscaling method. Different regression techniques were used for the development of the empirical models (EM) for the mean air temperature and precipitation amount. The input data were mean monthly near-ground air temperatures and sea-level pressures in Slovenia. The EM were developed by means of data from the ARSO archive and NCEP/NCAR reanalysis data for the period 1951-2002. The quality was the highest in case of air temperature. The EM for precipitation for the cold half of the year are of the similar quality. The quality was poorer in case of warm half of the year.

  Keywords: Meteorology, Climate change, Air temperature, Environmental temperature, Environmental factors, Precipitation, Models, Regional planning, Slovenia

- Bergant, K., Kajfez-Bogataj, L., 2005: **Climate Change and Drought in Slovenia.** Ujma no. 20, pp. 37-41. [Slovenian]

  Available for download at: http://www.sos112.si/slo/tdocs/ujma/2005/susa_2004.pdf

  ABSTRACT: The average temperature in Europe has increased by 1 °C over the past 100 years and is projected to rise by as much as a further 6.3 °C by 2100. Evidence is growing of climate change's impact on human and ecosystem health, as well as economic viability. The effects of climate change include economic losses resulting from weather and climate-related events such as droughts. Projections for central Europe indicate an increased risk of water shortage, which would harm vegetation. Long term average (1961-1990) precipitation (RR) and air temperature (T) data for the summer period (June, July and August) were used for estimating present potential soil moisture deficit (PSMD) areas. Data for T in the summer period for 108 locations were used to calculate the potential evapotranspiration (PET) using Thornthweite's method. Combining RR data for the same time period for 366 locations with calculated values for PET using GIS, maps of PSMD areas and their intensity, were made. Warm and dry climate change scenarios were applied and the entire procedure for estimating PSMD areas and their spatial visualization was repeated. Comparing the present state and predictions, some conclusions about the possible impact of climate change on soil mby for about 100 % or even more if the increase of T was 2 °C and the reduction of RR 10 % in summer. The separate effect of a 2 °C rise in T is similar to the separate effect of a 10 % RR reduction. These changes may require measures of adaptation and changes in agriculture and nature protection strategies.

  Keywords: Temperature, Climate change, Climate, Drought, Slovenia

- Bergant, K., Kajfez-Bogataj, L., 2005: **What Might the Climate of Slovenia Look Like in This Century?** Ujma no. 19, pp. 218-223. [Slovenian]

  Available for download at: http://www.sos112.si/slo/tdocs/ujma/2005/stoletje.pdf

  ABSTRACT: Global warming is no longer just a theory or a distant threat. The overwhelming agreement among the world's preeminent climate scientists is that its impact can already be seen today and may grow worse in the future. This global warming is expected to significantly disrupt the climate system. As a result, regional temperatures and precipitation patterns will shift across the globe, affecting nearly

every aspect of society. Changes in Slovenia's climate are dependent on changes in the global climate and on local phenomena. There are as yet no reliable predictions on how Slovenia's climate might change as the result of a change in the world's climate. However, regional scenarios can be derived from global climate models. These are not predictions per se, as they only provide an impression of the extent to which global climate change might affect Slovenia's climate. Such regional scenarios are needed for adaptation strategies. The results of the simulations with general circulation models (GCM) are the basis for future climate change and impact studies. In the case of Slovenia, the results of simulations with five GCM were used. These were projected for 5 locations in Slovenia (Ljubljana, Novo mesto, Murska Sobota, Rateče and Bilje) by using the empirical downscaling method. The projections for air temperature changes are more reliable than for the amount of precipitation, especially for the warm half of the year. From what we know at present, the following tendency is also plausible: the climate of Slovenia will become warmer and drier.

Keywords: Temperature, Climate change, Climate, Global warming, Slovenia

- Bergant, K., Kajfez-Bogataj, L., 2005: **N-PLS regression as empirical downscaling tool in climate change studies.** Theoretical and Applied Climatology, vol. 81, no. 1-2, pp. 11-23.
  ABSTRACT: An N–PLS regression technique was tested as an empirical downscaling method. Average monthly near-ground air temperature (t), specific humidity (q), and sea-level pressure (p) fields across Central and Western Europe were used as predictors for average monthly air temperature (T), dew temperature (D), and precipitation amount (P) at 4 locations in Slovenia. The empirical downscaling models (EM) were developed by means of available predictand data from the ARSO archive and predictor data from the NCEP/NCAR reanalysis project, for the period 1951–2002, separately for single months. Using the combination of t and p as predictors, the EM for T explained from 73% to 95% of predictand variability, for D from 74% to 97% of predictand variability, and for P from 31% to 76% of predictand variability. The use of q as an additional predictor did not improve the quality of the EM considerably. Developed EM using p and t as predictors were applied to the results of 5 general circulation models (GCM): CSIRO/Mk2, CCC/CGCM2, UKMO/HadCM3, DOE-NCAR/PCM, and MPI-DMI/ECHAM4-OPYC3. Only the simulations based on SRES A2 and B2 emission scenarios were considered in our calculations. Available mean monthly values of predictors for the period 1951–2100 were used. All the projections of GCM results indicate an increase in T and D and decrease in P in the 21st century at all 4 locations. The expected range of changes in T, D, and P is wide due to the different response of GCM to identical changes in the atmospheric composition, and represents a source of uncertainty in empirical downscaling results. Another important source of uncertainty in empirical downscaling studies, especially when temperature dependent predictors are used, is the problem of extrapolation. By using the proper mathematical approach for EM development we only reduce a part of the uncertainty related to the quality of empirical models that also strongly depend on the quality of input data and predictor selection. The N–PLS regression seems to be a suitable choice of mathematical method, as the feature selection from a large number of predictor time series is not predictand independent. Finally, any climate change and impact studies for the future are affected by many other uncertainties that we have to be fully aware of, while interpreting their results.

- Ipavec, T., Kajfez-Bogataj, L., 2010: **Potential climate change impacts on water balance in Slovenia.** Acta agriculturae slovenica, vol. 91, no. 2, pp. 427-441. [Slovenian]
  ABSTRACT: The latest climate change projections increasingly indicate the changing of soil water balance, which is then reflected back in climate change. This paper examines soil moisture availability time dynamics in Ljubljana and Murska Sobota in the last 46 years and under climate change scenarios for these locations through the end of the century. The basis was a thirty-year period 1961-1990 serving as a comparison with the period 1991-2006 and with projections of climate changes under three scenarios, presented in the form of incremental temperature and precipitation changes as a

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combination of alternative projections for Slovenia. Using the SIMPEL model, we determined variability of potential evapotranspiration (the EPIC Penman-Monteith method), water deficit (difference between the volume of precipitation and potential evapotranspiration) and the number of dry days. The analysis showed growing trends for all three variables in the period 1961-2006. Another subject of observation was variability change which is evident above all in the number of dry days and increases the risk of drought. The main results are presented by means of calculations of probability for the occurrence of a certain number of dry days. The probability of over 35 dry days in the vegetation period (April-September) of the second analysed period, under the medium and increasingly so high climate change scenario is much higher than such a probability in the first analysed period and under the low scenario.

Keywords: Climatic change, Water balance, Soil water balance, Soil water deficit, Models, Drought, Slovenia

- Kajfez-Bogataj, L., 2001: **Changes in the minimum and maximum temperatures in Slovenia over the last 50 years**. Zbornik Biotehniske fakultete Univerze Ljubljani, Kmetijstvo vol. 77, no. 2, pp. 299-307. [Slovenian]

  ABSTRACT: Long term monthly temperature data from four stations Kocevje, Ljubljana, Maribor and Ratece-Planica in Slovenia have been analysed. First trend analysis was performed on the years 1951 to 2000 annual and seasonal mean maximum and minimum temperature and diurnal temperature range (DTR) and secondly on last 30 years (1971 to 2000). Increasing trends of approximately 0.9øC/50 years in the annual mean temperatures were found at all stations. During the last 50 years an increase in annual mean maximum and mean minimum temperature has occurred also. In general the minimum daily temperatures have increased at a larger rate than the maximum daily temperatures, resulting in a slight decrease in the long-term diurnal temperature range. These results are consistent with trends over much of the global landmass. But in the last 30 years at all stations the increase in mean maximum was faster than in the mean minimum, resulting in an increase in mean diurnal temperature range except for autumn months. Whether DTR is increasing or decreasing depends very much upon the choice of time series under investigation so careful interpretation of trend is essential in the case of climate change detection.

  Keywords: Environmental temperature, Temperature, Climatic change, Climate, Meteorological observations, Trends, Slovenia

- Kobold, M., 2009: **The influence of climate change on extreme hydrological events.** Ujma no.23, pp.128-135. [Slovenian]

  Available for download at: http://www.sos112.si/slo/tdocs/ujma/2009/128.pdf

  ABSTRACT: The effects of global warming and climate change are reflected in more frequent natural catastrophes connected with surfeit or shortage of water. Very high discharges indicate floods, and a long-lasting precipitation deficit indicates low flows and hydrological drought. In 2008, the Intergovernmental Panel on Climate Change (IPCC) issued a Technical Paper on Climate Change and Water, in which it is shown that observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems. Europe's sensitivity to climate change increases from north to south. The frequency and occurrence of floods in Slovenia and impacts of climate change on flood discharges, including results of trend analysis, are presented in this article. Not only floods but also hydrological drought is increasing in Slovenia. The results of analysis of low flows and projected climate changes show a decrease of discharge and a longer dry season.

  Keywords: Temperature, Climate change, Climate, Drought, Floods, Slovenia

- Strojan, I., Robic, M., 2009: **Environmental indicators in Slovenia, sea level.** [Slovenian] Available for download at: http://kazalci.arso.gov.si/?anddata=indicatorandind_id=146andmenu_group_id=10
  ABSTRACT: During the observation period sea level recorded at the Slovenian coast in the direction of upward movement. Changes in sea level are similar as in the Mediterranean, 1 mm / year. It is estimated UNEP (2001) that the sea level in the Mediterranean will increase from 12 to 30 cm by 2100. Estimated sea level rise due to climate change will require multiple adaptations. **Keywords: Climate change, Sea level, Slovenia**

- Sušnik, A., 2007: Causes and effects of agricultural droughts in 2006. Ujma, no. 21, pp. 73–79 [Slovenian]
  Available for download at: http://www.sos112.si/slo/tdocs/ujma/2007/073.pdf
  ABSTRACT: Slovene agriculture was again struck by agricultural drought in 2006. It was specific from all points of view. Spatially it affected less than 25% of the area of Slovenia and lasted only slightly less than two months but was very intensive in the areas affected. According to the program for remedying the impact of damage to agriculture after natural disasters, around 21,000 agricultural claimants were affected in 139 municipalities, covering an area close to 170,000 hectares. The article provides a description of the weather conditions that triggered the development of the drought and the disrupted water balance of agricultural plants and an assessment of the level of damage caused. **Keywords: Agriculture, Climate change, Climate, Drought, Slovenia**

- Sušnik, A., Matajc, I., 2008: **Agricultural drought in Slovenia in 2007**. Ujma, no. 22, pp. 37–42 [Slovenian]
  Available for download at: http://www.sos112.si/slo/tdocs/ujma/2008/037.pdf
  ABSTRACT: Too dry and too warm weather with meager precipitation and high air temperatures between May and August 2007 was the principal cause of agricultural drought. The severity of the drought differed per various regions, as did the consequences visible on crops. The drought affected a total of 27,875 ha of agricultural area and the damage exceeded 16.5 million. Around 6500 farmers in 56 municipalities were affected. In its programme for the mitigation of the effects of drought the Government granted state aid in the amount of one quarter of the estimated damage. This paper presents an analysis of weather conditions, an analysis of the situation of supply to agricultural plants and the consequent deficit in drainage and soil waters, as well as a simulation of a shortage of water with the IRRFIB water balance model.
  Keywords: Agriculture, Climate change, Climate, Drought, Slovenia

3. Impacts of Climate Change on Biodiversity

- Alkemader, R., van Oorschot, M., Miles, L., Nellemann, C., Bakkenes, M. and Ten Brink, B. 2009: **GLOBIO3: A framework to investigate options for reducing global terrestrial biodiversity loss**. Ecosystems 12 (3), 374-390.

  ABSTRACT: The GLOBIO3 model has been developed to assess human-induced changes in biodiversity, in the past, present, and future at regional and global scales. The model is built on simple cause–effect relationships between environmental drivers and biodiversity impacts, based on state-of-the-art knowledge. The mean abundance of original species relative to their abundance in undisturbed ecosystems (MSA) is used as the indicator for biodiversity. Changes in drivers are derived from the IMAGE 2.4 model. Drivers considered are landcover change, land-use intensity, fragmentation, climate change, atmospheric nitrogen deposition, and infrastructure development. GLOBIO3 addresses (i) the impacts of environmental drivers on MSA and their relative importance, (ii) expected trends under various future scenarios, and (iii) the likely effects of various policy response options. GLOBIO3 has been used successfully in several integrated regional and global assessments. Three different global-scale policy options have been evaluated on their potential to reduce MSA loss. These options are: climate-change mitigation through expanded use of bio-energy, an increase in plantation forestry, and an increase in protected areas. We conclude that MSA loss is likely to continue during the coming decades. Plantation forestry may help to reduce the rate of loss, whereas climate-change mitigation through the extensive use of bioenergy crops will, in fact, increase this rate of loss. The protection of 20% of all large ecosystems leads to a small reduction in the rate of loss, provided that protection is effective and that currently degraded protected areas are restored.

  Keywords: biodiversity, MSA, policy options, climate change, land-use change, fragmentation, nitrogen, infrastructure, forestry, bioenergy, protected areas

- Campbell, A., Kapos, V., Scharlemann, J. P.W., Bubb, P., Chenery, A., Coad, L., Dickson, B., Doswald, N., Khan, M. S. I., Kershaw, F. and Rashid, M., 2009: **Review of the Literature on the Links between Biodiversity and Climate Change: Impacts, Adaptation and Mitigation.** Secretariat of the Convention on Biological Diversity, Montreal. Technical Series No. 42, 124 pages.

  Available for download at: https://www.cbd.int/doc/publications/cbd-ts-42-en.pdf

- EEA, 2010: **10 messages for 2010**.

  Each message provides a short assessment focusing on a specific ecosystem or issue related to biodiversity in Europe.

  Available for download at: http://www.eea.europa.eu/publications/10-messages-for-2010

  From the content:

  Climate change and biodiversity.

  The variety of life underpins our social and economic wellbeing and will be increasingly an indispensible resource in the battle against climate change. However, our consumption and production patterns are depriving ecosystems of their capacity to withstand climate change and deliver the services we need from them. As we understand more about the ways that climate change is impacting biodiversity, it becomes clear that we cannot tackle the two crises separately. Their interdependence requires us to address them together.

  Protected areas.

  Protected areas provide a wide range of services in a context of increasing pressures and a rapidly

changing environment. Europe is the region with the greatest number of protected areas in the world but they are relatively small in size. Europe's Natura 2000, unique in the world and still young, and the Emerald network under development, are international European networks of protected areas that catalyse biodiversity conservation.

Freshwater ecosystems.

Freshwater ecosystems in Europe are rich in biodiversity but at risk. They provide essential ecosystem services to humans, such as cleaning water, preventing floods, producing food, providing energy and regulating freshwater resources.

Marine ecosystems.

Marine ecosystems provide key services both globally and locally, which are essential for maintaining life on our planet. However, marine biodiversity faces an unprecedented range of pressures. In recent years climate change has caused changes in species distribution and presents new challenges for marine biodiversity as oceans become more acidic.

Forest ecosystems.

Forests cover a large part of Europe but the distribution of such ecosystems varies significantly across the continent. They fulfil multiple functions for society, providing economic, social and environmental benefits, including serving as a key reservoir of biodiversity.

Urban ecosystems.

In Europe, where the overwhelming majority of people live in urban areas, tackling the interlinked challenges between biodiversity and its network of towns and cities is crucial to help halting biodiversity loss.

Agricultural ecosystems.

Within the framework of the CAP, the last 50 years have seen increasing attention to biodiversity, but without clear benefits so far. With agriculture covering about half of EU land area, Europe's biodiversity is linked inextricably to agricultural practices, creating valuable agro-ecosystems across the whole of Europe.

Mountain ecosystems.

European mountain regions provide essential ecosystem services for lowlands and host a great diversity of habitats and species, many adapted to specific extreme climatic conditions. Mountain ecosystems are fragile and vulnerable, and face severe threats from land abandonment, intensifying agriculture, impacts of infrastructure development, unsustainable exploitation and climate change.

Coastal ecosystems.

Key messages: 1) As an interface between land and sea, European coastlines provide vital resources for wildlife, but also for the economy and human health and well-being. 2) Multiple pressures, including habitat loss and degradation, pollution, climate change and overexploitation of fish stocks, affect coastal ecosystems. 3) Coastal habitat types and species of Community interest are at risk in Europe, two thirds of coastal habitat types and more than half of coastal species have an unfavourable conservation status. 4) Integrated and ecosystem-based approaches provide the foundation for sustainable coastal management and development, supporting socio-economic development, biodiversity and ecosystem services. Coordinated action at the global, regional and local levels will be key to sustainable management of coastal ecosystems.

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Cultural landscapes and biodiversity heritage.

Key messages: 1) Diverse climatic conditions, varied geology and morphology and centuries of pre- and post-industrial land use created Europe's diverse mosaic of cultural and natural landscapes, rich in biodiversity. 2) Europe's landscapes have become highly fragmented and homogenised, threatening their biodiversity and affecting their multifunctional role. 3) By managing its multifunctional culture-historical landscapes and related biodiversity sustainably, Europe can secure valuable ecosystems services while preserving its cultural and natural heritage. 4) Various legal instruments and initiatives address European biodiversity heritage at the landscape level. Incorporating these into regional and local planning and involving local communities is necessary to secure Europe's biodiversity heritage and maintain multifunctional landscapes.

- Walther, G.-R., 2007: **Ecology: Tackling ecological complexity in climate impact research**. Science 315 (5812): pp. 606-607.

- Walther, G.-R., Nagy, L., Heikkinen, R.K., Penuelas, J., Ott, J., Pauli, H., Pöyry, J., Berger, S., Hickler, T., 2010: **Observed Climate-Biodiversity Relationships**. Settele et al. (Eds.). Atlas of Biodiversity Risk, Pensoft Publishers, Sofia (EU FP-6 Integrated Project ALARM).

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

  ABSTRACT: There is now ample evidence of the ecological impacts of recent climate change, from polar terrestrial to tropical marine environments. The responses of both flora and fauna span an array of ecosystems and organizational hierarchies, from the species to the community levels. Despite continued uncertainty as to community and ecosystem trajectories under global change, our review exposes a coherent pattern of ecological change across systems. Although we are only at an early stage in the projected trends of global warming, ecological responses to recent climate change are already clearly visible.

3.1. Ecosystems

- Walther, G.-R. 2010: **Community and ecosystem responses to recent climate change.** Phil. Trans. R. Soc. B (2010) 365, 2019-2024.

  ABSTRACT: There is ample evidence for ecological responses to recent climate change. Most studies to date have concentrated on the effects of climate change on individuals and species, with particular emphasis on the effects on phenology and physiology of organisms as well as changes in the distribution and range shifts of species. However, responses by individual species to climate change are not isolated, they are connected through interactions with others at the same or adjacent trophic levels. Also from this more complex perspective, recent case studies have emphasized evidence on the effects of climate change on biotic interactions and ecosystem services. This review highlights the 'knowns' but also 'unknowns' resulting from recent climate impact studies and reveals limitations of (linear) extrapolations from recent climate-induced responses of species to expected trends and magnitudes of future climate change. Hence, there is need not only to continue to focus on the impacts of climate change on the actors in ecological networks but also and more intensively to focus on the linkages between them, and to acknowledge that biotic interactions and feedback processes lead to highly complex, nonlinear and sometimes abrupt responses.

3.1.1. Forest ecosystems

- Badea, O., Tanase, M., Jianu, G., Lazar, A., Peiov, A., Uhrlikova, H., Pajtik, J., Wawrzoniak, J. and Shapryk, Y., 2004: **Forest health status in the Carpathian Mountains over the period 1997-2001.** Environmental Pollution 130: 93-98

  ABSTRACT: "The results of forest health status assessments in the Carpathian Mountains from the monitoring networks developed by the European Union Scheme on the Protection of Forest Against Atmospheric Pollution (EU Scheme) and International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forests), have led to a better understanding of the impact of air pollution and other stressors on forests at the regional scale. During the period 1997–2001, forests in the Carpathian Mountains were severely affected by air pollution and natural stresses with 29.7–34.9% of the trees included in defoliation classes 2–4. The broadleaves were slightly healthier than the conifers, and European beech (Fagus sylvatica) was the least affected species. Norway spruce (Picea abies) has poor health status, with 42.9–46.6% of the trees damaged (2–4% defoliation classes).

  Silver fir (Abies alba) damage was also high, with 46.0–50.9% in defoliation classes 2–4. Pines (primarily Pinus sylvestris) were the least affected of the conifers, with 24.9–33.8% in defoliation classes 2–4. The results from the transnational networks (16_16 km) show that the Carpathian forests are slightly more damaged than the average for the entire Europe. The correlative studies performed in individual European countries show the relationships between air pollution stressors with trends in defoliation and a possible effect of natural stresses at each site. More specific, effects of tree age, drought, ozone and acid deposition critical level exceedances were demonstrated to affect crown condition."
  Keywords: Carpathian Mountains, Forest ecosystem, Monitoring, Air pollution, Romania

- Badea, O. 2008: **Manual on methodology for long term monitoring of forest ecosystems status under air pollution and climate change influences**. Bucuresti: Edit. Silvică. 98 pp. [Romanian]
  Keywords: Climate Change, Air Pollution, Forest Ecosystem, Romania

- Bijtnerowicz, A., Badea, O., Fleischer, P., Godzik, B. and Grodzinska K. 2004: **Science, land Management and Policy in International Studies on the Effects of Air Pollution on the Carpathian Forest Ecosystems.** Scandinavian Journal of Forest Research 19(4): 129-137.
  ABSTRACT: In the Retezat Mountains concentrations of O3, NO2 and SO2 in summer season 2000e2002 were low and below toxicity levels for forest trees. While NH3 concentrations were low in 2000, the 2001 and 2002 concentrations were elevated indicating possibility for increased N deposition to forest stands. More than 90% of the rain events were acidic with pH values 5.5, contributing to increased acidity of soils. Crown condition of Norway spruce (Picea abies) and European beech (Fagus sylvatica) was good, however, defoliation described as 25% of foliage injured increased from 9.1% in 2000 to 16.1% in 2002. Drought that occurred in the southern Carpathians between fall 2000 and summer 2002 and frequent acidic rainfalls could cause the observed decline of forest condition. Both Norway spruce and European beech with higher defoliation had lower annual radial increments compared to the trees with low defoliation. Ambient O3 levels found in the Retezat did not affect crown condition of Norway spruce or European beech.

- Blujdea, V. 2005: S**tudy on the observation of the impact of the climate change on the forests**. Analele ICAS, 48: 3-11 [Romanian].
  ABSTRACT: The forester' perception on the effect of climate change on forests have been tested by a questionnaire sent to forest ranges all over the country. Answer rate has been like 50 % but the quality of answers has been quite variable, what suggests a limitation of further use of this methods for such

research purposes. According the answers the forests shows a very high capacity for regeneration and colonization, a worsening of environmental condition on hydro-ameliorated valleys, a vulnerability of moesic species stands in hilly areas as affected by more often droughts, an issuing of new and harmful forest insects and a decline of stands at the limits of natural range of species or to species cultivated outside natural range.

- Bytnerowicz A., Badea O., Popescu F., Musselman R. Tanase M., Barbu I., Fraczek W., Geambasu N., Surdu A., Danescu F., Postelnicu D., Cenusa R., Vasile C. 2005. **Air pollution, precipitation chemistry and forest health in the Retezat Mountains, Southern Carpathians, Romania.** Environmental Pollution 137: 546-567. doi: 10.1016/j.envol.2005.01.040
  ABSTRACT: In the Retezat Mountains concentrations of O3, NO2 and SO2 in summer season 2000e2002 were low and below toxicity levels for forest trees. While NH3 concentrations were low in 2000, the 2001 and 2002 concentrations were elevated indicating possibility for increased N deposition to forest stands. More than 90% of the rain events were acidic with pH values !5.5, contributing to increased acidity of soils. Crown condition of Norway spruce (Picea abies) and European beech (Fagus sylvatica) was good, however, defoliation described asO25% of foliage injured increased from 9.1% in 2000 to 16.1% in 2002. Drought that occurred in the southern Carpathians between fall 2000 and summer 2002 and frequent acidic rainfalls could cause the observed decline of forest condition. Both Norway spruce and European beech with higher defoliation had lower annual radial increments compared to the trees with low defoliation. Ambient O3 levels found in the Retezat did not affect crown condition of Norway spruce or European beech.

- Casalegno, S., Amatulli, G., Carnia, A., Nelson, A. and Pekkarinen, A. 2010: **Vulnerability of Pinus cembra L. in the Alps and the Carpathian Mountains under present and future climates.** Forest Ecology and Management 259 (4): 750-761.
  ABSTRACT: Proactive management should be applied within a forest conservation context to prevent extinction or degradation of those forest ecosystems that we suspect will be affected by global warming in the next century. The aim of this study is to estimate the vulnerability under climate change of a localized and endemic tree species Pinus cembra that occurs in the alpine timberline. We used the Random Forest ensemble classifier and available bioclimatic and ecological data to model present and future suitable areas for P. cembra and estimate its current and future vulnerability. Future projections for years 2020, 2050 and 2080 were simulated using two IPCC Special Report on Emission Scenarios run under four global climate models.
  The suitability model described the optimal environmental conditions for P. cembra. Model scores (k = 0.77, sensitivity = 0.99 and specificity = 0.80) are robust. The main factors defining the model were Kira's warmth index and summer temperatures. Results show that there is potential for P. cembra to regenerate and persist in currently suitable areas. Future trends analysis suggested a cumulated mean loss of suitable areas of between 53% and 72% for different scenarios. All modeled projections predicted an upslope shift of the optimally suitable P. cembra belt and no downslope shift. We discuss environmental factors/plant interactions, the theoretical assumptions behind the model, model strengths and limitations, and we highlight the conservative traits of our analysis. The results suggest that forest management practices will play a fundamental role in the conservation of P. cembra habitats in the Alps.
  Keywords: Climate change, Ensemble model, Vulnerability, Habitat suitability, Pinus cembra, Mountains

- Chmielewski, F.-M. and Rötzer, T. 2001: **Response of tree phenology to climate change across Europe.** Agricultural and Forest Meteorology 108 (2001), 101–112.
  ABSTRACT: To investigate the impact of recent climatic changes on the plant development in Europe,

this study uses phenological data of the International Phenological Gardens for the period 1969–1998. For this study, the leafing dates of four tree species (Betula pubescens, Prunus avium, Sorbus aucuparia and Ribes alpinum) were combined in an annual leaf unfolding index to define the beginning of growing season. The end of growing season was defined using the average leaf fall of B. pubescens, P. avium, Salix smithiana and R. alpinum. A nearly Europe-wide warming in the early spring (February–April) over the last 30 years (1969–1998) led to an earlier beginning of growing season by 8 days. The observed trends in the onset of spring corresponded well with changes in air temperature and circulation (North Atlantic Oscillation Index (NAO-index)) across Europe. In late winter and early spring, the positive phase of NAO increased clearly, leading to prevailing westerly winds and thus to higher temperatures in the period February–April. Since the end of the 1980s the changes in circulation, air temperature and the beginning of spring time were striking. The investigation showed that a warming in the early spring (February–April) by 1◦C causes an advance in the beginning of growing season of 7 days. The observed extension of growing season was mainly the result of an earlier onset of spring. An increase of mean annual air temperature by 1◦C led to an extension of 5 days.
Keywords: Phenology, Growing season, Climate change, Temperature, Tree species

- Ibisch, P. L. 2006: Klimaschutz versus Waldnaturschutz? Chancen, Gefahren und Handlungsoptionen für den Naturschutz im Wald. (**Climate protection versus nature conservation in forests? Chances, threats and options for nature conservation in forests**) In: Höltermann, A. and Hiermer, J. D.: Workshopdukumentation: Wald, Naturschutz, Klimawandel. Internationale Naturschutzakademie Insel Vilm. 71-81. [German]
Keywords: conservation, forest ecosystem, Natura 2000, nature conservation strategies

- Jump, A.S., Hunt, J.M. and Penuelas, J. 2006: **Rapid climate change-related growth decline at the southern range of Fagus sylvatica.** Global Change Biology 12: 2163-2174
ABSTRACT: Studies on Fagus sylvatica show that growth in populations toward the southern limit of this species' distribution is limited strongly by drought. Warming temperatures in the Mediterranean region are expected to exacerbate drought where they are not accompanied by increases in precipitation. We studied levels of annual growth in mature F. sylvatica trees over the last half-century in the Montseny Mountains in Catalonia (northeast Spain). Our results show significantly lower growth of mature trees at the lower limit of this species' distribution when compared with trees at higher altitudes. Growth at the lower Fagus limit is characterized by a rapid recent decline starting in approximately 1975. By 2003, growth of mature trees had fallen by 49% when compared with predecline levels. This is not an age-related phenomenon, nor is it seen in comparable populations at higher altitudes. Analysis of climate-growth relationships suggests that the observed decline in growth is a result of warming temperatures and that, as precipitation in the region has not increased, precipitation is now insufficient to ameliorate the negative effects of increased temperatures on tree growth. As the climate response of the studied forest is comparable with that of F. sylvatica forests in other southern European regions, it is possible that this growth decline is a more widespread phenomenon. Warming temperatures may lead to a rapid decline in the growth of range-edge populations and a consequent retreat of the species distribution in southern Europe. Assessment of long-term growth trends across the southern range edge of F. sylvatica therefore merits further attention.
Keywords: basal area increment, climate change, drought, European beech, geographical range, Mediterranean, range edge

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- Kellomaki S., Karjalainen T., Mohren F and Lapvetelainen T (eds.) 2000: **Expert Assessments of the Likely Impacts of Climate Change on Forest and Forestry in Europe.** EFI Proceedings nr. 34
  Available for download at: http://www.efi.int/files/attachments/publications/proc34_net.pdf
  Keywords: climate change impacts, Europe, forest, forestry

- Kenderes K, Aszalós R, Ruff J, Barton Z, Standovár T. 2007: **Effects of topography and tree stand characteristics on susceptibility of forests to natural disturbances (ice and wind) in the Börzsöny Mountains (Hungary).** Community Ecology 8: 209-220.
  ABSTRACT: We analysed the role of topography, tree stand characteristics and management on the susceptibility of forest stands to abiotic natural disturbances. In 1996, stands of Börzsöny Mts, Hungary were hit by a severe ice storm, then by strong winds three years later. Affected areas were mapped on aerial photos, and we built a GIS database containing variables describing topography and tree stand characteristics. The role of variables in predicting ice break and windfall was investigated by non-parametric statistical tests and by a series of CandRT (Classification and Regression Tree) analyses. Elevation, aspect and slope proved to have strong statistical relationships with the distribution of both ice break and windfall, with misclassification error (MER) of 18% and 15%, respectively, if studied without stand descriptors. Mixing ratio and age of beech were the most important stand descriptors to explain the distribution of ice break (MER=15%), whereas that of windfall was best described by the age and height of the two dominant tree species (MER=11%). The explanatory power could be increased if all variables (topographic + stand descriptors) were considered, though the increase in explanatory power was higher in the case of ice break (MER decreased from 15% to 11%) than for windfall (MER decreased from 11% to 10%). Since management related stand variables (beech mixture ratio, age, height, amount of recently felled stock, slenderness) and susceptibility to disturbance events seemed to be related, our results suggest that the sensitivity of tree stands could be decreased by increasing compositional and structural heterogeneity.
  Keywords: Beech, CandRT, *Fagus sylvatica*, Ice break, *Quercus petraea*, Sessile oak, Windthrow

- Kienast ,F., Wildi, O., Brzeziecki, B. 1998: **Potential impacts of climate change on species richness in mountain forests—An ecological risk assessment.** Biological Conservation, Volume 83, Issue 3, 291-305
  ABSTRACT: In this ecological risk assessment we evaluated potential climate-induced vegetation changes in mountain forests of Central Europe and possible impacts on species richness. The analysis was performed on all 1 km grid points of the Swiss forest inventory (c. 11,500 points) as well as on two subsets representing the forested points within the geographical limits of two inventories of legally protected reserve areas. The core of the approach is (a) a conceptual model of the movement of climatic ranges along altitudinal gradients as a result of global warming and (b) a spatially explicit forest community simulator that predicts a potential natural vegetation unit for any given 1 km grid point of the Swiss forest inventory for both current climate and for altered climate regimes. The model is derived from empirical data featuring the relationships between quasi-natural vegetation types and measured site variables. Species richness for any modelled forest community is estimated on the basis of phytosociological relevés. The conceptual model showed that out of 109 legally protected landscapes, sites and natural monuments of national importance (minimum area > 1 km^2) about 40-50% have an altitudinal or degree-day range that is able to to host migrating species within the reserve limits if climate is warming in a moderate way (increase of mean annual temperature between + 1.0 and + 1.4°C). In the case of strong warming (increase of mean annual temperature between + 2.0 and + 2.8°C) only 20-30% fulfil this criterion. The spatially explicit forest simulator showed that under a temperature increase without simultaneous increase in precipitation (warmer and more xeric due to

increased evapotranspiration), Fagus-dominated communities in the colline-submontane belt might eventually be replaced by oak-hornbeam (Carpinion) communities. In the montane belt, the dominance of conifers will be seriously threatened by an invasion of deciduous species from the low montane and submontane belt. Under warmer and wetter conditions the vegetation shifts might not be as drastic as under warmer and more xeric conditions and the shift towards oak and oak-hornbeam communities on the Plateau is not supported. Concerning species richness, the models showed that in the case of warmer temperatures and constant precipitation (warmer and more xeric due to increased evapotranspiration) overall species richness is increasing on all 1 km points of the Swiss Forest Inventory, as well as on all selected subsets representing the forested points within legally protected reserve areas. In the case of warmer and wetter conditions the risk assessment does not show any drastic changes in the long-term species richness.
Keywords: Species richness, Mountain, Forests, Climate modification, Planetary scale, Impact study, Species diversity, Vegetation type, Geographic information system, Switzerland, Spermatophyta, Europe

- Kozak J., Estregnil C and Vogt P. 2006: **Forest cover and pattern changes in the Carpathians over the last decades.** European Journal of Forest Research 126 (1): 77-90.
  ABSTRACT: This study aims at developing a satellite-based methodology for the implementation of two Ministerial Conference on the Protection of Forests in Europe indicators for the European Alpine Bio-geographic region, and their changes over time: (1) area of forest cover and (2) forest spatial pattern. The northern Carpathians were selected as a study area due to the documented recent increase of forest cover. Changes of forest cover were quantified using Landsat images for the years 1987 and 2000. Single-date forest–non-forest maps were derived by image segmentation and supervised classification, including the use of ancillary data (CORINE Land Cover and a digital elevation model). These maps were an input for the post-classification change detection. The forest spatial pattern maps with four classes (core, patch, edge and perforated forest) were derived with morphological image processing. A simple method to mask uncertainty areas on forest maps and related products was also developed. The accuracy of the resulting forest–non-forest map was assessed with orthophotos and amounts to 93.9%. Uncertainty areas, for which change assessment was judged more difficult and less reliable, were not considered for assessing forest cover change. The annual forest cover change rate of 0.38% was found over the 1987–2000 period. For the 13-year time period, we found a decrease of core forest and an increase of patch and perforated forest. We conclude that the proposed methodology allows to quantify changes of forest cover and forest spatial pattern at 1 ha minimum mapping unit.
  Keywords: Carpathians, European forests, Forest cover change, Forest spatial pattern, Remote sensing

- Kozak, J, Estregnil, C and Troll, M., 2007: **Forest cover changes in the northern Carpathians in the 20th century: a slow transition.** Journal of Land Use Science 2 (2): 127-146.
  ABSTRACT: The reversal from deforestation to forest increase is named forest transition. It combines factors related to social and economic development or policies attempting to overcome the possible scarcity of timber. This study focuses on forest transition in the northern Carpathians, stretching across four countries (Czech Republic, Poland, Slovakia and Ukraine) with complex history and variability with respect to present-day economical development. Forest maps were computed for the 1930s and 1990s on the basis of available topographical and satellite data. Forest cover changes were then analysed and discussed in the context of population change and environmental conditions of the area.
  Between the 1930s and the 1990s net forest cover change was between 5% and 31%. The highest values (>20%) were recorded in areas which suffered post-war re-settlement and depopulation. Medium values (10-15%) were found in areas affected by the post-war gradual marginalization and depopulation. The lowest values (<10%) were noted in areas where population has increased with

respect to the 1930s. In this latter case, gradual transformation of mountain agriculture related to overall social and economic changes has driven a slow forest cover increase. The forest cover increase was selective and occurred on areas less suitable to agriculture (higher and steeper). This selectiveness was less obvious in areas affected by re-settlement actions.

