Ecol Res (2018) 33: 517–522
DOI 10.1007/s11284-018-1611-3

SPECIAL FEATURE: PREFACE

Ultramafic Ecosystems: Proceedings of the 9th International Conference on Serpentine Ecology

Guillaume Echevarria · Alan J. M. Baker
Robert S. Boyd · Antony van der Ent
Takafumi Mizuno · Nishanta Rajakaruna
Shota Sakaguchi · Aida Bani

A global forum on ultramafic ecosystems: from ultramafic ecology to rehabilitation of degraded environments

Received: 19 March 2018 / Accepted: 29 March 2018 / Published online: 21 May 2018

Abstract The 9th International Conference on Serpentine Ecology (ICSE) was held in Tirana and Pogradec (Albania) from June 5 to 9, 2017. More than 100 delegates from 29 countries around the world gathered to present their research on recent advances in: (i) ultramafic soils, (ii) biogeochemistry, (iii) diversity of ultramafic flora, microflora and fauna, (iv) ecophysiology of ultramafic-adapted organisms, (v) interactions between ultramafic organisms and their ecology, (vi) nature rehabilitation of degraded ultramafic environments (resulting from mining activities), and (vii) the production of bio-based metals through agromining technology. Additionally, the ICSE featured the first symposium on ultramafic aquatic ecology and ecotoxicology. Albania has one of the most diverse ultramafic floras in Europe. During the conference delegates visited some of the most emblematic ultramafic sites in Albania as well as the first agromining field trial in Europe. Here, we present the major topics and provide some highlights of the 25 contributions in this Special Issue (Vol. 33 no.3 and 4).

Keywords International Conference on Serpentine Ecology · International Serpentine Ecology Society

G. Echevarria (✉) · Alan J. M. Baker · A. van der Ent
Université de Lorraine, INRA, Laboratoire Sols et Environnement, 54000 Nancy, France
E-mail: guillaume.echevarria@univ-lorraine.fr

Alan J. M. Baker
School of BioSciences, The University of Melbourne, Parkville-Melbourne, Australia

Alan J. M. Baker
Centre for Mined Land Rehabilitation, Sustainable Minerals Institute, The University of Queensland, St. Lucia, Queensland, Australia

Robert S. Boyd · A. van der Ent
Department of Biological Sciences, Auburn University, Auburn, AL 36849-5407, USA

T. Mizuno · S. Sakaguchi
Graduate School of Bioresources, Mie University, Kurimamachiya-cho, Tsu 514-8507, Japan

N. Rajakaruna
Biological Sciences Department, California Polytechnic State University, San Luis Obispo, CA 93407, USA

N. Rajakaruna
Unit for Environmental Sciences and Management, North-West University, Private Bag X6001, Potchefstroom 2520, South Africa

A. Bani
Agri-Environment Department, Agricultural University of Tirana, Kodër-Kamëz, Tirana, Albania

Introduction

Since the first conference in 1991 in Davis (California, USA), the International Conference on Serpentine Ecology (ICSE) has been building as a multidisciplinary group of scientists who study and aid in the conservation of serpentine biota, which are unique ecosystems globally. Their scientific expertise ranges from soil science to evolutionary ecology and applied agronomy. Each conference was held in an ultramafic region with outstanding biodiversity: California in 1991 (Baker et al. 1992), New Caledonia in 1995 (Jaffré et al. 1997), Mpumalanga (South Africa) in 1999 (Balkwill 2001), Cuba in 2003 (Boyd et al. 2004), Tuscany (Italy) in 2006 (Chiarucci and Baker 2007), Maine and eastern Canada in 2008 (Rajakaruna and Boyd 2009), Tras-ós-Montes (Portugal) in 2011 (with a number of articles that appeared in *Plant Ecology and Diversity*) and Sabah (Malaysia) in 2014 (van der Ent et al. 2015b).

