Conference Volume	6th Symposium for Research in Protected Areas 2 to 3 November 2017, Salzburg	pages 45 - 47

Threats of Climate Change to Single-Island Endemic Species in Protected Areas

Carl Beierkuhnlein & Severin D.H. Irl

Department of Biogeography, Bayreuth Center for Ecology and Environmental Research (BayCEER), Geographisches Institut Bayreuth (GIB), University of Bayreuth, Bayreuth, Germany

Abstract

The Island of La Palma (Canary Islands, Spain) is protected as a whole (La Palma World Biosphere Reserve) and within this frame in parts as a national park (Caldera de Taburiente) and additionally through sites of special conservation status, and Natura 2000 sites. The island hosts a large number of archipelago endemic (AE) plant species and also single-island endemic (SIE) plants. These species even contribute substantially to local species richness, biomass and functioning of ecosystems, and they cannot be replaced through species from other regions. In consequence, there is an urgent need to detect spatial patterns and changes in the distribution and performance of these species in order to adapt the management of Protected Areas to the increasing pressures. Here, we present together with local administrative management a detailed analysis of the contribution of endemic species and of the respective threats that need to be addressed in adaptation strategies. Also we show how monitoring and the control of success can be implemented with the support of Earth Observation. The study is part of the H2020 Project ECOPOTENTIAL.

Key Words

National Park, MAB, La Palma, Invasive Species, Herbivores, Trade Winds, Precipitation Change

Introduction

Endemic species that are restricted to a small area of distribution and small total population sizes, respectively, are particularly threatened by extinction. Several Protected Areas (PAs) are designed and justified mainly for the protection of such species. On islands, and particularly on oceanic islands that are highly isolated and have never been in contact with terrestrial surfaces of continents, the proportion of endemic species is remarkably high compared to other land surfaces. Endemicity is even enhanced in the case of a pronounced topography on these islands of volcanic origin (IRL et al. 2015, IRL 2016, STEINBAUER et al. 2016).

Climate change and the correlated increase of weather extremes are posing new challenges to nature conservation (BEIERKUHNLEIN et al. 2016). Island biota in particular are threatened through these rapid developments, because they cannot escape from their isolated habitats (HARTER et al. 2015a). Oceanic islands are generally poor in species, which even increases the importance to preserve populations of endemic species that contribute significantly to ecosystem functioning and to the provision of ecosystem services to mankind (BEIERKUHNLEIN et al. 2011, BEIERKUHNLEIN 2017).

The island of La Palma exhibits a strong altitudinal gradient (0 to 2426 m a.s.l.) with respective elevational zones of climate and ecosystems (IRL & BEIERKUHNLEIN 2011). The constant trade winds lead to a humid windward side on the northeastern side with extensive laurel forest and dry, leeward climatic conditions in the southwest of the island with desert-like vegetation. Human population density is low because steep coastlines are not appropriate for mass-tourism.

Methods

The ECOPOTENTIAL Project applies Earth Observation, both in-situ and from remote sensing, to European PAs of international importance. The focus is to use existing information and to link this with geoinformation and data from satellite-born sensors such as the Sentinel mission. As part of the Canary Islands, the island of La Palma is protected in various ways. The entire island is a Man and Biosphere Reserve of UNESCO. Additionally, in the center of the island, the Caldera de Taburiente National Park, protects very natural and difficult to access ecosystems, mainly forests of the endemic *Pinus canariensis*. And, furthermore, national protected areas and European Union-based Natura 2000 sites are designated for instance in the laurel forest.

For this study, we use in situ data for endemic plant species that have been recorded by our group in previous years. On almost 2000 plots distributed on the entire island of La Palma the presence and relative abundance of endemic plants was recorded. Data were differentiated into single-island endemics and archipelago endemic species. Climatic data were derived from local weather stations and then interpolated by geo-statistical approaches (IRL et al. 2015).

Results

We find clear patterns of climatic conditions that are reflected in the diversity and in the proportional contribution of endemic plant species to ecosystem structures and functioning (IRL et al. 2017). On the island of La Palma, habitats in low elevation that exhibit both sufficient water availability (precipitation through rain or clouds) and a high topographic complexity (steep valleys with different aspects) and respective low human impact are hot spots of species richness and also show a high diversity of both, single-island endemics and archipelago endemics (HARTER et al. 2015b). However, with increasing elevation, the proportion of endemic species rises (STEINBAUER et al. 2016, 2017).

Surprisingly, also anthropogenic structures such as incised rocks from local roads offer secondary habitats even for single-island endemic plant species such as various members of the *Aeonium* genus (IRL et al. 2014a). However, there are enormous threats to the endemic species through introduced herbivores such as rabbits, goats and barbary sheep (IRL et al. 2012). Rabbit traces can be found all over the island and they selectively feed on endemic plants that have no protective strategies. Goats were more important in the past. *Ammotragus lervia* (Barbary Sheep) does not exhibit a large population, but it can access even the steepest slopes, where remnant populations of some endemic plants are located. Finally, fire is a natural driver of ecosystem dynamics on the island (Irl et al. 2014), which is reflected in the astounding capacity of *Pinus canariensis* to regenerate after forest fire. However, in recent times the fire interval seems to shorten, supported by increasing periods of drought, with unclear consequences for the state and value of PAs.

Discussion

The isolation of island habitats results in low species richness and low ecological complexity, respectively. This fact makes islands the perfect place to study ecosystem processes and functions. Also, the effects of climate and climate change can be well investigated in these natural laboratories (BEIERKUHNLEIN et al. 2011, BEIERKUHNLEIN 2017). Translating the insights from island systems to continental habitats has led to the development of outstanding and seminal theories and to their implementation in practice such as the theory of island biogeography (MACARTHUR & WILSON 1967) which is the basis for spatial concepts on PAs.

