

# Implementing biodiversity risks in the classroom - the educational software PRONAS

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**Abstract:** Climate change and dramatic loss of biodiversity are essential subjects for EU research. However, little of current knowledge is reaching the young generation. In order to implement biodiversity research into the reality of school education we brought members of the scientific and educational communities together. Educational software has been developed which combines desk (or rather lap-)top work with field experiences by combining virtual excursions with real ones. The software PRONAS shows how scientists handle questions about the impact of climate change on species' habitats. It makes core results of research projects available for students from 12 to 19 and is freely accessible on [www.pronas.ufz.de](http://www.pronas.ufz.de). Three basic scenarios characterize "possible future worlds" – where the scenario GREEN is the optimal scenario describing sustainable development strategies for Europe. The pessimistic scenario RED stands for a growth applied strategy – a future world which is dominated by the market. The software has five parallel entries: (1) The storyline with "Tom and Tina", (2) the "Science" entry with detailed information, (3) four virtual excursions, (4) the "Species gallery" with more than 30 plant and animal species, and (5) Interactive projects. A special book for teachers - which was written in close cooperation with teachers - shows how to implement PRONAS in the in- and out-of-classroom learning.

**Keywords:** Biodiversity, climate change, scenarios, software, education

## 1 INTRODUCTION

In times of climate change and dramatic loss of biodiversity we are facing the risk of bringing up a generation that does not care about the conservation of animals, plants, and landscapes. Current education and leisure patterns lead to ongoing distraction of young people from nature (Brämer 2010). As their free time is taken up by computers, games, television and other multimedia, nature plays a minor role in daily life of the young generation. They spend increasingly more time in front of TVs and computers: In 2010 German school students (12 to 19 year old) surfed in the internet for more than two hours (138 min) per day. 63% own a personal internet connection – this is twice as much as it was ten years before (MPFS 2010). Subjects related to nature education had low priority in school curricula for many years. Formal education in many cases still focuses on subject-specific and theoretical contents. Students often learn about a wide range of biological topics, from assimilation and digestion to the components of the nucleus, but biodiversity education is mostly lacking (Ulbrich 2010).

As early as in 1992, the International Convention on Biological Diversity (CBD) emphasized the global commitment to the conservation of nature and it

underpinned biodiversity in the fields of environmental education. Scientists, teachers, and politicians have the duty to join forces in teaching young people to understand and appreciate biological diversity. New concepts and contents have to be created that have the potential to develop core competencies of future ecologically responsible citizens (eco-citizens).

The implementation of new concepts and contents into the educational system requires activities from policy, science, and society. Otherwise, we face the risk that inaction inevitably will lead to a lack of interest in biodiversity conservation.

How can scientists, in particular biodiversity researchers, bring across their research to the daily lives of school students? Furthermore, how can they get to motivation and sustainable engagement of young people as an essential stakeholder group - future citizens and decision makers?

Scientists have the responsibility to communicate the problem to politicians and policy makers to initiate top-down processes. On the other hand, bottom-up activities are necessary for which scientists and teachers should take the initiative to work together.

Close cooperation should be based on the awareness that high-quality science education is required not only for sustaining a lively scientific community that is able to address global problems like global change and biodiversity loss, but also to bring about and maintain a high level of scientific literacy in the younger generations. There is no doubt that effective education is the basis for enabling future decision-makers to solve global problems.

In the PRONAS project, the process of software design was led by environmental researchers. Experts from pedagogical research, teachers from schools and environmental visitor centres were invited to numerous workshops to discuss content and didactic related aspects. Evaluation was realised on three stages: Before, between and after software development. More than hundred students have been questioned about biodiversity issues at the first stage. About 10 classes with 13 to 17 year old students have been involved in evaluation at the second stage, and up to now about 10 classes tested the software after publication on 10 April. Software design was discussed and disseminated on several teacher qualification courses with more than 50 teachers.