The ninth International Conference on Serpentine Ecology (ICSE) was held in Albania from June 5 to 9, 2017. Albania has > 11% of its surface area consists of ultramafic bedrock or quaternary sediments of ultramafic geochemistry (alluvia, glacial deposits) (Bani et al 2014). Albania is also a plant biodiversity hotspot within the Balkans, to which the presence of ultramafic substrates contributes disproportionally (Stevanović et al. 2003). It is home to several interesting species of hyperaccumulators (Bani et al. 2013) and is the first country in Europe where full-scale nickel phytomining field trials have been implemented on ultramafic soils (Bani et al. 2015a, b).

Facts and figures about the 9th ICSE

The 9th International Conference on Serpentine Ecology (ICSE) was held at Tirana and Pogradec (Albania). More than 100 delegates from 29 countries worldwide participated (Fig. 1) including more than 30 delegates from Albania, Kosovo and other Balkan countries, among them a large proportion of PhD and MSc students. This showed the strong interest of local scientific communities in ultramafic ecology. The first 3 days of the conference were at the Agricultural University of Tirana. The mid-conference tour took place in the ultramafic regions of Elbasan, Shebenik-Jablanicë National Park, Prrenjas and Pogradec (Fig. 2), and the last day of the conference was held in Pogradec on the shores of Lake Ohrid. During the mid-conference tour, the delegates visited sites where the first full-scale nickel agromining field trials in Europe, that has been cultivated continuously since 2005 (Bani et al. 2015a, b). During the post-conference tour, the delegates had the possibility to visit the ultramafic massif of Morava (sites of Mborja and Boboshtica) close to the historical city of Korçë and also the ultramafic heart of Northern Pindus in Greece (Pindus National Park), where the largest number of European Ni hyperaccumulators occurring at the same location is reported (Bani et al. 2009).

Topics and discussions at the 9th ICSE

The conference consisted of nine sessions with five to 12 oral presentations in each session, as well as poster presentations. The nine sessions were the following:

1. 'Pedosphere and rhizosphere' dedicated to ultramafic pedogenesis, soil functioning and ecology (bacteria and fungi);
2. 'Ecophysiology and genetics' dedicated to all aspects of the specific metabolism of ultramafic-adapted organisms, including hyperaccumulator plants;
3. 'Ecology and evolution', the core session dealing with ultramafic ecology including the study of interactions between species;
4. 'Conservation and restoration', a session that is now fundamental in ultramafic ecology and which dealt with applied issues;
5. 'Biogeochemical cycles', a new session that introduced the specificities of ultramafic environments in terms of nutrient cycling (scarcity) or metal cycling (unusual levels) including the impacts on the quality of food products in ultramafic regions;
6. 'Metal hyperaccumulation', a popular session at ICSE that included both ultramafic environments and other metalliferous ecosystems;
7. 'Biodiversity and systematics' is also a significant session of ICSE because ultramafic environments are still areas to be discovered and described;
8. 'Agromining', a session in honour of the homeland of agromining in Europe;
9. 'Ultramafic aquatic chemistry, ecology and ecotoxicology', the first session ever held on ultramafic aquatic ecosystems.

This special issue of *ecological research*

The 25 articles published in this Special Issue represent an account of the ongoing research activities worldwide on ultramafic ecosystems and give a broad account of the sessions that were held so successfully during the conference. The papers published in this Special Issue are presented under the following session topic areas:

Ecology and evolution

This session is one of the major topics at ICSE since its inception. This session was dedicated as a tribute to the memory of Arthur ('Art') Kruckeberg, one of the fathers of Serpentine Ecology, who passed away in 2016 (Rajakaruna 2016). In the Special Issue, two articles deal with evolutionary and functional ecology. Hidalgo-Triana et al. (2018) report the establishment of groups according to their functional traits within ultramafic vegetation communities in California and Sakaguchi et al. (2018) provide a detailed comprehensive study on the phylogeography of one plant species in Japan, *Picris hieracioides* (Asteraceae). Three articles report specific ecological interactions within ultramafic environments, *i.e.* specific plant–plant or plant–animal interactions involving serpentine endemic Ni-hyperaccumulator species. Bani et al. (2018) report the interactions between the most common hyperaccumulator species in the Balkans, *Alyssum murale* (= *Odontarrhena muralis* s.l.), and the parasitic plant *Orobanche nowackiana*, which is the only ultramafic-obligate parasitic plant in Europe. The other two articles report interactions between insects and Ni-hyperaccumulator plants from the genus *Streptanthus* from western United States (Mincey and Boyd 2018; Mincey et al. 2018).