The clear climate-driven patterns of species richness and endemism are likely very susceptible to climatic changes in the near future, possible threatening endemic species on La Palma and other islands worldwide (HARTER et al. 2015a). High elevation ecosystems might be particularly threatened, owing to high degrees of range-restricted endemics (STEINBAUER et al. 2016, Irl et al. 2017), stronger temperature changes at high elevations than low elevation areas buffered by the ocean (EXPÓSITO et al. 2015) and advancing treelines (IRL et al. 2016). Future PAs need to address and account for the dynamics of a changing environment to optimally protect range-restricted endemics and prevent their extinction.

Figure 1: Two endemic legume species found on La Palma. Single-island endemic *Lotus pyranthus* (left) has become extremely rare, only few clones survived, and these need to be protected by fences from introduced rabbits. Archipelago endemic *Chamaecytisus proliferus* (right), in contrast, shows the economic potential of endemic species. It has become an important fodder plant in Australia, New Zealand and Africa. In consequence both need to be preserved but for different reasons.

Conclusion

Our study documents that decision making processes in the management of PAs need to be based on clear prioritization in nature conservation. The preservation of endemic species richness does not necessarily coincide with the preservation of ecosystems that are dominated by endemic species. We recommend a mixed strategy in order to cover all aspects of endemicity and endemic diversity.

Acknowledgements

We acknowledge support from the ECOPOTENTIAL project –EU Horizon 2020 research and innovation programme, grant agreement No. 641762. We are grateful to Dr. Felix Medina from the Cabildo Insular of La Palma for support in many fields.

References

BEIERKUHNLEIN, C (2017). Inseln als globale Versuchsanordnung und natürliche Laboratorien der Vegetationsökologie. Berichte der Reinhold-Tüxen-Gesellschaft, 29, in press.

BEIERKUHNLEIN, C; HAHN, I; JENTSCH, A; SCHMITT, T (2011). Inseln als natürliche Laboratorien der Biogeografie. Biologie in unserer Zeit, 41, 384-394.

BEIERKUHNLEIN, C; JAESCHKE, A; JENTSCH, A (2016). Weather extremes and extreme climate events as drivers of dynamic trends in nature conservation – a desk review of the literature. Natur und Landschaft, 91, 374-381.

EXPÓSITO, FJ et al. (2015) High-resolution future projections of temperature and precipitation in the Canary Islands. Journal of Climate, 28, 7846-7856.

HARTER, DEV et al. (2015a). Impacts of global climate change on the floras of oceanic islands - Projections, implications and current knowledge. Perspectives in Plant Ecology, Evolution and Systematics, 17, 160–183.

HARTER, DEV et al. (2015b). Spatial and ecological population genetic structures within two island-endemic *Aeonium* species of different niche width. Ecology and Evolution, 5, 4327–4344.

IRL SDH & BEIERKUHNLEIN C (2011) Distribution of endemic plant species on an oceanic island – a geospatial analysis of La Palma (Canary Islands). Procedia Environmental Sciences, 7, 170-175.

IRL, SDH (2016). Plant diversity on high elevation islands – drivers of species richness and endemism. Frontiers of Biogeography, 8, e29717.

IRL, SDH et al. (2016). Patterns of island treeline elevation – a global perspective. Ecography, 39, 427-436.

IRL, SDH et al. (2015). Climate vs. topography – spatial patterns of plant species diversity and endemism on a high-elevation island. Journal of Ecology, 103, 1621-1633.

IRL, SDH et al. (2017). An island view of endemic rarity – environmental drivers and consequences for nature conservation. Diversity and Distributions, doi: 10.1111/ddi.12605

IRL, SDH et al. (2012). An 11-yr exclosure experiment in a high-elevation island ecosystem: Introduced herbivore impact on shrub species richness, seedling recruitment and population dynamics. Journal of Vegetation Science, 23, 1114-1125.

IRL, SDH et al. (2014a). The hitchhiker's guide to island endemism - biodiversity and endemic perennial plant species in roadside and surrounding vegetation. Biodiversity and Conservation, 23, 2273–2287.

IRL, SDH et al. (2014b). Burned and devoured - Introduced herbivores, fire and the endemic flora of the high elevation ecosystem on La Palma, Canary Islands. Arctic Antarctic and Alpine Research, 46, 859-869.

MACARTHUR, RH & WILSON EO (1967). The Theory of Island Biogeography. Princeton University Press.

STEINBAUER, MJ et al. (2016). Topography-driven isolation, speciation and a global increase of endemism with elevation. Global Ecology and Biogeography, 25, 1097–1107.

STEINBAUER, MJ et al. (2017) Plant invasion and speciation along elevational gradients on the oceanic island La Palma, Canary Islands. Ecology and Evolution, 7, 771-779.

Contact

Carl Beierkuhnlein
carl.beierkuhnlein@uni-bayreuth.de
University of Bayreuth
Department of Biogeography
Universitaetsstr. 30
95440 Bayreuth
Germany
Phone: +49 921 552270
Fax: +49 921 552315
ORCID ID: 0000-0002-6456-4628

Severin D.H. Irl
severin.irl@uni-bayreuth.de
University of Bayreuth
Department of Biogeography
Universitaetsstr. 30
95440 Bayreuth
Germany
Phone: +49 921 552299
Fax: +49 921 552315
ORCID ID: 0000-0002-1734-8607