CV Rainer M. Krug

Personal Details

Name	Rainer M. Krug
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E-mail	Rainer.Krug@ieu.uzh.ch (work)
	Rainer@krugs.de (private)
Date of birth	12 April 1968
Civil status	married, one daughter

Languages

German native language

English reading, writing and speaking fluent

French reading, writing and speaking fair

Qualifications

Postgraduate

2008 **PhD in Conservation Ecology**, Stellenbosch University, South Africa

Thesis Title: Modelling seed dispersal in restoration and biological invasion.

1997 **MSc Conservation Biology**, University of Cape Town, South Africa

Thesis topic: The Genetic Diversity in a Founded Population of the African buffalo (*Syncerus caffer*): an example of an Artificial Bottleneck.

1995 **Diplom (MSc equivalent) in Physics**, Philips-Universität Marburg, Germany

Thesis Title: Der Einfluss von Habitat Heterogenität auf die mittlere Überlebensdauer von Populationen (The influence of habitat heterogeneity on the mean survival time of populations)
Subjects for oral examination: Experimental Physics, Theoretical Physics, Ecological Modelling, Biology

Undergraduate

1992 **Vor-Diplom (BSc equivalent) in physics**, Philips-Universität Marburg, Germany

Subjects for oral examination: Experimental Physics, Theoretical Physics, Mathematics, Chemistry.

Positions held

03/2017 – present	**Researcher / Research Assistant**
	Department of Evolutionary Biology and Environmental Studies, University Zürich
08/2015 – 09/2015	**Postdoctoral Researcher**
	Laboratoire Ecologie, Systematique et Evolution, Paris Sud
11/2014 – 12/2014	**Postdoctoral Researcher**
	Laboratoire Ecologie, Systematique et Evolution, Paris Sud
09/2013 – 11/2013	**Postdoctoral Researcher**
	Laboratoire Ecologie, Systematique et Evolution, Paris Sud
08/2011 – 12/2016	**Research Associate**
	DST-NRF Centre of Excellence for Invasion Biology, Stellenbosch University
2009 – 2015	**Child care ranging from 50% - 100%**
06/2008 – 06/2008	**Postdoctoral Research Fellow, hosted by Prof. Dave Richardson.**
	DST-NRF Centre of Excellence for Invasion Biology, Stellenbosch University
06/2007 – 06/2008	**Postdoctoral Research Fellow, hosted by Prof. Timm Hoffman.**
	Plant Conservation Unit, University of Cape Town
1999	**Accident induced time off** One year in Germany due to hospital visits and cancelation of started and financed PhD.

Other Positions / Roles

2022	Invited Academic Guest Editor for paper in the field of reporoducible methods
2021 – present	Fellow of the Center for Reproducible Science (CRS) at UZH
2021 – present	Co-Chair of the Dynamic Coalition on Environment (DCE) of the Internet Governance Forum (IGF)
2021	Member of Policy Network on Environment (PNE) , Intersessional workstream of the IGF
2019 – present	Elected Expert Member of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Task Force on Knowledge and Data, nominated by Switzerland
2017 – 2019	IPBES Chapter Scientist of the chapter 4 of the IPBES Global Assessment
08/2011 – 12/2016	Research Associate DST-NRF Centre of Excellence for Invasion Biology, Stellenbosch University

Research Projects

- Development of an R package for running a simulation in a transparent and reproducible way, including the running of the analysis, saving and reloading of parameter and results as well as support for analysis and graphing of the results using RMarkdown. (IEU UZH)
- Development, implementation and maintenance of an automatic data preprocessing and extraction pipeline to extract Research Ready (data which will be used in forecasting in this case) data from regularly measured data

and movies, recorded in open (but difficult to use) and proprietary formats. The data is converted in open formates and saved as Archive Ready (i.e. FAIR) data and further processed into Research Ready data which, in the final step, is further analysed by other researchers in the team. All elements of the pipeline are implemented in a completely transparent and reproducible way, written in R (several R packages to compartmentalise the pipeline), which is running in a docker container and controlled using makefiles and bash scripts. The docker container runs on a S3IT Science Cloud instance which is also accessible via a Samba server. (IEU UZH)