Biodiversity of ultramafic areas

Many articles published in this Special Issue address biodiversity of ultramafic ecosystems, the existence of specific communities of poorly studied organisms in ultramafic environments or the existence of yet unreported hyperaccumulator species. They include a full geoecological study of two ultramafic ecosystems in Ireland (Brearley 2018), a complete review of the rich-

Fig. 1 Group photograph of the delegates of the 9th ICSE in front of the Conference Room Building at the Agricultural University of Tirana on the first day of the Conference (June 5, 2017)

ness of circumboreal ultramafic ecosystems in the Northern Hemisphere (Teptina et al. 2018), the specificity of the communities of lichens in ultramafic environments (Favero Longo et al. 2018) and the specificity of the associations of organisms present in the biological crusts on ultramafic vs. non-ultramafic soils (Venter et al. 2018).

Metal (hyper)accumulation is presented and discussed in regions that were either previously poorly studied, such as Central Mexico (Navarrete Gutiérrez et al. 2018), Kosovo (Salihaj et al. 2018), or in well-studied regions where new hyperaccumulator species have been discovered, such as in Mpumalanga (South Africa) with the discovery of *Senecio conrathii* (Asteraceae) (Siebert et al. 2018), or in Central Turkey with the finding of *Isatis cappadocica* subsp. *cappadocica* (Brassicaceae) (Çelik et al. 2018). A major study undertaken in the ultramafic areas of Sabah (Malaysia) reports on the discovery of numerous new hyperaccumulators: Al (38 species), Co (3 species), Mn (7 species) and Ni (24 species) (van der Ent et al. 2018). For Ni, there seems to be a distinct phylogenetic pattern, as most hyperaccumulators are members of the Order Malpighiales (van der Ent et al. 2018). The use of hand-held X-ray fluorescence (XRF) instruments for the scanning of thousands of herbarium specimens was presented as a powerful tool to uncover hyperaccumulating plant taxa in herbarium collections (Gei et al. 2018). This approach has so far only been carried out in Sabah, Malaysia (Nkrumah et al. 2018) but it could revolutionize the search for new hyperaccumulators globally, and help to better understand the geographical distribution and the evolutionary history (phylogeny) of hyperaccumulation (Jaffré et al. 2013; Nkrumah et al. 2018). One species reported in this issue is the rare and extreme Ni hyperaccumulator *Antidesma montis-silam* (Phyllanthaceae), known previously from a few historic collections from Mount Silam in Sabah (Malaysia). It was discovered through XRF scanning of herbarium collections, and subsequently located in the field (Nkrumah et al. 2018).

Ecophysiology of metallophytes and metal hyperaccumulation

In the Special Issue, several articles provide new insights into metal homeostasis and hyperaccumulation from field collections (Reeves and Kruckeberg 2018) or from laboratory physiological experiments designed to investigate suspected mechanisms involved in the hyperaccumulation trait (Bartoli et al. 2018; Dehno and Mohtadi 2018; Ghasemi et al. 2018; DeGroote et al. 2018). One of the published articles stresses how important it is to fully assess elemental concentrations in plant parts collected in the field, as soil contamination of leaves can lead to mistaken attribution of hyperaccumulation, as has been the case of some Caryophyllaceae from California (Reeves and Kruckeberg 2018).

