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Source: Mountain Research and Development, 43(3)

Published By: International Mountain Society

URL: https://doi.org/10.1659/mrd.2023.00035

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

MountainPlatform

Africa's First Alpine and Transboundary Long-Term Socioecological Research Platform

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The austrotemperate alpine system of southern Africa's Maloti–Drakensberg is the only alpine system south of Mount Kilimanjaro, making it unique on the continent. With a difference in elevation of only 300–600 m and characterized by an undulating Gondwanan mature erosional land surface plateau around 2865–3500 masl, it is threatened by unsustainable land uses and climate change. To better understand these challenges, the Afromontane Research Unit of the University of the Free State, South Africa, is setting up the 1200 km^2 Mont-Aux-Sources Long-Term Socio-Ecological Research (LTSER) platform. It is the first alpine-focused, long-term monitoring protocol implemented in the Maloti–Drakensberg. Straddling the border between South Africa and Lesotho, it is also the only alpine and transboundary LTSER area in Africa.

Going, going, gone . . . but by when? Global change in southern Africa's alpine zone

Shared by the Kingdom of Lesotho and the Republic of South Africa, the Maloti–Drakensberg is the highest mountain system in Africa south of Mount Kilimanjaro (Nel and Sumner 2008; Delves et al 2021). Covering approximately 36,000 km^2, it is the only southern African mountain system with an alpine zone (Carbutt and Edwards 2006, 2015; Carbutt 2019). The alpine zone has an elevation range of around 2865 to 3500 masl but is mainly located between 2900 and 3100 masl (sensu Carbutt and Edwards 2015). Comprising a Miocene–Pliocene uplifted pre-Jurassic Gondwanan land surface (Moore and Blenkinsop 2006; Knight and Grab 2015), the shallow elevation depth and relatively low topographic heterogeneity of this zone make it vulnerable to the impacts of climate change—especially elevation-dependent warming (Pepin et al 2015). The geology mostly consists of basalt and nonintrusive dolerite (Carbutt 2019). The soil is primarily humified with high organic carbon content and effectively sequesters carbon, thus acting as a sink (Kotzé and van Tol 2023). The mature drainage patterns in the alpine zone (Moore and Blenkinsop 2006; Knight and Grab 2015) are exceptionally important in the Maloti–Drakensberg's crucial role of supplying water to southern Africa (Taylor et al 2016): the gentle topography has encouraged large alpine wetlands on the deep alluvial or colluvial and peat soils (Du Preez and Brown 2011). Combined with regular snowfalls, this enables slow percolation of ground and surface water into catchments that supply more than 30 million people—as well as industry—in South Africa, Lesotho, and Namibia (Taylor et al 2016).