- Development of an approach to develop domain specific metadata schemes, implemented in an accompanying R packege (dmdScheme). This approach was used to develop a domain specific metadata scheme for the experiments (aquatic microbial microcosm experiments), which is implemented in the package emeScheme and accompanying metadata scheme definition. The resulting emeScheme is used for the ongoing experiments in our group as well as retrospectively to make the data availabe on public repositories. (IEU UZH)
- Development of a data management strategy for our research group and of tools to facilitate the provision and improve the quality of metadata. (IEU UZH)
- Management of the large scale Literature Analysis for (**IPPBES Global Assessment Chapter 4**) (more than 20 authors, $>$ 5000 initial papers and a complex questionaire in excel sheet to collect the results from the review) and the generated data and from the Excel Database in a reproducible way for archiving as well as graphing of the results. (Laboratoire Ecologie, Systematique et Evolution, Paris Sud and IEU UZH)
- Analysis of measured vertical wind profiles to improve the performance of a forest growth model (CASTANEA) in regards to energy balance (Laboratoire Ecologie, Systematique et Evolution, Paris Sud)
- Modelling temporal and spatial dynamics of a range of different different alien species, alien control agents and management strategies (Centre for Invasion Biology, Stellenbosch University)
- Optimising alien invasive plant management through modelling of temporal and spatial modelling (Centre for Invasion Biology, Stellenbosch University)
- Modelling the role of seed dispersal in restoration and biological invasion (Department of Conservation Ecology and Entomology, Stellenbosh University)

Reproducibility and Data Management

- As **elected expert of the IPBES Knowledge and Data Task Force** I led the development of the Data and Knowledge Management Policy of IPBES. This is based based on FAIR and CARE data managememnt principles, which requires IPBES to follow reproducible workflows in all research related activities. The policy further requires IPBES to provide support to implement the policy to its experts which is mainly done by the Data TSU (Technical Support Unit). In addition, I am also working with the tsu on the develop of teaching and information material as well as technical guidelines to implement at all stages of the research process reproducible and open workflows. One direction the Task Force and the TSU are working towards is to use dynamic reports (on demand as well as in real-time updated) in

IPBES. Additionally, we developed the Data Vision 2030, defining a vision of how IPBES data should be managed and published, including milestones and tasks.

- Between 2015 and 2017 I was a **chapter scientist** for the Global Assessment, Chapter 4. Here, I managed the large scale literature review for the IPBES Global Assessment Chapter 4, including data collection, quality control, analysis, graphing and archival (finalising).
- In 2021 I was active in the in the **Policy Network on Environment** (PNE) (Internet Governance Forum) where I successfully promoted the FAIR use of data (Findable, Accessible, Interoperable and Reusable) as well as the CARE principles (Collective benefits, Authority of control, Responsibility and Ethics) to be included in the recommendations. Caused by the overall positive acceptance of the report, it was decided to continue the work in a new Dynamic Coalition, the DCE, of which I became a co-chair.
- After 2022, as the **co-chair of the DCE**, I am promoting the closer integration of environmental, particularly biodiversity, considerations and internet governance related questions. Combining this aim with my experience in the IPBES Knowledge and Data Task Force, particularly the role of FAIR and CARE data management, the charta of the DCE includes these open science principles as a cornerstone.

Teaching Experience

- **Computing consultant** in BIO144 (Data Analysis in Biology) at UZH (2021 - 2023)
- Development of **video tutorials** within IPBES regarding the data management policy and its implementation for interdisciplinary experts from diverse scientific backgrounds
- Development of **technical guidelines** for the implementation of the data management policy in IPBES for interdisciplinary experts from diverse scientific backgrounds
- teaching a week long **block course** Introduction to True Basic at the University of Cape Town for five years. Students were from different scientific backgrounds and from diverse universities attending Conservation Biology Masters course.