The first article reports on an experimental study of the physiology of the Ni-hyperaccumulator *Leptoplax emarginata* (Brassicaceae), and the results show that the highest Ni concentrations are in the actively transpiring young, thin leaves with the greatest stomatal densities (Bartoli et al. 2018). In another study (Ghasemi et al. 2018) investigating the role of the CAX1 Ca^{2+} vacuole

Fig. 2 Visit of the first full-scale nickel agromining field trial in Europe in Pojskë (District of Pogradec) by conference delegates during the mid-conference trip (June 8, 2017)

transporter in the Ni-hyperaccumulator *Alyssum inflatum* (Brassicaceae), it is concluded that high cytosolic Ca^{2+} is an important parameter that results in Ni tolerance. An investigation of the mechanisms involved in Mn hyperaccumulation by *Phytolacca americana* suggests that this trait may be a side effect of rhizosphere acidification as a phosphorus-acquisition mechanism, rather than an adaptation to high soil Mn per se (DeGroote et al. 2018). The final article in this section reports on a study on the interaction between Pb uptake and Fe nutrition in *Matthiola flavida* (Brassicaceae), a facultative Pb hyperaccumulator from Iran (Dehno and Mohtadi 2018). All these studies give a better understanding of the mechanisms of metal hyperaccumulation and show how much this trait is related to the homeostasis of essential nutrients (such as Ca, P, Fe).

Nature-based rehabilitation of ultramafic disturbed sites

Over the years, the issue of how to restore or rehabilitate ultramafic environments that have been affected by mining, quarrying or other activities, has gained substantial attention at the ICSEs. Three articles published in the Special Issue report on different case studies related to this topic (Boisson et al. 2018; Mizuno et al. 2018; Quintela Sabarís et al. 2018).

Quintela Sabarís et al. (2018) report how the properties of a topsoil in a nickel-laterite opencast mining operation evolve during stripping and storage and what consequences can be expected when re-using this material in post-mining rehabilitation. The following two papers report experiences and case-studies of how the use of metallophytes can be successful for the rehabilitation of mine and quarry sites. Mizuno et al. (2018) show how some native populations of Japanese wild thyme (*Thymus quinquecostatus,* Lamiaceae) from ultramafic sites in Japan can be successfully used as first vegetation covers of serpentinite quarries. Boisson et al. (2018) report how phytostabilisation of polluted areas using local endemic metallophytes, such as *Microchloa altera* (Poaceae), in the province of Katanga (DR of Congo) represents an opportunity to decrease the bioavailability of heavy metals in the highly polluted soils resulting from base metal mining.

Agromining

The session on agromining was dedicated to the life work of Dr. Rufus Chaney who was the earliest proponent of the idea of phytomining and a leading promotor of the technology (Chaney 1983). The new concept of agromining has been derived from phytomining and is conceived as the full (agronomic) chain of using metal hyperaccumulator plants for producing bio-based metals (van der Ent et al. 2015a). Two papers report on original results from the effects of agromining on soil biology, microbiology and quality. Saad et al. (2018) discuss the effects of a new agro-ecological nickel agromining system that uses co-cropping of hyperaccumulators with legumes. Kanso et al. (2018) report on the effect of nitrogen fertilization on agromining of Ni with *Alyssum murale* and subsequent effects on microbial diversity and functionality.

Conclusions and perspectives

The 9th ICSE has brought an even clearer message to the serpentine community: having a structured multi-scientific community working on these special ecosystems worldwide has made it a model for basic and applied ecological research (Harrison and Rajakaruna 2011). Over the years, we have discovered how metal homeostasis and biogeochemistry interplay on evolution, ecology, inter-species interactions, resistance to stress, and biogeochemical cycling. In turn, these insights have proved to be keys to developing nature-based solutions utilizing ultramafic plants, specifically post-mining restoration and agromining. The 9th ICSE and this Special Issue of *Ecological Research* are a clear demonstration of the interest in these areas of research. In future, we need to put more emphasis on ecosystem services provided by ultramafic regions, and continue the successful integration of scientific disciplines. The 10th ICSE will be held in 2020 in Yekaterinburg, Russia near to ultramafic sites in the southern Urals.