The education software PRONAS aims at improving biodiversity literacy among school students and their teachers, but also of the wide public. The main target group are students from 12 to 19 years. Students will gain core competencies that enable them to a responsible decision-making in the future and to ensure the development of the next generation of scientists (Ledley et al. 2011).

## **2 SCIENTIFIC BACKGROUND AND METHODS**

### **2.1 The ALARM-Project**

The scientific content for PRONAS has been mainly derived from the biodiversity research project ALARM (Assessing LArge-scale environmental Risks for biodiversity with tested Methods; Settele et al. 2010) which was an Integrated Project (IP) within the 6th Framework Programme of the European Commission (short: 'Com mission' or EC). The ultimate aim of the ALARM project was to develop and test methods and protocols for the assessment of large-scale environmental risks for biodiversity. To do so, ALARM has integrated the research results of more than 250 scientists of 68 institutions from 35 countries.

ALARM provides coherent scenarios of socio-economic, climate, land use and other biodiversity-relevant trends, exploring the framework conditions for biodiversity pressures (Spangenberg et al. 2012). Each ALARM scenario consists of a storyline or narrative, of which several elements are quantitatively illustrated by different, partly integrated models. Three draft storylines have been developed, one assuming a shift towards a coherent liberal, growth focussed policy (GRAS, GRowth Applied Strategy), the second a sustainability policy scenario (SEDG, Sustainable European Development Goal), and the third one (the reference case,

BAMBU – Business-As-Might-Be-Usual) a scenario describing the continuation of current policy trajectories.

Knowledge transfer to public policy makers, the business world, scientists, and civil society has been a key aspect of ALARM. Recommendations for political and socio-economic measures have been developed which indicate policy options to reduce the negative impacts of climate change on biodiversity. A Risk Assessment Toolkit (RAT) was developed which provides a web-based interface to a database created by the scientific teams within ALARM. Furthermore, the online resource Ker-ALARM (<http://keralarm.kerbabel.net/>) introduces visitors to key approaches and results of the ALARM project, and the ALARM Atlas (Settele et al. 2010) presents a complex array of quantitative and qualitative risk assessments. However, these resources are not suitable for educating the young generation. The project PRONAS has been initiated to bridge this gap.

## **2.2 PRONAS approach**

Can we still see the brimstone butterfly, the common toad and the spruce in 50 years? What about the impact of climate change on biological diversity? The educational software PRONAS shows, how scientists deal with such questions. The project has been started in the last year of the ALARM project. The overarching objective of PRONAS is to provide users an understanding of risks for biodiversity and the impacts of climate and land use. The main target group are students from 12 to 19 years.

The scenarios GREEN, YELLOW and RED are equivalent to the ALARM scenarios SEDG, BAMBU and GRAS. For the young users, the scenario names and descriptions have been adjusted and simplified. Understanding of the backcasting scenario approach will strengthen dynamic and critical thinking – core competencies addressed by the today's education system. An essential concern of PRONAS is the implementation of project results into the classroom. A handbook for teachers compiled in close cooperation with teachers provides the basis for effective application in school lessons. Furthermore, PRONAS supports the "out-of-classroom-learning": With virtual excursions the project aims to encourage students to move from the computer into nature. Excursions are designed in a way which favours "retracing" of virtual trips in reality, or – at least – those excursions may motivate to go out for individual trips.

## **2.3 PRONAS network**

The project PRONAS has been initiated for communicating ALARM results to the education sector. Thus, as a foundation, a network was needed consisting of biodiversity researchers and educators. In the course of the project work, close cooperation has been developed with teachers, environmental educators, pedagogical scientists and art educators. High school students have been involved to discuss and evaluate content and design. The network has been an indispensable resource for the implementation and dissemination of PRONAS.

# **3 THE SOFTWARE**

## **3.1 Structure**

The PRONAS-Software provides five entries for the user: (1) the story line with "Tom and Tina", (2) the chapter "Science" with detailed explanations based on research studies, (3) virtual excursions to four different regions, (4) a "species gallery" with short portraits of more than 30 plant and animal species, and (5) an entry named "Be active" which offers suggestions for individual activities, e.g. for

observation of trees, construction of trap nests for wild bees, monitoring plants (e.g. *Sanguisorba officinalis*), or energy saving.