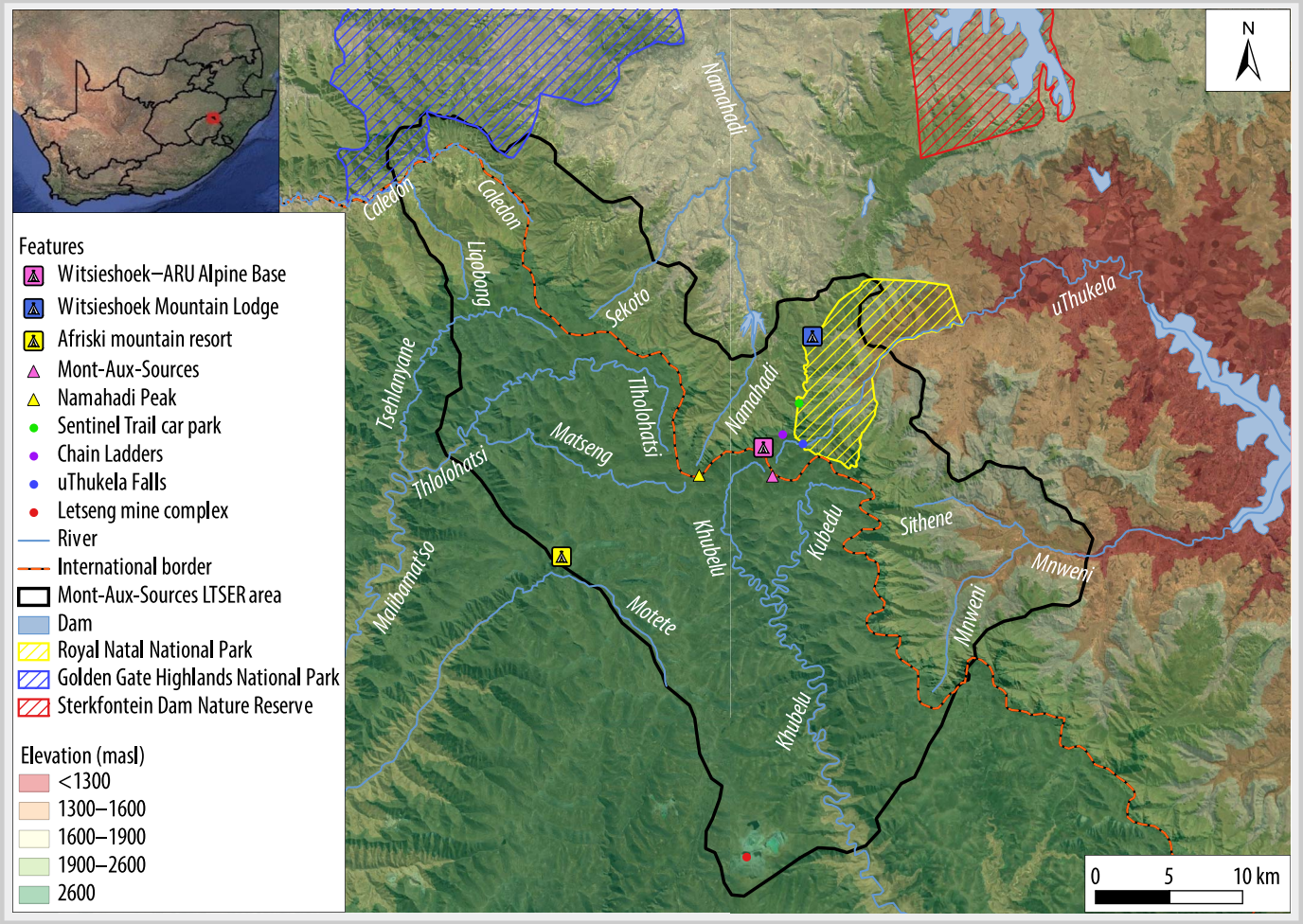
Despite the recognized value of the Maloti–Drakensberg regionally, the alpine zone is one of the mountain system's least-understood components (Carbutt 2019). In addition, it is under increasing pressure from climate change and direct land use impacts (notably intensive subsistence rangeland use, open-cast mining, and development of infrastructure, such as roads; eg Du Preez and Brown 2011; Knight and Grab 2015; Delves et al 2021; Mathinya et al 2022). This has put at risk nearly 30% of the endemic flora—mostly alpine endemics—of the Maloti–Drakensberg (Carbutt and Edwards 2006; Carbutt 2019). Alpine wetlands are particularly affected, impacting water supply and carbon stocks when degraded or eroded out (Du Preez and Brown 2011; Kotzé and van Tol 2023).

Africa's first alpine and transboundary LTSER area: the Mont-Aux-Sources LTSER platform

To improve our fundamental understanding of the Maloti–Drakensberg alpine zone and how it could be affected by global change drivers, the Afromontane Research Unit (ARU) is establishing the Mont-Aux-Sources Long-Term Socio-Ecological Research (LTSER) platform. It covers approximately 1200 km^2 of the northern Maloti–Drakensberg, centered on the transboundary area where 2 South African provinces (Free State and KwaZulu–Natal) and Lesotho meet on the Mont-Aux-Sources plateau (3282 masl; Figure 1). Much of it is poorly studied. The strategic goals of the platform are detailed in Box 1.

Most of the Mont-Aux-Sources LTSER area is a high-elevation grassland ecosystem (Carbutt 2019; Finch et al 2022). The rangeland is under traditional leadership governance (Basotho, Batlokoa, and Bakoena Royal Houses and the Inyongama Tribal Trust) and is used seasonally for communal grazing by domestic livestock. Other land uses

FIGURE 1 Mont-Aux-Sources LTSER platform (black boundary) in the northern Maloti–Drakensberg. (Map by Jaco Kotzé)



are conservation in the form of Royal Natal National Park (part of the uKhahlamba–Drakensberg Park and World Heritage Site), tourism nodes at Witsieshoek Mountain Lodge and Afriski (Mweni also hosts activities), industrial (Letseng Mine complex), and transport infrastructure (A1 in Lesotho). The area suffers extensively from cross-border crime that directly affects livestock owners in both commercial and subsistence or cultural contexts.

Topographically, the Mont-Aux-Sources LTSER area covers some of the highest-elevation ground in the Maloti–Drakensberg (around 3100–3300 masl) and includes world-famous features such as the uThukela (Tugela) Falls (now considered the world's highest), the renowned Amphitheatre in Royal Natal National Park, and all of the highest ground in the Free State province (including Namahadi Peak, the highest point in the province). The area is a summer rainfall region with cold winters and experiences mean annual rainfall of 1200–1500 mm (Cole et al 2018). The Mont-Aux-Sources plateau complex is the source of 4 important rivers (uThukela, Namahadi, Khubelu, and Malibamat'so), with many other, lesser rivers rising within the Mont-Aux-Sources LTSER area (Figure 1). It also holds some of the less degraded alpine areas in the Maloti–Drakensberg, providing good opportunities for baseline studies of this system. Increasing degradation in adjacent alpine parts of the Maloti–Drakensberg, as well as rangeland loss from the next phase of the Lesotho Highlands Water Scheme, may cause indirect effects on the Mont-Aux-Sources LTSER area that allow a baseline–change monitoring continuum.