Acknowledgements We wish to thank the Agricultural University of Tirana who supported the Conference and offered its facilities. We thank Université de Lorraine and the French National Research Agency through the national 'Investissements d'avenir' programme (ANR-10-LABX-21, LABEX RESSOURCES21), for financial support that helped participants from developing countries participate. We thank Progepi who managed the organization of the 9th ICSE. The Ecological Society of Japan (ESJ) and Prof. Atsushi Kume are owed our gratitude for their support in inviting the Scientific Committee of the 9th ICSE to attend the 64th annual meeting of the Ecological Society of Japan, and for hosting this Special Issue in *Ecological Research*. Finally, the EU-funded LIFE-AGROMINE project is acknowledged for the annual LIFE-AGROMINE meeting, which was held in Pogradec on June 10, 2017 immediately after the ICSE.

References

Baker AJM, Proctor J, Reeves RD (1992) The vegetation of ultramafic (serpentine) soils. In: Proceedings of the first international conference on serpentine ecology. Intercept, Andover, UK

Balkwill K (2001) Proceedings: third international conference on serpentine ecology. South Afr J Sci 97 **(Part 2/special issue)**

Bani A, Echevarria G, Mullaj A, Reeves RD, Morel JL, Sulçe S (2009) Ni hyperaccumulation by *Brassicaceae* in serpentine soils of Albania and NW Greece. Northeast Nat 16:385–404

Bani A, Imeri A, Echevarria G, Pavlova D, Reeves RD, Morel JL, Sulçe S (2013) Nickel hyperaccumulation in the serpentine flora of Albania. Fresenius Environ Bull 22:1792–1801

Bani A, Echevarria G, Pelletier-Montargès E, Gjoka F, Sulce S, Morel JL (2014) Pedogenesis and nickel biogeochemistry in a typical Albanian ultramafic toposequence. Environ Monit Assess 186:4431–4442

Bani A, Echevarria G, Sulçe S, Morel JL (2015a) Improving the agronomy of *Alyssum murale* for extensive phytomining: a five-year field study. Int J Phytoremediat 17:117–127

Bani A, Echevarria G, Zhang X, Laubie B, Benizri E, Morel JL, Simonnot MO (2015b) The effect of plant density in nickel phytomining field experiments with *Alyssum murale* in Albania. Aust J Bot 63:72–77

Bani A, Pavlova D, Benizri E, Shallari S, Miho L, Meco M, Shahu E, Reeves R, Echevarria G (2018) Relationship between the Ni hyperaccumulator *Alyssum murale* and the parasitic plant *Orobanche nowackiana* from serpentines in Albania. Ecol Res 33. https://doi.org/10.1007/s11284-018-1593-1

Bartoli F, Royer M, Coinchelin D, Le Thiec D, Rose C, Robin C, Echevarria G (2018) Multiscale and age-dependent leaf nickel in the Ni-hyperaccumulator *Leptoplax emarginata*. Ecol Res 33. https://doi.org/10.1007/s11284-018-1594-0

Boisson S, Séleck M, Le Stradic S, Collignon J, Garin O, Malaisse F, Shutcha MN, Mahy G (2018) Using phytostabilisation as a way to conserve threatened endemic species from the South-eastern D.R. Congo. Ecol Res 33. https://doi.org/10.1007/s11284-018-1604-2

Boyd RS, Baker AJM, Proctor J (2004) Ultramafic rocks: their soils, vegetation, and fauna. Science Reviews 2000, St Albans, UK

Brearley F (2018) Geo-ecological studies on two ultramafic sites in Western Ireland. Ecol Res 33. https://doi.org/10.1007/s11284-018-1584-2

Çelik J, Aksoy A, Leblebici Z (2018) Metal Hyperaccumulating Brassicaceae from the ultramafic area of Yahyalı in Kayseri province, Turkey. Ecol Res 33. https://doi.org/10.1007/s11284-018-1606-0

Chaney RL (1983) Plant uptake of inorganic waste constituents. In: Parr JF et al (eds) Land treatment of hazardous wastes. Noyes Data Corp, Park Ridge, pp 50–76