Keywords: Forest transition, Change detection, Land use/land cover change, Population trajectories

- Lindner, M., Gracia-Gonzalo, J., Kolström, M., Green, T., Reguera, R., Maroschek, M., Seidl, R., Lexer, M.J., Netherer, S., Schopf, A., Kremer, A., Delzon, S., Barbati, A., Marchetti, M. and Corona, P. 2008: **Impacts of climate change on European Forests and options for adaptation.** Report to the European Commission Directorate-General for Agriculture and Rural Development, AGRI-2007- G4-06, 279pp

  ABSTRACT: This study compiles and summarizes the existing knowledge about observed and projected impacts of climate change on forests in Europe and reviews options for forests and forestry to adapt to climate change. It has been commissioned by the Directorate General for Agriculture and Rural Development of the European Commission as an initial exploration of this complex issue. Forests are particularly sensitive to climate change, because the long life-span of trees does not allow for rapid adaptation to environmental changes. Adaptation measures for forestry need to be planned well in advance of expected changes in growing conditions because the forests regenerated today will have to cope with the future climate conditions of at least several decades, often even more than 100 years. Impacts of climate change and adaptation options were reviewed by synthesizing the existing knowledge from scientific literature, complemented with expert assessments. On-going and planned adaptation measures in EU27 Member States were surveyed with a questionnaire. The exposure to climate change was analysed by reviewing latest climate change scenario projections in Chapter 3. The main impact factors affecting forests under climate change were reviewed in Chapter 4.1. Next, the sensitivity to and potential impacts of climate change were analysed (Chapter 4.2). After reviewing different components of the adaptive capacity of forests and forestry (Chapter 5), vulnerability to climate change and related risks and opportunities were highlighted (Chapter 6). Chapters 7 to 9 analyse possible adaptation measures to respond to climate change, assess feasibility and efficiency of prominent measures, and survey their implementation in the 27 EU Member States. The results are presented for four main bioclimatic zones: Boreal, Temperate Oceanic, Temperate Continental, and the Mediterranean. Mountainous regions have been also analysed where appropriate.

  Keywords: Climate change impacts, Adaptive capacity, Forestry, Vulnerability, Regional differences

- Lindner, M., Maroschek, M., Netherer, S., Kremer, A., Barbati, A., Garcia-Gonzalo, J., Seidl, R., Delzon, S., Corona, P. Kolstro, M, Lexer, M. J. and Marchetti, M. 2010: **Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems.** Forest Ecology and Management 259 (2010) 698–709. Available at: http://sylvain-delzon.com/wordpress/www/wp-content/uploads/Lindner-et-al-2010-FEM.pdf

  ABSTRACT: This study compiles and summarizes the existing knowledge about observed and projected impacts of climate change on forests in Europe. Forests will have to adapt not only to changes in mean climate variables but also to increased variability with greater risk of extreme weather events, such as prolonged drought, storms and floods. Sensitivity, potential impacts, adaptive capacity, and vulnerability to climate change are reviewed for European forests. The most important potential impacts of climate change on forest goods and services are summarized for the Boreal, Temperate Oceanic, Temperate Continental, Mediterranean, and mountainous regions. Especially in northern and western Europe the increasing atmospheric CO2 content and warmer temperatures are expected to result in positive effects on forest growth and wood production, at least in the short–medium term. On the other hand, increasing drought and disturbance risks will cause adverse effects. These negative

impacts are very likely to outweigh positive trends in southern and eastern Europe. From west to east, the drought risk increases. In the Mediterranean regions productivity is expected to decline due to strongly increased droughts and fire risks.
Adaptive capacity consists of the inherent adaptive capacity of trees and forest ecosystems and of socio-economic factors determining the capability to implement planned adaptation. The adaptive capacity in the forest sector is relatively large in the Boreal and the Temperate Oceanic regions, more constrained by socio-economic factors in the Temperate Continental, and most limited in the Mediterranean region where large forest areas are only extensively managed or unmanaged. Potential impacts and risks are best studied and understood with respect to wood production. It is clear that all other goods and services provided by European forests will also be impacted by climate change, but much less knowledge is available to quantify these impacts. Understanding of adaptive capacity and regional vulnerability to climate change in European forests is not well developed and requires more focussed research efforts. An interdisciplinary research agenda integrated with monitoring networks and projection models is needed to provide information at all levels of decision making, from policy development to the management unit.
Keywords: Climate change impacts, Adaptive capacity, Forestry, Vulnerability, Regional differences

- Noss, R. F. 2001: **Beyond Kyoto: Forest Management in a Time of Rapid Climate Change.** Conservation Biology, no. 15, pp. 578-590
  ABSTRACT: Policies to reduce global warming by offering credits for carbon sequestration have neglected the effects of forest management on biodiversity. I review properties of forest ecosystems and management options for enhancing the resistance and resilience of forests to climate change. Although forests, as a class, have proved resilient to past changes in climate, today's fragmented and degraded forests are more vulnerable. Adaptation of species to climate change can occur through phenotypic plasticity, evolution, or migration to suitable sites, with the latter probably the most common response in the past. Among the land-use and management practices likely to maintain forest biodiversity and ecological functions during climate change are (1) representing forest types across environmental gradients in reserves, (2) protecting climatic refugia at multiple scales, (3) protecting primary forests, (4) avoiding fragmentation and providing connectivity, especially parallel to climatic gradients, (5) providing buffer zones for adjustment of reserve boundaries, (6) practicing low-intensity forestry and preventing conversion of natural forests to plantations, (7) maintaining natural fire regimes, (8) maintaining diverse gene pools, and (9) identifying and protecting functional groups and keystone species. Good forest management in a time of rapidly changing climate differs little from good forest management under more static conditions, but there is increased emphasis on protecting climatic refugia and providing connectivity.

- Teodosiu, M., Giuman, G., Bujila, M., Fratila, E., Coanda, C., Haruta, O., Dorog, S. 2005: **Phenological evaluation of the forest species during the vegetation of season of 2004.** Analele ICAS 48: 73-83.
  ABSTRACT: The paper presents the results of phenological observation registered during the growing season 2004 in 22 plots from Romania networks ICP Forests and FENOFOR on 8 forest tree species (Abies alba, Carpinus betulus, Fagus sylvatica, Picea abies, Quercus petraea, Quercus robur, Tilia cordata). The results are analyzed comparatively with the observation from closed sites from the period 1947-1965 or – where these were not available – related to an altitudinal gradient. For Norway spruce (Picea abies) it is presented an empirical model and, based on this, a probable map of the bud burst timing at the level of the entire Romania, for 2004.
  Keywords: forest, Type and locality of protected area: Carpathians Mountains, Impact of climate change, phenological changes

- Vădineanu A., Badea O., Gheorghe I.F., Neagu S. and Postelnicu D. 2008: **New insights on the dynamics of the forest vegetation from the Romanian Carpathian Mountains.** Ekologia (Bratislava) 27 (3): 269-286.

  ABSTRACT: In the framework of the established long-term monitoring of the Carpathian forest ecosystems, the assessment of changes in the plant species richness, type of plant communities and biometric characteristics and health status of forest trees, for getting relevant insights regarding the effects of the type of management, pollution and climate changes upon forest biodiversity and health, is one of the major objectives. The joint monitoring activities in the Carpathians from the Romanian territory were launched in 1998 by including six study sites in the network of twenty- six sites established for monitoring and assessment changes in the Carpathian forests at the scale of the entire Carpathian Mountain range. The paper addresses the results gained by repeating field studies protocols in 2005, in the same study sites from the Romanian stretch of Carpathian Mts, and shows first findings of the attempt of comparative analysis of two sets of empirical results collected in 1998 and 2005. The biometric characteristics of the investigated forest stands have changed between the years 1998–2005, due to moderate (Retezat) or intensive (Fundata) silvicultural interventions, progressive improvement of the amount of precipitations and significant decrease of pressure exerted by air pollution (Badea et al, 2006). Except a relatively low volume increment (4.8 m3 yr-1ha-1) estimated for Fundata forest stands, which is located at the upper altitudinal limit (1360 m asl), good (6.7–7.1 m3 yr-1ha-1) and high (10–11 m3 yr-1ha-1) volume increment were estimated for Magura Odobesti and Stana de Vale, respectively Obcina Mare and Retezat sites, according with the tree species composition and yield class. The data related to the share of damaged trees (defoliation classes 2–4) indicate that between 1998 and 2005 the health status of forests from the Romanian Carpathians has been slightly improved, as well as for all Romanian forests (Badea et al, 2006). The recorded data indicate also that the dominant plant species have not been changed, and thus, the type of plants associations. However, they indicate an increase with 5 species (SdV), 8 species (F, MO, R), 16 species (RA) and 19 species (OM) in the plant species richness between 1998 and 2005. In addition, the results of the comparative analysis based on Jaccard coefficient of similarity, show profound changes (78 percent) in species composition, in particular subordinate and transient species.

  Keywords: biodiversity, forest stand, ground vegetation, accumulation curve, forest health, subordinate and transient species

3.1.2. Grassland ecosystems

- Baur, B., Cremene, C., Groza, G., Rokasy, L., Schileyko, A.A., Baur, A., Stoll, P. and Erhardt, A. 2006: **Effects of abandonment of subalpine hay meadows on plant and invertebrate diversity in Transylvania, Romania.** Biological Conservation 132 (2): 261-273

  ABSTRACT: Recent changes in agriculture (intensification or abandonment) have resulted in a critical reduction of semi-natural grasslands in Eastern Europe. Subalpine semi-natural grasslands in Transylvania, Romania, harbour a high diversity of plants and invertebrates, including endemics, and are considered refugia for numerous threatened open-land species.

  We investigated effects of land abandonment by examining species richness, species abundance, proportion of open-land, endemic and threatened vascular plants, gastropods, and diurnal and nocturnal Lepidoptera in extensive hay meadows (initial stage), and three seral stages of succession (early stage of abandoned hay meadow, naturally growing birch forest, and mature forest) in the mountainous region of Baisoara in Transylvania. A total of 626 species (225 vascular plants, 16 gastropods, 68 diurnal and 317 nocturnal Lepidoptera) were found in the 16 study sites (four replicates per successional stage). The four taxonomic groups differed in their response to the abandonment of hay meadows. Each stage of succession harboured the maximum species richness for one taxonomic

group: extensive hay meadows for vascular plants, abandoned hay meadows for diurnal Lepidoptera, birch forests for nocturnal Lepidoptera, and mature forests for gastropods. In all four taxonomic groups the complementarity of species composition increased with successional age, whereas the number of characteristic open-land species decreased with successional age. The four successional stages did not differ in proportion of red-listed plant and diurnal Lepidoptera species. In nocturnal Lepidoptera, however, the proportion of red-listed species increased with successional age. Furthermore, successional stages did not differ in number of plant species endemic to the Carpathians and Eastern Europe. Our results indicate the high conservation value of all stages of subalpine grassland succession for the indigenous biodiversity of Transylvania. To prevent losses of characteristic species, we suggest a rotational grassland management program that maintains different successional stages.
Keywords: Land use change, Grassland succession, Carpathic endemic, Eastern Europe

- Baur, B., Cremene, C., Groza, G., Schileyko, A. A., Baur A. and Erhardt A. 2007: **Intensified grazing affects endemic plant and gastropod diversity in alpine grasslands of the Southern Carpathian Mountains (Romania).** Biologia 62 (4): 438-445.
  ABSTRACT: Alpine grasslands in the Southern Carpathian Mts, Romania, harbour an extraordinarily high diversity of plants and invertebrates, including Carpathic endemics. In the past decades, intensive sheep grazing has caused a dramatic decrease in biodiversity and even led to eroded soils at many places in the Carpathians. Because of limited food resources, sheep are increasingly forced to graze on steep slopes, which were formerly not grazed by livestock and are considered as local biodiversity hotspots. We examined species richness, abundance and number of endemic vascular plants and terrestrial gastropods on steep slopes that were either grazed by sheep or ungrazed by livestock in two areas of the Southern Carpathians. On calcareous soils in the Bucegi Mts, a total of 177 vascular plant and 19 gastropod species were recorded. Twelve plant species (6.8%) and three gastropod species (15.8%) were endemic to the Carpathians. Grazed sites had lower plant and gastropod species richness than ungrazed sites. Furthermore, grazed sites harboured fewer gastropod species endemic to the Carpathians than ungrazed sites. On acid soils in the Fagaras Mts, a total of 96 vascular plant and nine gastropod species were found. In this mountain area, however, grazed and ungrazed sites did not differ in species richness, abundance and number of endemic plant and gastropod species. Our findings confirm the high biodiversity of grasslands on steep slopes in the Southern Carpathian Mts and caution against increasing grazing pressure in these refuges for relic plants and gastropods as well as for other invertebrates.
  Keywords: Alpine grassland, biodiversity, Bucegi Mts, Gastropoda, grazing, Fagaras Mts, vascular plants

- Craioveanu C. 2007: **Effects of grassland management on plants and invertebrates in Transylvania, Romania: A threat to local biodiversity hotspots.** Inaugural dissertation, Basel: Philosophisch – Naturwissenschaftlichen Fakultait. 102 pp.
  Available for download at: http://edoc.unibas.ch/602/1/DissB_7909.pdf
  CONTENT: Alterations of Steppe-Like Grasslands in Eastern Europe: a Threat to Regional Biodiversity Hotspots, Steppe-Like Grasslands and their Abandonment in Romania: Highly Diverse Butterfly and Moth Communities at Risk, Effects of abandonment of subalpine hay meadows on plant and invertebrate diversity in Transylvania, Romania, Altered pastoral management reduces endemic plant and gastropod diversity in alpine grasslands of the Southern Carpathians, Romania

- Morgan, J.A., Milchunas, D. G., Lecain, D. R., West, M. and Mosier, A. R. 2007: **Carbon dioxide enrichment alters plant community structure and accelerates shrub growth in the shortgrass steppe.** Proceedings of the National Academy of Sciences of the United States of America, 104, 14724-14729.

  ABSTRACT: A hypothesis has been advanced that the incursion of woody plants into world grasslands over the past two centuries has been driven in part by increasing carbon dioxide concentration, [CO_2], in Earth's atmosphere. Unlike the warm season forage grasses they are displacing, woody plants have a photosynthetic metabolism and carbon allocation patterns that are responsive to CO_2, and many have tap roots that are more effective than grasses for reaching deep soil water stores that can be enhanced under elevated CO_2. However, this commonly cited hypothesis has little direct support from manipulative experimentation and competes with more traditional theories of shrub encroachment involving climate change, management, and fire. Here, we show that, although doubling [CO_2] over the Colorado shortgrass steppe had little impact on plant species diversity, it resulted in an increasingly dissimilar plant community over the 5-year experiment compared with plots maintained at present-day [CO_2]. Growth at the doubled [CO_2] resulted in an ≈40-fold increase in aboveground biomass and a 20-fold increase in plant cover of *Artemisia frigida* Willd, a common subshrub of some North American and Asian grasslands. This CO_2-induced enhancement of plant growth, among the highest yet reported, provides evidence from a native grassland suggesting that rising atmospheric [CO_2] may be contributing to the shrubland expansions of the past 200 years. Encroachment of shrubs into grasslands is an important problem facing rangeland managers and ranchers, this process replaces grasses, the preferred forage of domestic livestock, with species that are unsuitable for domestic livestock grazing.

- Suttle, K. B., Thomsen, M. A. and Power, M. E. 2007: **Species Interactions Reverse Grassland Responses to Changing Climate.** Science, Vol. 315, 640-642

  ABSTRACT: Predictions of ecological response to climate change are based largely on direct climatic effects on species. We show that, in a California grassland, species interactions strongly influence responses to changing climate, overturning direct climatic effects within 5 years. We manipulated the seasonality and intensity of rainfall over large, replicate plots in accordance with projections of leading climate models and examined responses across several trophic levels. Changes in seasonal water availability had pronounced effects on individual species, but as precipitation regimes were sustained across years, feedbacks and species interactions overrode autecological responses to water and reversed community trajectories. Conditions that sharply increased production and diversity through 2 years caused simplification of the food web and deep reductions in consumer abundance after 5 years. Changes in these natural grassland communities suggest a prominent role for species interactions in ecosystem response to climate change.

  Keywords: species, adaptation, grassland ecosystem, precipitation, biodiversity

3.1.3. Wetland ecosystems

- Belyea, L. R. and Malmer, N. 2004: **Carbon sequestration in peatland: patterns and mechanisms of response to climate change.** Global Change Biology Volume 10, Issue 7, 1043–1052

  ABSTRACT: The response of peatlands to changes in the climatic water budget is crucial to predicting potential feedbacks on the global carbon (C) cycle. To gain insight on the patterns and mechanisms of response, we linked a model of peat accumulation to a model of peatland hydrology, then applied these models to empirical data spanning the past 5000 years for the large mire Store Mosse in southern Sweden. We estimated parameters for C sequestration and height growth by fitting the peat accumulation model to two age profiles. Then, we used independent reconstruction of climate wetness

and model reconstruction of bog height to examine changes in peatland hydrology. Reconstructions of C sequestration showed two distinct patterns of behaviour: abrupt increases associated with major transitions in vegetation and dominant *Sphagnum* species (fuscum, rubellum–fuscum and magellanicum stages), and gradual decreases associated with increasing humification of newly formed peat. Carbon sequestration rate ranged from a minimum of 14 to a maximum of 72 g m^{-2} yr^{-1}, with the most rapid changes occurring in the past 1000 years. Vegetation transitions were associated with periods of increasing climate wetness during which the hydrological requirement for increased seepage loss was met by rise of the water table closer to the peatland surface, with the indirect result of enhancing peat formation. Gradual decline in C sequestration within each vegetation stage resulted from enhanced litter decay losses from the near-surface layer. In the first two vegetation stages, peatland development (i.e., increasing surface gradient) and decreasing climate wetness drove a gradual increase in thickness of the unsaturated, near-surface layer, reducing seepage water loss and peat formation. In the most recent vegetation stage, the surface diverged into a mosaic of wet and dry microsites. Despite a steady increase in climate wetness, C sequestration declined rapidly. The complexity of response to climate change cautions against use of past rates to estimate current or to predict future rates of peatland C sequestration. Understanding interactions among hydrology, surface structure and peat formation are essential to predicting potential feedback on the global C cycle.
Keywords: bog, carbon cycle, carbon sink, carbon storage, holocene, peat accumulation, peatland

- Bufková, I. and Prach, K. 2006: **Linking vegetation pattern to hydrology and hydrochemistry in a montane river floodplain, the Šumava National Park, Central Europe.** Wetlands Ecology and Management. Volume 14, Number 4, 317-327.
  ABSTRACT: Cover of higher plants (in 4 × 4 m plots), groundwater table height, and water chemistry in boreholes were sampled at 43 sites along three cross-sectional transects in a flat floodplain of the Upper Vltava River in the Šumava Mountains (Šumava National Park, Czech Republic). The goal was to describe the relationships between vegetation and alluvial environment. Correlations between hydrochemical and plant community characteristics were calculated, and Canonical Correspondence Analysis (CCA) was used to express relationships between the abiotic factors and vegetation. The following characteristics were significantly correlated with the vegetation pattern: mean height of the water table, distance from the river, pH, and concentration of NH_4 and humic acids in the groundwater. Two distinct zones were distinguished in the floodplain: Zone I was under direct influence of the river, and exhibited higher pH and ammonium content in a fluctuating groundwater table. Zone II, covering more than half of the floodplain extent, was under the prevailing influence of water coming from the adjacent upland, and exhibited lower pH, higher content of humic acids, and a higher and relatively stable groundwater table. A diverse mosaic of the riparian communities, especially of tall-sedge and tall-grass marshes and alluvial meadows, was typical for the former zone, while peatland vegetation characterised the latter one. The floodplain exhibited a rather oligo- to mesotrophic status with only very local eutrophication, and harboured diverse and valuable plant communities. The protection of this floodplain should be among the priorities of the National Park authorities.
  Keywords: Diversity, Floodplain, Vegetation, Water chemistry, Water table

- Cristofor S., Sarbu A., Vadineanu A., Ignat G., Iordache V., Postolache C., Dinu C., Ciubuc C., 1997: **Effects of hydrological regime on riparian vegetation in the Lower Danube Floodplain.** Proceedings 32nd Conference IAD, Vienna, 233-239
  ABSTRACT: The flood amplitude, duration period and frequency in the Lower Danube River System (LDRS), were emphasized as the most important factors determining the dynamics and dispersion of dependent plant and (semi)migratory animal populations. A special interest presents some studies on the influence of the water level variations on the colonization and growth of reed and bulrush stands in the Danube Delta and Floodplain or on the role of flood regimen, in interference with the type of water

running and sedimentation/erosion processes, on the establishment and succession of some vegetal communities. Last years studies on the role of riparian vegetation in the LDRS focused on the connection between plant diversity (as an important compartment of riparian biodiversity) and ecological functions along transversal gradients of the river margins. These studies are also connected to an European scale, on latitudinal and climatic gradients, in the framework of some international research programmes. This paper presents some results on the direct influence of hydrological regime on the space distribution and dynamics of this important compartment of the riparian/riverine system. Indirect influence and (by water running, light, soil moisture etc.) some response mechanisms are also revealed.

Keywords: riparian vegetation, Biosphere Reserve of Danube Delta, Impacts of climate change, hydrological regime

- Ebert, S., Hulea, O., Strobel, D., 2009: **Floodplain restoration along the lower Danube: A climate change adaptation case study.** Climate and Development
  Available for download at: http://iopscience.iop.org/1755-1315/6/40/402002/pdf/1755-1315_6_40_402002.pdf

  ABSTRACT: Conversion of the Danube river floodplains through dyke construction for farming and other development has cut off 95, 75 and 28% of the floodplains of the upper Danube, the lower Danube and the Danube delta, respectively. Together with channelization, this has exacerbated flood peaks. Anthropogenic climate change is anticipated to bring more frequent flooding and reduced water quality. In assessing ongoing floodplain restoration work that commenced in 1993, this paper finds the following. (a) Along the lower Danube River, restoration of floodplains by decommissioning underperforming flood protection infrastructure has provided many benefits. The benefits of these adaptation measures include improved natural capacity to retain and release floodwaters and remove pollutants, enhanced biodiversity, and strengthened local economies through diversification of livelihoods based on natural resources. (b) The drivers for more successful adaptation measures in the Danube included EU expansion, legal mechanisms, and local desire to improve livelihoods. The support of non-governmental organizations (WWF and partner organizations) for basin- and regional-level planning for more effective water resource management has also been a powerful driver of policy change in the lower Danube countries.

  Keywords: floodplain, Biosphere Reserve of Danube Delta, flooding and reduced water quality

- Lamentowicz, M., Obremska, M., Mitchell, E. 2008: **Autogenic succession, land-use change, and climatic influences on the Holocene development of a kettle-hole mire in Northern Poland.** Review of Palaeobotany and Palynology, Volume 151, Issues 1-2, Pages 21-40. ABSTRACT: We reconstructed the Holocene developmental history of a kettle-hole peatland in the Tuchola forest of Northern Poland, using pollen, testate amoebae and plant macrofossils indicators. Our aims were to determine the timing and pattern of autogenic succession and natural and anthropogenic influences on the peatland. Northern Poland is under mixed oceanic and continental climatic influences but has so far been less studied in a palaeoecological context than more oceanic regions of Europe. In the first terrestrial developmental phase of the mire, the testate amoebae-inferred depth to water table revealed two major dry shifts at ca 9400 (end of lake phase) and ca. 7100 cal. BP (a period of global cooling and dry shift in western Europe). Conditions became wetter again in two steps at ca. 6700 and ca. 5800 BP after a dry event at ca. 6100 BP. The timing of the wet shift at 5800 BP corresponds to wet periods in Western Europe. Peat accumulation rates were low (0.1 mm yr-1) between ca. 5600 and ca. 3000 BP when sedges dominated the peatland. In the last 2500 years surface moisture fluctuated with wet events at ca 2750-2400, and 2000 BP, and dry events at ca. 2250-2100 and 1450 BP. After 1450 BP a trend towards wetter conditions culminated at ca. 500 cal. BP, possibly caused by local deforestation. Over the mire history, pH (inferred from testate amoebae) was

mostly low (around 5) with two short-lived shifts to alkaline conditions (7.5) at ca. 6100 and 1450 BP indicating a minerotrophic influence from surface runoff into the mire. Up to about 1000 BP the ecological shifts inferred from the three proxies agree with paleoclimatic records from Poland and Western Europe. After this date, however correlation is less clear suggesting an increasing local anthropogenic impact on the mire. This study confirms that kettle-hole peatlands can yield useful palaeo-environmental data as well as recording land-use change and calls for more comparable studies in regions are the interface between major climate influences.
Holocene, palaeohydrology, human impact, testate amoebae, pollen, plant macrofossils, peatland, wetland, hydrology, succession, community, ecology

3.1.4. Freshwater ecosystems

- ARNELL, N.W. and Reynard, N. S. 1996: **The effects of climate change due to global warming on river flows in Great Britain.** Journal of Hydrology 183: 397-424
  ABSTRACT: Global warming due to an increasing concentration of greenhouse gases in the atmosphere will affect temperature and rainfall, and hence river flows and water resources. This paper presents results from an investigation into potential changes in river flows in 21 catchments in Great Britain, using a daily rainfall-runoff model and both equilibrium and transient climate change scenarios. Annual runoff was simulated to increase by 2050 by over 20% in the wettest scenarios and decline by over 20% in the driest scenarios — and different catchments respond differently to the same change scenario. Monthly flows change by a greater percentage than annual flows, and under all the scenarios considered there would be a greater concentration of flow in winter. Snowfall, and hence snowmelt, would be almost entirely eliminated. Progressive changes in river flows over the next few decades would be small compared with year-to-year variability, but would be noticeable on a decade-to-decade basis.

- BROOKES, C.J. et al. 2000: **Modelling vegetation interactions with channel flow in river valleys of the Mediterranean region.** Catena 40 (1): 93-118. [ZOTERO>CC]

- BUZBY, K.M. and Perry, S. A. (2000): **Modelling the potential effects of climate change on leaf pack processing in central Appalachian streams.** Canadian Journal of Fisheries and Aquatic Sciences 57(9): 1773-1783. [ZOTERO>CC]

- Cyberski J., Grześ M., Gutry-Korycka M., Nachlik E. and Kundzewicz Z. (2006): **History of floods on the River Vistula.** Hydrological Sciences Journal 51 (5): 799–817.
  ABSTRACT: The history of floods on the River Vistula in Poland, covering the period from AD 988 to the present is reviewed. General information is given on the River Vistula, its basin and its floods, for the Upper, Middle, Lower Vistula and the Vistula Delta. Information on floods in the pre-instrumental period is derived from documentary sources. It is only since the re-establishment of Polish independence in 1945 that instrumental data make it possible to analyse floods on relatively homogeneous, uniform and gap-free observational material. In order to extend the flood-related records, recourse must be made to historical hydrology. Sources of flood-related information are examined and the particularities of the situation, driven by the history of Poland, are explained. Interpretation is offered of changes in flooding, caused by land use, river training and climate change. Changing characteristics of floods of different generation mechanisms (convective or advective rainfall, snowmelt, ice-jam) are discussed.
  Keywords: floods, historical hydrology, Poland, pre-instrumental records, River Vistula

- Dąbrowski M., Marszelewski W., Skowron R. 2004: **The trends and dependencies between air and water temperatures in lakes in northern Poland from 1961–2000.** Hydrology and Earth System Sciences 8: 79-87.
  ABSTRACT: Over 40 years, from 1961–2000, daily mean values of surface lake water temperatures at 0.4 m depth in six lakes in northern Poland were recorded with nearby mean daily air temperatures at 2 m. Air temperatures increased on average from 0.020 to 0.025°C year–1 while lake-water temperatures varied more but increased by 0.005 to 0.028°C year-1. For shorter periods (for instance, for 10 days) the pattern of trend directions and values was more complex, depending on the morphometric and trophic conditions of the lakes. It has been concluded that changes in lake water temperatures during climate warming may be documented by studies of lakes located relatively closely together (up to 300 kilometres).
  Keywords: physical limnology, climate changes, lake water, temperature

- De Toffol, S., Engelhard, C., Rauch, W. 2008: **Influence of climate change on the water resources in an alpine region.** Water Science and Technology, IWA Publishing, 58.4, 839-846. [ZOTERO>CC]
  ABSTRACT: It is widely accepted that the global warming will impact on water resources. This study investigates the possible influence of climate change on the water resources in an alpine region. A description of the actual situation with emphasis on the water resources from the one side and on the water consuming factors, here called stressors, is given. The probable effects of climate change in the region and their influence on its water resources are then described. The main outcome is that in the analysed region the climate change will rather have positive influence on the water balance by inducing higher precipitations during the rivers' natural low flow period (winter). This outcome contradicts many common predictions, however, this due to the specifics induced by the alpine nature of the catchment.
  Keywords: alpine region, climate change, water resources

- Dokulil, M.T., Teubner, K., Jagsch, A., Nickus, U., Adrian, R., Straile, D., Jankowski, T., Herzig, A., Padisak, J., 2010: **The Impact of Climate Change on Lakes in Central Europe.** In: George, G. (ed.): The Impact of Climate Change on European Lakes. Springer, Dordrecht, Heidelberg, London, New York, 387-409.
  ABSTRACT: In this book, scientists from eleven countries summarize the results of an EU project (CLIME) that explored the effects of observed and projected changes in the climate on the dynamics of lakes in Northern, Western and Central Europe. Historical measurements from eighteen sites were used to compare the seasonal dynamics of the lakes and to assess their sensitivity to local, regional and global-scale changes in the weather. Simulations using a common set of water quality models, perturbed by six climate-change scenarios, were then used to assess the uncertainties associated with the projected changes in the climate. The book includes chapters on the phenology and modelling of lake ice, the supply and recycling of nitrogen and phosphorus, the flux of dissolved organic carbon and the growth and the seasonal succession of phytoplankton. There are also chapters on the coherent responses of lakes to changes in the circulation of the atmosphere, the development of a web-based Decision Support System and the implications of climate change for the Water Framework Directive.