Current research facilities and projects

The core instrumentation area of the Mont-Aux-Sources LTSER platform is the 250-ha alpine lease area that the ARU has with Witsieshoek Mountain Lodge on the Free State side of Mont-Aux-Sources. The lease area includes the Witsieshoek–ARU Alpine Base, the only alpine research facility of its kind in southern Africa (Box 2). Current instrumentation at the alpine base includes an automatic weather station (as part of an elevation continuum with 3 other stations from around 1500–3060 masl), the RangeX project installation (open top chambers, soil moisture probes, and automatic cameras), and waterflow gauges in the nearby first-order alpine stream.

Within the Mont-Aux-Sources LTSER Alpine Lease area, the ARU, as part of the Mountain Invasion Research Network (MIREN), has implemented a MIREN protocol transect (Haider et al 2022) from the Witsieshoek toll gate (around 1950 masl) to the summit plateau above the Chain Ladders (around 3000 masl). The purpose of the transect is to study global change effects on species' distributions and biodiversity

BOX 1: Strategic aims of the Mont-Aux-Sources LTSER

The primary objective of the Mont-Aux-Sources LTSER Platform is to gain a comprehensive understanding and quantification of socio-ecological processes and interactions within the alpine regions of the northern Maloti–Drakensberg area. The Mont-Aux-Sources LTSER platform adopts an interdisciplinary and transdisciplinary approach, providing a collaborative space for scientists from diverse backgrounds and non-scientific stakeholders.

The Platform aims to achieve the following:

1. Conduct in-depth studies on alpine wetlands, including mapping procedures, examination of key properties, investigation of ecosystem functions, and engagement in restoration activities. The degradation of these wetlands can disrupt stream-water regimes and release sequestered carbon, resulting in the loss of the globally important biodiversity of the Maloti–Drakensberg area, which exhibits high levels of endemism.
2. Study the socioeconomics of highland herders to promote the protection and restoration of rangelands. Degradation of rangelands, erosion, reduced biomass and vegetation diversity, and decreased carrying capacity can negatively impact both the ecosystem and the livelihoods of those dependent on it. This research is crucial as the Maloti–Drakensberg mountain system serves as a significant water source for southern Africa, supplying water directly to South Africa, Lesotho, and southern Namibia.
3. Quantify the carbon sequestration capabilities of alpine soils. The assessment of carbon stocks in the Maloti–Drakensberg region is essential due to its designation as a carbon hotspot. The region's high rainfall and cool climate contribute to the presence of soils with a high carbon content, making it an important carbon sink.
4. Conduct comprehensive research on the region's climate, weather patterns, and the impacts of climate change. Given the complexity of the region, studying the microclimate and how it is influenced by topography is crucial. Additionally, due to its high hydrological importance, the platform will make hydrological predictions about soil and stream water and quantify the impact of climate change on livelihoods.
5. Investigate and monitor land-use changes in the region. The area is subject to mining activities, overgrazing, and cultivation by farmers. These land use practices can have detrimental effects on biodiversity and hydrological functions. Therefore, research is needed to provide recommendations and implement land use management systems, and if needed, promote restorative land-use practices.

in mountains through observational and experimental studies across elevation gradients. Witsieshoek is a focus area for an ARU-led bioblitz that is looking for elevational patterns in biodiversity, from montane to alpine (1800–3300 masl). Other projects around fire management, biodiversity research, pollination ecology, transboundary crime, and traditional governance linked to the Sustainable Development Goals are being developed with various partners.

Future collaboration

The International Long-Term Ecological Research (ILTER) Network fosters international cooperation, facilitates synthesis and knowledge exchange across ecosystems, and contributes to a more comprehensive understanding of long-term ecological dynamics (Box 3). Collaborating with other research platforms is also an important aim for the Mont-Aux-Sources LTSER platform. The platform provides an important opportunity for alpine contribution to other long-term initiatives in the region, such as the South African Environmental Observation Network's Expanded Freshwater and Terrestrial Environmental Observation Network, Lesotho Meteorological Services, and research activities undertaken by the National University of Lesotho. In this regard, the Mont-Aux-Sources LTSER platform fits the objectives of the Maloti–Drakensberg Transfrontier Programme by creating an active space for transboundary research, collaboration, and internationalization in the Maloti–Drakensberg that did not exist before with regard to this alpine context (Figure 2).