A hand book for teachers is provided for free download. This book was elaborated jointly with teachers and is therefore designed straight for teachers' use in the classroom. It contains worksheets with concrete links to the curricula and suggestions how to implement PRONAS in everyday teaching.

### 3.2 The storyline with “Tom and Tina”

The storyline is a tour guided by two virtual companions called Tom and Tina (Fig. 2). For many users, in particular for younger ones, this might be the preferred entry. The starting point is the schoolyard where Tom and Tina discuss what climate change is about. The storyline provides interactive tests and simulations. Potential geographical distributions of the Titania's Fritillary butterfly (*Boloria titania*) and its food plant, the Common Bistort (*Polygonum bistorta*), can be simulated up to the year 2100 with a time step of one year. Permanently occupied, lost and newly gained areas are shown under the assumptions of the scenarios GREEN, YELLOW, and RED. Recent studies indicate that there will be an increasing spatial mismatch over time regarding the niches of some plants and butterflies (Schweiger et al. 2008). As the butterfly is limited both by climate and host plant, the area suitable for the butterfly may decrease significantly.

### 3.3 The Science entry

The second entry provides information about the topics of scenarios, climate change, biodiversity, pollination, and the method of climate niche modelling. This entry might fit the need of high school students. As managing change faces the challenge of the intrinsic uncertainties of future, scenarios are alternative, dynamic stories that capture key ingredients of our uncertainty about the future. Rather than predictive frames, scenarios are regarded as tools for preparing societal and individual responses to plausible futures. The scenarios GREEN, YELLOW, and RED are based on the ALARM scenarios SEDG, BAMBU and GRAS (Settele et al. 2010).

- The scenario RED describes a future world based on economic imperatives like primacy of the market, free trade, and globalisation. Deregulation (with certain limits) is a key means, and economic growth a key objective of politics actively pursued by governments. Environmental policy will focus on damage repair (supported by liability legislation) and some preventive action which is based on cost-benefit calculations and thus limited in scale and scope. Mean temperature is assumed to increase by 4, 1 °C until 2080.
- YELLOW describes a continuation into the future of currently known and foreseeable socio-economic and policy trajectories. Policy decisions already made are implemented and enforced. At the national level, deregulation and privatisation continue except in “strategic areas”. Internationally, there is free trade. Environmental policy is perceived as another technological challenge, tackled by innovation, market incentives and some legal regulation. The result is a rather mixed bag of market liberalism and socio-environmental sustainability policy. In this scenario, mean temperature increases by 3, 1°C until 2080.
- GREEN describes a policy primacy scenario focused on the achievement of a socially, environmentally and economically sustainable development. It includes attempts to enhance the sustainability of societal developments by integrating economic, social and environment policies. Aims actively pursued include a competitive economy, a healthy environment, social justice, gender equity and international cooperation. As a normative backcasting scenario, policies are derived from the imperative of stabilising atmospheric Greenhouse gas concentrations and ending biodiversity loss. Mean temperature increases by 2, 4 °C until 2080.

Based on the scenarios, geographical distributions of species throughout Europe are presented – they include 15 butterflies, 2 amphibians, 4 reptiles, 3 trees, 3 flowers. Geographical distributions of species groups include amphibians, reptiles, mammals, birds and vascular plants in Europe. The projections demonstrate which area could be lost for a species as a consequence of climate change. It is also shown which new regions could be occupied by the species in the case it is able to disperse there. An example for a typical “loser” of climate change is the Scarce Copper (*Lycaena virgaureae*) – one of our most beautiful butterflies. The Scarce Copper is expected to lose a significant part of its territory in Europe until 2080 even if the sustainable scenario GREEN is assumed (Settele et al. 2008).