- Domnişoru, A. 2007: **Long term effects of climate change on Europe's water resources. Case study Romania**. Techneau case study.
  ABSTRACT: Climate variations from last century show a global warming trend. Evidence from the past reveals that the anthropogenic greenhouse effect caused changes in climate parameters (temperature, precipitation and evaporation) at the European scale as well. On long-term this might have essential impact on temporal and spatial distribution of water resources. The long-term effects are related to

gradual hydrological changes. For example, changes in the frequency of extreme events (floods and droughts) may affect water quantity and quality while changes in land use (as an adaptive measure to climate change) will possibly alter water's qualitative characteristics. On long-term climate change might be the most serious issue that the world must face. Assessing now the long-term effects is essential in decision making regarding the adaptation measures to future climate changes. The aim of this report is to identify the long-term effects of climate change on Europe's water resources. This report has two objectives. The first one is to identify the most important climate related factors and trends that lead to changes on the long-term in Europe. The second objective is to study the trends in availability and quality of water resources based on a case study in the Arges catchment, Romania. The identification of the driving factors and trends is based on available literature. For the case study, necessary information and data was obtained from literature and from different authorities and organizations from Romania. The results show that on long-term water resources in Europe are affected by climate change. The impact is temporally and regionally differentiated. Generally, northern Europe becomes warmer and wetter and water availability increases. More affected will be southern Europe where decrease in discharges and increase in temperature lead to a reduction of water availability. Water quality is also affected by climate change through changes in temperature, suspended sediment, nutrients and eutrophication. For Arges catchment, studies at regional scale reveal that on long-term, water resources may be affected by climate change. The mean annual discharge may decrease, causing water shortages, especially in the dry periods. Data analysis for the period 1999-2004 shows that climate has a much lower impact on water quality than other factors (e.g. technological, political, and economical).

Keywords: Romania, Dobrogea, CC impact

- EAWAG (2002): Deliverable No. 9 – **Report providing a descriptive overview of collated available long-term historical data on temperature and ice cover in lakes and rivers relevant to the determination of direct climate change impacts on surface waters.** Integrated Project to evaluate the Impacts of Global Change on European Freshwater Ecosystems, Project no. GOCE-CT-2003-505540. Available for download at: http://www.refresh.ucl.ac.uk/ euro-limpacs/deliverablesandview=abstractanddelid=9

  SUMMARY: This data report provides a descriptive overview of the long-term historical data on temperature and ice cover in lakes and rivers for Task 3(i) of Work package 1. The extent of the available data is outlined and some examples are provided. The most valuable data sets from the point of view of climate research are those that are not only long, but complete. However, most long-term environmental data series do have gaps, and those described here are no exception. Small gaps can often be filled by interpolation, but larger gaps can cause substantial problems. The frequency of occurrence of large gaps in most of the data sets described here is low enough not to have a serious effect on overall data quality. The data sets described in this report include the following:

  i) Daily river water temperature data covering the last 25–35 years. Examples include data from the Rhine (1969–2002) and Rhône (1968–2002),

  ii) Monthly mean river water temperature data covering much of the 20th century. Examples include data from the Rhine, Danube and Inn (all 1901–1990),

  iii) Monthly lake water temperature profiles covering much of the second half of the 20th century. Examples include data from the Swiss lakes Zürichsee (1936–40 , 1945–2004), Greifensee (1956–2004) and Walensee (1972–2002),

  iv) Daily lake surface water temperatures covering the last part of the 20th century. Examples include data from Lough Feeagh, Ireland (1960–2004) , Windermere, UK (1960–2000) and Müggelsee, Germany (1976–2004).

  v) Monthly mean lake surface water temperatures covering much of the 20th century. Examples include data from Lake Constance (1901–1990), Zeller See (1901–1990), Traunsee (1905–1990) and

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Mondsee (1909–1990), all in Austria.
vi) Historical observations of the timing of ice–on and ice–off on rivers and lakes distributed
vii) Ice cover datasets throughout Europe and the rest of the Northern Hemisphere, including many that go back to the 19th and 18th centuries, and some that extend back even further. Examples include the Tornionjoki River, Finland (ice-off, since 169 2/93), the Miramichi River, Canada (ice-off, since 1829/30), Kallavesi, Finland (ice-on and ice–off, since 1833/34) , Lej da San Murezzan, Switzerland (ice–off, since 1831/32), Lake Baikal, Russia (ice-off, since 1868/69) , and Lake Suwa, Japan (ice-on, since 1443/44).
Very few of the data sets described here have been published and access to the vast majority of them is by arrangement with the respective owners on a case–by–case collaborative basis only.

- Gibson, C.A., Meyer J.L., Poff N. L., Hay L.E., Georgakakos A. 2005: **Flow regime alterations under changing climate in two River basins: implications for freshwater ecosystems.** Wiley InterScience, River Research and Applications 21: 849–864. [ZOTERO>CC]
ABSTRACT: We examined impacts of future climate scenarios on flow regimes and how predicted changes might affect river ecosystems.We examined two case studies: Cle Elum River, Washington, and Chattahoochee–Apalachicola River Basin, Georgia and Florida. These rivers had available downscaled global circulation model (GCM) data and allowed us to analyse the effects of future climate scenarios on rivers with (1) different hydrographs, (2) high future water demands, and (3) a river–floodplain system. We compared observed flow regimes to those predicted under future climate scenarios to describe the extent and type of changes predicted to occur. Daily stream flow under future climate scenarios was created by either statistically downscaling GCMs (Cle Elum) or creating a regression model between climatological parameters predicted from GCMs and stream flow (Chattahoochee–Apalachicola). Flow regimes were examined for changes from current conditions with respect to ecologically relevant features including the magnitude and timing of minimum and maximum flows. The Cle Elum's hydrograph under future climate scenarios showed a dramatic shift in the timing of peak flows and lower low flow of a longer duration. These changes could mean higher summer water temperatures, lower summer dissolved oxygen, and reduced survival of larval fishes. The Chattahoochee–Apalachicola basin is heavily impacted by dams and water withdrawals for human consumption, therefore, we made comparisons between pre-large dam conditions, current conditions, current conditions with future demand, and future climate scenarios with future demand to separate climate change effects and other anthropogenic impacts. Dam construction, future climate, and future demand decreased the flow variability of the river. In addition, minimum flows were lower under future climate scenarios. These changes could decrease the connectivity of the channel and the floodplain, decrease habitat availability, and potentially lower the ability of the river to assimilate wastewater treatment plant effluent. Our study illustrates the types of changes that river ecosystems might experience under future climates.
Keywords: climate change, freshwater ecosystems, flow regimes, river, ecological integrity, Indicators of Hydrologic Alteration

- Gren, I.-M., Groth, K.-H., Sylvén, M., 1995: **Economic Values of Danube Floodplains.** Journal of Environmental Management, No. 45, pp. 333-345
ABSTRACT: The Danube floodplains are shared by several countries and provide a complex ecosystem with various habitats or biotopes. Three of them have been selected, forests, grasslands and wetlands, which produce services of value to society. Examples of the ecosystem's services are water purification, biodiversity, flood control, wind protection and food supply. In order to make appropriate estimates of these services, ecosystem models are needed to describe how these services are produced and how they are linked to the economies of the countries concerned. Such models are not currently available. Therefore, this study makes rough calculations of values by transferring results obtained in other

studies to the Danube floodplains. The services subjected to valuation are provision of input resources, recreation and nutrient purification. The estimated total annual value of the existing Danube floodplains amounts to ECU 374/ha. The total annual value of the entire actual area of Danube floodplains corresponds to ECU 650 million per year. Approximately two-thirds of this value is obtained in Romania. The value of the land as a nutrient sink accounts for about one-half of the total value. It should be noted that the calculations are based on several simplified assumptions and the results must therefore be interpreted with caution.
Keywords: Danube, floodplains, economic values, forest, grassland, wetlands

- Hari R.E., Livingstone D.M., Siber R., Burkhardt-Holm P., Güttinger H. 2006: **Consequences of climatic change for water temperature and brown trout populations in Alpine rivers and streams.** Global Change Biology 12, 10–26.
  ABSTRACT: Twenty-five years of extensive water temperature data show regionally coherent warming to have occurred in Alpine rivers and streams at all altitudes, reflecting changes in regional air temperature. Much of this warming occurred abruptly in 1987/1988. For brown trout populations, the warming resulted in an upward shift in thermal habitat that was accelerated by an increase in the incidence of temperature-dependent Proliferative Kidney Disease at the habitat's lower boundary. Because physical barriers restrict longitudinal migration in mountain regions, an upward habitat shift in effect implies habitat reduction, suggesting the likelihood of an overall population decrease. Extensive brown trout catch data documenting an altitudinally dependent decline indicate that such a climate-related population decrease has in fact occurred. Our analysis employs a quantitatively defined reference optimum temperature range for brown trout, based on the sinusoidal regression of seasonally varying field data.
  Keywords: Alpine rivers and streams, altitude dependence, brown trout, climatic change, habitat shift, optimum temperature, Proliferative Kidney Disease, regional coherence, sinusoidal regression, water temperature

- Herzig, A., 1994: **Monitoring of lake ecosystems.** Stapfia 31 (The International Waterfowl and Wetlands Research Bureau, Publ. 30): 17 - 28.
  ABSTRACT: The essential component of management strategies for the conservation of lake biota is a reasonably complete understanding of the factors and processes regulating the composition, organization and dynamics of the communities. One aspect of the habitat quality is the trophic state, which can be defined on the basis of, e.g. nutrient content, primary production or secondary production. Within the International Biological Programme the basic parameters of production, metabolism and energy flow in freshwaters and the controlling factors were studied. During the 1970s, an international OECD cooperative study on Eutrophication of Freshwaters was performed to explore the strengths and weaknesses of nutrient load assessment and to relate external nutrient loading to the trophic response of lakes. Within this context, a number of relationships between areal phosphorus load, lake phosphorus concentration and primary production as a function of morphological and hydrological lake characteristics were developed. As a result, a few dominant regulating factors have been identified and are still in use in monitoring programmes within the context of eutrophication. As an example of an Austrian case study, the limnological development of Neusiedler See is briefly described and discussed. The need for more quantitative information on biotic interactions and their changes in the context of lake management strategies, biomanipulation and lake conservation is put forward. Finally, the example of Seewinkel pinpoints the need for the determination of areal changes in the landscape, especially with regard to water and the land - water ecotone.
  Keywords: lake ecosystems, monitoring, trophic state, Neusiedler See

- IUCN 2009: **Perspectives on water and climate change adaptation. Environment as infrastructure – Resilience to climate change impacts on water through investments in nature**
  Available for download at:
  http://www.iucn.org/about/work/programmes/water/resources/wp_resources_reports/
  ABSTRACT: As floods, drought and other impacts of climate change on water become more frequent or intense, economies and livelihood security will weaken. Adapting to such impacts by building resilience is integral to addressing these global priorities. As water is at the centre of climate change impacts, this demands a focus on resilience to impacts on water. The environment has a critical role in building resilience to climate change and reducing vulnerabilities in communities and economies. Well-functioning watersheds and intact floodplains and coasts provide water storage, flood control and coastal defence. They are 'natural infrastructure' for adaptation.

- Kaczmarek, Z. 2003: **The Impact of Climate Variability on Flood Risk in Poland**. Risk Analysis Vol. 23, No. 3, 559-566.
  ABSTRACT: This article examines the role of climatic and hydrological variability in assessing the cumulative risk of flood events in Poland over a T-year period. In a broad sense flood-risk estimation combines a frequency analysis of extreme hydrological phenomena with an evaluation of flood-induced damages. The damage from floods depends on the critical values of the river discharges. The probabilistic flood analysis usually includes an estimation of the expected annual probability of the critical dischargeQcr being exceeded and the equivalent long-term risk of it being exceeded over the next T years. If, however, the process is nonstationary, the T-year risk of flood damage may depend importantly on the variation of hydrological processes. As a possible explanation for the variations observed in snowmelt-induced floods in Polish rivers, this article investigates the possible impact of the North Atlantic Oscillation (NAO) on surface air temperature T and precipitation P. The spatial distribution of the correlation coefficients between NAO and T, as well as NAO and P, show very significant differences in the NAO impact on meteorological variables in various parts of Europe. To assess the implications of NAO variations on spring flood discharges, a simple model of Snow CoverWater Equivalent (SCWE) was applied to selected Polish river catchments. The conclusion of this analysis is that the yearly maximum of SCWE values significantly decreases with increasing NAO. This leads to a temporal redistribution of winter and spring runoff. The question of spring flood characteristics being stationary or nonstationary may therefore be linked with stochastic properties of the NAO index time series.
  Keywords: Flood risks, snow cover, NAO index, climate variability

- Kirschner, A.K.T., Eiler, A., Zechmeister, T.C., Velimirov, B., Herzig, A., Mach, R., Farnleitner, A.H. 2002: **Extremely productive microbial communities in shallow saline pools respond immediately to changing meteorological conditions.** Environmental Microbiology 4 (9): 546 – 555. [ZOTERO>CC]

- Kirschner, A.K.T., Schlesinger, J., Farnleitner, A.H., Hornek, R., Süss, B., Golda, B., Herzig, A., Reitner, B., 2008: **Rapid growth of planktonic Vibrio cholerae non-O1/non-O139 strains in a large alkaline lake in Austria: dependence on temperature and dissolved organic carbon quality.** Applied and Environmental Microbiology 74: 2004-2015. [ZOTERO>Monitoring]
  ABSTRACT: Vibrio cholerae non-O1/non-O139 strains have caused several cases of ear, wound, and blood infections, including one lethal case of septicemia in Austria, during recent years. All of these cases had a history of local recreational activities in the large eastern Austrian lake Neusiedler See. Thus, a monitoring program was started to investigate the prevalence of V. cholerae strains in the lake

over several years. Genetic analyses of isolated strains revealed the presence of a variety of pathogenic genes, but in no case did we detect the cholera toxin gene or the toxin-coregulated pilus gene, both of which are prerequisites for the pathogen to be able to cause cholera. In addition, experiments were performed to elucidate the preferred ecological niche of this pathogen. As size filtration experiments indicated and laboratory microcosms showed, endemic V. cholerae could rapidly grow in a free-living state in natural lake water at growth rates similar to those of the bulk natural bacterial population. Temperature and the quality of dissolved organic carbon had a highly significant influence on V. cholerae growth. Specific growth rates, growth yield, and enzyme activity decreased markedly with increasing concentrations of high-molecular-weight substances, indicating that the humic substances originating from the extensive reed belt in the lake can inhibit V. cholerae growth.
Keywords: Health, Impact of CC, water

- Rastner 2008: **Modellierung des Abflusses der Ahr im Tauferer Ahrntal für verschiedene Klimaszenarien. (Run-off Modelling of Ahr in Tauferer Ahrntal for different climate scenarios)** Diplomarbeit, Universität Innsbruck. [German]
  Available for download at:
  http://imgi.uibk.ac.at/sekretariat/diploma_theses/Rastner_Lukas_2008_Dipl.pdf
  ABSTRACT: In this thesis the hydrometeorological model OEZ (¨Osterreichische Einzugsgebiete, engl.: austrian basins), developed at the institute of Meteorology and Geophysics, University of Innsbruck, was used for runoff modeling in the South Tyrolean ”Tauferer Ahrntal“. With four runoff measurement stations in the valley, four basins were defined. The basin of St. Georgen, with 607 km2 the biggest of the four basins, includes the three smaller basins of Kematen (419 km2), Steinhaus (148 km2) and Rein. The smallest, but highest basin Rein (91 km2) also has the greatest glacier cover. This climatological model, with monthly time steps and 100 m altitude intervals, was initially calibrated using the climatological values (1986 - 2006) of temperature and precipitation and their derived parameters such as temperature and precipitation gradient, before the runoff was modeled for different climatic scenarios. In doing so scenarios with a pure temperature rise (+1◦C, +2 ◦C, +3◦C) but also with a pure precipitation change (+ - 20 %) were modeled. But since climate change won‘t appear only in a pure change of temperature or precipitation, a scenario was calculated in which changes in temperature as well as precipitation occur. The values were taken from the book ”Klima¨anderung und die Schweiz - Erwartete Auswirkungen auf Umwelt, Gesellschaft und Wirtschaft”, engl.: ”Climate change and Switzerland - Expected impacts on nature, society and economy”. The results, strongly dependent on the scenario, show from the most realistic and most interesting scenario, in which both temperature and precipitation change, that compared to now the total runoff will decrease, primarly during summer, and that during April and May higher runoff will occur. All model runs were calculated with the glacier cover of the initial model. A decrease of the glacier area shows clearly the great importance of glaciers in alpine catchments, because glaciers make a large contribution to the runoff in the months July, August and September.

- Reitner, B., Herndl, G. J., Herzig, A., 1997: **Role of ultraviolet-B radiation on photochemical and microbial oxygen consumption in a humic-rich shallow lake.** Limnol. Oceanogr. 42, 950-960.
  ABSTRACT: In a humic-rich, shallow lake (Lake Neusiedl), the seasonal dynamics of the humic and the nonhumic dissolved organic carbon (DOC) were investigated and the photochemical oxygen consumption rates of these DOC fractions exposed to surface solar radiation levels were compared with that of the bulk DOC and bacterial respiration. Furthermore, bacterial utilization of the humic, nonhumic, and bulk DOC pre-exposed to solar radiation was compared with utilization of the different fractions of DOC held in the dark prior to inoculating natural bacterial assemblages. The concentration of the unfractionated DOC pool ranged from ~ 3 mmol C liter-1 during summer to 1.3 mmol C liter-1 in

late spring. The mean contribution of humic DOC was 35.2% of bulk DOC. Under the full spectrum of solar radiation, photochemical oxygen consumption of the unfractionated DOC was 3.3 µ mol O2 liter-1 h-1, 1.8µ mol O2 liter-1 h-1 of the humic DOC, and 1.7 µ mol O2 liter-1 h-1 of the nonhumic DOC. In the absence of UVB, photochemical oxygen consumption was reduced by 35% in the unfractionated DOC, 38% in the humic, and 27.5% in the nonhumic DOC. Under the full spectrum of solar radiation, the photochemical oxygen consumption normalized to DOC was more than twice as high (2.83 µ mol O2 mmol-1 C h-1) for humic than for nonhumic DOC. The bacterial oxygen consumption rate was ~ 30% of the photochemical oxygen consumption of the unfractionated DOC. In batch culture experiments with natural bacterial assemblages as inocula, the bacterial yield was generally higher with substrate exposed to the full spectrum of solar radiation than with substrate held in the dark prior to inoculation. Exposure of 0.8 µ m filtered water to the full spectrum of surface solar radiation for 2-3 h resulted in a decline in activity (measured by thymidine incorporation) to 47% of the activity measured in the dark. If UVB was excluded, bacterial activity was 62% of that in the dark. Subsequent incubation at 5-20-cm depth under in situ radiation for another 2-3 h resulted in bacterial activity similar to that detected in the dark incubations at the surface. Bacteria exposed to the full range of solar radiation at the surface and incubated subsequently in the dark exhibited significantly lower activity than bacteria exposed to in situ solar radiation in distinct depth layers. This result indicates that bacteria rapidly recover from previous UV stress in the absence of UVB. Based on our results, we estimate that the photooxidation-mediated residence times in the top 5-cm layer of the water column are 90 and 45.5 d for the nonhumic and humic fractions and 75 d for unfractionated DOC. For the entire water column, ~ 10% of the remineralisation activity (bacterial respiration + photochemical oxygen consumption) is due to photooxidation of the DOC, and the mean residence time of DOC is ~ 80 d.

- Sandin L. 2009: **The relationship between land-use, hydromorphology and river biota at different spatial and temporal scales: a synthesis of seven case studies.** Fundamental and Applied Limnology, Archive for Hydrobiology, Vol. 174/1: 1–5. [ZOTERO>LandUsePlan]
  ABSTRACT: The aim of this paper is to summarize seven case studies that were analysed as part of the research theme “the interaction between land-use and climate change” forming part of the EU-funded Euro-limpacs project “Evaluating the impacts of global change on European freshwater ecosystems”. Different aspects of the relationships between climate change, land-use at different spatial scales, in-stream hydrology and morphology, and lotic biota were studied. The papers included analyses of: i) effects of historical changes in stream hydromorphology and biota, ii) infl uences at different spatial scales on physical features (hydrology and morphology), and iii) infl uences at different spatial scales on lotic biota. A multitude of environmental variables and gradients at different spatial scales affect in-stream physical as well as biological parameters. Disentangling which of these variables extort the strongest infl uence on hydromorphology and lotic biota seems to differ among studies as can be seen from the seven papers summarized here. The studies showed a general pattern with gradients from up-stream headwaters to down-stream stream reaches with predictable changes in vegetation and hydromorphological relationships along the gradient. This is of course nothing new, but rather it was surprising how many different spatial scales and types of environmental variables were found to be important in structuring in-stream physical and biotic variables in the different studies. Further investigations using standardised sets of environmental variables and possibly also standardised biotic sampling methods as well as clear definitions of which spatial scales are investigated are needed to further disentangle the importance of land-use at different spatial scales on in-stream hydromorphology and biota. It is also clearly necessary to widen the analysis methods from correlative to such methods that investigate the mechanistic relationships among variables within a catchment.
  Keywords: climate change, hydromorphology, land-use, running water, spatial scale

- Sarbu, A., Cristofor, S., Vadineanu, A. 1997: **Effects of hydrological regime on submerged macrophytes in the Lower Danube Floodplain and Delta.** Proceedings 32nd Conference IAD Vienna, 237-240
  ABSTRACT: Submerged macrophytes as important primary producers in shallow lakes and in other aquatic/wetland ecosystems of the Lower Danube River System (LDRS), including the Danube Delta and Floodplain. Eutrophication is the most important deterioration phenomenon which affected the LDRS in the last seventeen years and submerged macrophytes in these circumstances. Hydrological regime and nutrient load were identified as the main factors affecting response mechanisms if submerged macrophytes on the background of eutrophication of the Danube Delta. This is a comparative study on the effects of hydrology (depth and running) on submerged vegetation, to explain different behaviour of the main types of shallow aquatic ecosystems located in the Danube Delta and Lower Floodplain.

- Schöner W., Auer, I., Böhm, R. 2009: **Long term trend of snow depth at Sonnblick (Austrian Alps) and its relation to climate change.** Hydrological Processes: Hydro-meteorology and Snow Seasonality in mountains 23 (7), 1052-1063. [ZOTERO>CC]

- Simeoni U., Corbau C. 2009: **A review of the Delta Po evolution (Italy) related to climatic changes and human impacts.** Geomorphology 107, 64–71. [ZOTERO>CC]

- UNIBUC-ECO 2005: Deliverable No. 50 – **Report on existing hydrological, climatological and limnological data in a Danube sub-basin including identification of gaps in the data and new analyses to be undertaken** (Task 4.4). Integrated Project to evaluate the Impacts of Global Change on European Freshwater Ecosystems (Euro-limpacs), Project no. GOCE-CT-2003-505540. [ZOTERO>CC]

3.1.5. Alpine Areas, Mountain ecosystems

- Beniston 2003: **Climatic change in mountain region: a review of possible impacts.** Kluwer Academic Publishers. Printed in the Netherlands. Climatic Change 59: 5-31
  ABSTRACT: This paper addresses a number of issues related to current and future climatic change and its impacts on mountain environments and economies, focusing on the 'Mountain Regions' Chapter 13 of Agenda 21, a basis document presented at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, and the International Year of the Mountains (IYM) 2002. The awareness that mountain regions are an important component of the earth's ecosystems, in terms of the resources and services that they provide to both mountain communities and lowland residents, has risen in the intervening decade. Based upon the themes outlined in the supporting documents for IYM, this paper will provide a succinct review of a number of sectors that warrant particular attention, according to IYM. These sectors include water resources, ecosystems and biological diversity, natural hazards, health issues, and tourism. A portfolio of research and policy options are discussed in the concluding section, as a summary of what the IYM and other concerned international networks consider to be the priority for mountain environmental protection, capacity building, and response strategies in the face of climatic change in the short to medium term future.
  Keywords: Mountain regions, Climate change impacts

- Damm, B. 2007: **Mountain Permafrost in Change – Status Quo and Scenarios. Case Study: Rieserferner-Ahrn Nature Park in South Tyrol.** In: Alparc, eds: The Alps under Pressure - Virtual Library and Conference Documents (CD-Rom).

- Damm und Felderer 2008: **Identifikation und Abschätzung von Murprozessen als Folge von Gletscherrückgang und Permafrostdegradation im Naturpark Rieserferner-Ahrn (Südtirol).** – Abh. Geol. B.-A. 62: 29-32.

  ABSTRACT: Based on model calculations on the current permafrost area in the Nature Park Rieserferner-Ahrn the geomorphological hazard potential derived from glacier retreat and permafrost degradation were estimated. There were identified and analysed debris flow initiation zones and their potential development under conditions of changing climate. The results show that the study area shows a high quantity of unconsolidated, unvegetated sediments located in critical slope areas as a consequence of general glacier retreat and permafrost degradation since the end of the Little Ice Age about 150 years ago. The amount of erodible debris will increase in future and will develop other potential debris flow starting zones.

  Keywords: Italy, South Tyrol, Ostalpen, natural hazard, Gletscherschwund, Permafrost, Mure

- Damm, B., Langer, M. 2006: **Kartierung und Regionalisierung von Permafrostindikatoren im Rieserfernergebiet (Südtirol/Osttirol)**. Mitt. Österr. Geogr. Ges. 148:295-314.

  ABSTRACT: Mapping and Regionalisation of Permafrostphenomena to provide a basis of natural hazard analyses in South Tyrol (Italy)

  In the Rieserferner-Ahrn natural park (South Tyrolean Alps, Italy) mapping of the spatial distribution of permafrost phenomena is carried out. The work is intended to provide the basis of a natural hazard analyses. The work is based on surveying the characteristics of geomorphologic, hydrological and physical permafrost indicators, as rockglaciers, ice-cored debris and moraine deposits, perennial snow patches, temperatures of the base of the winter snow cover (BTS) as well as temperatures and electrical conductivity of melt water. Using a statistical model it is analysed, to what extend the spatial density of perennial snow patches is appropriate to forecast the spatial distribution of permafrost. First results document that the so far not approved approach produces a significant approximation to determine the lower limit of discontinuous permafrost areas.

  Keywords: Italy, South Tyrol, Permafrost indicators, natural hazard

- Falarz, M. 2002: **Long-term variability in reconstructed and observed snow cover over the last 100 winter seasons in Cracow and Zakopane (southern Poland).** Climate Research, vol. 19, no. 3, 247-256.

  ABSTRACT: An attempt to reconstruct the seasonal snow cover data in Cracow (for 26 winter seasons) and Zakopane (for 19 winter seasons) at the turn of the 20th century based on climatic data was made by using multiple regression. The results of the reconstruction were more successful for the station located at lower altitude (Cracow, 206 m above sea level) and allowed an analysis of nival conditions to be extended over 104 winter seasons. The reconstructed data obtained for Zakopane (857 m above sea level) appear to be overestimated for the number of snow cover days and sum of daily snow cover depth. Thus, they were excluded from further calculations. The mean snow cover duration at Zakopane (128 d yr^{-1}) is twice as long as that at Cracow. An analysis of long-term variability of seasonal snow cover duration, seasonal maximum snow depth and sum of daily snow cover depth in Cracow for the period 1895/96-1998/99 and in Zakopane for the periods 1895/96-1998/99 and 1914/15-1998/99 showed no statistically significant trend in any case. The statistically significant ($p < 0.05$) decreasing trend of snow cover duration at both stations (-13 d/10 yr in Cracow, -8 d/10 yr in Zakopane) in the period 1961-1990 could be selected for the whole period investigated. The variation coefficient for snow cover duration is over twice as large for Cracow (37%) as for Zakopane (15%).

  Keywords: Snow cover, Reconstruction, Climate variability, Time series analysis, Southern Poland

- Grodzinska, K., Godzik, B., Fraczek, W., Badea, O., Oszlanyi, J., Postelnicu, D. and Shparyk, Y. 2004: **Vegetation of the selected forest stands and land use in the Carpathian Mountains.** Environmental Pollution 130 (2004) 17-32

  ABSTRACT: Within the framework of the project ''Effects of forest health on biodiversity with emphasis on air pollution in the Carpathian Mountains'' 26 permanent study sites were established in the vicinity of the ozone monitoring sites. The study sites were located on the NW–SE transect through the Western (12 sites), Eastern (11 sites) and Southern (3 sites) Carpathians in forest ecosystems typical of each area. Some of the forest monitoring sites were located in national parks, biosphere reserves and areas of protected landscape. Each permanent site of 0.7 ha area consisted of 5 small 500m2 circular plots, arranged in the form of a cross, i.e. four placed on the cardinal points (N, E, S, W) and one in the center. Phytosociological records were done twice during the 1998 growing season using the Braun–Blanquet's method. The study sites represented various types of forest: Picea abies stands (8), beech (Fagus sylvatica) stands (10), fir (Abies alba) stands (2) and mixed beech–fir, spruce–fir and beech–spruce stands (6). Age of most stands was 80–100 years. Degree of crown damage varied greatly between sites, a percentage of damaged trees decrease in Carpathians from West to East. It corresponds well with the O3 level in these areas. Typical damage by O3 in herb layer species in several Carpathian sites were found. Land-use map for the entire Carpathian Mountains and two detailed land use maps for Tatras (Western Carpathians) and Retezat (Southern Carpathians) are presented. A little more than half of the Carpathian territory is forested. The most densely forested are Eastern Carpathians, while the most sparsely Western Carpathians. Arable lands occupy 22.6% of the Carpathians, pastures and meadows 6.2%, water bodies 1.9%, and build up areas several percent. In the highest elevation of the Carpathians alpine meadows (11.3%) and rocks (3.5%) are distributed. **Keywords: Forests, Species diversity, Forest health, Ozone, Carpathian Mountains**

- Gurung, A. B., Bokwa, A., Chełmicki, W., Elbakidze, M., Hirschmugl, M., Hostert, P., Ibisch, P., Kozak, J., Kuemmerle, T., Matei, E., Ostapowicz, K., Pociask-Karteczka, J., Schmidt, L., Linden, V. D. S., Zebisch, M. 2009: **Global Change Research in the Carpathian Mountain Region.** Mountain Research and Development 29 (3): 282–288

  ABSTRACT: The Carpathian Mountains in Europe are a biodiversity hot spot, harbor many relatively undisturbed ecosystems, and are still rich in seminatural, traditional landscapes. Since the fall of the Iron Curtain, the Carpathians have experienced widespread land use change, affecting biodiversity and ecosystem services. Climate change, as an additional driver, may increase the effect of such changes in the future. Based on a workshop organized by the Science for the Carpathians network, this paper reviews the current status of global change research in the Carpathians, identifies knowledge gaps, and suggests avenues for future research.

  Keywords: Mountains, Carpathians, biodiversity change

- Klebelsberg, R. v. 1923: **Alte Gletscherstände im Ahrntal (Zillertaler Alpen - Hohe Tauern).** Z. für Gletscherkunde, 17, 1-3: 214-218, Leipzig (Borntraeger).

- Price M. F. 1995: **Climate change in mountain region: a marginal issue?** The Environmentalist 15 (4): 272-280.

  ABSTRACT: Mountain regions comprise one-fifth of the world's land surface. They are home to a tenth and important in the lives of half of humankind. Yet mountains are often regarded as physically, politically and economically marginal, their importance has only recently been globally recognized. The potential impacts of climate change in mountain regions will vary considerably between different types of regions. These are briefly described, as an introduction to an evaluation of the potential impacts with regard to agriculture, forestry, water resources, tourism, energy, transport and health. It is concluded that climate change cannot be considered a marginal issue and that the ability of mountain

and downstream people to adapt and respond in the long term will require attention to the maintenance and use of local knowledge and cooperative social networks, as well as considerable scientific research.