Areas of Interest and expertise

Keywords open science; FAIR; CARE; reproducibility; open source tools; data and metadata management and policy;

combined modelling and experimental approaches; ecological modelling; statistical computing; invasive species management; biodiversity research;

Research My current focus of work at UZH is in the field of data management, metadata management, reproducible workflows and data archival, embedded in the principles of open science, FAIR and reproducibility. This includes the development of a framework for continuous data analysis and preparation for archival which is used by an ongoing project, development of data management guidelines for our research group, development of a domain specific metadata scheme to make entering and useful metadata as easy as possible for the researcher while at the same providing all the information needed for a useful re-use of the archived data;

Throughout my research career I have developed and used different types of models, ranging from individual based models, hybrid models using individual based approaches together with grid based elements, to pure grid based models. The systems studied ranged from populations and communities on the local scale to community dynamics (e.g. grassland - shrubland dynamics, two biocontrol species one invasive species system, spread of three alien invasive species) on the local scale and spread simulations of individual species on the national scale under different climate change or management actions.

All the programming, simulation and analysis tools I use are Open Source software (R, GRASS GIS, QGIS). This e.g. provides provides me with the flexibility to develop the simulation models and analysis protocols and pipelines without additional costs, distribute them freely and to enable others (scientists as well as other implementing agencies and users) to use, evaluate, and develop the code further without limitations and without having to purchased specific software.

Rmarkdown (lately quarto) is my tool of choice to document and run data preparation (e.g. conversion and filtering of outliers / fault results) and analysis / graphing of data. This 'Docs as Code' type of document enables one to focus on the documentation and what one wants to do and embeds the code as well as the results in the final document.

I use the R package structure as the template for projects. This takes the reproducibility even one step further, as dependencies can be communicated clearly (and are enforced during installation) and thinking in 'functions' instead of long scripts is encouraged. Consequently I maintain number of R packages for internal as well as public usage (see e.g. my R-Universe repository).

At UZH / IEU, my work involves research support, ranging from informal discussion on how workflows and scripts could be improved in regards to reproducibility as well as execution speed and data management aspects, designing and writing R packages to simplify or automate workflows up to designing workflows which use different computing platforms to the actual management of research data to finally submitting it to Zenodo for long term preservation.

Open Science

I am particularly interested in the implementation of open science and reproducibility principles, how these can be implemented and how perceived hurdles can be overcome in individual groups (e.g. IPBES or the research group I am in). Apart from the technological aspects of open science and reproducibility, I am interested in the policy level in how these principles can be codified in Data Management Policy form in different organisations. The development of the IPBES Data and Knowledge Management Policy provided fascinating insight into the problems facing non-traditional science institutes in handling data and codify open science and reproducibility principles for a wide variety of different data, ranging from quantitative to qualitative data, western science paradigme based to indigenous and local knowledge and peer revieweed to gray literature.

Software

In my carrer, I obtained expertise in

- different programming languages (recently mainly R and bash, earlier Delphi / Pascal and rudimentary work in Python and C),
- linking these through e.g. scripting into automated processing and data work flows,
- setting up and usage of virtual computing platforms (most recently S3IT Science Cloud) using docker, and virtual machines,

- using version control, mainly git via command line and through github,
- setting up and maintenance of small MySQL and sqlite databases as well as SAMBA servers and trouble shooting of a wide variety of software problems associated with the provision of these programs and their maintenance. All setup steps are documented in documents to make the re-creation of the instances / servers possible not only for me but for others as well.
- all three major operating systems (Mac and Linux expert user, Windows advanced user) and a wide range of programs, dominantely but not exclusively open source (Rstudio, Emacs, MS Office, Apple office products, GRASS, etc).

Grants

2009 – 2010 NRF Freestanding Postdoctoral Fellowship

1999 – 2000 Deutscher Akademischer Austauschdienst (DAAD: German Academic Exchange Service) grant to conduct fieldwork for PhD at Gobabeb, Namibia.

1996 – 1997 Deutscher Akademischer Austauschdienst (DAAD: German Academic Exchange Service) grant to attend MSc in Conservation Biology course at UCT.

Publications

Data publications are not included. For an autogenerated list of the all publications see https://orcid.org/0000-0002-7490-0066

Articles & Pre-Prints

Krug, R.M., Petchey, O., 2023. Microxanox: An R Package for Simulating an Aquatic MICRobial Ecosystem That Can Occupy OXic or ANOXic States. Preprint. Ecology. doi:10.1101/2023.02.06.527266.

Krug, R.M., Petchey, O.L., 2021. Metadata Made Easy: Develop and Use Domain-Specific Metadata Schemes by following the dmdScheme approach. Ecology and Evolution 11, 9174–9181. doi:10.1002/ece3.7764.

