

News from the Mountain Research Initiative (MRI)

MRI invited the MIREN collaborators to introduce their organization in the first Newsletter of the Mountain Research Initiative, which has appeared in September 2008. Like the Mountain Research Initiative, MIREN is a research network, which aims at supporting mountain ecosystem managers through problem-oriented research. This summary for the Mountain Views Newsletter was updated by Christoph Kueffer and coauthors in December 2008.

The Mountain Invasion Research Network (MIREN)—a boundary organization bridging research and management for addressing plant invasions in mountains

Christoph Kueffer¹, Jake Alexander², Curt Daehler³, Keith McDougall⁴, Aníbal Pauchard⁵ & MIREN Consortium⁶

¹ MIREN Coordinator, Department of Botany, University of Hawaii at Manoa, USA & Institute of Integrative Biology, ETH Zurich, Switzerland, christoph.kueffer@env.ethz.ch

² Postdoctoral Researcher, Institute of Integrative Biology, ETH Zurich, Switzerland

³ MIREN Co-Chair, Department of Botany, University of Hawaii at Manoa, USA

⁴ MIREN Co-Chair, NSW Department of Environment and Climate Change, Australia

⁵ Assistant Professor, Universidad de Concepción, Chile & Researcher, Institute of Ecology and Biodiversity, Chile

⁶ <http://www.miren.ethz.ch/people/>

Introduction

As a result of global change invasive non-native plants increasingly may threaten mountain areas. The Mountain Invasion Research Network (MIREN, www.miren.ethz.ch), launched in 2005, initiates and integrates surveys, monitoring, experimental research, and management of plant invasions into mountains at a global scale (Dietz et al. 2006). MIREN is associated with the Mountain Research Initiative (MRI), the Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT, <http://www.fs.fed.us/psw/cirmount/>), and the Global Mountain Biodiversity Assessment (GMBA, <http://www.gmba.unibas.ch/index/index.htm>), one of the 4 transversal networks of DIVERSITAS. The MIREN core research program includes 6 mountain regions (Pacific Northwest [USA], Swiss Alps, Chilean Andes, Australian Alps, Hawaii, and the Canary Islands [Spain]), covering the major climatic zones and including island and continental systems. All core areas participate in standardized monitoring of non-native plant distributions and demography, and comparative experiments. Beyond the core program, MIREN networks researchers and managers in an extensive set of mountain regions and thereby functions as a boundary organization bridging research and management for addressing plant invasions in mountains (compare Kueffer & Hirsch Hadorn 2008).

MIREN reviews, integrates and advances knowledge on plant invasions, uses elevational gradients in mountains as a model system for global change ecology, and promotes proactive approaches to managing potential future risks of plant invasions into mountains. The following sections briefly illustrate each of the three pillars of MIREN and give some current developments.

1. *Towards a conceptual framework for understanding and predicting plant invasions into mountain ecosystems*

In 2005, a special issue of *Perspectives in Plant Ecology, Evolution and Systematics on plant invasions into mountains* (Vol 7 No 3) brought together 6 articles showing that non-native plants are present in mountain ecosystems around the world, but that the distribution patterns and impacts along elevation gradients differ between regions. In an upcoming article of the journal *Frontiers in Ecology and the Environment* (Pauchard et al. in press), we present a conceptual framework for understanding these differences and more generally plant invasion into mountains. Although factors determining plant invasions into high elevations are the same as in other ecosystems, the manner by which they influence the outcome of invasions changes in mountains because of the extreme conditions. Harsh climatic conditions, isolation and limited human pressure have made mountain ecosystems relatively resistant to plant invasions. However, this situation may start changing as species adapt to colder and harsher environments, as the climate changes, and as human pressures expand into mountainous environments, making mountain ecosystems as susceptible to invasions as other historically invaded areas.

2. *Mountains as model system for global change ecology*

MIREN believes that due to steep environmental gradients over small spatial scales, mountainous regions provide particularly useful model systems for understanding ecological and evolutionary processes associated with plant inva-



Figure 1: *Hieracium aurantiacum* infestation (in flower) in Kosciuszko National Park, Australia. This species has the capacity to invade undisturbed vegetation and quickly attain dominance. The site shown was searched two years prior to the photograph and no *Hieracium* was detected (photo by Keith McDougall).

sions. As most non-native plant species reach their distribution limit at some point along these gradients, mountains provide the opportunity to study processes at the invasion front. This can help to disentangle the relative contributions of propagule pressure (i.e. input of seeds or other types of propagules to a site), biotic interactions, phenotypic plasticity and local adaptation as limiting factors of invasions. At the Ecology and Management of Alien Plant Invasions (EMAPi) 10 meeting in August 2009 in Stellenbosch, South Africa Anibal Pauchard and José Ramon Arevalo (MIREN) will chair a session where the value of mountains as a model system for invasion biology will be discussed with a broader audience of researchers.