- Väre, H., Lampinen, R., Humphries, C. and Williams, P., 2003: **Taxonomic diversity of vascular plants in the European alpine areas.** In: Nagy, L., Grabbher, G., Körner, C. and Thompson, D.B.A. (ed.). Alpine Biodiversity in Europe — A Europe wide Assessment of Biological Richness and Change. Springer: 133–148.

- Nagy, L 2007: **European High Mountain (Alpine) Vegetation and its Suitability for Indicating Climate Change Impacts.** Biology and Environment: Proceedings of the Royal Irish Academy, vol. 106, no. 3, pp. 335-341.
  ABSTRACT: High mountain (alpine) vegetation in Europe occurs above the climatic treeline or substitute vegetation from north of the Arctic Circle to the Mediterranean. As bearing the least modified ecosystems, high mountains offer an opportunity to use their plant and animal species for studying climate change impacts. However, the indicator value of the different vegetation types varies. Treelines, often used in reconstructing past climate by palaeo-scientists, are, in most cases, suppressed by past or present land use and, as a result, their changes need careful interpreting. Glacier forefields are the theatre of primary succession and vegetation changes there have an innate temporal dimension that needs to taken into account. Changes in snowbeds can occur over a relatively short time and are readily interpretable, as long as potential confounding impacts by herbivores are excluded. In the long–term, remote alpine summits with long-established vegetation (but less so those in the sub-nival zone, where primary succession is underway) are likely to yield useful and interpretable information beyond the short- to medium–term impacts of the vagaries of mountain weather.

3.2. Species

- Bergant, K, Trdan, S, Žnidarcic, D, Črepinsek, Z, Kajfez-Bogataj, L 2005: **Impact of climate change on developmental dynamics of Thrips tabaci (Thysanoptera: Thripidae): can it be quantified?** Environmental entomology, Vol. 34, No. 4, 755-766.
  ABSTRACT: We attempt to quantify the impact of future climate change on the developmental dynamics of onion thrips in Slovenia. Monthly averaged results of simulations of future climate from four different general circulation models (GCMs) were projected to local scale by empirical downscaling. The GCM simulations were based on two emission scenarios (IPCC SRES A2 and B2). Local estimates of monthly averaged air temperatures for five locations in Slovenia were adjusted for an additional four emission scenarios (SRES A1T, A1F1, A1B, and B1) using a pattern scaling technique. They were further transferred to a daily scale using a first-order autoregressive model. A simple degree-day model, based on data reported in the literature, was used to relate the development of onion thrips to temperature. Potential changes in the period with favorable developmental conditions for onion thrips (i.e., temperatures above the lower developmental threshold) and in the number of generations per season were estimated with regard to the expected future climate change in Slovenia. The changes are influenced by the magnitude of temperature increase, its asymmetry within the year, and present climate conditions. Using this approach, one can obtain quantitative estimates of the impact of climate change on the developmental dynamics of an insect pest, but one must be fully cognizant of all the assumptions made in the procedure, which introduce uncertainties in the final results. Further research is needed to evaluate the plausibility of such simplified projections. **Keywords: Climate change, Downscaling, Degree-days, Developmental dynamics, Thrips tabaci**

- Normand, S., Svenning, J.-C. and Skov, F. 2006: **National and European perspectives on climate change sensitivity of the habitats directive characteristic plant species**. Journal for Nature Conservation, Vol. 15, No. 1, 41-53.

  ABSTRACT: The main goal of the Habitats Directive, a key document for European conservation, is to maintain a 'favourable' conservation status of selected species and habitats. In the face of near-future climatic change this goal may become difficult to achieve. Here, we evaluate the sensitivity to climate change of 84 plant species that characterise the Danish habitat types included in the Habitats Directive. A fuzzy bioclimatic envelope model, linking European and Northwest African species' distribution data with climate, was used to predict climatically suitable areas for these species in year 2100 under two-climate change scenarios. Climate sensitivity was evaluated at both Danish and European scales to provide an explicit European perspective on the impacts predicted for Denmark. In all 69–99% of the species were predicted to become negatively affected by climate change at either scale. Application of international Red List criteria showed that 43–55% and 17–69% would become vulnerable in Denmark and Europe, respectively. Northwest African atlas data were used to improve the ecological accuracy of the future predictions. For comparison, using only European data added 0–7% to these numbers. No species were predicted to become extinct in Europe, but 4–7% could be lost from Denmark. Some species were predicted to become positively affected in Denmark, but negatively affected in Europe. In addition to nationally endangered species, this group would be an important focus for a Danish conservation strategy. A geographically differentiated Danish conservation strategy is suggested as the eastern part of Denmark was predicted to be more negatively affected than the western part. No differences in the sensitivity of the Habitats Directive habitats were found. We conclude that the conservation strategy of the Habitats Directive needs to integrate the expected shifts in species' distributions due to climate change.

  Keywords: Bioclimatic envelope modelling, Conservation, Global warming, Vegetation impact

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

  ABSTRACT: Ecological changes in the phenology and distribution of plants and animals are occurring in all well-studied marine, freshwater, and terrestrial groups. These observed changes are heavily biased in the directions predicted from global warming and have been linked to local or regional climate change through correlations between climate and biological variation, field and laboratory experiments, and physiological research. Range-restricted species, particularly polar and mountaintop species, show severe range contractions and have been the first groups in which entire species have gone extinct due to recent climate change. Tropical coral reefs and amphibians have been most negatively affected. Predator-prey and plant-insect interactions have been disrupted when interacting species have responded differently to warming. Evolutionary adaptations to warmer conditions have occurred in the interiors of species' ranges, and resource use and dispersal have evolved rapidly at expanding range margins. Observed genetic shifts modulate local effects of climate change, but there is little evidence that they will mitigate negative effects at the species level.

  Keywords: aquatic, global warming, phenology, range shift, terrestrial, trophic asynchrony

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

  ABSTRACT: Causal attribution of recent biological trends to climate change is complicated because non-climatic influences dominate local, short-term biological changes. Any underlying signal from climate change is likely to be revealed by analyses that seek systematic trends across diverse species and geographic regions, however, debates within the Intergovernmental Panel on Climate Change (IPCC) reveal several definitions of a 'systematic trend'. Here, we explore these differences, apply diverse analyses to more than 1,700 species, and show that recent biological trends match climate change

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predictions. Global meta-analyses documented significant range shifts averaging 6.1 km per decade towards the poles (or metres per decade upward), and significant mean advancement of spring events by 2.3 days per decade. We define a diagnostic fingerprint of temporal and spatial 'sign-switching' responses uniquely predicted by twentieth century climate trends. Among appropriate long-term/large-scale/multi-species data sets, this diagnostic fingerprint was found for 279 species. This suite of analyses generates 'very high confidence' (as laid down by the IPCC) that climate change is already affecting living systems.
Keywords: species distribution, climate change

- Pulido, F. and Berthold, P. 2010: **Current selection for lower migratory activity will drive the evolution of residency in a migratory bird population.** Proceedings of the National Academy of Sciences (PNAS), doi/10.1073/pnas.0910361107.
  ABSTRACT: Global warming is impacting biodiversity by altering the distribution, abundance, and phenology of a wide range of animal and plant species. One of the best documented responses to recent climate change is alterations in the migratory behavior of birds, but the mechanisms underlying these phenotypic adjustments are largely unknown. This knowledge is still crucial to predict whether populations of migratory birds will adapt to a rapid increase in temperature. We monitored migratory behavior in a population of blackcaps (*Sylvia atricapilla*) to test for evolutionary responses to recent climate change. Using a common garden experiment in time and captive breeding we demonstrated a genetic reduction in migratory activity and evolutionary change in phenotypic plasticity of migration onset. An artificial selection experiment further revealed that residency will rapidly evolve in completely migratory bird populations if selection for shorter migration distance persists. Our findings suggest that current alterations of the environment are favoring birds wintering closer to the breeding grounds and that populations of migratory birds have strongly responded to these changes in selection. The reduction of migratory activity is probably an important evolutionary process in the adaptation of migratory birds to climate change, because it reduces migration costs and facilitates the rapid adjustment to the shifts in the timing of food availability during reproduction.
  Keywords: adaptation, bird migration, climate change, genetic variation, natural selection

- 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, L., Vliegenthart, A., Wynhoff, I., Schweiger, O. 2008: **Climatic Risk Atlas of European Butterflies.** Biorisk 1 (*Special Issue*) Sofia.
  Keywords: Butterflies, Europe, Impact

- Thuiller, W., Albert, C., Araújo, M. B., Berry, P. M., Cabeza, M., Guisan, A., Hickler, T., Midgley, G. F., Paterson, J., Schurr, F. M., Sykes, M. T. and Zimmermann, N. E. 2008: **Predicting global change impacts on plant species' distributions: Future challenges.** Perspectives in Plant Ecology, Evolution and Systematics 9, 137–152
  ABSTRACT: Given the rate of projected environmental change for the 21st century, urgent adaptation and mitigation measures are required to slow down the on-going erosion of biodiversity. Even though increasing evidence shows that recent human-induced environmental changes have already triggered species' range shifts, changes in phenology and species' extinctions, accurate projections of species' responses to future environmental changes are more difficult to ascertain. This is problematic, since there is a growing awareness of the need to adopt proactive conservation planning measures using forecasts of species' responses to future environmental changes. There is a substantial body of literature describing and assessing the impacts of various scenarios of climate and land-use change on species' distributions. Model predictions include a wide range of assumptions and limitations that are widely acknowledged but compromise their use for developing reliable adaptation and mitigation strategies for biodiversity. Indeed, amongst the most used models, few, if any, explicitly deal with

migration processes, the dynamics of population at the ‘‘trailing edge’’ of shifting populations, species’ interactions and the interaction between the effects of climate and land-use. In this review, we propose two main avenues to progress the understanding and prediction of the different processes occurring on the leading and trailing edge of the species’ distribution in response to any global change phenomena. Deliberately focusing on plant species, we first explore the different ways to incorporate species’ migration in the existing modelling approaches, given data and knowledge limitations and the dual effects of climate and land-use factors. Secondly, we explore the mechanisms and processes happening at the trailing edge of a shifting species’ distribution and how to implement them into a modelling approach. We finally conclude this review with clear guidelines on how such modelling improvements will benefit conservation strategies in a changing world.

Keywords: Species distribution modeling, Habitat models, Process-based models, Global change, Conservation planning

3.2.1. Species distribution

- Araújo, M. B. and Rahbek, C. 2006: **How does climate change affect biodiversity?** Science 313 (5792): pp. 1396-1397.

  ABSTRACT: The most recent and complex bioclimate models excel at describing species’ current distributions. Yet, it is unclear which models will best predict how climate change will affect their future distributions.

  Keywords: biodiversity, species, modelling

- 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.

  ABSTRACT: Aim: We explore the relationship between current European distributions of amphibian and reptile species and observed climate, and project species potential distributions into the future. Potential impacts of climate warming are assessed by quantifying the magnitude and direction of modelled distributional shifts for every species. In particular we ask, first, what proportion of amphibian and reptile species are projected to lose and gain suitable climate space in the future? Secondly, do species projections vary according to taxonomic, spatial or environmental properties? And thirdly, what climate factors might be driving projections of loss or gain in suitable environments for species?

  Location Europe: Distributions of species are modelled with four species–climate envelope techniques (artificial neural networks, generalized linear models, generalized additive models, and classification tree analyses) and distributions are projected into the future using five climate-change scenarios for 2050. Future projections are made considering two extreme assumptions: species have unlimited dispersal ability and species have no dispersal ability. A novel hybrid approach for combining ensembles of forecasts is then used to group linearly covarying projections into clusters with reduced inter-model variability.

  Results: We show that a great proportion of amphibian and reptile species are projected to expand distributions if dispersal is unlimited. This is because warming in the cooler northern ranges of species creates new opportunities for colonization. If species are unable to disperse, then most species are projected to lose range. Loss of suitable climate space for species is projected to occur mainly in the south-west of Europe, including the Iberian Peninsula, whilst species in the south-east are projected to gain suitable climate. This is because dry conditions in the south-west are projected to increase, approaching the levels found in North Africa, where few amphibian species are able to persist.

  Main conclusions The impact of increasing temperatures on amphibian and reptile species may be less deleterious than previously postulated, indeed, climate cooling would be more deleterious for the

persistence of amphibian and reptile species than warming. The ability of species to cope with climate warming may, however, be offset by projected decreases in the availability of water. This should be particularly true for amphibians. Limited dispersal ability may further increase the vulnerability of amphibians and reptiles to changes in climate.
Keywords: Amphibian decline, bioclimatic-envelope models, climate change, ensemble forecasting, Europe, reptile decline, uncertainty

- Grüll, A., Ranner, A., 1998: **Populations of the Great Egret and Purple Heron in relation to ecological factors in the reed belt of the Neusiedler See**. Colonial Waterbirds 21: 328 – 334.
ABSTRACT: We investigated population fluctuations and distribution, colony size, and continuity of colony occupation of the Great Egret (Casmerodius albus) and Purple Heron (Ardea purpurea) in relation to various ecological factors in the reed belt of the Neusiedler See, Austria. In two cases, the increasing egret population (737 nesting pairs in 1997) showed a decline in the second year after a drop in the water level of the lake. Population increases of this species resulted in an increase in colony size in all parts of the reed belt, but not in the colonization of new areas. A stepwise multiple regression indicates that, in both species, colony size was not related to water depth at the colony site, but was correlated positively with the width of the reed belt.

- Harrison, P. A., Berry, P. M., Butt, N., New, M. 2006: **Modelling climate change impacts on species' distributions at the European scale: implications for conservation policy.** Environmental Science and Policy, Vol. 9, 116-128.
ABSTRACT: The availability of suitable climate space across Europe for the distributions of 47 species chosen to encompass a range of taxa (including plants, insects, birds and mammals) and to reflect dominant and threatened species from 10 habitats was modelled for the current climate and three climate change scenarios using the SPECIES neural network model. The present European distribution was satisfactorily simulated for 45 species, which showed good statistics of fit between observed species' distributions and derived models. The predicted responses to climate change demonstrate that the distribution of many species in Europe may be affected by climate change, but that the effects are likely to differ between species. The general pattern is of a south-west to north-east shift in suitable climate space, with gains balancing losses for many species. Based on the total change in potential climate space in Europe, the species most sensitive to climate change were Rubus chamaemorus (Cloudberry, negatively affected) and Genista acanthoclada (Hairy greenweed, positively affected). This disparity in species' response has important implications for EU biodiversity policy as the significance of different countries changes in terms of their future contribution to the conservation of habitats and species.
Keywords: species, habitat suitability, conservation, policy

- Keith, S. A., Newton, A. C., Herbert, R. J.H., Morecroft, M. D. and Clive E. Bealey 2009: **Non-analogous community formation in response to climate change.** Journal for Nature Conservation, Vol. 17, No. 4, 228-235
ABSTRACT: Palaeoecological and current ecological evidence suggests that species will respond individualistically to future climate change. This is likely to lead to the formation of Non-Analogous Communities (NACs), which may be defined as communities that are different in species composition from any communities that can be recognised at a selected reference point in time. We explore the process of NAC formation, with reference to the key processes of immigration and extinction and the potential influence of landscape pattern, in the context of a metacommunity framework. NAC formation has considerable implications for the development and implementation of conservation policies, which frequently refer to the maintenance of current communities. The achievement of such an objective represents a substantial challenge in an era of rapid environmental change, and fails to

accept the dynamic nature of communities. We suggest that conservation policies should identify potential responses to community change based on an understanding of the processes of NAC formation.
Keywords: Climate change, Community, Composition, Conservation, Immigration, Extinction, Metacommunity, Non-analogous community, Vulnerability

- Walther, G.-R., Berger, S. and Sykes, M. T. 2005: **An ecological 'footprint' of climate change.** Proceedings of the Royal Society London Series B - Biological Sciences, 272, 1427-1432.
ABSTRACT: Recently, there has been increasing evidence of species' range shifts due to changes in climate. Whereas most of these shifts relate ground truth biogeographic data to a general warming trend in regional or global climate data, we here present a reanalysis of both biogeographic and bioclimatic data of equal spatiotemporal resolution, covering a time span of more than 50 years. Our results reveal a coherent and synchronous shift in both species' distribution and climate. They show not only a shift in the northern margin of a species, which is in concert with gradually increasing winter temperatures in the area, they also confirm the simulated species' distribution changes expected from a bioclimatic model under the recent, relatively moderate climate change.
Keywords: range shift, global warming, bioindicator, bioclimatic model, evergreen broad-leaved species, Ilex aquifolium

3.2.2. Phenology

- Aikawa, S., Kobayashi, M.J., Satake, A., Shimizu, K.K. und Kudoh, H. 2010: **Robust control of the seasonal expression of the Arabidopsis FLC gene in a fluctuating environment.** Proceedings of the National Academy of Sciences, doi: 10.1073/pnas.0914293107.
ABSTRACT: Plants flower in particular seasons even in natural, fluctuating environments. The molecular basis of temperature-dependent flowering-time regulation has been extensively studied, but little is known about how gene expression is controlled in natural environments. Without a memory of past temperatures, it would be difficult for plants to detect seasons in natural, noisy environments because temperature changes occurring within a few weeks are often inconsistent with seasonal trends. Our 2-y census of the expression of a temperature-dependent flowering-time gene, *AhgFLC*, in a natural population of perennial *Arabidopsis halleri* revealed that the regulatory system of this flowering-time gene extracts seasonal cues as if it memorizes temperatures over the past 6 wk. Time-series analysis revealed that as much as 83% of the variation in the *AhgFLC* expression is explained solely by the temperature for the previous 6 wk, but not by the temperatures over shorter or longer periods. The accuracy of our model in predicting the gene expression pattern under contrasting temperature regimes in the transplant experiments indicates that such modeling incorporating the molecular bases of flowering-time regulation will contribute to predicting plant responses to future climate changes.
Keywords: plant phenology modeling

- Erschbamer 2006: **Climate Change – A risk for Alpine Plants?** (Klimawandel – Risiko für alpine Pflanzen?) In: R. Psenner, R. Lackner (eds.) Die Alpen im Jahr 2020. 2006 IUP Innsbruck University Press. [German]
ABSTRACT: Climate is one of the major determinants for occurrence, growth and altitudinal range of plant species. Due to the temperature enhancement, ongoing for more than 100 years, growth processes and altitudinal ranges are expected to change. Especially in the alpine zone, i.e. above tree line, pronounced effects were suggested. Plant species from lower altitudes migrate higher and higher, out-competing alpine species which have to climb also higher and higher. Finally they may get extinct. After a general introduction to this topic, two research projects are presented. One project deals with

the reaction of glacier foreland species to experimentally enhanced temperatures. During 9 years, the growth of selected target species was studied in open top chambers ("mini growing chambers"). Winners and losers were found and scenarios for the future are outlined.
The second project is the meanwhile worldwide operating GLORIA project. The main aim is to install a global observation network in high mountain regions. In each region an altitudinal gradient with four summits from the zone above tree line up to the nival zone will be studied. The permanent plots will be monitored in intervals of 5 to 10 years. With the surveys a risk assessment for alpine species and environments will be provided. Two GLORIA regions in South Tyrol, one in the western Dolomites and one in the Central Alps (Nature Park Texelgruppe), are introduced.
Keywords: plant species, alpine zone

- Estrella N., Sparks T.H., Menzel A. 2009: **Effects of temperature, phase type and timing, location, and human density on plant phenological responses in Europe.** Climate Research. Vol. 39: 235–248
  ABSTRACT: Phenological onset dates are closely linked to temperature. In this study, we analysed a phenological dataset collected during the COST 725 Action 'Establishing a European phenological data platform for climatological applications', which contained more than 36000 phenological time series for Europe covering 1971–2000. We analysed the temperature response of the phenological phases, their regional differences, and the relationship between the sizes of the local temperature and phenology trends in connection with a high-resolution climate grid of Europe. As an external factor, we examined the influence of human population density on phenology. Our analyses confirm differences in behaviour between annual and perennial plants in Europe. The average temperature response of perennial plants was significantly greater (–4.2 d °C–1) than that of annual agricultural crops (–3.0 d °C–1). The correlation between temperature and phenology trends was greatest for leaf unfolding of fruit trees and deciduous trees (r = –0.63 and –0.46, respectively). The geographic coordinates (latitude and longitude) had only a modest influence on the mean onset of the groups of phases, however, inclusion of altitude improved the models for some groups.
  Keywords: Climate impacts, Phenology, Population density, Temperature response

- Menzel A., Fabian P. 1999: **Growing season extended in Europe.** Nature Vol. 397, 659.
  ABSTRACT: Changes in phenology (seasonal plant and animal activity driven by environmental factors) from year to year may be a sensitive and easily observable indicator of changes in the biosphere. We have analysed data from more than 30 years of observation in Europe, and found that spring events, such as leaf unfolding, have advanced by 6 days, whereas autumn events, such as leaf colouring, have been delayed by 4.8 days. This means that the average annual growing season has lengthened by 10.8 days since the early 1960s. These shifts can be attributed to changes in air temperature.

- Menzel, A., Sparks, T. H., Estrella, N., Koch, E., Aasa, A., Ahas, R., Alm-Kübler, K., Bissolli, P., Braslavská, O., Briede, A., Chmielewski, F. M., Crepinsek, Z., Curnel, Y., Dahl, Å., Defila, C., Donnelly, A., Filella, Y., Jatczak, K., Måge, F., Mestre, A., Nordli, Ø., Peñuelas, J., Pirinen, P., Remisová, V., Scheifinger, H., Striz, M., Susnik, A., Wielgolaski, F.-E., Vliet, A. V., Zach, S., Zust, A. 2006: **European phenological response to climate change matches the warming pattern.** Global Change Biology 12, 1–8.
  ABSTRACT: Global climate change impacts can already be tracked in many physical and biological systems, in particular, terrestrial ecosystems provide a consistent picture of observed changes. One of the preferred indicators is phenology, the science of natural recurring events, as their recorded dates provide a high-temporal resolution of ongoing changes. Thus, numerous analyses have demonstrated an earlier onset of spring events for mid and higher latitudes and a lengthening of the growing season. However, published single-site or single-species studies are particularly open to suspicion of being

biased towards predominantly reporting climate change-induced impacts. No comprehensive study or meta-analysis has so far examined the possible lack of evidence for changes or shifts at sites where no temperature change is observed.We used an enormous systematic phenological network data set of more than 125 000 observational series of 542 plant and 19 animal species in 21 European countries (1971–2000). Our results showed that 78% of all leafing, flowering and fruiting records advanced (30% significantly) and only 3% were significantly delayed, whereas the signal of leaf colouring/fall is ambiguous. We conclude that previously published results of phenological changes were not biased by reporting or publication predisposition: the average advance of spring/summer was 2.5 days decade_1 in Europe. Our analysis of 254 mean national time series undoubtedly demonstrates that species' phenology is responsive to temperature of the preceding months (mean advance of spring/summer by 2.5 days 1C_1, delay of leaf colouring and fall by 1.0 day 1C_1). The pattern of observed change in spring efficiently matches measured national warming across 19 European countries (correlation coefficient r5_0.69, Po0.001).
Keywords: climate change, Europe, growing season, meta analysis, phenology, season, temperature response, trend

- Somagyi, Z. 2008: **Recent trends of tree growth in relation to climate change in Hungary.** Acta Silvatica and Lignaria Hungarica, Vol. 4 (2008) 17-27.
  ABSTRACT: The paper addresses two related issues. One is whether, and how, growth patterns of stand mean height have changed in Hungary in the last few decades, and the other is whether recently observed increases in mean annual temperature might have caused changes in growth trends. Changes in tree growth were investigated for beech (Fagus sylvatica), sessile oak (Quercus petraea) and Turkey oak (Quercus cerris) by comparing stand mean heights over age using data from the forest inventories of 1981 and 2001, and for sessile oak using stand mean height data from permanent sample plots since 1961. Tree growth was found to have accelerated for each species mentioned, with Turkey oak showing the largest acceleration. To study the second issue, stand mean height was related to elevation, wich in turn was related to mean annual temperature and precipitation. For these analyses, too, data of many thousands of stands in the forest inventory was used. Stand mean height was found to increase with decreasing elevation, i.e. with increasing mean annual temperature, for each of the three species. As the annual precipitation and air humidity decreases with decreasing elevation, it was concluded that increases of mean annual temperature could positively have affected tree growth in the last few decades. However, this effect is expected to be soon limited by water availability. **Keywords: climate change, tree growth, beech, sessile oak, Turkey oak**

- Thuiller, W., Lavorel, S., Araújo, M. B., Sykes, M. T. and Prentice, I. C. 2005: **Climate change threats to plant diversity in Europe.** PNAS, Vol. 102, No. 23, 8245-8250.
  ABSTRACT: Climate change has already triggered species distribution shifts in many parts of the world. Increasing impacts are expected for the future, yet few studies have aimed for a general understanding of the regional basis for species vulnerability. We projected late 21st century distributions for 1,350 European plants species under seven climate change scenarios. Application of the International Union for Conservation of Nature and Natural Resources Red List criteria to our projections shows that many European plant species could become severely threatened. More than half of the species we studied could be vulnerable or threatened by 2080. Expected species loss and turnover per pixel proved to be highly variable across scenarios (27–42% and 45–63% respectively, averaged over Europe) and across regions (2.5–86% and 17–86%, averaged over scenarios). Modeled species loss and turnover were found to depend strongly on the degree of change in just two climate variables describing temperature and moisture conditions. Despite the coarse scale of the analysis, species from mountains could be seen to be disproportionably sensitive to climate change (60% species loss). The boreal region was projected to lose few species, although gaining many others from immigration. The greatest changes

are expected in the transition between the Mediterranean and Euro-Siberian regions. We found that risks of extinction for European plants may be large, even in moderate scenarios of climate change and despite inter-model variability.
Keywords: Intergovernmental Panel on Climate Change storylines, species, extinction, species turnover, niche-based model

- Vilhar, U and Kajfez-Bogataj, L 2003: **Phenological development of fagus sylvatica L. and Aesculus hipocastanum L. in relation to mean monthly temperatures for the Kočevje locality during 1961-1990**. Zbornik gozdarstva in lesarstva, No. 72, 63-81. [Slovenian]
ABSTRACT: Long-term phenological development of forest trees and shrubs is an important indicator of changes in the onset of specific phenological phase at different sites in relation to meteorological conditions. Correlation analysis and linear multiple regression were used to establish relationship between phenological phases for Fagus sylvatica and Aesculus hippocastanum and mean monthly air temperatures for the Kocevje locality in the period 1961-1990. Correlation coefficients between the onset of phenological phases with air temperature of the previous 2-3 months were relatively high. For Fagus sylvatica, the highest variability was explained with phenological model for the beginning of leaf colouring (58 %) with first independent variable mean monthly temperature for the months of February, April and May and as second independent variable mean monthly temperature for the months of July, August and September. For Aesculus hippocastanum, the highest variability was explained with phenological model for the beginning of flowering (65 %) with first independent variable mean monthly temperature for the months of April and May and as second independent variable mean monthly temperature for the months of January, February and March. In general, the beginning of leaf colouring in Fagus sylvatica is a good indicator of temperature characteristics of the site.
Keywords: Fagus sylvatica, Aesculus, Phenology, Ecology, Air temperature, Site factors

3.2.3. Invasive species

- Bradley, B. A. 2009: **Regional analysis of the impacts of climate change on cheatgrass invasion shows potential risk and opportunity**. Global Change Biology 15 (1): 196-208.
ABSTRACT: Interactions between climate change and non-native invasive species may combine to increase invasion risk to native ecosystems. Changing climate creates risk as new terrain becomes climatically suitable for invasion. However, climate change may also create opportunities for ecosystem restoration on invaded lands that become climatically unsuitable for invasive species. Here, I develop a bioclimatic envelope model for cheatgrass (Bromus tectorum), a non-native invasive grass in the western US, based on its invaded distribution. The bioclimatic envelope model is based on the Mahalanobis distance using the climate variables that best constrain the species' distribution. Of the precipitation and temperature variables measured, the best predictors of cheatgrass are summer, annual, and spring precipitation, followed by winter temperature. I perform a sensitivity analysis on potential cheatgrass distributions using the projections of 10 commonly used atmosphere-ocean general circulation models (AOGCMs) for 2100. The AOGCM projections for precipitation vary considerably, increasing uncertainty in the assessment of invasion risk. Decreased precipitation, particularly in the summer, causes an expansion of suitable land area by up to 45%, elevating invasion risk in parts of Montana, Wyoming, Utah, and Colorado. Conversely, increased precipitation reduces habitat by as much as 70%, decreasing invasion risk. The strong influence of precipitation conditions on this species' distribution suggests that relying on temperature change alone to project future change in plant distributions may be inadequate. A sensitivity analysis provides a framework for identifying key climate variables that may limit invasion, and for assessing invasion risk and restoration opportunities with climate change.

- CoE Council of Europe, 2003: **European Strategy on Invasive Alien Species.** Convention on the Conservation of European Wildlife and natural habitats. Council of Europe.
  Available for download at:
  https://wcd.coe.int/wcd/ViewDoc.jsp?Ref=Rec%282003%29099andLanguage=lanEnglishandVer=originalandSite=COEandBackColorInternet=DBDCF2andBackColorIntranet=FDC864andBackColorLogged=FDC864

- DAISIE, 2009: **Handbook of Alien Species in Europe.** Invading nature — DAISIE. Springer Series in Invasion Ecology, *Vol. 3*. Springer, Dordrecht, 2009.
  CONTENT: Biological invasions by alien (non-native) species are widely recognized as a significant component of human-caused global environmental change and the second most important cause of biodiversity decline. Alien species threaten many European ecosystems and have serious environmental, economic and health impacts. The DAISIE (Delivering Alien Invasive Species Inventories for Europe) project has now brought together all available information on alien species in Europe (terrestrial, aquatic and marine) and from all taxa (fungi, plants, animals). Thus for the first time, an overview and assessment of biological invasions in the Pan-European region is finally possible.
  The Handbook of Alien Species in Europe summarises the major findings of this groundbreaking research and addresses the invasion trends, pathways, and both economic as well as ecological impact for eight major taxonomic groups. Approximately 11.000 alien species recorded in Europe are listed, and fact sheets for 100 of the most invasive alien species are included, each with a distribution map and colour illustration.
  The book is complemented by a regularly updated internet database providing free additional information. With its highly interdisciplinary approach, DAISIE and its Handbook will be the basis for future scientific investigations as well as management and control of alien invasive species in Europe.

- Delivering Alien Invasive Species Inventories for Europe (DAISIE):
  Available for download at: http://www.europe-aliens.org/

- EEA European Environment Agency, 2009: **Killer slugs and other aliens — Europe's biodiversity is disappearing at an alarming rate.**
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- Lövei, G.L. 1997: **Biodiversity – Global change through invasion.** Nature 388: 627-628

- SEBI Indicators, 2010: **Streamlining European 2010 Biodiversity Indicators.**
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3.3. Impact of land use and land use change

- Berry, P. M., Rounsevell, M. D. A., Harrison, P. A. and Audsley, E. 2006: **Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation.** Environmental Science and Policy, 9, 189-204.

  ABSTRACT: The term vulnerability has been used in a variety of contexts, including climate change impact assessment. In this paper those issues relevant to climate change impacts on agriculture and species are discussed. Outputs from models are used to assess the vulnerability of farmers and species to climate and socio-economic change by estimating their sensitivity and capacity to adapt to external factors as a means of identifying what causes the differences in their vulnerability. The results showed that the vulnerability of both farmers and species is dependent on the scenario under consideration. In agriculture, it is the socio-economic scenarios that particularly lead to different patterns of intensification, extensification and abandonment.

  For species, vulnerability is more related to the climate change scenarios. In both cases, the adaptation options and potential were associated with the different socio-economic futures and policy intervention. The conceptual linking of the two sectors shows that impacts in the agriculture sector and consequent adaptation could have a significant effect on the adaptation potential of species. This demonstrates the importance of cross-sectoral assessments of vulnerability and highlights the importance of sectoral integration in policy development and implementation.

  climate change, agriculture, species, vulnerability, adaptation, policy

- Latocha, A. 2009: **Land-use changes and longer-term human–environment interactions in a mountain region** (Sudetes Mountains, Poland). Geomorphology, Volume 108, Issues 1-2, 1 July 2009, 48-57

  ABSTRACT: Long-term socio-economic changes in the mountain communities, best documented as land-use changes, have been reflected in alternating functioning of the environmental system in the upper valleys in the Sudetes Mountains. The main role that human activity played on morphogenetic processes was to intensify or to weaken the linkages between hillslope and river systems. All stages of environmental change as a result of increasing or decreasing human impact, are easily recognisable in the area, both as human-made landforms and as sediment records. Therefore they provide archives of past and present human activities, allowing for the reconstruction of morphogenetic processes in the past. Detailed sedimentological and geomorphological analyses, along with studies on archival documents, topographic maps and aerial photographs from various periods, reveal many local variations, even within one small drainage basin. Occasionally, human impact might be of the same type and intensity in the entire catchment, but coeval environmental records, for example the thickness of colluvial or alluvial sediments, may differ substantially. The role of local topography (hillslope and valley length, hillslope gradient and microrelief, etc.) considerably influences sediment transfer and depositional processes. Hillslope–channel coupling is of importance as only in some places transport and sediment export from the catchment was favoured. In other places, local topographic conditions favoured sediment storage, limiting transport distance. Human impact turned out to be more important and much more widespread than previously assumed. Despite fewer human-induced sediments in the upper valley reaches, these are actually better archives for reconstructing the linkages between land-use changes and hillslope and channel response. Small-size catchments in the upstream parts of the study area are therefore suitable areas for reconstructing, assessing and quantifying past morphological human–environment interactions.