### 3.4 Virtual excursions

The third entry invites to virtual excursions. These excursions take the user to regions in lowland meadows, in mountainous regions (with an altitude of about 700 m asl), and in the foothills of the Alps (Fig. 3). They provide frames for discussing the impact of climate change on species living there. Plants and animals are “discovered” and “monitored” on the trips. The excursions are about 5 kilometres in length and can be easily done in practice. Maps with the positions described in the software are available for download.

### 3.5 Species gallery

The coverflow-like gallery includes portraits of more than 30 plant and animal species. We had to select a reasonable number of species out of a data base of many hundreds of plants and animals. For this purpose, more than 100 students have been asked which species they wished to be included in PRONAS. Evaluations resulted in a significant interest for butterflies (although the knowledge on particular species was very low). The highest ranked amphibian was the Fire Salamander (*Salamandra salamandra*), the most popular tree species was the German Oak (*Quercus robur*). High scores also were received by the Big Nettle (*Urtica dioica*) and the Poppy (*Papaver rhoeas*). Species such as the nettle (which is a common food plant for butterflies) are of particular importance for education purposes as they allow the analysis of species-species interactions. Results of the polls have been considered in the composition of the species gallery.

### 3.6 “Be active”

The last entry provides suggestions for “Citizen Science” projects – for monitoring and nature conservation activities as well. Examples are the monitoring of trees and their phenological stages, construction of artificial nests for wild bees, monitoring of *Sanguisorba officinalis* which is a basic food plant for the *Maculinea* butterflies, and several others.

## 4 CONCLUSIONS

PRONAS intends to bring knowledge, which is available in Earth Science, from the spheres of science really “down to Earth”, i.e. into classrooms. The supportive structure of both the software and the associated teacher handbook convey effective application. With virtual excursions PRONAS intends to bridge the gap between virtual and real world – stimulating to real excursions. Broad dissemination has been favoured by the capable network of scientists and educators. PRONAS provides alternative learning approaches that can encourage a variety of young users – those who are open to new learning techniques and even those who may not respond well to traditional teaching formats. Through provision of scientific information based on current research projects such as ALARM the software

supports the development of critical and dynamical thinking and other competencies and skills that are essential for the young generation (see also Ulbrich et al. 2008). In this way, PRONAS offers an opportunity to better understand how human activities, like land-use and climate change, impact on biodiversity at local and global levels. It increases the sensitivity of young people concerning their roles and responsibility in these processes.

The design process included several evaluation events. Results improved our understanding of the target groups and caused numerous changes in concepts and design. A survey among more than hundred students was arranged just at the beginning. It confirmed that students accept educational software for individual homework. This encouraged us to design teaching modules for flexible use – where the software is combined with conservative teaching methods. Tests conducted with about forty 15 year old students at an early stage of software design indicated that students disliked graphical solutions of the storyline with “Tom and Tina”, Considering that graphical solutions are crucial for young users, we changed the design using photographs of students as the basis for storyline actors.

The target group of young teachers had a considerable impact on the description of the scenarios, adjusting phrasing to pupils’ attitudes and choosing the intuitive names GREEN, YELLOW, and RED.

Test runs in the final phase of the design process resulted in the improvement of interactive exercises. Their number was increased; exercises of different difficulty levels were made available in many places. About fifty teachers tested PRONAS at teacher qualification seminars and gave constructive feedback, in particular related to best practice projects in the entry “Be active”, to formulations of texts and to incentive algorithms for quizzes.

The educational software PRONAS was published in April 2012 on [www.pronas.ufz.de](http://www.pronas.ufz.de). Feedback of users will be analysed carefully and considered in update versions.

## ACKNOWLEDGEMENTS

We thank the DBU - Deutsche Bundesstiftung Umwelt (AZ 26271-41) for the financial support.