Krug, R.M., Richardson, D.M., 2014. Modelling the effect of two biocontrol agents on the invasive alien tree Acacia cyclops - Flowering, seed production and agent survival. Ecological Modelling 278, 100–113. doi:10.1016/j.ecolmodel.2014.01.028.

Krug, R.M., Roura-Pascual, N., Richardson, D.M., 2010. Clearing of invasive alien plants under different budget scenarios: Using a simulation model to test efficiency. Biological Invasions 12, 4099–4112. doi:10.1007/s10530-010-9827-3.

Le Maitre, D.C., Krug, R.M., Hoffmann, J.H., Gordon, A.J., Mgidi, T.N., 2008. Hakea sericea: Development of a model of the impacts of biological control on population dynamics and rates of spread of an invasive species. Ecological Modelling 212, 342–358. doi:10.1016/j.ecolmodel.2007.11.011.

Limberger, R., Daugaard, U., Gupta, A., Krug, R., Lemmen, K., van Moorsel, S., Suleiman, M., Zuppinger-Dingley, D., Petchey, O., 2022. Functional Diversity Can Facilitate the Collapse of an Undesirable Ecosystem State. Preprint. Preprints. doi:10.22541/au.165513066.66785786/v1.

Marques, A., Pereira, H.M., Krug, C., Leadley, P.W., Visconti, P., Januchowski-Hartley, S.R., Krug, R.M., Alkemade, R., Bellard, C., Cheung, W.W., Christensen, V., Cooper, H.D., Hirsch, T., Hoft, R., van Kolck, J., Newbold, T., Noonan-Mooney, K., Regan, E.C., Rondinini, C., Sumaila, U.R., Teh, L.S., Walpole, M., 2014. A framework to identify enabling

and urgent actions for the 2020 Aichi Targets. Basic and Applied Ecology 15, 633–638. doi:10.1016/j.baae.2014.09.004.

Martinez-Harms, M.J., Gelcich, S., Krug, R.M., Maseyk, F.J.F., Moersberger, H., Rastogi, A., Wambugu, G., Krug, C.B., Spehn, E.M., Pascual, U., 2018. Framing natural assets for advancing sustainability research: Translating different perspectives into actions. Sustainability Science doi:10.1007/s11625-018-0599-5.

Privett, S., Krug, R., Forbes, G., Gaertner, M., 2014. Wild flower harvesting on the Agulhas Plain, South Africa: Impact of harvesting intensity under a simulated commercial harvesting regime for two re-seeding and two re-sprouting fynbos species. South African Journal of Botany 94, 270–275. doi:10.1016/j.sajb.2014.06.015.

Richardson, D.M., Iponga, D.M., Roura-Pascual, N., Krug, R.M., Milton, S.J., Hughes, G.O., Thuiller, W., 2010. Accommodating scenarios of climate change and management in modelling the distribution of the invasive tree Schinus molle in South Africa. Ecography 33, 1049–1061. doi:10.1111/j.1600-0587.2010.06350.x.

Roura-Pascual, N., Bas, J.M., Thuiller, W., Hui, C., Krug, R.M., Brotons, L., 2009. From introduction to equilibrium: Reconstructing the invasive pathways of the Argentine ant in a Mediterranean region. Global Change Biology 15, 2101–2115. doi:10.1111/j.1365-2486.2009.01907.x.

Roura-Pascual, N., Krug, R.M., Richardson, D.M., Hui, C., 2010. Spatially-explicit sensitivity analysis for conservation management: Exploring the influence of decisions in invasive alien plant management: Sensitivity analysis of decision-support models. Diversity and Distributions 16, 426–438. doi:10.1111/j.1472-4642.2010.00659.x.

Roura-Pascual, N., Richardson, D.M., Arthur Chapman, R., Hichert, T., Krug, R.M., 2011. Managing biological invasions: Charting courses to desirable futures in the Cape Floristic Region. Regional Environmental Change 11, 311–320. doi:10.1007/s10113-010-0133-5.