  Keywords: Land-use change, Human–environment interactions, Anthropogenic landforms and sediments, Sudetes Mountains, Poland

- Liszewska M., Osuch M., Romanowicz R., 2010: **Simulating land use changes in the Upper Narew catchment using the RegCM model.** Geophysical Research Abstracts, Vol. 12, EGU2010-15425, 2010, EGU Assembly.

4. Strategies of Climate Impact Assessment and Adaptation to Climate Change

- Adger, W. N., Arnell, N. W. and Tompkins, E. L. 2005: **Successful adaptation to climate change across scales**. Global Environmental Change, vol. 15, pp. 77–86.
  ABSTRACT: Climate change impacts and responses are presently observed in physical and ecological systems. Adaptation to these impacts is increasingly being observed in both physical and ecological systems as well as in human adjustments to resource availability and risk at different spatial and societal scales. We review the nature of adaptation and the implications of different spatial scales for these processes. We outline a set of normative evaluative criteria for judging the success of adaptations at different scales. We argue that elements of effectiveness, efficiency, equity and legitimacy are important in judging success in terms of the sustainability of development pathways into an uncertain future. We further argue that each of these elements of decision-making is implicit within presently formulated scenarios of socio-economic futures of both emission trajectories and adaptation, though with different weighting. The process by which adaptations are to be judged at different scales will involve new and challenging institutional processes.
  Keywords: adaptation, vulnerability, scenarios, sustainability, decision making

- Berry, P., Paterson, J., Cabeza, M., Dubuis, A., Guisan, A., Jäättelä, L., Kühn, I., Midgley, G., Musche, M., Piper, J. and Wilson, E. 2008: MACIS - **Minimisation of and Adaptation to Climate change Impacts on biodiversity.** Deliverables 2.2 and 2.3: Meta-analysis of adaptation and mitigation measures across the EU25 and their impacts and recommendations how negative impacts can be avoided.

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  http://www.worldwildlife.org/climate/Publications/WWFBinaryitem4922.pdf

- Heller and Zavaleta 2009: **Biodiversity management in the face of climate change: A review of 22 years of recommendations**. Biological Conservation, 142, 14-32.
  ABSTRACT: Climate change creates new challenges for biodiversity conservation. Species ranges and ecological dynamics are already responding to recent climate shifts, and current reserves will not continue to support all species they were designed to protect. These problems are exacerbated by

other global changes. Scholarly articles recommending measures to adapt conservation to climate change have proliferated over the last 22 years. We systematically reviewed this literature to explore what potential solutions it has identified and what consensus and direction it provides to cope with climate change. Several consistent recommendations emerge for action at diverse spatial scales, requiring leadership by diverse actors. Broadly, adaptation requires improved regional institutional coordination, expanded spatial and temporal perspective, incorporation of climate change scenarios into all planning and action, and greater effort to address multiple threats and global change drivers simultaneously in ways that are responsive to and inclusive of human communities. However, in the case of many recommendations the how, by whom, and under what conditions they can be implemented is not specified. We synthesize recommendations with respect to three likely conservation pathways: regional planning, site-scale management, and modification of existing conservation plans. We identify major gaps, including the need for (1) more specific, operational examples of adaptation principles that are consistent with unavoidable uncertainty about the future, (2) a practical adaptation planning process to guide selection and integration of recommendations into existing policies and programs, and (3) greater integration of social science into an endeavor that, although dominated by ecology, increasingly recommends extension beyond reserves and into human-occupied landscapes.

Keywords: conservation, adaptation, biodiversity, resilience

- Huntley, B. 2007: **Climatic change and the conservation of European biodiversity: Towards the development of adaptation strategies.** Discussion paper prepared for the 27th meeting of the Standing Committee of the Convention of the Conservation of European Wildlife and Natural Habitats, 60 pages, Strasbourg.

  Keywords: climate change, conservation, biodiversity, adaptation, ecological network, buffer zones, ecosystem, species

- National Wildlife Federation 2009: **A New Era for Conservation: Review of Climate Change Adaptation Literature.** Reston, VA: Glick, P., Staudt, A., and Stein, B.
  Available for download at: http://www.nwf.org/News-and-Magazines/Media-Center/Faces-of-NWF/~/media/PDFs/Global%20Warming/Reports/NWFClimateChangeAdaptationLiteratureReview.ashx

  ABSTRACT: Natural resource managers and conservationists are coming to grips with the fact that rapid global warming and associated climate changes are already having a considerable impact on the world's ecological systems. More and larger shifts are expected, even in the best-case scenarios for greenhouse gas emissions reductions and future warming. These climate changes are ushering in a fundamental shift in natural resource management and conservation, to help natural systems withstand and adapt to new climate conditions. This literature review summarizes recent science on climate change adaptation in the context of natural resource management and fish and wildlife conservation. The review was prepared as a background contribution to the *Adaptation 2009* conference being held February 2009 in Washington, DC, under the auspices of the National Council on Science and the Environment (NCSE) and National Wildlife Federation (NWF). The review starts with an overview of the concept of climate change adaptation, including overarching principles and barriers experienced to date in adaptation planning and implementation. We then provide specific examples of adaptation strategies for four broad habitat types: (1) forests, (2) grasslands and shrublands, (3) freshwater systems, and (4) coasts and estuaries.

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  Keywords: impacts, adaptation, Europe, regional

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- Piper, J., Wilson, E., Weston, J., Thompson, S., Glasson, J. 2006: **Spatial planning for biodiversity in our changing climate.** English Nature Research Reports, No. 677
  Available for download at:
  http://naturalengland.etraderstores.com/NaturalEnglandShop/ R677
  The work focused on assessing the effectiveness of policies and other mechanisms for spatial planning at international (EU), national (France, Netherlands and England), regional and local levels to provide for the protection and enhancement of biodiversity in a changing climate. It provides recommendations, including new tools and mechanisms to improve effectiveness.

- Sadowski, M. 2008: **An approach to adaptation to climate changes in Poland.** Climatic Change 90: pp. 443-451
  ABSTRACT: Adopted by COP 10 (Dec 1/CP.10) and approved by the MOP1, the Buenos Aires programme of adaptation and response measures opens doors to intensify preparations for expected climate change. By this decision the COP, requested the SBSTA to develop a structured 5-year programme of work of the SBSTA on the scientific, technical and socio-economic aspects of impacts of, and vulnerability and adaptation to, climate change. Consequently, the COP, by its decision 2/CP. ·11, adopted the "Five-year programme of work of the Subsidiary Body for Scientific and Technological Advice on impacts, vulnerability and adaptation to climate change" Finally during COP12 this programme was approved as "Nairobi Work Programme on impacts, vulnerability and adaptation to climate change". This programme has fundamental significance not only for developing countries, but also for industrialized nations in which some sectors of the or social life are particularly vulnerable to climate change, specifically, inter alia EIT countries and new EU Member States. Further development of this adaptation programme economy should contain steps that provide optimum economic and social effectiveness, risk management, identification of vulnerable sectors and gaps in knowledge, preparation of a list of policy options, including an analysis of cost effectiveness, selection of the most effective policies, and a preparedness implementation plan. In Poland the preliminary adaptation programme covered agriculture, water management, and coastal zone management. For the time being, gaps in knowledge and preparedness measures have been identified. An estimation of possible impact on these areas was based on chosen GCMs, and sea level rise IPCC scenarios. In conclusion, it was stated that the results achieved should be seen as a first step forward and a more comprehensive study is necessary to update the results and cover other sectors of the economy, such as health protection, spatial planning, ecosystems and forestry, and to develop specific guidelines and recommendations for policy-makers.
  Keywords: Adpatation, Poland

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Group on Biodiversity and Climate Change. Montreal, Technical Series No. 41, 126 pp.
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- The World Bank, 2010: **Convenient Solutions to an Inconvenient Truth.** Ecosystem-based Approaches to Climate Change. Washington, USA. 114 pp.
  Available for download at: http://siteresources.worldbank.org/ENVIRONMENT/Resources/ESW_EcosystemBasedApp.pdf
  ABSTRACT: Current efforts to address climate change focus mainly on reducing GHG emissions by adopting cleaner energy strategies and on reducing the vulnerability of communities at risk by improving infrastructure to meet new energy and water needs. This book offers a compelling argument for including ecosystem-based approaches to mitigation and adaptation as an essential pillar in national strategies to address climate change. Such ecosystem-based strategies can offer cost-effective, proven and sustainable solutions that contribute to, and complement, other national and regional adaptation strategies.
  Global warming and changes in climate have already had observed impacts on natural ecosystems and species. Natural systems such as wetlands, mangroves, coral reefs, cloud forests, and Arctic and high-latitude ecosystems are especially vulnerable to climate-induced disturbances. However, enhanced protection and management of biological resources and habits can mitigate the impacts and contribute to solutions as nations and communities strive to adapt to climate change. Biodiversity is the foundation and mainstay of agriculture, forests, and fisheries. Biological resources provide the raw materials for livelihoods, agriculture, medicines, trade, tourism, and industry. Forests, grasslands, freshwater, and marine and other natural ecosystems provide a range of services often not recognized in national economic accounts but vital to human welfare: regulation of water flows and water quality, flood control, pollination, decontamination, carbon sequestration, soil conservation, and nutrient and hydrological cycling.
  The World Bank's mission is to alleviate poverty and support sustainable development. Climate change is a serious environmental challenge that could undermine these goals. Since the Industrial Revolution the mean surface temperature has increased an average 0.6 degrees Celsius due to the accumulation of greenhouse gases (GHGs) in the atmosphere. Most of this change has occurred in the last 30 to 40 years, and the rate of increase is accelerating. These rising temperatures will have significant impacts at a global scale and at local and regional levels. While reducing GHG emissions and reversing climate change are important long-term goals, many of the impacts of climate change are already in evidence. As a result, governments, communities, and civil society are increasingly concerned with anticipating the future effects of climate change, while searching for strategies to mitigate, and adapt to, its current and future effects.
  Keywords: Climatic changes, Conservation of natural resources, Ecosystem management, World Bank

- Tompkins, E. L. and Adger, W. N. 2004: **Does Adaptive Management of Natural Resources Enhance Resilience to Climate Change?** Ecology and Society, vol. 9(2), no. 10 [online]
  ABSTRACT: Emerging insights from adaptive and community-based resource management suggest that building resilience into both human and ecological systems is an effective way to cope with environmental change characterized by future surprises or unknowable risks. We argue that these emerging insights have implications for policies and strategies for responding to climate change. We

review perspectives on collective action for natural resource management to inform understanding of climate response capacity. We demonstrate the importance of social learning, specifically in relation to the acceptance of strategies that build social and ecological resilience. Societies and communities dependent on natural resources need to enhance their capacity to adapt to the impacts of future climate change, particularly when such impacts could lie outside their experienced coping range. This argument is illustrated by an example of present-day collective action for community-based coastal management in Trinidad and Tobago. The case demonstrates that community-based management enhances adaptive capacity in two ways: by building networks that are important for coping with extreme events and by retaining the resilience of the underpinning resources and ecological systems. **Keywords: adaptive management, ecosystem, Climate change, adaptation, resilience**

- Wilby, R. L., Troni, J., Biot, Y., Tedd, L., Hewitson, B. C., Smith D. M., et al. 2009: **A review of climate risk information for adaptation and development planning**. International Journal of Climatology *29*: 1193-1215. doi: 10.1002/joc.1839.
  ABSTRACT: Although the use of climate scenarios for impact assessment has grown steadily since the 1990s, uptake of such information for adaptation is lagging by nearly a decade in terms of scientific output. Nonetheless, integration of climate risk information in development planning is now a priority for donor agencies because of the need to prepare for climate change impacts across different sectors and countries. This urgency stems from concerns that progress made against Millennium Development Goals (MDGs) could be threatened by anthropogenic climate change beyond 2015. Up to this time the human signal, though detectable and growing, will be a relatively small component of climate variability and change. This implies the need for a twin-track approach: on the one hand, vulnerability assessments of social and economic strategies for coping with present climate extremes and variability, and, on the other hand, development of climate forecast tools and scenarios to evaluate sector-specific, incremental changes in risk over the next few decades. This review starts by describing the climate outlook for the next couple of decades and the implications for adaptation assessments. We then review ways in which climate risk information is already being used in adaptation assessments and evaluate the strengths and weaknesses of three groups of techniques. Next we identify knowledge gaps and opportunities for improving the production and uptake of climate risk information for the 2020s. We assert that climate change scenarios can meet some, but not all, of the needs of adaptation planning. Even then, the choice of scenario technique must be matched to the intended application, taking into account local constraints of time, resources, human capacity and supporting infrastructure. We also show that much greater attention should be given to improving and critiquing models used for climate impact assessment, as standard practice. Finally, we highlight the over-arching need for the scientific community to provide more information and guidance on adapting to the risks of climate variability and change over nearer time horizons (i.e. the 2020s). Although the focus of the review is on information provision and uptake in developing regions, it is clear that many developed countries are facing the same challenges.

4.1. Conservation and protected area management

- Cabeza, M., Araujo, M., Alagador, D. A. and Thuiller, W. 2008: **MACIS - Minimisation of and Adaptation to Climate change Impacts on biodiversity.** Deliverable 3.4: Report on improved method for reserve selection

- Kareiva, P., Enquist, C., Johnson, A., Julius, S. H., Lawler, J., Petersen, B., et al. 2009: Synthesis and Conclusions, Chapter 9. In: **Preliminary review of adaptation options for climate-sensitive ecosystems and resources**: Final Report, Sysnthesis and Assessment Product 4.4.
  ABSTRACT: The Nation's public lands and waters traditionally have been managed using frameworks

and objectives that were established under an implicit assumption of stable climate and the potential of achieving specific desirable conditions. Climate change implies that past experience may not apply and that the assumption of a stable climate is in some regions untenable. Previous chapters in this report examine a selected group of management systems (National Forests, National Parks, National Wildlife Refuges, Wild and Scenic Rivers, National Estuaries, and Marine Protected Areas) and assess how these management systems can adapt to climate change. Using these chapters and their case studies, as well as more general scientific literature concerning adaptive management and climate change, this chapter presents a synthesis of suggested principles and management approaches for federal management agencies as well as other resource managers.

- Office of Technology Assessment (OTA) and U.S. Congress 1993: **Preparing for an Uncertain Climate**. Vol. I. Published by U.S. Congress. Office of Technology Assessment. Washington D.C..

- Olofsson, J., Hickler, T., Sykes, M. T., Araújo, M. B., Baletto, E., Berry, P. M., Bonelli, S., Cabeza, M., Dubuis, A., Guisan, A., Kühn, I., Kujala, H., Piper, J., Rounsevell, M., Settele, J. and Thuiller, W. 2008: **MACIS - Minimisation of and Adaptation to Climate change Impacts on biodiversity**. Deliverable 1.1: Climate change impacts on European biodiversity – observations and future projections

  ABSTRACT: We review observed and projected future changes in processes that affect biodiversity in Europe, concentrating on terrestrial ecosystems. Large numbers of species from a variety of organism groups have shown an earlier onset of their annual life cycle (*phenology*) in the order of several days per decade. The recorded changes have been more pronounced in northern Europe, partly because of the larger temperature increases compared with southern Europe, but also because fewer studies are available along the southern trailing edges of species ranges. Most species studied have recently expanded their *ranges* towards the north by several km, but species with limited dispersal capability have responded much less and amphibians and reptiles, in particular, show range contractions. Some species have also expanded uphill whilst others have contracted at low altitudes. *Extinctions* primarily caused by climate change have been reported for amphibians and butterflies, but attributing extinctions to a single factor is difficult, partly because of poorly known time lags between climate change and extinctions. *Community and ecosystem* structure and the spatial distribution of different vegetation types have also changed in response to recent climate change. In particular, tree lines have moved up in altitude, and northern, temperature-limited ecosystems have become more productive, primarily because of longer growing seasons. *Indirect changes*, in particular in land use resulting in the loss and increased fragmentation of habitats, and *sea level rise* further strengthen the pressure from climate change on biodiversity.

  The observed trends are generally projected to continue in the future, but responses will likely be more pronounced because climate is projected to change faster than in the recent past. Climate zones in Europe are expected to move towards the north-east with rates likely to exceed the species' capacity to track suitable climates. As current techniques for projecting changes in biodiversity do not account for all factors influencing species, it is difficult to predict accurate extinction rates for species. However, available estimates, based on different modelling approaches, indicate that globally 20-30% of assessed plant and animal species are likely to face substantially increased risk of extinction within the 21st century. Species with limited dispersal, small ranges, or habitat specialists will be substantially more affected than good dispersers, wide ranging, or generalist species. While recent climate changes have been primarily characterized by changes in temperature and precipitation patterns, changes in water availability might play an important role in southern and central Europe. Pronounced drought could have strong effects in particular in the south-west of the Iberian Peninsula, potentially leading to ecosystem-level changes such as forest die-back. Even though projections for individual species are

highly uncertain, a number of robust patterns emerge from the available studies and should be considered in conservation planning.

- Pyke, C. R., Bierwagen, B. G., Furlow, J., Gamble, J., Johnson, T., Julius, S. and West, J. 2007: **A decision inventory approach for improving decision support for climate change impact assessment and adaptation**. In: Environmental Science and Policy, H. 10, S. 610–621.
  ABSTRACT: Assessing and adapting to the impacts of climate change requires balancing social, economic, and environmental factors in the context of an ever-expanding range of objectives, uncertainties, and management options. The term decision support describes a diverse class of resources designed to help manage this complexity and assist decision makers in understanding impacts and evaluating management options. Most climate-related decision support resources implicitly assume that decision making is primarily limited by the quantity and quality of available information. However, a wide variety of evidence suggests that institutional, political, and communication processes are also integral to organizational decision making. Decision support resources designed to address these processes are underrepresented in existing tools. These persistent biases in the design and delivery of decision support may undermine efforts to move decision support from research to practice. The development of new approaches to decision support that consider a wider range of relevant issues is limited by the lack of information about the characteristics, context, and alternatives associated with climate-related decisions. We propose a new approach called a decision assessment and decision inventory that will provide systematic information describing the relevant attributes of climate-related decisions. This information can be used to improve the design of decision support resources, as well as to prioritize research and development investments. Application of this approach will help provide more effective decision support based on a balanced foundation of analytical tools, environmental data, and relevant information about decisions and decision makers. **Keywords: Decision support, Decision making, Climate change, Climate adaptation, Knowledge management**

- Woolsey S., Capelli F., Gonser T. et al. 2007: **A strategy to assess river restoration success.** Freshwater Biology 52 (4), pp. 752-769.
  ABSTRACT: 1. Elaborate restoration attempts are underway worldwide to return human-impacted rivers to more natural conditions. Assessing the outcome of river restoration projects is vital for adaptive management, evaluating project efficiency, optimising future programmes and gaining public acceptance. An important reason why assessment is often omitted is lack of appropriate guidelines.
  2. Here we present guidelines for assessing river restoration success. They are based on a total of 49 indicators and 13 specific objectives elaborated for the restoration of low- to midorder rivers in Switzerland. Most of these objectives relate to ecological attributes of rivers, but socio-economic aspects are also considered.
  3. A strategy is proposed according to which a set of indicators is selected from the total of 49 indicators to ensure that indicators match restoration objectives and measures, and that the required effort for survey and analysis of indicators is appropriate to the project budget.
  4. Indicator values are determined according to methods described in detailed method sheets. Restoration success is evaluated by comparing indicator values before and after restoration measures have been undertaken. To this end, values are first standardised on a dimensionless scale ranging from 0 to 1, then averaged across different indicators for a given project objective, and finally assigned to one of five overall success categories.
  5. To illustrate the application of this scheme, a case study on the Thur River, Switzerland, is presented. Seven indicators were selected to meet a total of five project objectives. The project was successful in achieving 'provision of high recreational value', 'lateral connectivity' and 'vertical connectivity' but failed to meet the objectives 'morphological and hydraulic variability' and 'near natural abundance and

diversity of fauna'. Results from this assessment allowed us to identify potential deficits and gaps in the restoration project. To gain information on the sensitivity of the assessment scheme would require a set of complementary indicators for each restoration objective.

- Araújo, M. B., Cabeza, M., Thuiller, W., Hannah, L. and Williams, P. H. 2004 : **Would climate change drive species out of reserves? An assessment of existing reserve-selection methods.** Global Change Biology, vol. 10, pp. 1618-1626.
  ABSTRACT: Concern for climate change has not yet been integrated in protocols for reserve selection. However if climate changes as projected, there is a possibility that current reserveselection methods might provide solutions that are inadequate to ensure species' longterm persistence within reserves. We assessed, for the first time, the ability of existing reserve-selection methods to secure species in a climate-change context. Six methods using a different combination of criteria (representation, suitability and reserve clustering) are compared. The assessment is carried out using European distributions of 1200 plant species and considering two extreme scenarios of response to climate change: no dispersal and universal dispersal. With our data, 6–11% of species modelled would be potentially lost from selected reserves in a 50-year period. Measured uncertainties varied in 6% being 1–3% attributed to dispersal assumptions and 2–5% to the choice of reserve-selection method. Suitability approaches to reserve selection performed best, while reserve clustering performed poorly. We also found that 5% of species modelled would lose their entire climatic envelope in the studied area, 2% of the species modelled would have nonoverlapping distributions, 93% of the species modelled would maintain varying levels of overlapping distributions. We conclude there are opportunities to minimize species' extinctions within reserves but new approaches are needed to account for impacts of climate change on species, especially for those projected to have temporally nonoverlapping distributions.
  Keywords: modelling, climate change, complementarity, conservation planning, dispersal, distribution models, habitat suitability

- Araújo, M. B., Lobo, J. M. and Moreno, J. C. 2007: **The effectiveness of Iberian protected areas for conserving terrestrial biodiversity**. Conservation Biology 21, 1423-1432.
  ABSTRACT: The Iberian Peninsula harbors about 50% of European plant and terrestrial vertebrate species and more than 30% of European endemic species. Despite the global recognition of its importance, the selection of protected areas has been ad hoc and the effectiveness of such choices has rarely been assessed. We compiled the most comprehensive distributional data set of Iberian terrestrial plant and vertebrate species available to date and used it to assess the degree of species representation within existing protected areas. Existing protected areas in Spain and Portugal reasonably represented the plant and animal species we considered (73–98%). Nevertheless, species of some groups (amphibians, reptiles, birds, and gymnosperms) did not accumulate in protected areas at a rate higher than expected by chance ($p > 0.05$). We determined that to conserve all vertebrate and plant species in the Iberian Peninsula, at least 36 additional areas are needed. Selection of additional areas for conservation would be facilitated if such areas coincided with sites of community importance (SCI) designated under the European Commission Habitats Directive. Additional areas required for full representation of the selected plant and animal species all coincide with SCI in Spain. Nevertheless, the degree of coincidence varies between 0.3% and 74.6%, and there is a possibility that important areas for conservation occur outside the SCI. Our results support the view that current SCI can be used for prioritization of areas for conservation, but a systematic reevaluation of conservation priorities in Spain and Portugal would be necessary to ensure that effective conservation of one of European's most important biodiversity regions is achieved.
  Keywords: complementarity, conservation planning, gap analysis, Iberian Peninsula, Natura 2000, reserve selection

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- Baron, J., Gunderson, L., Allen, C. D., Fleishman, E., McKenzie, D., Meyerson, L. A.. Oropeza, J. and Stephenson, N. 2009: **Options for National Parks and Reserves for Adapting to Climate Change**. Environmental Management Vol. 44, No. 6, 1033-1042, DOI: 10.1007/s00267-009-9296-6

  ABSTRACT: Past and present climate has shaped the valued ecosystems currently protected in parks and reserves, but future climate change will redefine these conditions. Continued conservation as climate changes will require thinking differently about resource management than we have in the past, we present some logical steps and tools for doing so. Three critical tenets underpin future management plans and activities: (1) climate patterns of the past will not be the climate patterns of the future, (2) climate defines the environment and influences future trajectories of the distributions of species and their habitats, (3) specific management actions may help increase the resilience of some natural resources, but fundamental changes in species and their environment may be inevitable. Science-based management will be necessary because past experience may not serve as a guide for novel future conditions. Identifying resources and processes at risk, defining thresholds and reference conditions, and establishing monitoring and assessment programs are among the types of scientific practices needed to support a broadened portfolio of management activities. In addition to the control and hedging management strategies commonly in use today, we recommend adaptive management wherever possible. Adaptive management increases our ability to address the multiple scales at which species and processes function, and increases the speed of knowledge transfer among scientists and managers. Scenario planning provides a broad forward-thinking framework from which the most appropriate management tools can be chosen. The scope of climate change effects will require a shared vision among regional partners. Preparing for and adapting to climate change is as much a cultural and intellectual challenge as an ecological challenge.

  Keywords: Adaptation, Climate change, National parks, Reserves, Uncertainty, Scenario planning, Adaptive management

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  Keywords: ecological network, ecological corridor, biodiversity, conservation, coherence

- Biesbroek, G. R., Swart, R. J., van der Knaap, W. G. M. 2009: **The mitigation-adaptation dichotomy and the role of spatial planning**. *Habitat International,* Vol. 33, No. 3, pp. 230-237.

  ABSTRACT: There is a growing awareness that both adaptation and mitigation measures are needed to reduce the impacts of climate change. Historically, due to a wide variety of reasons, mitigation and adaptation have been framed by scientists and policy makers as two different approaches to deal with the same problem: climate change. As a result, there are large differences in the way knowledge is produced, the analytical approaches that are used, and the designed policy strategies. This paper discusses the origin of the adaptation–mitigation dichotomy. Second, the paper addresses the relationship between climate change responses and spatial planning since there is a growing awareness that spatial planning can function as a switchboard for mitigation, adaptation and sustainable development objectives. Furthermore, the paper explores the role that spatial planning can play in developing effective mitigation and adaptation options in an integrated manner, searching for synergies and trade-offs. This creates the necessity to take climate change responses into account in

spatial planning practices. We argue that climate change could also lead to changes in the traditional administrative structures that spatial planners are accustomed to. Since many of the main impacts of climate change have a water dimension, we discuss the river basin approach as the new administrative level at which spatial planning can increase the effectiveness of adaptation and mitigation measures and integrate these into other sustainable development policies.
Keywords: Climate change, Spatial planning, River basin approach, Adaptation, Mitigation, Sustainable development

- Bomhard, B. and Midgley, G., 2005: **Securing Protected Areas in the Face of Global Change: Lessons Learned from the South African Cape Floristic Region.** pp 69. World Commission on Protected Areas (WCPA) IUCN -The World Conservation Union and South African National Biodiversity Institute (SANBI), Climate Change Research Group
  Keywords: protected area, agriculture, biodiversity, climate change, adaptation, management, invasive species, global change

- Cliquet, A., Backes, C., Harris, J. and Howsam, P. 2009: **Adaptation to climate change - Legal challenges for protected areas.** Utrecht Law Review Vol 5, No 1, pp. 158-175
  Keywords: adaptation, protected areas, legislation

- European Commission: **Natura 2000-Newsletter**.
  Available for download at:
  http://ec.europa.eu/environment/nature/info/pubs/natura2000nl_en.htm
  CONTENTS:
  Natura 2000-Newsletter Nr. 22
  ABSTRACT: The impact of climate change on Europe's biodiversity can already be observed – for example in changing distributions of species, flowering times and bird migrations. Biodiversity will be more resilient to climate change, more able to adapt, if we maintain our ecosystems in a healthy state. Natura 2000 – which aims to maintain habitats and species in favourable conservation status – is in this context a critical climate change adaptation measure. The protected area network provides space for nature and helps sustain nature's 'adaptation options'. This issue of the magazine looks at Natura 2000's role in combatting climate change, as well as a range of mitigation strategies and adaptation measures.
  Keywords: adaptation, mitigation, Natura 2000's role in comabatting climate change

  Natura 2000-Newsletter Nr. 23
  ABSTRACT: Plants are vital to almost every aspect of our daily lives. Despite their undeniable importance, plants everywhere are under threat. The EU is firmly committed to halting the loss of Europe's biodiversity, including endangered plant species, and to restoring habitats and natural systems. This issue explores the challenges for conservation of Europe's endangered plants and examines the role of the Natura 2000 network in combating these threats.
  Keywords: plant species, biodiversity

  Natura 2000-Newsletter Nr. 25
  ABSTRACT: Invasive species as a threat to biodiversity has not yet received the attention it deserves. By out-competing native species, invaders from outside an ecosystem can cause significant damage. Together with other threats this issue needs to be addressed if we are to have a realistic chance of halting biodiversity loss in Europe. This newsletter illustrates the background of this growing problem, and looks at Natura 2000's role in tackling as well as at a range of strategies and measures to

combating invasive alien species.
Keywords: invasive species, biodiversity, economy, Europe

Natura 2000-Newsletter Nr. 26
ABSTRACT: The first systematic assessment of the conservation status of Europe's most endangered habitats and species has been carried out by the Member States, as part of the regular reporting on the EU Habitats Directive. The results, examined in this issue of Natura 2000, show that only a small proportion of the habitats and species of Community interest are in a favourable conservation status. The findings highlight the critical importance of conservation actions at EU level, both in the establishment and development of the Natura 2000 network, and suggest a need to urgently intensify ecological restoration efforts.
Keywords: conservation status, Natura 2000

Natura 2000-Newsletter Nr. 27
Keywords: Natura 2000, connectivity, habitat network, economic value of biodiversity, TEEB

- Dodd, A., Hardiman, A., Jennings, K. and Williams, G. 2010: **Protected areas and climate change - Reflections from a practitioner's perspective.** Utrecht Law Review Vol 6, No 1, pp. 141-148
Keywords: protected area, climate change, Birds Directive, Habitats Directive

- Gaston, K. J., Charman, K., Jackson, S. F., Armsworth, P. R., Bonn, A., Briers, R. A., Callaghan, C. S. Q., Catchpole, R., Hopkins, J., Kunin, W. E., Latham, J., Opdam, P., Stoneman, R., Stroud, D. A. and Tratt, R. 2006: **The ecological effectiveness of protected areas: The United Kingdom.** Biological Conservation, 132, 76-87.
ABSTRACT: Given the importance placed on protected areas, determining their effectiveness in representing and maintaining biodiversity is a core issue in conservation biology. Nonetheless, frameworks identifying the breadth of issues associated with this effectiveness, and case studies of how well these are understood in particular regions, remain lacking. In this paper, we provide such a framework and an overview of the current state of knowledge of the ecological effectiveness of protected areas in the United Kingdom. Arguably, better data are available to address such issues in this region than anywhere else in the world. Nonetheless, studies remain scarce and have focussed foremost on the, rather narrow, issue of the effectiveness of management actions on individual sites in order to deliver fixed conservation objectives and discharge statutory responsibilities. Some attention has also been paid to how well the regional collection or portfolio of protected areas performs, particularly in capturing biodiversity features. Work on the extent to which protected areas in the United Kingdom form effective functional networks is in its infancy, but initiatives are under development. We identify some of the questions about the effectiveness of protected areas to which answers need to be known at the site, portfolio and network levels, and how significant progress might be achieved in addressing these.
Keywords: Condition assessment, Management, Networks, Portfolios, Protected areas

- Hannah, L., Midgley, G. F. and Millar, D. 2002: **Climate change-integrated conservation strategies**. Global Ecology and Biogeography, 11, 485-495.
ABSTRACT: Aim: Conservation strategies currently include little consideration of climate change. Insights about the biotic impacts of climate change from biogeography and palaeoecology, therefore, have the potential to provide significant improvements in the effectiveness of conservation planning. We suggest a collaboration involving biogeography, ecology and applied conservation. The resulting Climate Change-integrated Conservation Strategies (CCS) apply available tools to respond to the

conservation challenges posed by climate change.
Location: The focus of this analysis is global, with special reference to high biodiversity areas vulnerable to climate change, particularly tropical montane settings.
Methods: Current tools from climatology, biogeography and ecology applicable to conservation planning in response to climate change are reviewed. Conservation challenges posed by climate change are summarized. CCS elements are elaborated that use available tools to respond to these challenges.
Results: Five elements of CCS are described: regional modelling, expanding protected areas, management of the matrix, regional coordination, and transfer of resources. Regional modelling uses regional climate models, biotic response models and sensitivity analysis to identify climate change impacts on biodiversity at a regional scale appropriate for conservation planning. Expansion of protected areas management and systems within the planning region are based on modelling results. Management of the matrix between protected areas provides continuity for processes and species range shifts outside of parks. Regional coordination of park and off-park efforts allows harmonization of conservation goals across provincial and national boundaries. Finally, implementation of these CCS elements in the most biodiverse regions of the world will require technical and financial transfer of resources on a global scale.
Main conclusions: Collaboration across disciplines is necessary to plan conservation responses to climate change adequately. Biogeography and ecology provide insights into the effects of climate change on biodiversity that have not yet been fully integrated into conservation biology and applied conservation management. CCS provide a framework in which biogeographers, ecologists and conservation managers can collaborate to address this need. These planning exercises take place on a regional level, driven by regional climate models as well as general circulation models (GCMs), to ensure that regional climate drivers such as land use change and mesoscale topography are adequately represented. Sensitivity analysis can help address the substantial uncertainty inherent in projecting future climates and biodiversity response.
Keywords: biodiversity, climate change, conservation, matrix management, modelling, protected areas, range shifts

- Hannah, L., Midgley, G. F., Andelman, S., Araújo, M. B., Hughes, G., Martinez-Meyer, E., Pearson, R. G. and Williams, P. H. 2007: **Protected area needs in a changing climate.** Frontiers in Ecology and Environment, 5, 131-138.
  ABSTRACT: Range shifts due to climate change may cause species to move out of protected areas. Climate change could therefore result in species range dynamics that reduce the relevance of current fixed protected areas in future conservation strategies. Here, we apply species distribution modeling and conservation planning tools in three regions (Mexico, the Cape Floristic Region of South Africa, and Western Europe) to examine the need for additional protected areas in light of anticipated species range shifts caused by climate change. We set species representation targets and assessed the area required to meet those targets in the present and in the future, under a moderate climate change scenario. Our findings indicate that protected areas can be an important conservation strategy in such a scenario, and that early action may be both more effective and less costly than inaction or delayed action. According to our projections, costs may vary among regions and none of the three areas studied will fully meet all conservation targets, even under a moderate climate change scenario. This suggests that limiting climate change is an essential complement to adding protected areas for conservation of biodiversity.