Chiarucci A, Baker AJM (2007) Proceedings of the fifth international conference on serpentine ecology. Plant Soil 293(1–2):1–2

DeGroote KV, McCartha GL, Pollard AJ (2018) Interactions of the manganese hyperaccumulator *Phytolacca americana* L. with soil pH and phosphate. Ecol Res 33. https://doi.org/10.1007/s11284-017-1547-z

Dehno AH, Mohtadi A (2018) The effect of different iron concentrations on lead accumulation in hydroponically grown *Matthiola flavida* Boiss. Ecol Res 33. https://doi.org/10.1007/s11284-018-1558-4

Favero Longo SE, Matteucci E, Giordani P, Paukov AG, Rajakaruna N (2018) Diversity and functional traits of lichens in ultramafic areas: a literature-based worldwide analysis integrated by field data at the regional scale. Ecol Res 33. https://doi.org/10.1007/s11284-018-1573-5

Gei V, Erskine PD, Harris HH, Echevarria G, Mesjasz-Przybyłowicz J, Barnabas AD, Przybyłowicz WJ, Kopittke PM, van der Ent A (2018) Tools for the discovery of hyperaccumulator plant species and understanding their ecophysiology. In: van der Ent A, Echevarria G, Baker AJM, Morel JL (eds) Agromining: farming for metals. Extracting unconventional resources using plants. Mineral resources series. Springer, Cham, Switzerland, pp 117–133

Ghasemi R, Share H, Sharifi R, Boyd RS, Rajakaruna N (2018) Inducing Ni sensitivity in the Ni hyperaccumulator plant *Alyssum inflatum* Nyárády (Brassicaceae) by transforming with CAX1, a vacuolar membrane calcium transporter. Ecol Res 33. https://doi.org/10.1007/s11284-018-1560-x

Harrison S, Rajakaruna N (2011) Serpentine. The evolution and ecology of a model system. University of California Press, Berkeley

Hidalgo-Triana N, Pérez Latorre AV, Thorne JH (2018) Plant functional traits and groups in a Californian serpentine chaparral. Ecol Res 33. https://doi.org/10.1007/s11284-017-1532-6

Jaffré T, Reeves RD, Becquer T (1997) 'Écologie des milieux sur roches ultramafiques et sur sols métallifères: actes de la deuxième conference internationale sur l'écologie des milieux serpentiniques, Nouméa, 31 juillet–5 août 1995'. Documents scientifiques et techniques III.2. Centre ORSTOM de Nouméa, Nouméa

Jaffré T, Pillon Y, Thomine S, Merlot S (2013) The metal hyperaccumulators from New Caledonia can broaden our understanding of Ni accumulation in plants. Front Plant Sci 4:279

Kanso A, Sirguey C, Azoury S, Benizri E, Kobaissi A, Echevarria G (2018) Improvement of Ni phytoextraction by *Alyssum murale* and its rhizosphere microbial activities by applying nitrogen fertilizer. Ecol Res 33. (in press)

Mincey KA, Boyd RS (2018) Elemental defense of nickel hyperaccumulator seeds against a generalist insect granivore. Ecol Res 33. https://doi.org/10.1007/s11284-018-1583-3

Mincey KA, Cobine PA, Boyd RS (2018) Nickel hyperaccumulation by *Streptanthus polygaloides* is associated with herbivory tolerance. Ecol Res 33. https://doi.org/10.1007/s11284-018-1569-1

Mizuno T, Nakahara Y, Fujimori T, Yoshida H (2018) Natural revegetation potential of Japanese wild thyme (*Thymus quinquecostatus* Celak.) on serpentine quarries. Ecol Res 33. https://doi.org/10.1007/s11284-018-1575-3

Navarrete Gutiérrez DM, Pons MN, Cuevas Sánchez JA, Echevarria G (2018) Is metal hyperaccumulation occurring in ultramafic vegetation of central and southern Mexico? Ecol Res 33. https://doi.org/10.1007/s11284-018-1574-4