Roura-Pascual, N., Richardson, D.M., Krug, R.M., Brown, A., Chapman, R.A., Forsyth, G.G., Le Maitre, D.C., Robertson, M.P., Stafford, L., Van Wilgen, B.W., Wannenburgh, A., Wessels, N., 2009. Ecology and management of alien plant invasions in South African fynbos: Accommodating key complexities in objective decision making. Biological Conservation 142, 1595–1604. doi:10.1016/j.biocon.2009.02.029.

Singer, A., Johst, K., Banitz, T., Fowler, M.S., Groeneveld, J., Gutiérrez, A.G., Hartig, F., Krug, R.M., Liess, M., Matlack, G., Meyer, K.M., Pe'er, G., Radchuk, V., Voinopol-Sassu, A.J., Travis, J.M., 2016. Community dynamics under environmental change: How can next generation mechanistic models improve projections of species distributions? Ecological Modelling 326, 63–74. doi:10.1016/j.ecolmodel.2015.11.007.

Book Chapters

Hui, C., Krug, R.M., Richardson, D.M., 2010. Modelling Spread in Invasion Ecology: A Synthesis, in: Richardson, D.M. (Ed.), Fifty Years of Invasion Ecology. Wiley-Blackwell, Oxford, UK, pp. 329–343.

Krug, C.B., Krug, R.M., 2007. Restoration of old fields in Renosterveld : A case study in a Mediterranean-type shrubland of South Africa, in: Cramer, V.A., Hobbs, R.J. (Eds.), Old Fields: Dynamics and Restoration of Abandoned Farmland. Island Press, Washington. The Science and Practice of Ecological Restoration.

Maertens, B., Henle, K., Kuhn, W., Krug, R., Jost, K., Grosse, W.R., Wissel, C., 1996. Survival of the Sand Lizard (Lacerta Agilis Linnaeus, 1758) (Sauria, Lacertidae) in Relation to Habitat Quality and Heterogeneity, in: Species Survival in Fragmented Landscapes. Springer Netherlands, Dordrecht, pp. 241–271.

Marques, A., Krug, C., Regan, E., Bowles-Newark, N., Burgess, N., Visconti, P., Walpole, M., Tittensor, D., Pereira, H., Leadley, P., Krug, R.M., 2014. Integrated Analysis of the 2020 Strategic Goals: Time Lags, Indicators and Interactions, in: Leadley, P., Krug, C., Alkemade, R., Pereira, H., U.R., S., Walpole, M., Marques, A., Newbold, T., Teh, L., van Kolck, J., Bellard, C., Januchowski-Hartley, S., Mumby, P. (Eds.), Progress towards the Aichi Biodiversity Targets: An Assessment of Biodiversity Trends, Policy Scenarios and Key Actions. Secretariat of the Convention on Biological Diversity, Montreal, Canada., pp. 441–467.

Conference proceedings

Krug, C.B., Krug, R.M., Iponga, D.M., Walton, B.A., Milton, S.J., Shiponeni, N.N., 2004a. Restoration of West Coast Renosterveld: Facilitating the return of a highly threatened vegetation type , 12.

Krug, R., Roura-Pascual, N., Richardson, D., 2009. Prioritising areas for the management of invasive alien plants in the CFR: Different strategies, different priorities? South African Journal of Botany 75, 408–409. doi:10.1016/j.sajb.2009.02.072.

Krug, R.M., Johst, K., Wissel, C., Maertens, B., 1996. Wirkung der raeumlichen Heterogenitaet innerhalb eines Habitats auf die mittlere Ueberlebensdauer einer Zauneidechsen-Population. Verhandlungen der Gesellschaft fuer Oekologie .

Krug, R.M., Krug, C.B., Midoko-Iponga, D., Walton, B.A., Milton, S.J., Newton, I.P., Farley, N., Shiponeni, N.N., 2004b. Reconstructing West Coast Renosterveld: Past and present ecological processes in a Mediterranean shrubland of South Africa. Ecology, Conservation and Management of Mediterranean Ecosystems. Proceedings of the 10th International Conference on Mediterranean Ecosystems, April 25 – May 1, 2204, Rhodes, Greece. , 1–12.

Roura-Pascual, N., Krug, R., Richardson, D., 2009. Identifying priority areas for the management of invasive alien plants in the Cape Floristic Region. South African Journal of Botany 75, 439. doi:10.1016/j.sajb.2009.02.161.