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  ABSTRACT: The major challenge to stewardship of protected areas is to decide where, when, and how to intervene in physical and biological processes, to conserve what we value in these places. To make such decisions, planners and managers must articulate more clearly the purposes of parks, what is valued, and what needs to be sustained. A key aim for conservation today is the maintenance and restoration of biodiversity, but a broader range of values are also likely to be considered important, including ecological integrity, resilience, historical fidelity (ie the ecosystem appears and functions much as it did in the past), and autonomy of nature. Until recently, the concept of "naturalness" was the guiding principle when making conservation-related decisions in park and wilderness ecosystems. However, this concept is multifaceted and often means different things to different people, including notions of historical fidelity and autonomy from human influence. Achieving the goal of nature conservation intended for such areas requires a clear articulation of management objectives, which must be geared to the realities of the rapid environmental changes currently underway. We advocate a pluralistic approach that incorporates a suite of guiding principles, including historical fidelity, autonomy of nature, ecological integrity, and resilience, as well as managing with humility. The relative importance of these guiding principles will vary, depending on management goals and ecological conditions.

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  ABSTRACT: It is widely accepted by the scientific community that the earth, which has always experienced climate variation, is now undergoing a period of rapid climate change that is enhanced by anthropogenic atmospheric carbon enrichment during the past 100 years. These climatic changes are accelerating and projections for the next 100 years indicate extensive warming in most (but not all) areas, changing patterns of precipitation, and a significant acceleration of sea level rise. Other likely components of ongoing climate change include changes in season lengths, decreasing range of nighttime versus daytime temperatures, declining snowpack, and increasing frequency and intensity of severe weather events. The many components of climate change, and especially the unprecedented rapid rate of change, are just as important as increasing temperatures. Wildlife species are closely adapted to their environments and readily respond to climate variation. However, as discussed in this technical review, the climate change now underway has extensive potential to affect wildlife throughout North America, either directly or indirectly through responses to changing habitat conditions. When considered in combination with other factors (e.g., pollution, ozone depletion, urbanization, etc.), the potential effect is even greater. The effects of climate change on populations and range distributions of wildlife are expected to be species specific and highly variable, with some effects considered negative and others considered positive. In North America the ranges of habitats and wildlife are predicted to generally move northward as temperatures increase. Variations in this overall pattern will be dependent upon specific local conditions, changing precipitation patterns, and the response of different species to different components of climate change. It follows that the structure of plant–animal communities will also change. Ignoring climate change is likely to increasingly result in failure to reach wildlife management objectives. Wildlife managers need to become

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knowledgeable about climate change, ways to cope with it, and ways to take advantage of it. Management options currently available include protecting coastal wetlands to allow for sea level rise, reducing the risks to wildlife from potential catastrophic events, adjusting yield and harvest models, accounting for known climatic variations, and taking climate change into consideration when selecting the location and other characteristics of conservation areas. Wildlife managers also need to expect the unexpected and reduce nonclimate stressors on ecosystems. Overall, wildlife managers can minimize negative impacts to wildlife and take advantage of positive aspects by planning ahead and employing adaptive management.

- Joppa, L. N. and Pfaff, A., 2010: **Global protected area impacts.** Proceedings of the Royal Society, published online before print November 17, 2010, doi: 10.1098/rspb.2010.1713
ABSTRACT: Protected areas (PAs) dominate conservation efforts. They will probably play a role in future climate policies too, as global payments may reward local reductions of loss of natural land cover. We estimate the impact of PAs on natural land cover within each of 147 countries by comparing outcomes inside PAs with outcomes outside. We use 'matching' (or 'apples to apples') for land characteristics to control for the fact that PAs very often are non-randomly distributed across their national landscapes. Protection tends towards land that, if unprotected, is less likely than average to be cleared. For 75 per cent of countries, we find protection does reduce conversion of natural land cover. However, for approximately 80 per cent of countries, our global results also confirm (following smaller-scale studies) that controlling for land characteristics reduces estimated impact by half or more. This shows the importance of controlling for at least a few key land characteristics. Further, we show that impacts vary considerably within a country (i.e. across a landscape): protection achieves less on lands far from roads, far from cities and on steeper slopes. Thus, while planners are, of course, constrained by other conservation priorities and costs, they could target higher impacts to earn more global payments for reduced deforestation.
Keywords: protected areas, conservation impacts, REDD, land cover, deforestation, matching

- Lawler, J. 2009: **Climate change adaptation strategies for resource management and conservation planning.** Annals of the New Yorker Academy of Science, 1162, pp. 79-98.
ABSTRACT: Recent rapid changes in the Earth's climate have altered ecological systems around the globe. Global warming has been linked to changes in physiology, phenology, species distributions, interspecific interactions, and disturbance regimes. Projected future climate change will undoubtedly result in even more dramatic shifts in the states of many ecosystems. These shifts will provide one of the largest challenges to natural resource managers and conservation planners. Managing natural resources and ecosystems in the face of uncertain climate requires new approaches. Here, the many adaptation strategies that have been proposed for managing natural systems in a changing climate are reviewed. Most of the recommended approaches are general principles and many are tools that managers are already using. What is new is a turning toward amore agile management perspective. To address climate change, managers will need to act over different spatial and temporal scales. The focus of restoration will need to shift from historic species assemblages to potential future ecosystem services. Active adaptive management based on potential future climate impact scenarios will need to be a part of everyday operations. And triage will likely become a critical option. Although many concepts and tools for addressing climate change have been proposed, key pieces of information are still missing. To successfully manage for climate change, a better understanding will be needed of which species and systems will likely be most affected by climate change, how to preserve and enhance the evolutionary capacity of species, how to implement effective adaptive management in new systems, and perhaps most importantly, in which situations and systems will the general adaptation strategies that have been proposed work and how can they be effectively applied.

Keywords: adaptation, adaptivemanagement, climate change, conservation planning, management, scenario planning

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- Rowell, T.A. 2009: **Management planning guidance for protected sites in the UK, a comparison of formats and definitions in nine guides**. Journal for Nature Conservation, Vol. 17, No. 2, pp. 99-111.
  ABSTRACT: Nine easily available management planning guides, all aimed at UK protected sites (SSSI, Natura 2000, Ramsar, etc.), were compared. Basic formats recommended by these guides were similar, so that plans based on them should look superficially alike. In contrast, definitions of key terms (*vision*, *objective*, and *constraint* or *factor*) often varied significantly between guides, even though there is a great deal of collaboration between publishing organisations. Additional guidance and rules for objectives only increased differences between guides, and created differences even where definitions were similar. The variable nature of management planning guidance raises concerns about the consistency of plan preparation for protected sites across the UK. Suggestions are made for standardising management planning guidance.
  Keywords: Management planning, Objectives, Habitats Directive, NNR, Ramsar, SAC, SSSI, UK

- Vohland, K. 2007: **Protected areas under climate change - risks and policy options.** Report on an ongoing research project at the Potsdam Institute for Climate Impact Research. [German] Anliegen Natur, Vol. 31, No. 1: 60-67
  ABSTRACT: The observed global warming leads to changes In natural systems and impacts biodiversity. also in Germany. Animals and plants move polewards due to rising temperatures and changing precipitation patterns. The composition of flora and , fauna changes. As these effects will Increase in future. Adaptation of nature conservation strategies is necessary. In this report the risks to reach the specific protections aims I are pointed out for forests and grassland as well as for standing and running waters. Different management options as well as the strategic importance of the Natura 2000 network to support dispersal and migration from animals and plants are discussed.
  Keywords: protected area, species, Natura 2000, adaptation

- Vohland, K. 2008: **Gefährdung von Naturschutzgebieten und mögliche Anpassungsstrategien** [German] In: Warnsignal Klima: Gesundheitsrisiken - Gefahren für Pflanzen, Tiere and Menschen: 352-356
  ABSTRACT: Vulnerability of conservation areas and possible adaptation strategies: Protected areas play an increasingly important role in nature conservation because many habitats are under threat from land use change or have disappeared already. Climate change increases the risk that many protected area might no longer host the plants, animals, and therefore biotopes and ecosystems they have been designed for. Adapting to actual new and expected future habitat conditions has profound implications for nature conservation strategies, but opportunities exist. One is to ensure that the entire landscape is made more suitable to host wild plants and animals (including insects for pollination!) and to interconnect the various habitats by migration and dispersal pathways. Another one is to support and balance natural processes in the ecosystem with efforts taken to protect specific species. Finally, degraded and devastated land should be ecologically improved, in order to provide as much space as

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4.2. Monitoring, Indicator systems

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  ABSTRACT: The paper presents an overview of the objectives and exemplary results of the FP 5 project "Spatial Indicators for European Nature Conservation" (SPIN). The SPIN project is focused on the development and testing of advanced classification methods and spatial indicators based on multisensor satellite data and GIS to accomplish monitoring and management tasks in the context of Natura 2000 and nature conservation. A representative selection of eight regional test areas covers a pan-European network and allows comparative investigations to provide accepted recommendations for regional and European nature conservation. The selected results of four case studies are presented and discussed. The range of work covers the production of regional and local habitat maps by object-oriented classification, a case-based reasoning method for change detection as a management support tool for planning and regulating local land use, the selection and application of structural indicators for the monitoring of Natura 2000 habitats and the downscaling and disaggregation of soil information. Results and the further implementation of presented methods are discussed in the conclusions.

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  Available for download at: http://teodoor.icg.kfa-juelich.de/overview/downloads/TERENO_Implementation_Plan_Draft_version_2010_07_30.pdf/view
  The establishment of **TER**restrial **EN**vironmental **O**bservatories (TERENO) is an initiative funded by the large research infrastructure programme (Ausbauinvestitionen) of the Helmholtz Association within the research area “Earth and Environment”. This funding amounts to 12 Million Euro for the period 2008-2010 and supports the installation of equipment at three observatories selected within the TERENO initiative in Germany. In 2009 the decision was taken to further instrument a fourth observatory with a funding of 3 Million Euro for the period 2011-2013. In 2008 the scientific motivation and justification for the TERENO was also evaluated by an international review panel responsible for the evaluation within the research programmes of the HGF research area “Earth and Environment”. The personal

resources to operate TERENO in terms of technical and scientific staff is supported by the core funding of the research institutes involved in the initiative and is not part of TERENO funding. The objectives to be reached by the establishment of TERENO have been outlined in the programme document in terms of expected results and milestones to be obtained within the five year funding period. The implementation plan outlined in this document identifies more specifically the research hypotheses and questions as well as the measurement platforms required to meet these objectives.

- Braimoh A.K., Onishi T. 2007: **Geostatistical techniques for incorporating spatial correlation into land use change models.** International Journal of Applied Earth Observation and Geoinformation 9 (4), 438-446. [ZOTERO>LandUsePlan]
  ABSTRACT: Land use modeling requires large amounts of data that are typically spatially correlated. This study applies two geostatistical techniques to account for spatial correlation in residential land use change modeling. In the first approach, we combined generalized linear model (GLM) with indicator kriging to estimate the posterior probability of residential development. In the second approach, generalized linear mixed model (GLMM) was used to simultaneously model spatial correlation and regression fixed effects. Spatial agreement between actual and modeled land use change was higher for the GLM incorporating indicator kriging. The GLMM produced more reliable estimates and could be more useful in analyzing the effects of driving factors of land use change for land use planning.
  Keywords: Generalized linear mixed model, Indicator kriging, Land use change, Lagos, Land use planning

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  Keywords: Monitoring

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  https://msw.botanika.hu/META/0_publikaciok/ Czucz_Torda Molnar_Horvath_Botta-Dukat_Kroel-Dulay_2009_A_spatially_explicit.pdf
  ABSTRACT: Ecosystems contribute inconspicuously, yet fundamentally, to human well-being by supplying vital goods and services, including genetic resources, habitat maintenance and climate and runoff regulation. The combined effects of climate change and other global change drivers may impose dramatic impacts on species and ecosystems worldwide, with potentially detrimental consequences on human society. In this chapter we present a vulnerability assessment for the natural and semi-natural ecosystems of Hungary, calculating the local exposure, sensitivity and adaptive capacity of different habitat types. Exposure was calculated using six different global climate model (GCM) outputs comprising of four different models and three emission scenarios, providing a cross-section of the climatic and socio-economic uncertainties within the projections. To estimate the sensitivity of habitats, four types of climate sensitivity were identified and estimated either quantitatively or semi-

quantitatively. Adaptive capacity of habitat occurrences was assessed using landscape ecological evaluation of the quality and distribution of habitat patches. Three potential indicators of adaptive capacity were identified, describing (1) the potential resilience of the individual habitat patches, (2) the local refuge-providing ability of the landscape, and (3) the connectivity and permeability of the landscape. By combining results of exposure, sensitivity and adaptive capacity, climatic vulnerability maps of natural ecosystems were produced. This ease study, prepared for the Hungarian National Climate Change Strategy, provides the first example of a methodology to give quantitative estimation of the potential climatic vulnerability and adaptive capacity of ecosystems based on a detailed habitat database.

- Duelli, P., Obrist, M. K. 2003: **Biodiversity indicators: the choice of values and measures.** Agriculture, Ecosystems and Environment, Vol. 98, Iss. 1-3, 87-98. [ZOTERO>Biodiv]
  ABSTRACT: Ideally, an indicator for biodiversity is a linear correlate to the entity or aspect of biodiversity under evaluation. Different motivations for assessing entities or aspects of biodiversity lead to different value systems, their indicators may not correlate at all. For biodiversity evaluation in agricultural landscapes, three indices are proposed, each consisting of a basket of concordant indicators. They represent the three value systems “conservation” (protection and enhancement of rare and threatened species), “ecology” (ecological resilience, ecosystem functioning, based on species diversity), and “biological control” (diversity of antagonists of potential pest organisms). The quality and reliability of commonly used indicators could and should be tested with a three-step approach. First, the motivations and value systems and their corresponding biodiversity aspects or entities have to be defined. In a time consuming second step, a number of habitats have to be sampled as thoroughly as possible with regard to one or several of the three value systems or motivations. The third step is to test the linear correlations of a choice of easily measurable indicators with the entities quantified in the second step. Some examples of good and bad correlations are discussed.

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  ABSTRACT: Based on a literature review, the different approaches to biological indicator systems in floodplains are summarised. Four general categories of bioindication are defined and proposed here: 1. Classification indicators, 2.1 Environmental indicators, 2.2 Biodiversity indicators, 3. Valuation indicators. Furthermore, existing approaches in floodplains are classified according to the four categories. Relevant and widely used approaches in floodplains are explained in more detail. The results of the RIVA project are put into the context of these indication approaches. It is concluded that especially functional assessment approaches using biological traits of the species can be seen as very promising and deserve more attention by conservation biologists and floodplain ecologists.

- European Environment Agency EEA (Project manager: André Jol) 2002: **Proposed Set of Climate Change State and Impact Indicators in Europe**. Technical Report No. XX, prepared by: Markus Erhard, Jelle van Minnen and Thomas Voigt, ETC on Air and Climate Change.
  Available for download at: http://air-climate.eionet.europa.eu/reports/CC%20State%20Impact%20Indicators%20in%20Europe
  ABSTRACT: This report provides a preliminary list of climate change state and impact indicators that have been developed by the European Topic Centre on Air and Climate Change (ETC/ACC), as part of its work programme for the EEA, and with input from several other ETCs. The report starts with a summary of the objectives of the work, followed by a short background on different types of climate change indicators. Then the methods and approaches used for the initial selection process are presented. Based on an initial proposed list of indicators prepared by ETC/ACC and the outcome of an

expert meeting at the EEA by the end of 2001 a preliminary list of potential indicators was compiled which is presented in this report. These preliminary selected indicators are thought to be suitable to describe the main currently occurring and in some cases expected future trends in climate change and its impacts on ecosystems, human health and socio-economic sectors. In addition "Indicator Description Sheets" are presented that contain more detailed information on the preliminary selected indicators, including background information, sources of data and a detailed assessment of the suitability of the indicator for policy making processes, based on EEA and OECD criteria. The report provides a picture of the current situation on climate change state and impact indicators but also gives an impression of the efforts which have to be taken in the near future to compile and develop a set of useful indicators for monitoring climate change and its impacts. The preliminary list of potential climate change indicators will be distributed for comments to climate change contact points in EEA member countries, experts in the scientific community and others interested, to enable a final selection of indicators for EEA reporting in the coming years.

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- Fanelli G., Tescarollo P., Testi A. 2006: Ecological indicators applied to urban and suburban floras. Ecological Indicators Vol.6, Iss. 2, p444-457. [ZOTERO>Monitoring]
  ABSTRACT: Among the many approaches to ecological indicators, ecological indicators derived from the floristic composition of a site (i.e. Raunkiaer's forms spectrum or the percentage of different geographical distribution types-chorotypes) are well established in botanical and ecological literature. Nonetheless their relationship with other indicators, such as Ellenberg's ecological indicators, or the Grime model [Grime, J.P., 2002. Plant Strategies, Vegetation Processes and Ecosystem Properties. Wiley, Chichester] and the Hemeroby index [Kowarik, I., 1990. Some responses of flora and vegetation to urbanization in Central Europe. In: Sukopp, H., Hejny, S., Kowarik, I. (Eds.), Urban Ecology. Plants and plant communities in urban environments. SPB Academic Publishing, The Hague] is still poorly explored. We concentrated on an urban ecosystem because such areas, due to their high degree of artificialization, are particularly well suited for studying the interaction of anthropical disturbance with other processes of the ecosystems. This paper attempts to select a small indicator frameset of many already proposed indicators which best express the variability of the sites studied. A floristic-ecological investigation has been carried out in 10 urban sites, of which 6 were archeological, located in the centre of Rome and 4 suburban, semi-natural, in the NE of the town. Ecological indicators have been calculated on this data set. The Pearson correlation test was then applied to verify whether the indicators were independent, while stepwise regression analysis was done to evaluate the statistical weight of each ecoindicator. Disturbance and temperature are the main factors shaping the composition of the sites studied. They are largely interacting and are well expressed with the help of a small subset of the initial set of 19 indicators, namely, by indicators related to life forms and to the geographical distribution of species: Therophytes/Hemicryptophytes, Mediterranean/large distribution, Eurasiatic/ large distribution, Mediterranean/Eurasiatic species. The information provided by Ellenberg's indicators values and Grime's life strategies are largely summarized by these chorological indicators.

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  Keywords: indicators, DPSIR, Hungary, water resources

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  The purpose of this Technical Paper is to rehearse some fundamental concepts surrounding the development and delineation of adaptation indicators. It builds upon the outputs of an Expert meeting on climate change vulnerability and adaptation indicators (Budapest, September 2008) and on the contents of a Background Paper that was prepared for the meeting. A major contemporary issue for policy and decision-makers is to understand and address the projected impacts of climate change and the related vulnerability of environmental, social, and economic systems. There is also a growing demand from stakeholders to share information on good practice in adapting to climate change impacts and to measure progress and effectiveness of resource commitments. Clarity over the primary purpose of such monitoring activity is crucial to guide the development of appropriate indicators. The nature and focus of indicators will depend on the desired purpose of the evaluation. Given the range of potential evaluation needs, it is unlikely that a single indicator or set of indicators would be universally applicable.

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  Keywords: Monitoring, nature conservation, Germany

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  ABSTRACT: The paper presents a possibility to identify the relevance of interferences into the water balance of soils in the habitat type 9190 (Old acidophilous oak woods with Quercus robur in sandy plains) according to Natura 2000. To answer this question soil humidity is regarded as central parameter. It has been used as ordinal value referring to soil type and depth to ground water. The ecological range of the habitat type has been derived from the site tolerances of its characteristic plant species regarding the ordinal values of soil humidity. Outside the tolerance thresholds a transition zone can be defined on the base of the different, partly varying site demands of the plant species and from the general variability of ecosystems. The range without site suitability has been defined to one level outside the defined site range . Within the transition zone site suitability decreases from 1 to O. In order to scale the intensity of the changing soil humidity the study has defined "levels of concernment". These refer to the ecological range and to the transi tion zone, and they correlate with the consequences for the state of preservation of the habitat type. The levels of concernment are weighted depending on the assessment values of the conventions for the identification of the relevance in the context of assessments of plans and projects significantly affecting Natura 2000 sites.
  Keywords: Soil humidity, forest, Natura 2000, site suitability

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  ABSTRACT: The anticipated impacts of climate change on biodiversity are usually assessed using computer models which can be classified into (i) statistical and (ii) process based models. The former describe natural patterns in a statistically formalized way but ignore several ecologically relevant

processes. However, they are relatively fast to parameterize even across many species. The latter recognize natural processes and are hence closer to ecological relationships but much more time-consuming to set up. Therefore they are usually only used to model small numbers of species, functional types or vegetation units.
Keywords: Methodology, statistical models process based models climate change impacts, biodiversity

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  As European integration increasingly affects pan-European nature conservation, indicators for the assessment of habitats are urgently needed to support ecosystem integrity monitoring as well as the target of halting biodiversity loss by 2010. The Natura 2000 network of protected sites with a strong focus on the protection of habitat types and strict monitoring obligations is now legally binding for all Member States. From a set of indicators that have been proposed for habitat monitoring by the SPIN project (Spatial Indicators for European Nature Conservation) we describe measures of landscape structure and soil function and their potential for the monitoring and management of protected areas and the surrounding landscape. In a case study from Austria, we show that structure-related indicators hold potential for the documentation of local-scale changes on a degraded raised bog Natura 2000 site. In a regional scale case study in northern Germany, we show how landscape metrics relate agricultural statistics, e.g. farm size and livestock density to landscape structure. In a third case study from Slovenia, we show how coarse-scale soil data can be disaggregated to finer scale by integrating topographic information and additional parameters for modelling, and production of soil-related habitat suitability maps. From these case studies we provide an overview of some of the critical issues affecting the selection and application of spatial indicators for nature conservation monitoring tasks. End users of spatial indicators work at different scales and in different biogeographical regions. The indicator selection and application demonstrated in our three case studies reveals the capability to contribute to a more quantitative evidence base for monitoring and management of biodiversity in Europe.
  Keywords: Structural indicators, Functional indicators, Natura 2000, Soil maps, DEM, Agricultural statistics, Monitoring biodiversity

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  ABSTRACT: Global climate change and its broad spectrum of effects on human and natural systems has become a central research topic in recent years, biodiversity informatics tools—particularly ecological niche modeling (ENM)—have been used extensively to anticipate potential effects on geographic distributions of species. Misuse of these tools, however, is counterproductive, as biased conclusions might be reached. In this paper, I discuss some issues related to niche theory, geographic distributions, data quality, and algorithms, all of which are relevant when using ENM in climate change projections for biodiversity. This assortment of opinions and ideas is presented in the hope that ENM applications to climate change questions can be made more realistic and more predictive.
  Keywords: climate change, ecological niche, niche modeling, species distribution, envelope of species

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- Nagy, M. 2010: **Übersicht zu den Monitoringaktivitäten in Österreich.** [German] Lecture presented at the Environment Observation Conference, Essen, Germany, 23.-24.9.2010. Available for download at: http://www.lanuv.nrw.de/umwelt/ubk/Nagy,%20Michael%20%282010%29.pdf
  Keywords: Monitoring, Austria

- Noss, R.F. 1990: **Indicators for Monitoring Biodiversity: A Hierarchical Approach.** Conservation Biology, Vol. 4, No. 4, 355-364.
  ABSTRACT: Biodiversity is presently a minor consideration in environmental policy. It has been regarded as too broad and vague a concept to be applied to real-world regulatory and management problems. This problem can be corrected if biodiversity is recognized as an end in itself, and if measurable indicators can be selected to assess the status of biodiversity over time. Biodiversity, as presently understood, encompasses multiple levels of biological organization. In this paper, I expand the three primary attributes of biodiversity recognized by Jerry Franklin — composition, structure, and function—into a nested hierarchy that incorporates elements of each attribute at four levels of organization: regional landscape, community-ecosystem, population-species, and genetic. Indicators of each attribute in terrestrial ecosystems, at the four levels of organization, are identified for environmental monitoring purposes. Projects to monitor biodiversity will benefit from a direct linkage to long-term ecological research and a commitment to test hypotheses relevant to biodiversity conservation. A general guideline is to proceed from the top down, beginning with a coarse-scale inventory of landscape pattern, vegetation, habitat structure, and species distributions, then overlaying data on stress levels to identify biologically significant areas at high risk of impoverishment. Intensive research and monitoring can be directed to high-risk ecosystems and elements of biodiversity, while less intensive monitoring is directed to the total landscape (or samples thereof). In any monitoring program, particular attention should be paid to specifying the questions that monitoring is intended to answer and validating the relationships between indicators and the components of biodiversity they represent.

- Öster, M., Persson, K., Eriksson, O. 2008: **Validation of plant diversity indicators in semi-natural grasslands.** Agriculture, Ecosystems and Environment Vol. 125 No. 1-4: 65-72. [ZOTERO>Biodiv]

- Pop, O. G. 2006: **Development of a Biodiversity Monitoring Program for the Romanian protected area. Experiences in Piatra Craiului National Park.** In Pop Oliviu, Hanganu Horatiu, Research in Piatra Craiului National Park. Editura Universitatii Transilvania, Brasov: 229-247
  ABSTRACT: The high biodiversity and the permanent threats on nature from the continuous increase of human incursion necessitated the creation of a unitary monitoring program for all Romanian protected areas. To create a unitary monitoring program, three distinct models of mountain protected areas, including Piatra Craiului National Park, facing with different problems, were chosen as a model to be following by all the other Romanian protected areas. This program has been developed within the current context of the park system in Romania, to rely upon minimal equipment and resources inputs, and to take account of the constraints on staff time, and limited future funding. The output of the present work proved to be the first long-term biodiversity monitoring program, based mainly on biological indicators designed for the Romanian protected areas and focused on the specific management necessities of each area. It is developed to provide a basis for long-term assessment of the status of the biodiversity and the effectiveness of management activities in protecting the protected areas' biodiversity and landscape. The biodiversity monitoring program was tested and

redefined for three selected areas and it proved to be realistic. We have suggested that this model should be used for all Romanian protected areas under a national framework.

- Rocchini, D. 2007: **Effects of spatial and spectral resolution in estimating ecosystem [alpha]-diversity by satellite imagery.** Remote Sensing of Environment Vol. 111, No. 4, 423-434. ABSTRACT: Remote sensing represents a powerful tool to derive quantitative and qualitative information about ecosystem biodiversity. In particular, since plant species richness is a fundamental indicator of biodiversity at the community and regional scales, attempts were made to predict species richness (spatial heterogeneity) by means of spectral heterogeneity. The possibility of using spectral variance of satellite images for predicting species richness is known as Spectral Variation Hypothesis. However, when using remotely sensed data, researchers are limited to specific scales of investigation. This paper aims to investigate the effects of scale (both as spatial and spectral resolution) when searching for a relation between spectral and spatial (related to plant species richness) heterogeneity, by using satellite data with different spatial and spectral resolution. Species composition was sampled within square plots of 100 m2 nested in macroplots of 10,000 m2. Spectral heterogeneity of each macroplot was calculated using satellite images with different spatial and spectral resolution: a Quickbird multispectral image (4 bands, spatial resolution of 3 m), an Aster multispectral image (first 9 bands used, spatial resolution of 15 m for bands 1 to 3 and 30 m for bands 4 to 9), an ortho-Landsat ETM+ multispectral image (bands 1 to 5 and band 7 used, spatial resolution, 30 m), a resampled 60 m Landsat ETM+ image. Quickbird image heterogeneity showed a statistically highly significant correlation with species richness (r=0.69) while coarse resolution images showed contrasting results (r=0.43, r=0.67, and r=0.69 considering the Aster, Landsat ETM+, and the resampled 60 m Landsat ETM+ images respectively). It should be stressed that spectral variability is scene and sensor dependent. Considering coarser spatial resolution images, in such a case even using SWIR Aster bands (i.e. the additional spectral information with respect to Quickbird image) such an image showed a very low power in catching spectral and thus spatial variability with respect to Landsat ETM+ imagery. Obviously coarser resolution data tend to have mixed pixel problems and hence less sensitive to spatial complexity. Thus, one might argue that using a finer pixel dimension should inevitably result in a higher level of detail. On the other hand, the spectral response from different land-cover features (and thus different species) in images with higher spectral resolution should exhibit higher complexity. Spectral Variation Hypothesis could be a basis for improving sampling designs and strategies for species inventory fieldwork. However, researchers must be aware on scale effects when measuring spectral (and thus spatial) heterogeneity and relating it to field data, hence considering the concept of scale not only related to a spatial framework but even to a spectral one.
  Keywords: α-Diversity, Grain, Plant species richness, Spatial resolution, Spectral resolution, Spectral Variation Hypothesis

- Schönthaler, K., Andrian-Werburg, S. v., Wulfert, K., Luthardt, V., Kreinsen, B., Schultz-Sternberg, R. and Hommel, R. 2010: **Establishment of an Indicator Concept for the German Strategy on Adaptation to Climate Change.** German Federal Environment Agency, Dessau-Roßlau.
  Available for download at: http://www.umweltdaten.de/publikationen/fpdf-l/4031.pdf

- Seidenstuecker, C. 2010: **NRW auf dem Weg zu einem Klimafolgenmonitoring.** [German] Lecture presented at the Environment Observation Conference, Essen, Germany, 23.-24.9.2010.
  Available for download at:
  http://www.lanuv.nrw.de/umwelt/ubk/AG2/Seidenstuecker,Christina

%282010%29.pdf
Keywords: Germany, monitoring, climate change, indicators, regional approach

- Smith, G.F., Gittings, T., Wilson, M., French, L., Oxbrough, A., O'Donoghue, S., O'Halloran, J., Kelly, D.L., Mitchell, F.J.G., Kelly, T. et al. 2008: **Identifying practical indicators of biodiversity for stand-level management of plantation forests.** Biodiversity and Conservation, 17:991–1015. [ZOTERO>Biodiv]
  ABSTRACT: Identification of valid indicators of biodiversity is a critical need for sustainable forest management. We developed compositional, structural and functional indicators of biodiversity for five taxonomic groups-bryophytes, vascular plants, spiders, hoverflies and birds-using data from 44 Sitka spruce (Picea sitchensis) and ash (Fraxinus excelsior) plantation forests in Ireland. The best structural biodiversity indicator was stand stage, defined using a multivariate classification of forest structure variables. However, biodiversity trends over the forest cycle and between tree species differ among the taxonomic groups studied. Canopy cover was the main structural indicator and affected other structural variables such as cover of lower vegetation layers. Other structural indicators included deadwood and distances to forest edge and to broadleaved woodland. Functional indicators included stand age, site environmental characteristics and management practices. Compositional indicators were limited to more easily identifiable plant and bird species. Our results suggest that the biodiversity of any one of the species groups we surveyed cannot act as a surrogate for all of the other species groups. However, certain subgroups, such as forest bryophytes and saproxylic hoverflies, may be able to act as surrogates for each other. The indicators we have identified should be used together to identify stands of potentially high biodiversity or to evaluate the biodiversity effects of silvicultural management practices. They are readily assessed by non-specialists, ecologically meaningful and applicable over a broad area with similar climate conditions and silvicultural systems. The approach we have used to develop biodiversity indicators, including stand structural types, is widely relevant and can enhance sustainable forest management of plantations. © 2007 Springer Science+Business Media B.V.
  Keywords: Biodiversity, indicators