The Mont-Aux-Sources LTSER platform also provides an opportunity to contribute to global initiatives in which (southern) Africa is often poorly represented. Initiatives include the Global Mountain Biodiversity

BOX 2: The Witsieshoek-ARU Alpine Base

Located at 3069 masl (28°45′17″S 28°52′00″), the Witsieshoek-ARU Alpine Base is the highest mountain hut in southern Africa south of Mount Kilimanjaro, and the 21st highest mountain hut in Africa. Situated 530 m from the international border with Lesotho, and 830 m from the provincial border with KwaZulu-Natal (and Royal Natal National Park/World Heritage Site), the Alpine Base provides secure and relatively easy access to the Mont-Aux-Sources LTSER area. Access is by foot (via the Sentinel Trail up the Chain Ladders), by horseback (up the Namahadi Pass), or by helicopter (there is a designated landing space).

The Alpine Base was created between May 2022 and June 2023 by restoring the old Basutoland (now Lesotho) Namahadi Police Border Post. The Border Post was originally constructed in 1917 at the head of the Namahadi Pass, in South Africa. These buildings have been in ruins for perhaps as long as a century, and much of the history is unknown. The original footprint of 2 of the 3 buildings was retained, and the original stone was used to rebuild the walls. A reinforced roof was added with some modern conveniences such as a solar geyser and solar power, and rain-fed running water. The sanitation system was specially designed for the alpine conditions to ensure best practice in wastewater treatment in this locality (monthly water samples are taken to determine output quality).

The smaller building is currently the security guard facility, and the larger building a science-tourist combination facility. The third building will be restored as and when funds allow. The facility can currently accommodate 20 people and is managed by Witsieshoek Mountain Lodge on behalf of the ARU.

BOX 3: The International Long-Term Ecological Research (ILTER) Network

LTSER platforms are collaborative frameworks that integrate diverse disciplines to understand the interactions between society and the environment over extended periods. They contribute to sustainable development by addressing socio-ecological challenges, facilitating long-term monitoring, and informing policymaking. The ILTER Network (https://www.ilter.network/) ensures standardized methodologies and data sharing among research sites worldwide, fostering global collaboration and synthesis across diverse ecosystems.

FIGURE 2 Views of (A) the Amphitheatre from Witsieshoek and (B) Sentinel Peak hidden in the clouds, photographed during a hike to the summit area. (C) A herder watching over a flock of sheep grazing on the alpine grasslands. (D) Well-preserved alpine wetlands. (E) Severely degraded alpine wetlands. (F) View from the Amphitheatre summit area over the Fika-Patso Dam. (Photos A, C, E by Johan van Tol; B, D, F by Jaco Kotzé)

Assessment, GEO Mountains and the Mountain Research Initiative, and the Global Observation Research Initiative in Alpine Environments. The first sister LTSER area to the Mont-Aux-Sources LTSER platform will be the Matsch–Mazia LTSER site (South Tyrol, Italy; one of the few LTSER areas in Europe), managed by Eurac Research and providing a framework for closer North–South cooperation between the 2 LTSER areas, as well as

between the ARU and the Global Mountain Safeguard Programme.

FURTHER READING AND INFORMATION

The Mont-Aux-Sources LTSER platform can be explored virtually on the Dynamic Ecological Information Management System–Site and Dataset Registry at https://deims.org/3caf19a6-2d81-472e-be2e-06825e6b6217 and the ARU's website at https://www.ufs.ac.za/aru/. ARU-led projects in the LTSER area can be explored at https://www.ufs.ac.za/aru/mas-ltser/projects. Information regarding the RangeX project can be found on the web via https://rangex.w.uib.no/.

There is a large body of work on the Maloti–Drakensberg in general, good starting points for which are Carbutt and Edwards (2006, 2015) and Carbutt (2019).

Queries for projects and collaborations in the Mont-Aux-Sources LTSER platform can be submitted to the ARU director, Prof. Ralph Clark (clarkvr@ufs.ac.za) and copied to the Mont-Aux-Sources LTSER program manager, Prof. Johan van Tol (vantoljj@ufs.ac.za).

ACKNOWLEDGMENTS

The ARU is grateful to the South African Department of Science and Innovation and the National Research Foundation for their support and contribution to the alpine base through a Risk and Vulnerability Science Centre award (Grant No. 128386) to V. Ralph Clark. The ARU thanks Witsieshoek Mountain Lodge and Transfrontier Parks Destinations for the mutual relationship that enabled the alpine lease, alpine base, and a new platform for secure alpine research in the Maloti–Drakensberg. V. Ralph Clark thanks Eurac Research for hospitality and engagements in visiting the Matsch–Mazia LTSER site in September 2019. The various project leads, collaborators, and partners in the Mont-Aux-Sources LTSER area (too numerous to mention individually here) are appreciated.

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