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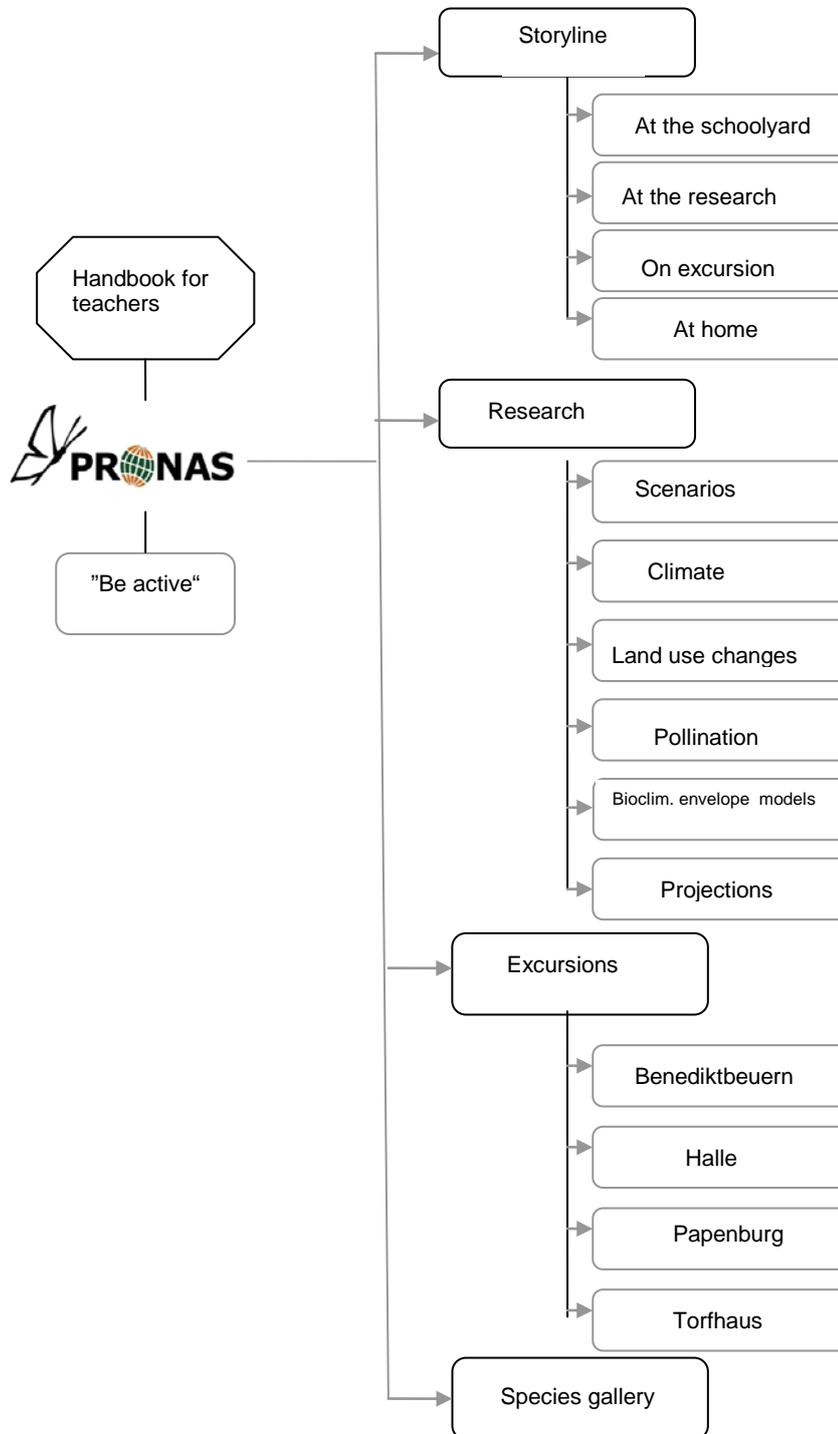


Figure 1, Sitemap of the software PRONAS



Figure 2, Storyline with „Tom and Tina“



Figure 3, Virtual excursions in PRONAS