- Sommer, W. 2010: **Indikatoren für das Klimafolgenmonitoring - Möglichkeiten und Grenzen.** [German] Lecture presented at the Environment Observation Conference, Essen, Germany, 23.-24.9.2010. Available for download at:
  http://www.lanuv.nrw.de/umwelt/ubk/AG2/Sommer,Werner%282010%29.pdf
  Keywords: Germany, monitoring, climate change, indicators, regional approach

- Tasser, E., Sternbach, E., Tappeiner, U. 2008: **Biodiversity indicators for sustainability monitoring at municipality level: An example of implementation in an alpine region.** Ecological Indicators, Vol. 8 No. 3: 204-223.
  ABSTRACT: As is laid down in the convention on biodiversity, it is essential to install a sustainability monitoring system with integrated biodiversity indicators on both the regional and local levels. The resulting data derived from such a system would be instrumental in supporting the work of policy- and decision-makers as well as stakeholders. However, the integration of biodiversity indicators on the local level is still uncommon. Our aim was therefore to produce a set of biodiversity indicators that: (1) reflects all requirements for regional sustainability monitoring on the municipality level and (2) enables the derived multifaceted information to be simplified and used to improve the applicability and implementation of the system. To this end, we also aimed to assess the validity of the selected indicators in a case study area. Together with a team of 20 local experts composed of officials, stakeholders and scientists, we selected five common biodiversity indicators: landscape diversity,

undissected landscape, hemeroby, naturalness of the riparian area and agricultural intensity. In addition, to describe the quality of an area in terms of the richness of species living in it, we developed two further indicators 'area weighted mean species richness of vascular plants' and 'frequency weighted absolute species richness of vascular plants'. In terms of practical and political implementation, we also defined theory-based desired levels, from which we derived performance rates. The study was carried out in 2004 for each of the 116 municipalities of South Tyrol, an alpine region in northern Italy and data were analysed using a maximum likelihood estimation (spatial lag model). The results clearly showed that the large variance of indicator values mainly arises from anthropogenic activities, and that all indicators are robust to spatial extent, and thus appropriate for multiscale assessment. Further, applying a factor analysis allowed three dimensions to be identified that account for more than 76% of the total variance: (1) naturalness, (2) landscape structure and (3) species diversity. Hence, factor analysis is an objective approach to reduce the number of indicators without loosing too much information. However, it should be borne in mind that for specific ecological questions, the use of single indicators is still inevitable.
Keywords: Biodiversity, indicators

- Grantham, T.E., Merenlender, A.M., Resh, V.H. 2010: **Climatic influences and anthropogenic stressors: An integrated framework for streamflow management in Mediterranean-climate California, U.S.A.** Freshwater Biology 55 (SUPPL. 1), pp. 188-204.
  ABSTRACT: 1. In Mediterranean and other water-stressed climates, water management is critical to the conservation of freshwater ecosystems. To secure and maintain water allocations for the environment, integrated water management approaches are needed that consider ecosystem flow requirements, patterns of human water demands and the temporal and spatial dynamics of water availability.
  2. Human settlements in Mediterranean climates have constructed water storage and conveyance projects at a scale and level of complexity far exceeding those in other, less seasonal climates. As a result, multiple ecological stressors associated with natural periods of flooding and drying are compounded by anthropogenic impacts resulting from water infrastructure development.
  3. Despite substantial investments in freshwater ecosystem conservation, particularly in California, U.S.A., success has been limited because the scales at which river management and restoration are implemented are often discordant with the temporal and spatial scales at which ecosystem processes operate. Often, there is also strong social and political resistance to restricting water allocation to existing consumptive uses for environmental protection purposes. Furthermore, institutions rarely have the capacity to develop and implement integrated management programmes needed for freshwater ecosystem conservation.
  4. We propose an integrated framework for streamflow management that explicitly considers the temporal and spatial dynamics of water supply and needs of both human and natural systems. This approach makes it possible to assess the effects of alternative management strategies to human water security and ecosystem conditions and facilitates integrated decision-making by water management institutions.
  5. We illustrate the framework by applying a GIS-based hydrologic model in a Mediterranean-climate watershed in Sonoma County, California, U.S.A. The model is designed to assess the hydrologic impacts of multiple water users distributed throughout a stream network. We analyse the effects of vineyard water management on environmental flows to (i) evaluate streamflow impacts from small storage ponds designed to meet human water demands and reduce summer diversions, (ii) prioritise the placement of storage ponds to meet human water needs while optimising environmental flow benefits and (iii) examine the environmental and social consequences of flow management policies designed to regulate the timing of diversions to protect ecosystem functions.
  6. Thematic implications: spatially explicit models that represent anthropogenic stressors (e.g. water diversions) and environmental flow needs are required to address persistent and growing threats to

freshwater biodiversity. A coupled human–natural system approach to water management is particularly useful in Mediterranean climates, characterised by severe competition for water resources and high spatial and temporal variability in flow regimes. However, lessons learned from our analyses are applicable to other highly seasonal systems and those that are expected to have increased precipitation variability resulting from climate change.
Keywords: freshwater ecosystem, endangered species, water resource management

- He, C., Malcolm, S.B., Dahlberg, K.A., Fu, B. 2000: **A conceptual framework for integrating hydrological and biological indicators into watershed management.** Landscape and Urban Planning, Vol. 49, No. 1-2, p 25-34. [ZOTERO>AdaptManag]
  ABSTRACT: Development of integrated ecological indicators for assessment of the condition of altered watersheds is fundamental to sound policy and decision making in water resource management. This paper proposes a conceptual framework for developing and integrating a set of hydrological and biologic indicators that can show the modified spatial and temporal distributions of hydrological and biological conditions which result from land use/cover changes across the study watersheds by using Geographic Information Systems, remote sensing, multiple physical and biological databases, and simulation models. Effects of management practices and programs can be evaluated by comparing the temporal distributions of these indicators over a certain period. The paper further outlines steps needed to bridge the gaps between the largely physical and structural aspects of research on watershed indicators and the work on biological processes and indicators of ecosystems for integrating these indicators into watershed planning and management processes.
  Keywords: Indicators, Watersheds, Ecosystems, Planning and management

4.3. Adaptation of sectors

- Starkel L., Kundzewicz Z., 2008: **Consequences of climate change for spatial organization of Poland.** (Konsekwencje zmian klimatu dla zagospodarowania przestrzennego kraju) Nauka 1/2008, 85-101.
  ABSTRACT: Climate Changes have been observed in Poland in the recent decades and more pronounced climate changes are projected for the future. They impact on the natural and built environment of Poland, which has been shaped by both circulation of energy and matter, typical for moderate latitudes, and the properties of the landscape, inherited from the geological past. In the present paper, consequences of climate change (corresponding to model-based projections) for spatial organization of Poland have been reviewed.

4.3.1. Forestry

- Bolte, A., Eisenhauer, D.-R., Ehrhart, H.-P., Groß, J., Hanewinkel, M., Kölling, C., Profft, I., Rohde, M., Röhe, P. and Amereller, K. 2009: **Climate change and forest management – accordances and differences between the German states regarding assessments for needs and strategies towards forest adaptation.** Landbauforschung - vTI Agriculture and Forestry Research 59, 4: 269-278. [German]
  ABSTRACT: A federal working group of German forest research that was mandated by the Federal Forest Task Force (FCK) reports on the accordances and differences between the German states (Bundeslaender) regarding assessments of forest adaptation to climate change. Regarding the threats of climate change and the possibility of adaptation to it, responses were mostly quite similar within the group. The highly significant nature of climate change and the scope of its regional impacts were evaluated by the respondents in a similar manner. The important role of biotic threats was likewise

acknowledged by all parties. We found also only slight differences in the assessment of forest tree species' adaptive potential to climate change: Norway spruce is expected to have low adaptive potential whereas the introduced species Douglas fir and red oak will presumably be more highly adaptive. Several native species are still considered to be quite tolerant against climate change effects as well. However, differences are obvious regarding adaptation strategies. Some states prefer active adaptation (e.g. forest transformation aiming at replacing sensitive tree species), while others prefer a combination of active adaptation and risk minimization strategies (e.g. by establishing tree species mixtures). Passive adaptation is predominantly a less preferred option. All respondents agreed on the need for more intensive interdisciplinary research and for coordinated trials concerning forest adaptation and forest management in the face of climate change.
Keywords: Forestry, drought, storm, adaptiveness, tree species, biotic threats, stress tolerance, silviculture, monitoring, site mapping

- Frischbier, N. and Profft, I. 2008: **Praxisorientierte Regionalisierung forstlich relevanter Klimawerte und –szenarien für Thüringen.** Forst und Holz 63 (10), S. 24-29. [German]
  ABSTRACT: The use of forest specific climate parameters for tree species recommendation and other long term decisions, raises problems of data availability and questions of appropriate downscaling techniques. Based on an approach already in use in Thuringia, an effective, comprehensible and reproducible downscaling method for climate parameters like climatic water balance and length of growing season is presented. The method is carried out by means of stepwise linear regression in combination with expert knowledge of site specific conditions. Plausibility checks and stringent statistical controls ensure a sound basis for the subsequent working process and should greatly facilitate the acceptance of regionalisation techniques.

- Frischbier, N., Profft, I. and Arenhövel, W. 2010: **Die Ausweisung klimawandelangepasster Bestandeszieltypen für Thüringen.** Forst und Holz 65 (2), S. 28-35. [German]
  ABSTRACT: The final article completes a four-part series about new tree species recommendations for Thuringia. In addition to a complex vegetation model, a recently published map of the potential natural vegetation of Thuringia, previous tree species recommendations and various growth analyses have been used to develop this essential instrument for a prospective forest strategy taking into account effects of climate change. The now available catalogue of recommended forest stand types is based on area-wide soil information and regionalized climate projections for the period 2041-2070. Presenting at least two but in average eight alternative types, forest owners and forest authorities have sufficient scope for silvicultural decisions. The article ends with a short outlook on further work to fulfil specific ecological, economic or social aspects and emphasises the need for regular modifications due to ongoing climate change.
  Keywords: Thuringia, forestry

- Frischbier, N., Profft, I. and Arenhövel, W. 2010: **Thuringian tree species recommendations for adaptation to climate change.** Forst und Holz 65 (2), S. 28-35. [German]
  ABSTRACT: The final article completes a four-part series about new tree species recommendations for Thuringia. In addition to a complex vegetation model, a recently published map of the potential natural vegetation of Thuringia, previous tree species recommendations and various growth analyses have been used to develop this essential instrument for a prospective forest strategy taking into account effects of climate change. The now available catalogue of recommended forest stand types is based on area-wide soil information and regionalized climate projections for the period 2041-2070. Presenting at least two but in average eight alternative types, forest owners and forest authorities have sufficient scope for silvicultural decisions. The article ends with a short outlook on further work to fulfil specific

ecological, economic or social aspects and emphasises the need for regular modifications due to ongoing climate change.

- IUFRO 2009: **Forest Agencies' Early Adaptations to Climate Change.** IUFRO Occasional Paper No 23. Available for download at: www.iufro.org/download/file/4375/3753/op23.pdf/
  ABSTRACT: Forest agencies around the world are expected to manage their forests not only under today's climatic conditions, but also tomorrow's. The expected impacts of climate change on particular forests are often highly uncertain, which hampers effective planning. Nevertheless, many agencies are introducing new policies and management measures to respond to the effects or the threats of climate change. This review studies the responses in fourteen countries and classifies adaptation measures under twelve headings, each with a unique set of characteristics. Although forests' adaptations are clearly still in early stages, the variety of responses discovered gives confidence that solutions are available. Forests around the world are both vulnerable to climate change and a substantial part of a portofolio of mitigation strategies. Forest agencies are expected to deal with these uncertainties through the development of a wide range of adaptation strategies. This report seeks to determine to what extent forest agencies are changing their policies and management operations in response to current and anticipated future climate change. In order to achieve this goal, we summarize the state of the art of forest policy responses regarding adaptation to climate change in Australia, Austria, Brazil, Canada, Chile, China, Costa Rica, Finland, France, Germany, Russia, Spain, Sweden, and the United States. The diversity of adaptation measures encountered during the expert survey and content analysis of major agency documents is clustered according to timing, temporal and spatial scope, function, and form (Table 1). The main findings resulting from the analysis are:
  - Most countries are in the early stages of adaptation, mainly developing enabling programs and stimulating research.
  - The prevailing functions of forests and the expected impacts shape the strategy chosen by forest agencies.
  - Anticipatory measures are more frequently adopted than reactive ones, probably due to the expected long term effect of climate change in forests and the difficulty of finding evidences of actual impacts.
  - In contrast with mitigation mechanisms, economic instruments are rarely developed for adaptation.
  - It is difficult to disentangle adaptation to climate change from general sustainable forest management practices.

- Jenssen, M., Hofmann, G. and Pommer, U. 2007: **Die natürlichen Vegetationspotentiale Brandenburgs als Grundlage klimaplastischer Zukunftswälder.** In: Gesellschaft Deutsches Arboretum (Ed.)(2007): Beiträge zur Gehölzkunde. Hansmann Verlag, Hemmingen, pp. 17-29. [German]
  Available for download at: http://www.waldkunde-eberswalde.de/PreprintGehoelzkunde.pdf
  Keywords: Forest ecosystem, Germany

- Milad, M., Schaich, H., Bürgi, M. and Konold, W. 2011: **Climate change and nature conservation in Central European forests: a review of consequences, concepts and challenges.** Forest Ecology and Management, Vol. 261 No. 4, pp. 829-843.
  ABSTRACT: With a predicted rise in average global surface temperature at an unprecedented rate, as well as changes in precipitation and disturbance regimes, climate change will bring forth new challenges for nature conservation in forest ecosystems. Species and habitats to be protected will be affected as well as related concepts and area specific objectives. Climate change impacts are likely to be aggravated by other anthropogenic stresses such as fragmentation, deposition or habitat destruction. To be reliable and effective, current objectives and guidelines of forest conservation need to be reassessed and improved. Our study analyses possible impacts of climate change on forests and

identifies key future challenges for nature conservation in forests and ecosystem research. We reviewed 130 papers on climate change impacts on forest ecosystems and species published between 1995 and 2010. The geographical focus of the study is Central Europe. Papers were analysed accounting for direct and indirect impacts of gradual changes as well as stochastic disturbance events in forest ecosystems and their possible consequences for nature conservation.
Even though broader aspects of nature conservation (protected areas, biodiversity) are frequently mentioned, little attention is given to forest-specific nature conservation. Particular aspects are insufficiently represented, such as the influence of climate change on different forest succession stages, the development of dead wood volume and quality, responses of secondary broadleaved species, azonal or extrazonal forests as well as ancient woodlands or remnants of historical silvicultural systems. Challenges arise in the context of great uncertainties about future developments. Nature conservation concepts and objectives in forests need to be adapted either within a permanent evaluation process or through the inclusion of further changes *a priori*, even if they are to some extent unpredictable. In some cases adaptation measures within nature conservation (e.g. adjusting protected areas) may conflict with interests of other stakeholders. Further research, particularly on interrelations between different impacts and the adaptive capacity of current forest ecosystems, associated species and existing genotypes is urgently needed. The scale and complexity of the task at hand calls for the establishment and further strengthening of international research networks.
Keywords: Conservation, Forest ecosystem, Forest management, Global warming, Central Europe

- Profft, I. and Frischbier, N. 2008: **Options and limits of climate scenarios in long term forest adaption strategies.** Forst und Holz, Vol. 63, No. 9, pp. 22-27. [German]
  ABSTRACT: Since the Pleistocene, climate conditions have been regarded as stable, despite slight variations occurring in Europe and elsewhere. However, climate change is expected to increase the variability of climatic frame conditions in the upcoming decades considering spatial and temporal temperature and precipitation patterns. Forestry has to take these changes into account for decisions with a long term perspective. One important question is the use of climate scenarios rather than historical measurements. Even with present uncertainties, climate scenarios provide helpful information for the decision making process regarding long term strategies in forestry. Against the background of the decision to employ scenario data in Thuringia, the choice of scenarios and planning horizon needs to be addressed.

- Profft, I. and Frischbier, N., 2009: **Forestry in a Changing Climate – The Necessity of Thinking Decades Ahead.** In: Feldmann, F., Alford, D.V., Furk, C.: Crop Plant Resistance to Biotic and Abiotic Factors – Current potential and future demands. Proceedings of the 3rd International Symposium on Plant Protection and Plant Health in Europe, Deutsche Phytomedizinische Gesellschaft, DPG-Selbstverlag, Braunschweig, S. 66-73.

- Schlutow, A., Profft, I. and Frischbier, N., 2009: **The BERN model as an instrument for the evaluation of tree species suitability and development of long term tree species recommendations in the context of climate change.** Forst und Holz 64 (4), S. 31-37. [German]
  ABSTRACT: Despite a long tradition, forestry and its associated research activities has hitherto been unable to provide sufficient and satisfactory information about mitigation and adaptation in terms of climate change. Because of the immediate need to develop adaptation strategies for forestry, it is not viable to postpone decisions until more and better information regarding tree species and their long term potential are available. Alternatively, the BERN model can be used to derive potential tree species suitability for Thuringia. Within this model, and associated vegetation surveys, the existence of plant species, and their dependence on various site factors, is assessed and potential distribution functions of plant communities and their related species are developed. These functions have been applied for

present and future conditions (based on scenario A1B for 2041-2070) in Thuringia to define forest communities and related tree species for specific soil and climate conditions. These results take into account the projected effects of climate change and the presumed consequences for forest ecosystems. They will be used in the assessment of present tree species recommendations and for the development of new recommendations within a complex evaluation process involving ecological, economic as well as welfare and social aspects.

4.3.2. Agriculture

- Demidowicz, G., Deputat, T., Górski, T., Krasowicz, S., Kuś, J. and Sroczyński, T. 2000: **Adaptation scenarios of agriculture in Poland to future climate change.** Environment Monitoring and Assessment, Vol. 61, No. 1, pp. 133-144.
  ABSTRACT: This paper demonstrates the ability of Polish agriculture to adapt to predicted climate change according to GISS and GFDL scenarios. Both climate-change scenarios will significantly affect farming conditions in Poland through water deficit, shifts in planting and harvesting seasons, changes in crop yields and crop structure. Neither scenario seems to endanger the self-sufficiency of Poland as long as preventative measures are taken. Moreover, the realization of GISS creates the possibility of a surplus in production. It must be emphasized that regardless of the scenario, the adaptation of agriculture to an expected climate change cannot be handled by the farming community itself.

- Kajfez-Bogataj, L 1996: **Effects of climate warming on ceres-maize yield in Slovenia: sensitivity study.** Zbornik Biotehniske fakultete Univerze Ljubljani, Kmetijstvo, Vol. 67, pp. 11-18.
  ABSTRACT: Quantitative assessment of risks related to climate variability is possible through use of dynamic crop simulation models. When models are validated for a region, they provide powerful tools for replacing much of the trial-and-error type of experimental research. Furthermore comprehensive crop models seem to be the only possible method for estimation of crop production sensitivity to climate change. This study concerns the investigation of how changes in climate could affect agricultural production in Slovenia. As an example of such an approach maize yields were simulated at location Ljubljana using CERES-Maize model. The simulations were run using baseline years (1969-1991) and two climate change scenarios: warming of 1 and 2 K, with no precipitation changes. The direct physiological effect of increased CO2 concentration was not considered in this study. Results indicate that maize and other C4 crops can benefit from global warming in Slovenia. **Keywords: Agriculture, CC impact, Slovenia, Model**

- Kajfez-Bogataj, L 2005: **Climate change and agriculture vulnerability.** Acta agriculturae Slovenica, Vol. 85, No. 1, pp. 25-40.
  ABSTRACT: Global warming is no longer just a theory or a distant threat. The overwhelming agreement among the world's preeminent climate scientists is that its impact can already be seen today and may grow worse in the future. This global warming is expected to significantly disrupt the climate system. As a result, regional temperatures and precipitation patterns will shift across the globe, affecting nearly every aspect of society. The linkages between agriculture and climate are pronounced and often complex. Crops and livestock are sensitive to climate change in both positive and negative ways. Agricultural systems are most sensitive to extreme climatic events such as droughts, floods and hail storms, and to seasonal variability such as periods of frost, cold or high temperatures, and changing rainfall patterns. Climate change could alter the frequency and magnitude of extreme events and could change seasonal patterns in both favorable and unfavorable ways, depending on regional conditions. Regional patterns of agriculture production are likely to change. Agriculture is fortunately a sector that

can adapt but farmer adaptations are influenced by many factors, including government agricultural policy, prices, technology research and development, and agricultural extension services.

- Kotschi, J. 2007: **Agricultural biodiversity is essential for adapting to climate change.** Gaia-Ecological Perspectives for Science and Society, Vol. 16, pp. 98-101.
  ABSTRACT: Agricultural biodiversity and climate change are rarely discussed in the same context. However, there are close mutual links. Biodiversity is reduced through climate change and – at the same time – is a strategic resource for coping with its consequences: The entirety of plants, animals and microorganisms in agricultural ecosystems and their genetic diversity represent the re-source base for food. With genetic resources gaining a new quality, present conservation approaches have to be re-vised. Instead of ex-situ conservation in gene banks a broader concept has to be envisaged which emphasises farmer conservation and is complemented by gene banks. The reason is twofold:
  As future needs are unknown, a maximum of genetic resources has to be conserved at the lowest possible public cost. On-farm conservation is not necessarily less costly, but the costs are mainly borne by farmers while it produces both private and public benefits, Secondly, adaptation of genetic resources to environmental change is necessary, a process that requires exposure to the environment, instead of being stored deep-frozen in a gene bank.
  Civil society organisations have taken a front-runner position in developing and spreading suit-able concepts at grassroots level. They have catalysed worldwide a boom of farmer initiatives that practise organic agriculture based on maintaining biodiversity, avoiding the use of hybrid seeds and prohibiting transgenic crops. Secondly, they are increasingly supporting local seed conservation initiatives that aim to empower local communities to protect their biodiversity and defend their community rights to seeds and knowledge. Thirdly, they have founded an alternative market for plant breeding and seed production. Mainly in Europe, various initiatives have emerged that maintain, improve and make available open-pollinating varieties of cereals and vegetables, many of which are the result of crossbreeding and selection over centuries and in danger of being lost.
  All such activities make very clear: genetic resources must remain largely in the public domain with well-balanced benefit-sharing concepts among the various stakeholders that use and con-serve agro-genetic resources.

- Laczka, É. and Faragó, T. 2008: **Climate Change Policy and Need for Adequate Statistical Information with Special Regard to Agriculture.** Lecture presented at the Conference on Climate Change and Official Statistics, 14-16 April 2008 in Oslo, Norway.
  Available for download at:
  http://unstats.un.org/unsd/climate_change/docs/presentations/CCPresentation_Hungary.pdf
  Keywords: Hungary, Climate Change Policy, Agriculture

4.4. Participation and public perception of Climate Change

- Bednar-Friedl, B., Buijs, A., Dobrovodská, M., Dumortier, M., Eberhard, K., Fischer, A., Geamana, N., Langers, F., Mauz, I., Musceleanu, O., Tátrai, I. and Young, J. 2010: **Public perceptions of biodiversity change – results from a (pilot) survey in 8 European countries.**
  Available for download at:
  http://www.alter-net.info/POOLED/DOCUMENTS/a311258/3_R5_D2_ALTER-Net_RA5_survey_report_FINAL.pdf
  ABSTRACT: For land use and conservation policies to be sustainable, there is an urgent need to better understand people's views on biodiversity, perceptions of change and their attitudes towards biodiversity management. As part of the EU FP6 Network of Excellence ALTER-Net we developed a

flexible but standardised survey instrument that could be used across a range of European countries. Our main research objective was to better understand how members of the public in different sites perceived biodiversity change, and how they evaluated these changes. In particular, we wanted to explore if the discourse of biodiversity loss – which appears rather dominant in the media and environmental policies – was shared by the general public.

In a multidisciplinary team we developed and tested a survey design which we then implemented in eight sites across Europe. Each site had to include urban, semi-urban and rural areas, and interviewees were randomly selected through common sampling procedures. Overall, we collected 2378 completed questionnaires (approximately 300 per site). While the majority of respondents seemed to perceive the number of animal and plant species to be decreasing and was worried about this, these concerns were in almost all sites stronger with regard to global than with regard to local changes. In an open-ended question, we also asked for changes that the respondents had noticed themselves in their own environment. Here, not only species loss, but also increasing diversity was reported. This implies that for many people, biodiversity loss was at the global level a shared concern, whilst local changes were seen as more complex, including the reappearance of species that had previously been under pressure. Our study also investigated the context of such perceptions and evaluations, and elicited attitudes towards changes in six different habitats and eight animal and plant species, including iconic, problematic and non-native species. These attitudes were found to be embedded in the respondents' perceptions of the species as such, as well as in their value orientations with regard to the natural environment. Other aspects of the questionnaire addressed trust in political actors, perceived effectiveness of management approaches, and the relationships between people's own experience gained through outdoor activities and engagement in nature-related NGOs and their views on biodiversity change.

Our findings have important implications for biodiversity management policies. Our results suggest that public perceptions of changes in the natural environment are much more differentiated than often assumed, and are thus likely to clash with simplified messages of either "biodiversity loss" or "alien invasions". These perceptions are well-embedded in social representations of biodiversity issues and broader worldviews, und hence unlikely to be easily manipulated through simple awareness campaigns. Communication and negotiation of biodiversity policies need to take these complex representations and their social patterns into account. In addition to elucidating these patterns, our survey instrument can serve as a basis for the development of more sophisticated indicators of public awareness of opinion than those currently applied, and could also be used for long-term studies.

Keywords: Biodiversity change, public perceptions, biodiversity policies

- Ioras F., Render M. 2006: **Conflict migration in Piatra Craiului National Park: policy recommendations.** In: Pop O. and Hanganu H. (eds.), Research in Piatra Craiului National Park. Brasov: Edit. Universitatii Transilvania, pp: 248-255.

  ABSTRACT: In the past, the general view among both conservationists and local populations has been that wildlife conservation and animal husbandry are incompatible forms of land use and should be kept apart. However, competition and conflicts over land use and access to water have intensified as demographic pressure on pastures and international concern for the conservation of biological diversity have increased. New opportunities to address these conflicts and concerns derive from more dynamic concepts of pasture ecology and changes in conservation philosophies to incorporate benefits to local people. However, the impacts of efforts to integrate conservation and development are difficult to appraise or evaluate. This paper endeavours to propose a policy for mitigating conflicts between local communities and the Piatra Craiului National Park administration, drawing on the sustainable livelihoods approach.

- Mostert, E., Pahl-Wostl, C., Rees, Y., Searle, B., Tàbara, D., Tippett, J. 2007: **Social learning in European river-basin management: barriers and fostering mechanisms from 10 river basins.** Ecology and Society, Vol. 12, No. 1, p. 19. [ZOTERO>AdaptManag]
  ABSTRACT: We present and analyze 10 case studies of participatory river-basin management that were conducted as part of the European HarmoniCOP project. The main theme was social learning, which emphasizes the importance of collaboration, organization, and learning. The case studies show that social learning in river-basin management is not an unrealistic ideal. Resistance to social learning was encountered, but many instances of social learning were found, and several positive results were identified. Moreover, 71 factors fostering or hindering social learning were identified, these could be grouped into eight themes: the role of stakeholder involvement, politics and institutions, opportunities for interaction, motivation and skills of leaders and facilitators, openness and transparency, representativeness, framing and reframing, and adequate resources. Promising topics for further research include the facilitation of the social learning processes, the role of power, and interactions in political and institutional contexts.
  Keywords: collaboration, Europe, public participation, river-basin management, social learning

- Stringer, L.C., Scrieciu, S.S. and Mark, S. 2009: **Biodiversity, land degradation, and climate change: Participatory planning in Romani**a. Applied Geography, Vol. 29 (2009), pp. 77-90
  ABSTRACT: This paper considers the role of stakeholder participation in drawing together the three Rio Conventions, exploring how participatory activities to combat desertification in southern Romania can both support and hinder efforts to conserve biodiversity and mitigate the effects of climate change. It suggests that Romania's growing civil society sector has a potentially vital role to play in promoting synergy through participation, and that participatory pact as an important mechanism for harnessing multiple benefits. The paper argues that participation needs to be further institutionalised within the Romanian context and in doing so, should emphasise empowerment, equity, trust and learning, integrating different knowledge bases to allow the development of sustainable and synergistic environmental solutions.
  Keywords: Romania, Stakeholder participation, land degradation, desertification

- Stringer L.C., Scrieciu S.S. and Reed, M. S. 2008: **Linking climate change mitigation, biodiversity conservation and the rehabilitation of degraded land in southern Romania: Synergy through participation Participating in Nature: Communities and Protected Areas in Central and Eastern Europe**. Available for download at:
  htpp://www.eci.ox.ac.uk/research/humaneco/romania-conference08.php
  ABSTRACT: Three international environmental conventions were negotiated following the 1992 Rio Conference on Environment and Development: the United Nations Convention on Biological Diversity (UNCBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD). Each of these global agreements has a different focus, yet each promotes participatory approaches to some degree. This paper considers the role of stakeholder participation in drawing together these three agreements, exploring how participatory activities to combat desertification in southern Romania interact with efforts to conserve biodiversity and mitigate the effects of climate change. Data from interviews, questionnaire surveys and transect walks are integrated with the literature in our case study, to examine participation of stakeholders from the southern Romanian community of Mârşani in efforts to rehabilitate desertified and degraded land. We identify areas of synergy where participation helped to achieve the shared goals of the three Rio Conventions, but also caution that in our case, efforts to reduce desertification and manage the effects of climate change could negatively impact biodiversity. Our case study suggests that Romania's growing civil society sector has a potentially vital role to play in promoting synergy

through participation and empowerment, and that participatory processes act as an important mechanism for harnessing multiple benefits. We argue that participation needs to be further institutionalised within the Romanian context and suggest that future participatory processes could benefit from the involvement of relevant stakeholders at all levels in order to more effectively foster synergy. In doing so, participatory processes should emphasise empowerment, equity, trust and learning and integrate different knowledge bases to allow the development of sustainable and synergistic environmental solutions.

5. Legislation and guidelines concerning climate change and nature conservation

5.1. European framework

"A number of EU directives on the environment have a significant influence on the state of biodiversity. The two EU nature directives for birds (EC, 2009a) and habitats (EC, 1992) aim to ensure a favourable conservation status for birds and their habitats as well as for other selected animal and plant species and habitat types in need of conservation. The Environmental Impact Assessment and the Strategic Environmental Assessment Directives require consideration of the potential impacts on protected species and sites of certain regional and territorial developments. The Environmental Liability Directive (EC, 2004) implements the polluter pays principle and covers damage to protected natural habitats. The Water Framework Directive (EC, 2000), in which the Nitrates Directive (EC, 1991) was integrated, has established a framework for the protection of all water bodies in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems, and mitigate the effects of floods and droughts. The Renewable Energy Directive (EC, 2009b) includes some precautionary measures for the preservation of biodiversity. The National Emission Ceiling Directive (EC, 2001), one of the main EU instruments for reducing nitrogen and sulphur emissions, binds EU Member States to respect emission ceilings. The Marine Strategy Framework Directive (EC, 2008a) brings about the obligation to manage human activities at sea sustainably through an ecosystem-based approach and links to the envisioned Integrated Maritime Policy. […]" (EEA 2010: The European environment — state and outlook 2010. Biodiversity. pp. 6 ff.)

Table 1: Focal EU Directives

(Terminology source: http://glossary.eea.europa.eu)

Directive	Description
Directive on the conservation of wild birds (79/49/EEC)	The […] Directive seeks to protect all wild birds and the habitats of listed species, in particular through the designation of special protection areas (SPA).
Habitats Directive (92/43/EEC)	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. The aim of this directive is to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Convention on Biological Diversity applies.
Water Framework Directive (2000/60/EC)	"[…] Directive establishing a framework for the Community action in the field of water policy. It aims to secure the ecological, quantitative and qualitative functions of water. It requires that all impacts on water will have to be analysed and actions will have to be taken within river basin management plans."

Climate Change Mitigation

Mitigation and adaptation are the central policy responses to tackle climate change. Climate change mitigation is being addressed globally by the United Nations Framework Convention on Climate Change (UNFCCC). The Convention's Kyoto Protocol sets emission reduction targets for 37 industrialised countries, including all countries taking part of the Habit-Change Project.

The 15 pre-2004 EU Member States (EU-15) have a joint emission reduction target of 8 % below 1990 levels by 2008–2012 below 1990 levels. Most EU-12 Member States (that joined the EU since 1 May 2004) have targets of 6-8 % emissions reduction from their base years (mostly 1990) (http://www.eea.europa.eu/themes/climate/policy-context). Parties to the UNFCCC have to submit national communications on implementation of the Convention and GHG-inventories to the Conference of the Parties. These reports provide an overview on the countries progress in reducing GHG emissions.