A particularly promising approach is to make reciprocal comparisons of mountain regions, using species native to one region but invasive in the other, and vice versa. In a recent study, Alexander et al. (accepted) compared patterns of trait variation in natural populations of eight Asteraceae species along altitudinal gradients in the Willowa Mountains, Oregon (USA) and the southern Swiss Alps. Four of the species were native to North America and four to Eurasia, and all were present in both study areas. Despite having been introduced to these regions only within the last 200 years, all species had similar altitudinal ranges and showed parallel clines in plant height, capitulum (flower head) number and seed size. These results indicate that the need to respond to altitudinal gradients, possibly by local adaptation, has not limited the ability of these species to invade mountain

regions. However, the authors also found differences in patterns of resource allocation to capitula among species in the native and the introduced areas. These suggest that the mechanisms underlying trait variation, for example increasing seed size with altitude, might differ between ranges.

3. *A proactive approach for managing potential future risks of plant invasions into mountains*

At the recent annual meeting of MIREN, held in Australia at Kosciuszko National Park, a Mountain Biosphere Reserve, priorities for control of invasive species in mountains were discussed with park managers. The meeting was timely because Australian park managers face a significant threat to mountain biodiversity in the form of a recent invasion and rapid spread of two Hawkweed species (*Hieracium aurantiacum* and *H. prealtum*; see Figure 1). Dr. Peter Espie gave a graphic account of the New Zealand experience with Hawkweeds, which now cover several million ha of grazing land and natural vegetation in montane areas. Land managers in Australia are now working with researchers to understand the invasion process for hawkweeds and respond quickly to eradicate these threats in the Australian Alps.

The emergence of the Hawkweeds as a threat in Australia is typical of a global change in invasion patterns in mountains. A review of mountain invasions by MIREN (McDougall et al., in prep.) has identified almost 1500 plant taxa worldwide that are naturalized or invasive in mountain areas.



Figure 2: Globally, the most widespread mountain plant invaders to date are species typical of European pastures (e.g. grasses, *Trifolium* spp., *Verbascum thapsus*), which were probably introduced during an early phase of livestock grazing in many mountain regions. The picture shows a pasture in the native range of these species in the Swiss Alps (photo by Tim Seipel).

Far from being resistant to invasion as commonly thought, mountains are home to a large number of non-native plant species. More than half the taxa are confined to a single mountain region suggesting that all regions can expect further invasions. The most widespread mountain plant invaders are species typical of European pastures (e.g. *Holcus lanatus*, *Rumex acetosella*, *Trifolium repens*, compare Figure 2), which were probably introduced during the past few hundreds years for livestock grazing in many mountain regions. These species appear to have had relatively little impact on local biodiversity. Some invaders (e.g. *Hieracium* spp., *Cytisus* spp., *Salix* spp.), however, have appeared recently, as mountain land use has shifted in many regions from agriculture to tourism. These species have often been selected for the cold adaptation and now pose an important threat to biodiversity. This threat is likely to grow as tourism expands and global warming allows invaders to reach higher altitudes.

Prevention is widely considered the most cost-efficient management strategy against the threat posed by invasive non-native species. Mountains are one of very few ecosystems not yet badly affected by plant invasions. In mountains, therefore, invasive species researchers and managers have the unique opportunity to respond in time to the threat by preventing invasions before they are actually happening. MIREN is therefore researching and promoting efficient implementation of proactive measures, such as restricting the transport of likely invasive species into mountain areas and early detection searches, to prevent invasions before they become another major threat of vulnerable mountain ecosystems.

References

- Alexander, J.M., Edwards, P.J., Poll, M., Parks, C.G., & Dietz, H., accepted.
 Establishment of parallel altitudinal clines in traits of native and introduced forbs. *Ecology*.
- Dietz, H., Kueffer, C., & Parks, C.G., 2006. MIREN: A new research network concerned with plant invasion into mountain areas. *Mountain Research and Development* 26: 80-81.
- Kueffer, C., & Hirsch Hadorn, G., 2008. How to achieve effectiveness in problem-oriented landscape research: The example of research on biotic invasions. *Living Reviews in Landscape Research* 2: 2. <http://www.livingreviews.org/lrlr-2008-2>
- Pauchard, A., Kueffer, C., Dietz, H., Daehler, C.C., Alexander, J., Edwards, P.J., Arévalo, J.R., Cavieres, L., Guisan, A., Haider, S., Jakobs, G., McDougall, K., Millar, C.I., Naylor, B.J., Parks, C.G., Rew, L.J., & Seipel, T. (2009) Ain't no mountain high enough: Plant invasions reaching new elevations. *Frontiers in Ecology and the Environment*, in press, doi:10.1890/080072.