Conference presentations Only first author, except invited keynote presentations

Krug, R., Roura-Pascual, N., Richardson, D., 2009a. Prioritising areas for the management of invasive alien plants in the CFR: Different strategies, different priorities? South African Journal of Botany 75, 408–409. doi:10.1016/j.sajb.2009.02.072.

Krug, R.M., a. Bringing Science to Management: Using Simulation- and Scenario-Based Approaches to Guide Decision Making in Invasive Species Management — one tool which can do both.

Krug, R.M., b. Population size, sample size and Microsatellites.

Krug, R.M., 2007. Two Approaches — same Answer?

Krug, R.M., 2011. Spatial modelling with the R-GRASS Interface.

Krug, R.M., 2022. Add CARE to FAIR - The Story Behind the New Ipbes Data Management Policy.

Krug, R.M., Le Maitre, D.C., Richardson, D.M., 2012. The Impact of two biological control agents at the landscape scale: Implications for management.

Krug, R.M., Petchey, O.L., 2019a. MetaData can be easy!

Krug, R.M., Petchey, O.L., 2019b. MetaData made easy!

Krug, R.M., Richardson, D.M., 2011. Biocontrol Agents, Aliens and Energy.

Krug, R.M., Roura-Pascual, N., Richardson, D.M., 2009b. Towards more efficient management of invasive alien plants: Spatial prioritisationse.

Krug, R.M., Roura-Pascual, N., Richardson, D.M., 2009c. Towards more Eficient Management of Invasive Alien Plants (AIPs): Spatial Prioritisation.

Krug, R.M., Roura-Pascual, N., Richardson, D.M., 2016. From Scenarios over Models to Management — Alien Spread Management.

Le Maitre, D.C., Krug, R.M., 2006. An alien invasive species, an agent and experts: A case study of hakea spread and two seed feeding biocontrol agents.

Milton, S.J., Krug, R.M., 2002. Pattern in Vegetation Dynamics: Identification and Application in Modelling Restoration of Old Fields in West Coast Renosterveld.

Milton, S.J., Krug, R.M., Newton, I.P., Farley, N., Midoko-Iponga, D., Shiponeni, N., Walton, B.A., . Reconstructing Ecological Processes in West Coast Renosterveld: The Grazers, the Fires and the Humans.

Milton, S.J., Wiegand, T., Krug, R.M., 2003. Optimal Patch Size for Restoration of Renosterveld? A Seeds View.

Roura-Pascual, N., Richardson, D.M., Krug, R.M., 2009. Towards More Efficient Management of Invasive Alien Plants in the Cape Floristic Region: Optimising the Priorities.

Rushworth, I., Krug, R.M., 2012. Optimising the Use of and Motivating for Funding - one tool which can do both.

Rushworth, I., Krug, R.M., 2016. Integrating Scenarios and Models into Ecosystem Management: An example from the Maloti-Drakensberg Park World Heritage Site, South Africa.

Software Packages

Krug, R.M., Eddelbuettel, D., . Earthmovdist: Wrapper to the Emd-L1 library by Haibin Ling and Kazunori Okada.

Krug, R.M., Petchey, O., 2023. Microxanox: An R Package for Simulating an Aquatic MICRobial Ecosystem That Can Occupy OXic or ANOXic States. Preprint. Ecology. doi:10.1101/2023.02.06.527266.

Krug, R.M., Petchey, O.L., 2019a. dmdScheme: An r Package for Working with Domain Specific MetaData Schemes. doi:10.5281/zenodo.3581970.

Krug, R.M., Petchey, O.L., 2019b. emeScheme: A Package for Working with Ecological Microbial Experimental MetaData. Zenodo. doi:10.5281/zenodo.1544945.

Krug, R.M., Petchey, O.L., 2022. Microxanox: Model to simulate three functional group system. Zenodo. doi:10.5281/ZENODO.6624125.

Guest lectures

Krug, C.B., Krug, R.M., 2004. West Coast Renosterveld: Ökologische Prozesse und Restaurierung (West Coast Renosterveld: Ecological Processes and Restoration).

Krug, R.M., 2004. Ecological Modelling — A Taxonomy.