- The latest submitted national communications (2009) are available for download at: http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/4903.php
- Latest GHG-inventories are available for download at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php

5.2. Climate Change Adaptation Strategies

- Commission of the European Communities 2009: **WHITE PAPER — Adapting to climate change: Towards a European framework for action.** Available for download at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:EN:PDF
- Swart, R., Biesbroek, R., Binnerup, S., Carter, T. R., Cowan, C., Henrichs, T., Loquen, S., Mela, H., Morecroft, M., Reese, M. and Rey, D. 2009: **Europe Adapts to Climate Change: Comparing National Adaptation Strategies.** PEER Report No 1. Helsinki: Partnership for European Environmental Research. Available for download at: http://www.peer.eu/fileadmin/user_upload/publications/PEER_Report1.pdf
- Prutsch, A., Grothmann, T., Schauser, I., Otto, S. and McCallum, S. 2010: Guiding principles for adaptation to climate change in Europe. ETC/ACC Technical Paper 2010/6. Available for download at: http://air-climate.eionet.europa.eu/docs/ETCACC_TP_2010_6_guiding_principles_cc_adaptation.pdf

Some EEA member countries have prepared National Climate Change Adaptation Strategies or have started preparing these.

Table 2: National Climate Change Adaptation Strategies

(Source: based on http://www.eea.europa.eu/themes/climate/national-adaptation-strategies, accessed in February 2011)

National Adaptation Strategy adopted	Year	Links
Germany	2008	Combating Climate Change. The German Adaption Strategy: http://www.bmu.de/english/climate/downloads/doc/44003.php http://www.bmu.de/english/climate/downloads/doc/42841.php KomPass: http://www.anpassung.net/cln_110/DE/Home/homepage__node.html?__nnn=true
Hungary	2008	**National Climate Change Strategy (NÉS):** http://klima.kvvm.hu/documents/14/nes_080219.pdf [Hungarian] VAHAVA project: http://ec.europa.eu/environment/water/adaptation/workshops/pdf/budapest/pres_istvan_lang.pdf
NAS in preparation	**Year**	**Links**
Romania		**National Strategy on Climate Change** of Romania (NSCC): http://unfccc.int/resource/docs/nap/romadd1.pdf **National Action Plan on Climate Change** (NAPCC): http://ns1.mmediu.ro/vechi/departament_mediu/schimbari_climatice/1_Documentatie/PNASC_en.pdf **National Action Plan for Adaptation** (NAPA): currently under elaboration
Czech Republic		National Programme To Abate the Climate Change Impacts in the Czech Republic: http://www.mzp.cz/C125750E003B698B/en/national_programme/$FILE/OZK-National_programme-20040303.pdf
Austria		Auf dem Weg zu einer nationalen Anpassungsstrategie [German] http://www.umweltnet.at/filemanager/download/68173/ „Anpassungsstudie“ – Ist-Stand-Erhebung zur Anpassung an den Klimawandel in Österreich http://www.austroclim.at/fileadmin/user_upload/reports/Endbericht_Anpassungsstudie_final.pdf

5.3. National legislation

The following section contains information about the legal basis of nature protection, the management of protected areas and the adaptation to climate change. The information was provided by project partners from participating states and was partly supplemented by the authors of this review. No information from the Ukraine was obtained.

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5.3.1. Austria

Table 3: Relevant Austrian legislation

(Source: UniV (PP2), Legal Information System of the Federation (www.ris.bka.gv.at, 2010))

Legal regulation	Content
Water Act 1059	Waters Condition Monitoring Regulation: "The in § § 59c to 59f WRG 1959 provided guidelines for the establishment of monitoring programs for surveying and as the operational monitoring of surface and ground water will be met by regulation of the subject. There are criteria for monitoring stations construction, set to be monitored parameter, the frequency and the frequency of measurements, methods and procedures for sampling and analysis and for evaluation of measurement data and specifications for the data processing and transmission."
Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006): 479. Verordnung: **Gewässerzustandsüberwachungsverordnung** – GZÜV, BGBl. II Nr. 479/2006.	
Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): 103. Verordnung: **Nationale GewässerbewirtschaftungsplanVO** 2009 – NGPV 2009. Bundesgesetzblatt für die Republik Österreich, BGBl. II Nr. 103/2010.	
Water Act 1959, as amended by Federal Law Gazette I No 123/2006.	"Made with the WRG 2006 amendment, Federal Law Gazette I No 123/2006 have been with the goal of cost reduction in the WRG following changes: Introduction of a notification procedure for certain geothermal heat pumps, possibility of the elimination of the official inspection, possibility of the elimination of most recent review of expiration precautions, changes in protected areas. With the WRG 2003 amendment, Federal Law Gazette I No 82/2003, the EU Water Framework Directive was transposed into national law."

Legal regulation	Content
Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006): Bundesgesetz, mit dem das Wasserrechtsgesetz 1959 geändert wird (**Wasserrechts-Gesetznovelle** 2006), BGBl. I Nr. 123/2006.	"Proclamation of the Provincial Governor of Burgenland of 16 May 1999 concerning the agreement referred to in Article 15a B -VG between the Federal Government and the Province of Burgenland to maintain and develop the national park Neusiedler See- Seewinkel The federal government , represented by the Federal Government and the Province of Burgenland , represented by the Governor - in the following Parties called - led by the desire to be given to ecologically particularly valuable areas of national and international importance in the region Neusiedler See- Seewinkel and Further development of the national park Neusiedler See- Seewinkel have agreed to support , in furtherance of the agreement between the federal and state Burgenland for the establishment and maintenance of a national park Neusiedler See- Seewinkel of 10 September 1993 to complete in accordance with Article 15a B -VG the following agreement."
Federal Ministry of Agriculture, Forestry, Environment and Water Management (2010): Regulation of the Minister of Agriculture, Forestry, Environment and Water.	On one hand the publication of the planning document for national water management plan will be announced and on the other hand, a program of actions and priorities, and the designation of sections of water bodies as heavily modified or artificial water bodies in the context of the national water management plan be adopted.
Land Burgenland: Entire legislation for conservation and development of the NP Neusiedler See-Seewinkel , version of 16/5/1999	§ 1 (1) On the paints in the Seewinkel, Neufelder the lake and the Neusiedlersee , the shipping of vehicles and floats that are equipped with an internal combustion engine is prohibited , such prohibition applies to idle vehicles and floats . (2) As per paragraph 1, the installation equipment , attachments or other carrying a combustion engine. .§ 2 (a) The prohibition of § 1 are excluded. [...] § 3 Infringements of the prohibition of § 1 shall be punished according to § 42 maritime law as administrative violations. .§ 4 The regulation occurs with the announcement in the Official Gazette for the following day Burgenland in force. At the same time the regulation comes LGBl 10/1987 , except as amended by Regulation No. 28/1992 LGBl , strength. 250"
Land Burgenland: Entire legislation relating to restrictions on the navigation on lakes Burgenland , version of 10.08.2007	
Federal Law Gazette II No. 99/2010: Quality objective	“The regulation aims to assess the ecological quality of surface waters using fixed values according to

Legal regulation	Content
Regulation Ecology	§ 30a para 1 WRG 1959 to reach target states, and for the prevention of deterioration in terms of relevant conditions for types of surface waters. The regulation for the biological, hydro-morphological and general physical-chemical quality elements for high, moderate good, bad and unsatisfactory environmental condition should be established. The type-specific as determined, i.e. separately for rivers and lakes types types that differ by natural spatial and biotic factors, some significantly. Furthermore, the Regulation contains provisions on the handling of the legal water quality objectives in the approval process and about the quality components of what sort of pressures and influences to assess the ecological status should be specified."
Austrian National Assembly (2001): 96th federal law on attendant regulations for EMAS-V II (environmental management law - UMG) EMAS = Regulation (EEC) No 761/2001 of 19 March 2001 allowing voluntary participation of organisations a Community eco-management and audit scheme	
Austrian National Assembly (2009): Federal law on environmental liability for avoidance and remediation of environmental damages.	"…regulates measures for avoidance and remediation of environmental damages on the basis of the polluter-pays principle." (§1, Aims)
Bundesminister für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2006): 478. Verordnung: Wasserkreislaufserhebungsverordnung [Water Cycle Collection Regulation]:. BGBl. II, Nr. 478/2006.	"The in § 59c paragraph 3 WRG 1959 normalized opening and operation of a basic monitoring network for the collection of the water cycle to ensure the provision of sufficient knowledge of the available water to the amount and nature in their temporal and spatial variability. This is also the prerequisite for the identification of impacts of anthropogenic impacts on water resources and for the calculation of potential climate trends. It is further to provide basics for creation of the National Water Management Plan as well as monitoring and action programs. For the design of monitoring networks, this results in the essential requirement to arrange the measuring points so that the characteristics of the water cycle in the respective surface and subsurface catchment areas can be detected."

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- Alpine Convention 2009: Aktionsplan zum Klimawandel in den Alpen. [German, Italian] Available for download at: http://www.alpconv.org/NR/rdonlyres/D5209BD1-64A4-42DA-883B-0067E501C56D/0/AC_X_B6_fin_fin_de.pdf
  Keywords: adaptation, alpine region

- Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): Nationaler Gewässerbewirtschaftungsplan 2009. [German] Available for download at: http://wisa.lebensministerium.at/article/archive/29367
  „…Flussgebietsbezogene Planung basiert auf einem integrierten Ansatz zum Schutz, zur Verbesserung und zur nachhaltigen Nutzung der Gewässer. Sie bezieht sich auf Grundwasser und alle Oberflächengewässer, ebenso wie direkt mit dem Grundwasser oder Oberflächengewässern verbundene Landökosysteme und Feuchtgebiete im Hinblick auf ihren Wasserhaushalt. […] Der NGP soll die Planung in die Lage versetzen, einen ausgewogenen kostenwirksamen Zugang zu Gewässerschutz und Gewässerverbesserung zu finden, der die Wassernutzer – unter Berücksichtigung des Verursacherprinzips – in angemessener Weise zu Leistungen heranzieht.“
  ["...River Area-based planning is based on an integrated approach to the protection, improvement and sustainable use of water. It relates to groundwater and surface waters, as well as directly to the groundwater or surface waters associated terrestrial ecosystems and wetlands in relation to their water budget. [...] The NGP is intended to enable the planning in a position to find a balanced cost-effective access to water protection and water improvement, which draws the water users in an appropriate way to care (efforts) - taking into account the polluter pays principle."]

- Oberleitner, I., Ellmauer, T., Tiefenbach, M. (2007): Schutzgebietsbetreuung in Österreich, Grundsatzpapier der Österreichischen Naturschutzplattform, Umweltbundesamt, REP-0078.
  [http://www.naturschutz.at/fileadmin/inhalte/naturschutz/pdfs/Schutzgebietsbetreuung_OEsterreich_REP0078.pdf]
  „Eckpunkte einer umfassenden Schutzgebietsbetreuung sind Managementpläne, Bestandsaufnahmen, Monitoring, Einbeziehung aller Betroffenen und Beteiligten, Öffentlichkeitsarbeit und Bewusstseinsbildung. Die Einrichtung von Schutzgebietsbetreuungen kann zur nachhaltigen Regionalentwicklung und Arbeitsplatzschaffung beitragen.”
  [Protected area management in Austria, position paper of the Austrian conservation platform, Federal Environmental Agency:
  "Key Elements of a comprehensive protected area management are management plans, inventories, monitoring, involvement of all stakeholders and interested parties, public relations and awareness-raising. The establishment of protected area care can contribute to sustainable regional development and job creation."]

- Oberleitner, I. (2006): Österreichische Feuchtgebietsstrategie – Ziele und Maßnahmen 2006–2010. Umweltbundesamt Wien, Lebensministeriums, Abt. II/4.
  [http://www.naturschutz.at/fileadmin/inhalte/naturschutz/pdfs/Feuchtgebietsstrategie__Ziele_und_Massnahmen.pdf]

[Austrian Wetland Strategy – Aims and Actions 2006-2010. Federal Environmental Agency Vienna, Ministry of Life, Dept. II/4.

"Aims:

1. Area protection: a further decrease of wetland areas in Austria is to be opposed for ecological reasons with appropriate measures.
2. Biodiversity: The entire spectrum of the animal and plant types in Austria, bound to wetland habitats, is to become secured in viable and developable populations.
3. System quality: The ecosystems of the wetlands including their catchment areas are to be maintained regarding their functions and processes in the utmost naturalness. This means above all the protection of each specific water regime.
4. Welfare function: Recovery and experience value as well as cultural functions of the wetlands are to be guaranteed also for the future.
5. Improvement of the wetland qualities: The revitalization („revival") of impaired areas and/or disturbed functions should, wherever possible, be advanced.
6. Improvement of the wetland facilities: Where it is ecologically meaningful, wetlands should be created.
7. Development, implementation and control: All uses should be made with due regard to the protection of natural areas and on the basis of partnership developed concepts. The current use of wetlands is to check their ecological compatibility. Uses, which doesn't suit these objectives should be withdrawn, or be adapted so that they are ecologically sound."

5.3.2. Germany

Table 4: Relevant German legislation

(Sources: http://www.gesetze-im-internet.de/, http://www.bmu.de/english/soil_conservation_contamined_sites/downloads/doc/3286.php (Access 14.02.2011))

Legal regulation	Content
Federal Nature Conservation Act (Bundesnaturschutzgesetz)	Contains regulations on environmental monitoring, the German instruments of intervention regulation, and landscape planning, designation and management of protected areas, species conservation, recreation, Implementation of Community Legislation and International Law
Act on Managing Water Resources (Wasserhaushaltsgesetz)	Provisions for usage of surface waters, coastal water and the water body, river works, maintenance of waters, water protection areas and handling of water endangering matter.
Federal Soil Protection Act (Bodenschutzgesetz)	The purpose of this Act is to protect or restore the functions of the soil on a permanent sustainable basis. These actions shall include prevention of harmful soil changes (to the soil), rehabilitation of the soil, of contaminated sites and of waters contaminated by such sites; and precautions against negative soil impacts. Where impacts are made on the soil, disruptions of its natural functions and of its function.

5.3.3. Hungary

Table 5: Relevant Hungarian legislation

(Source: SIU (PP8))

Legal regulation	Description
1996./LIII. Law on Nature Conservation	neither climate change as a concept/idea nor adaptation or mitigation is mentioned
2009./XXXVII. Law on the Forests, their Protection and Management	it is the first aim to reduce the effects of CC, and the intention to organize the forest management in favour of this. According to this law, a forest can be of protective desigantion, in this case it needs proper management in front of economic function
National Nature Conservation Plan 2009-2014 (2nd Annex of the National Environmental Program for 2009-2014)	alarms on global changes, e.g. CC, and declares that actions, studies and evaluations about adaptation is of high importance. It points out the carbon capturing capacity of habitats with turf and fens.
3/2008. (II. 5.) KvVM (Ministry of Environment and Water) Regulation on the Preparation and Contents of Nature Conservation Management Plans	does not contain separate actions on CC, but the rules and methods should be followed also during ac ons in favour of adaptation.
Hungary Rural Development Program 2007-2013	The new system of agricultural (incl. management of environmentally sensitive areas) compensations is declared by the New Hungary Rural Development Program 2007-2013. Among its aims we can find the fight against effects of CC. Among defensive strategies it mentions the afforestation of agricultural and non-agricultural areas, protection against erosion, widening resources of forestry for mitigating CC effects, increasing biodiersity, protecting the state of waters etc.
Parliament decree 29/2008. (III. 20.) – National Climate Change Strategy 2008-2025 (NÉS)	The two main groups of tasks for nature conservation are adaptation locally and helping the ecological corridors between nature protected areas.
Government decree No. 1005/2010. (I. 21.) – National Climate Change Program (NÉP)	It was developped to implement the aims of the NÉS, considering also international engagements. Within the frames of adaptation to CC, the NÉP formes instructions in favour of helping local adaptation and preserving the existing biological diversity.

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- Collection of **recommendations for preparing management plans on Natura 2000 areas** according to the Habitat Directive. [Hungarian]
  English-language extract for the project entitled „Preparation of the management plans of the Natura 2000 areas and rendering the related services", 2009: www.naturaterv.hu/dok/Natura2000-final-report-extract.pdf

5.3.4. Italy

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- Bioitaly. Available for download at: http://wwwbioitaly.casaccia.enea.it/wwwbioitaly/
- Nature Park Guidelines and legislation available for download at: http://www.provinz.bz.it/ressorts/generaldirektion/lexbrowser_d.asp
- Rilasciati, Vaghi and Clini December 2002: Italy Country Base Line Study: Water, Wetlands and Climate Change, Buliding Linkages for their Integrated Management, Mediterranean Regional Roundtable Athens, Greece.
  http://www.uicnmed.org/web2007/CDCambio_climatico/contenido/E/PDF/CC_e4.pdf

  "[…] this country baseline study will examine which polices and management practices Italy has already considered and is planning to carry out to respond to climate change effects to water and wetland resources. In particular, the study will point out and suggest feasible climate change adaptation strategies for water and wetland resources, lined up to national and regional priorities. After a brief analysis of the country context and the identification of key vulnerabilities components of water and wetland resources to climate change (Part A), the study focuses on the national institutional system dealing with climate change, water management and wetlands (Part B), the level of integration of water and wetland resource management and climate change (Part C), and finally the possible adaptation strategies (Part D). A noteworthy climate variability has been observed during the last decades through the analysis of historical series and scientific data: according to these figures, temperature has increased and rainfall decreased on the overall national territory, giving as overall result drier conditions. Therefore, water remains a critical factor in Italy in terms of vulnerability of both hydrological cycle and ecological systems as wetland resources, which are closely interrelated.
  Part A identifies the key vulnerabilities components to water and wetlands resources to climate change such as water consumption by agriculture, coastlands resources and typical Mediterranean ecosystems. **Part B** shows that, if on the one hand the institutional framework of climate change, water

resource management and wetlands sectors, taken individually, is broad and well organized, on the other, taking into account the strong inter-connection among the three sectors, a closer collaboration would be desirable. The recent reform of the Ministry for the Environment and Territory represent a further important step toward a better coordination among all environmental sectors. With the new structure, the Ministry has both an ecosystem protection function, through the definition of sustainable development models, and a new role in planning policy, with the aim to protect the environment. Nonetheless, other Ministries, National Administrations, Regional and Local Authorities have also a fundamental role in the management and implementation of defined environmental policy areas.

Part C illustrates that adaptation policies and measures must be identified in the sectoral legislation regarding: the soil defense; the remediation of contaminated site; the extractive activities; the hydrological vulnerability; the protected areas; the natural habitat; the water resources and water defense

The research conducted for this study brought to the conclusion that Italy does not have a specific legal framework where adaptation to climate change is expressly mentioned. The recent climate change National Action Plan, prescribed by law 120/2002 ratifying the Kyoto Protocol, which defines guidelines for greenhouse gases reductions, has not changed this approach. Emphasis is given to the energy and transport sectors, nonetheless, its approach has a broad, indirect effect on the entire water sector, integrating the existing national and local provisions on water and wetlands. Hence, the National Action Plan can be seen as a natural step toward the achievement of the goals set by the 2002 Environmental Action Strategy for Sustainable Development. Thus, if on the one hand planned measures and policies demonstrate that Italy is moving to comply with the UNFCCC climate change commitments, major efforts must be undertaken to strengthen water and wetland adaptation instruments to climate change policies. In fact the UNFCCC includes clauses to the effect that that all Parties shall formulate, implement, publish and regularly update national and regional programs containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change (Article 4, Section 1 (b). The Convention further records agreement to the effect that all shall take climate change considerations into account, to the extent feasible, their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessment, formulated and determined nationally, with a view to minimizing adverse effects on the economy on public health, and on quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change (Article 4, Section 1 (f)). An appropriate step towards implementation of the above mentioned commitments is the draft of the Third National Communication to the UNFCCC where adaptation planning measures for water and wetland resources are also considered. In fact Italy is one of the first countries beside the wider-EU to prepare the Third National Communication to the UNFCCC including a specific chapter with concrete adaptation measures and actions on sea level rise, desertification, agriculture, and forests. The proposed actions of the National Action Plan and the Third National Communication would suggest that climate change needs to be taken into account in sectoral legislation - as well as policy, planning and management activities in those sectors, at all levels of government, where it is relevant.

Finally, **Part D** presents different opportunities to reduce the risk of climate variability and change for Italian water and wetlands resources. A number of

key assumptions for developing adaptation responses for water and wetland resource sectors is presented. In addition a series of suggestions are offered to integrate adaptation responses into the water, wetland and climate sectors. Since it is difficult to predict far in advance how climate change will affect a particular site, the study suggests that it should be better to avoid adaptation measures that could fail or have unanticipated social or economic consequences if climate change impacts turn out to be different than anticipated (IPCC 1998). More appropriate would be "no regrets" adaptation measures that would be justified even in the absence of climate change. Examples of least-regret measures include data and information collection, training and other forms of capacity building, scientific research and institutional development. Another type of least regret measures involves the additional investment in infrastructure with long turnover times to take anticipated climate change into account."

- Autonome Provinz Bozen-Südtirol 2007: **Natura 2000 Managementplan. Naturpark Rieserferner-Ahrn.** Autonome Provinz Bozen-Südtirol. Available for download at: http://www.provinz.bz.it/natur/Natura2000/d/default.htm

5.3.5. Poland

Table 6: Relevant Polish legislation

(Source: BNP (PP9), IOS (PP10))

Legal regulation	Content
Legal acts concerning air protection, including climate protection[1]:	
Act of 27 April 2001 on Environmental Protection Law (Official Journal of Laws of 2008, No. 25, Item 150, as amended)	The Act contains provisions concerning air protection which consists in ensuring its best quality.
Act of 22 December 2004 on the Emission Allowance Trading Scheme for Greenhouse Gases and Other Substances (Official Journal of Laws of 2004, No. 281, Item 2784, as amended)	The Act transposes Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.
Act of 17 July 2009 on the System to Manage the Emissions of Greenhouse Gases and Other Substances (Official Journal of Laws of 2009, No. 130, Item 1070)	The Act lays down the responsibilities of the National Centre for Emission Balancing and Management, the principles of the operation of the National System for Emission Balancing and Forecasting, the principles of the management of emissions of greenhouse gases and other substances, the principles of the operation of the National Registry of the Kyoto Units, the principles of trading in and managing the Kyoto units, the principles of the operation of the National Green Investment Scheme and the Climate Account, the terms and conditions of the management of the Joint Implementation projects in the territory of the Republic of Poland, the terms and conditions of the management of the Joint Implementation projects and the Clean

[1] The air protection instruments under the abovementioned regulations include, inter alia:
carbon dioxide emission allowances; emission limit values; the obligation to measure pollutant emissions; environmental quality standards; air quality assessment system; the obligation to measure the levels of substances in the air (the air monitoring within the framework of the State Environmental Monitoring System (SEMS) comprises the measurement and assessment of air quality in terms of its pollution with a view to observing phenomena of continental nature and research on phenomena of global nature); permits for the use of the environment; environmental management systems – voluntary commitments of stakeholders to take measures to systematically reduce the environmental impacts of the activities carried out; fees for the release of gases or particulate matter; administrative fines (imposed for exceeding the quantity or type of substances defined in the permit as allowed to be released into the air); information on the environment.

Legal regulation	Content
	Development Mechanism projects outside the territory of the Republic of Poland.
Act of 20 July 1991 on the Inspectorate for Environmental Protection (Official Journal of Laws of 2007, No. 44, Item 287, as amended)	This Act establishes the State Environmental Monitoring System and the rights and duties of the State in the scope of the control of the state of the environment and enforcement of the regulations on the protection of the environment for all its elements (including e.g. air, forests, waste).
Act of 3 October 2008 on the on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Official Journal of Laws of 2008, No. 199, Item 1227, as amended)	The Act regulates the principles and procedures of the provision of information on the environment and its protection, environmental impact assessments and the principles of public participation in environmental protection and establishes the General Directorate for Environmental Protection with the aim of improving the process of managing the environment. The Act provides that projects likely to have a significant or potential impact on the environment or Natura 2000 sites will require an assessment to cover the environment, human health and the quality of human life, property, cultural heritage, access to mineral deposits, the ways of preventing and reducing the adverse impact of the planned projects on the environment and the required scope of the monitoring of the projects.
Further legislation:	
Act of 3 February 1995 on protection of agricultural and forest lands (Dz.U. Issue 16, item 78 as amended, last amendment of 2 April 2004 (Dz.U. of 2004, Issue 121, item 1266).	The Act regulates the principles of protection of agricultural and forest lands reclamation and improvement of land use value. It specifies permissible transformations of forest areas for non-forest purposes.
Act of 28 September 1991 on forests (Dz.U. of 2005, Issue 45, item 435 as amended).	The Act lays down the principles for preserving, protecting and increasing forest resources, as well as the principles of forest management in conjunction with other elements of the environment and of the national economy.
Act of 16 April 2004 on natural protection (Dz.U. of 2004, Issue 92, item 880 as amended).	The act corrects and expands the regulations setting out the scope of protection plan, which was necessary for the effective Natura 2000 areas protection. Preparation of the protection plan and protective actions plan for the Natura 2000 area and its subsequent implementation will a manner of meeting the obligation resulting from Art. 6(1) of the

Legal regulation	Content
	Habitat Directive and Art. 4 of the Bird Directive and implementation of the directive goal in an appropriate scope – maintenance or restoration of the proper condition of protection of protection subjects in the Natura 2000 network. An important purpose of amendment of the Act of 16th April, 2004 on environmental protection (that was made in 2008) was improvement of principles of protection planning for the Natura 2000 areas in a way that would make it faster and more flexible to implement planning procedures. Protection activities plan will be developed for the Natura 2000 areas for the period of 10 years.
Act of 3 October 2008 on making available information on the environment and its protection, social participation in environmental protection and on environmental impact assessments (Dz.U. of 2008, Issue 199, item 1227 as amended)	The act regulates principles and procedures during making available information on the environment and its protection, environmental impact assessments and principles of social participation in environmental protection. It also establishes the General Directorate for Environmental Protection, the purpose of which will be to make the environment management process more efficient. The act introduces a provision according to which enterprises that may significantly or potentially significantly affect the environment and the Natura 2000 areas will require carrying out an assessment within the confines of which specified were: environment, health and living conditions of the people, property, historical monuments, availability of fossil fuels, methods of prevention and limitation of environmental impact of planned investments as well as the scope of monitoring of the enterprise. The act also applies to forestry, in particular the basic forest document, i.e. the forest organisation plan, which may be treated as one of the strategic documents. Forest organisation plans, the scope of which includes the Natura 2000 areas are subject to environmental impact assessment through preparation of a Natura 2000 area impact forecast.
Act of 13 April 2007 on prevention of environmental loss and its remediation (Dz.U. of 2007, Issue 74, item 493)	The acts regulates principles of responsibility for environmental damages prevention and its remediation.

Guidelines

- **State Environmental Policy for the Years 2009–2012, considering perspectives for 2016**: The key governmental document formulating the national climate policy is the State Environmental Policy for 2009–2012, considering perspectives for 2016, approved by the Parliament (Sejm) on 22 May 2009. The document specifies objectives, priorities, challenges and tasks for the years 2009-2012 considering perspectives until 2016 as regards all natural components. The document takes into account, to a broader extent, issues mentioned in the Climate Convention and Kyoto Prot ocol, which results from the fact that climate protection has gained importance not only for environmental protection, but also for economic and social activities. For the purpose of ecological policies implementation, environmental protection programmes are prepared.

- **Poland's Climate Policy. Strategies for greenhouse gas emissions reduction in Poland until 2020**: The document specifies the state climate policy, specifies the basic objectives, priorities and tasks concerning economic sectors that are responsible for the majority of the national GHGs emissions.

- **National Strategy for biodiversity preservation and reasonable use with an action programme. Document approved by the Council of Ministers on 25 February 2003**: The ultimate goal of the Strategy is to preserve all natural environmental values and ensure sustainability in the development at all organizational levels. Biodiversity preservation must apply to the entire nature of Poland, irrespective of the form of its use or the degree of its transformation or damage. The National Strategy for biodiversity preservation and reasonable use with an action programme is taken account of in undertaking all activities connected with the protection and management of natural resources in Poland.

5.3.6. Romania

Table 7: Relevant Romanian legislation

(Source: UniB (PP 12), DDNI (PP 14))

Legal regulation
National Action Plan regarding the climate changes (PNASC)
Romanian National Strategy regarding climate changes 2005-2007
The Constitution of Romania (hereinafter CR) was promulgated and approved by referendum in 1991. Articles 38 (Paragraph 2) and 41 (Paragraph 6) from the constitution are based on the concept included in Art. 100 a) Paragraph 1 of the Treaty establishing the European Union: principles concerning health, safety, and environmental protection. http://archive.rec.org/REC/Publications/EUlaw/FeeBased/Romania3.html
EA Nr. 9/1973 mentions that environmental protection is a national problem which is integrated into the general social and economic planned activity of the state (Art. 1), specifying that environmental protection is primarily the duty of legal and natural persons. (Art.2)
Law no. 137 - 1995 on the environmental protection http://www.camera-deputatilor.ro/legislatie/eng/vol19eng.pdf
Law no. 26 - 1996 Forest Code http://faolex.fao.org/docs/texts/rom13320.doc
Law no. 107 - 1996 Water Law http://www.cdep.ro/legislatie/eng/vol28eng.pdf
Law no. 182 - 2000 regarding the protection of the movable national heritage http://www.cultura.ro/Files/GenericFiles/Law-182-2000.pdf
Law no. 407 - 2006 Law on Hunting
Law no. 255 - 1998 on the protection of new plant varieties http://www.upov.int/en/publications/npvlaws/romania/Romania-Law-2001.pdf
Law no.24/1994 according to United Nations Framework Conventions on Climate Change, Rio de Janeiro 1992
Law no.1294/2003 regarding the approval of governmental emergency ordinance no. 91/2002 for add-ons in law 137/1995 Law no.462/2001 regarding the status of protected areas, conservation of natural habitats, flora and fauna
Law no.86/2000 regarding the information accession, public participation on decisions for environmental problems
Government Resolution no. 349/2005 on waste storage, repealing HG 162/2002
Government Resolution no. 621/2005 on the management of packaging and packaging waste, repealing HG 349/2002 and HG 899/2004
Government Resolution no. 645/2005 for the approval of Romanian National Strategy regarding the climate changes

Legal regulation
Government Resolution no. 1877/2005 concerning the approval of National Action Plan on climate changes
Government Resolution no. 658/2006, concerning the re-establishment of National Committee for climate changes, published in Official Gazette no.465 / 2006
The ministerial Order no. 880/2004 of the Ministry of Environment and Waters Administration on reporting procedures for packaging and packaging waste
The ministerial Order no. 462/1993 on Technical Conditions concerning Air Protection and Methodological norms on Determining Emissions of Air Pollutants of Stationary Sources
The ministerial Order no. 1170 - 2008 on guide approval regarding the adaptation on climate changes effects

Guidelines

- **Guide regarding adaptation process to climate change effects**. (english version)
- **Climate changes scenarious concerning the changes in climatic regime in Romania for the period 2001-2030.**
- **The Mayor management manual for extreme floods conditions**
- **The National Strategy of Management on flooding risks**
- **Management Master Plan of Danube Delta Biosphere Reserve Administration**
- Stanciu E., Florescu F. 2009. **Ariile protejate din Romania. Notiuni introductive.** Brasov: Edit. Green Steps. 87 pp. [Romanian]
  CONTENT: I. Biodiversity conservation in protected areas, II. What represent the protected areas and which is their importance?, III. From the history of protected areas in Romania, IV. Categories of management used in the protected areas according the IUCN rules and Romanian legislation, V. The protected areas values and benefices, VI. The protected areas pressure and threats, VII. The Romanian system of protected areas administration, VIII. The decision system in protected areas , IX. The management of protected areas

6. Résumé

With this literature review a comprehensive information basis on climate-change related publications on impacts, modelling and the management of protected areas is now available for all project partners of the Habit-Change Project. Though the review is already very extensive it has to be admitted that it covers only a part of the topical literature available, as a search in Google Scholar or other search engines shows.

The selection made with this review follows the topics and problems dealt with in this project. Most of the sources in this review contain a large number of citations and references that may also be of interest for the project. Therefore we recommend to start with the literature compiled in this review and proceed with the cited sources.

To facilitate the work with this review we added as many hyperlinks as possible and also abstracts of the content where they were available. Literature on different topics is subsumed in separate chapters to make search a little easier. Even though the particular literature focuses on defined subjects and therefore is listed in the matching chapters, it may also contain information on subjects that are listed in other chapters. To find all relevant literature of interest it is recommended to use the search function of the document to search the whole review for relevant sources.

Since research on climate-change related topics is still very substantial, more relevant literature will be published in the remaining time of the Habit-Change Project. Although it is not planned to update this review the Zotero database used in the project offers an excellent chance to keep up to date and provide new information for all project partners. All project partners who stumble over literature that is so far not included in this review are encouraged to use the Zotero database for distribution and send links to interested partners.

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