Nkrumah PN, Echevarria G, Erskine PD, van der Ent A (2018) Nickel hyperaccumulation in *Antidesma montis-silam*: from herbarium discovery to collection in the native habitat. Ecol Res 33. https://doi.org/10.1007/s11284-017-1542-4

Quintela Sabarís T, L'Huillier L, Mouchon LC, Montargès-Pelletier E, Echevarria G (2018) Chemico-mineralogical changes of ultramafic topsoil during stockpiling: implications for post-mining restoration. Ecol Res 33. https://doi.org/10.1007/s11284-018-1609-x

Rajakaruna N (2016) In Memoriam. Arthur rice kruckeberg: geobotanist extraordinaire (1920–2016). Madroño 63:367–370

Rajakaruna N, Boyd R (2009) Advances in serpentine geoecology: a retrospective. Northeast Nat 16:1–7

Reeves RD, Kruckeberg AR (2018) Re-examination of the elemental composition of some Caryophyllaceae on North American ultramafic soils. Ecol Res 33. https://doi.org/10.1007/s11284-017-1556-y

Saad RF, Kobaissi A, Machinet G, Villemin G, Echevarria G, Benizri E (2018) Crop rotation associating a legume and the nickel hyperaccumulator *Alyssum murale* improves the structure and biofunctioning of an ultramafic soil. Ecol Res 33. https://doi.org/10.1007/s11284-017-1526-4

Sakaguchi S, Horie K, Kimura T, Nagano AJ, Isagi Y, Ito M (2018) Phylogeographic testing of alternative histories of single-origin versus parallel evolution of early flowering serpentine populations of *Picris hieracioides* L. (Asteraceae) in Japan. Ecol Res 33. https://doi.org/10.1007/s11284-017-1536-2

Salihaj M, Bani A, Shahu E, Benizri E, Echevarria G (2018) Metal accumulation by the ultramafic flora of Kosovo. Ecol Res 33. (in press)

Siebert SJ, Schutte NC, Bester SP, Komape DM, Rajakaruna N (2018) *Senecio conrathii* N.E.Br. (Asteraceae), a new hyperaccumulator of nickel from serpentinite outcrops of the Barberton Greenstone Belt, South Africa. Ecol Res 33. https://doi.org/10.1007/s11284-017-1541-5

Stevanović V, Tan K, Iatrou G (2003) Distribution of the endemic Balkan flora on serpentine I.—obligate serpentine endemics. Plant Syst Evol 242:149–170

Teptina A, Paukov A, Rajakaruna N (2018) Ultramafic vegetation and soils in the circumboreal region of the Northern Hemisphere. Ecol Res 33. https://doi.org/10.1007/s11284-018-1577-1

van der Ent A, Baker AJM, Reeves RD, Chaney RL, Anderson CWN, Meech JA, Erskine PD, Simonnot M-O, Vaughan J, Morel JL, Echevarria G, Fogliani B, Rongliang Q, Mulligan DR (2015a) Agromining: farming for metals in the future? Environ Sci Technol 49:4773–4780

van der Ent A, Rajakaruna N, Boyd R, Echevarria G, Repin R, Williams D (2015b) Global research on ultramafic (serpentine) ecosystems (8th International conference on serpentine ecology in Sabah, Malaysia): a summary and synthesis. Aust J Bot 63:1–16

van der Ent A, Mulligan DR, Repin R, Erskine PD (2018) Foliar elemental profiles in the ultramafic flora of Kinabalu Park (Sabah, Malaysia). Ecol Res 33. https://doi.org/10.1007/s11284-018-1563-7

Venter A, Siebert S, Rajakaruna N, Barnard S, Levanets A, Ismail A, Allam M, Peterson B, Sanko T (2018) Biological crusts of serpentine and non-serpentine soils from the Barberton Greenstone Belt of South Africa. Ecol Res 33. https://doi.org/10.1007/s11284-017-1546-0