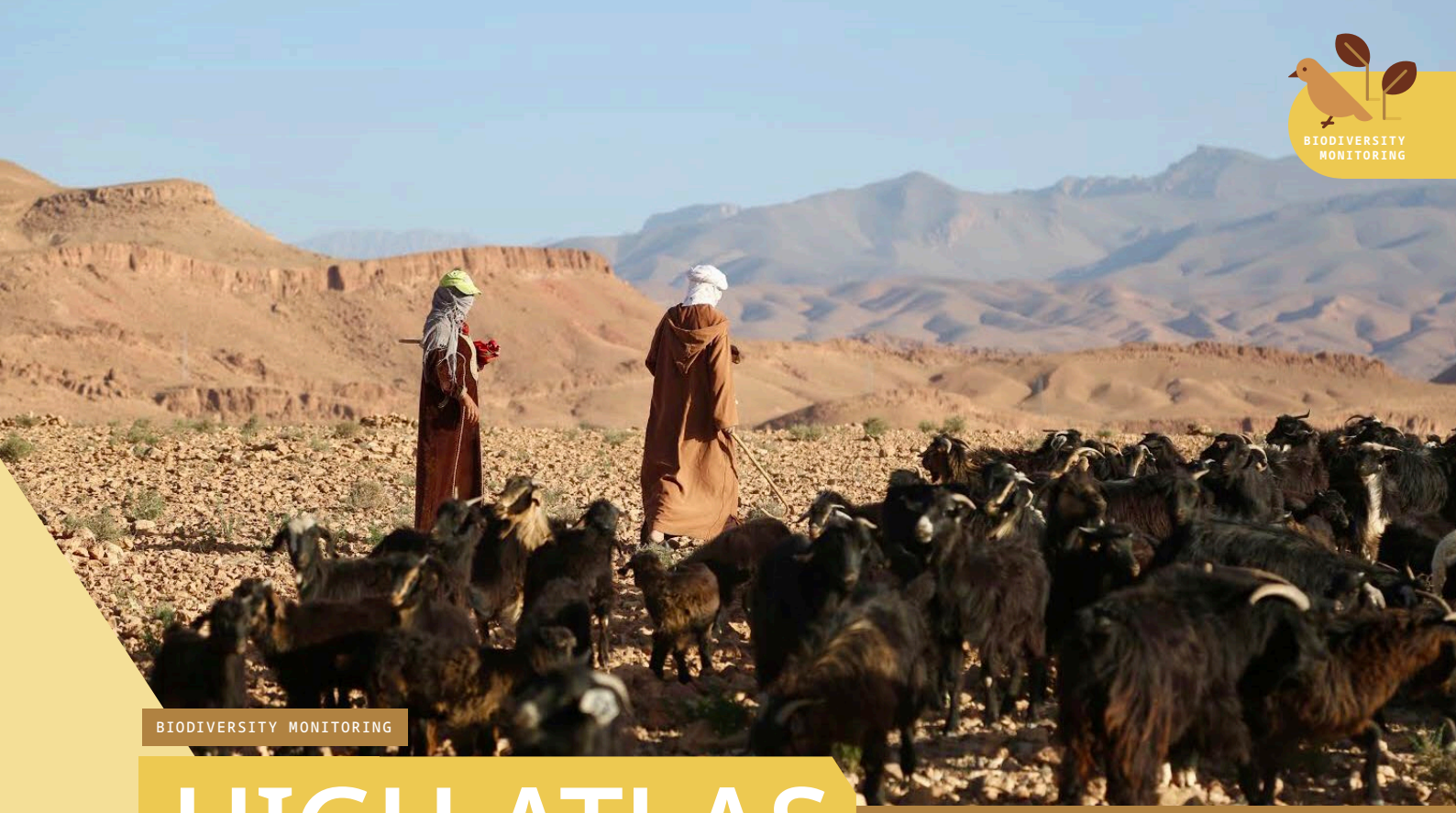

BIODIVERSITY MONITORING

HIGH ATLAS

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THE HIGH ATLAS IS A MOUNTAIN RANGE THAT STRETCHES THROUGH CENTRAL MOROCCO, AND SEPARATES THE HEARTLAND OF MOROCCAN ECONOMIC ACTIVITY TO THE NORTH FROM THE SAHARAN INFLUENCE TO THE SOUTH.

It is considered a biodiversity hotspot within the Mediterranean basin, and houses a large number of endemic (24%) and threatened species. The cultural practices of the native population maintain the ecological mosaic of the landscape, contribute to a sustainable local livelihood and increase the biodiversity in the region. The tribes in the High Atlas uphold in total more than 20 cultural practices (Teixidor-Toneu et al. 2020). Most focus has been on *agdal*[1] sylvo-pastoral resource management system, and its contribution to the conservation of biological and cultural diversity. This system protects the plants in the spaces against grazing during the period of the flowering and fructification. It is deeply rooted in the local culture and is passed on from generation to generation.

The current exodus of young people from the region to the urban areas threatens the survival of the *agdals* and other traditional practices. The lack of socioeconomic opportunities and difficulties of making a living in the harsh High Atlas environment results in a high rate of out-migration. Besides this erosion of traditional knowledge, the survival of this cultural landscape and traditional practices is threatened by (I) increased pressure from the global market favouring the use of intensive agriculture, (II) harsher summer droughts, exacerbated by climate change, causing conflicts around the governance of *agdals* and access to water, (III) less involvement of the community on the religious traditions and rituals surrounding the *agdals*.

1 Areas for which the access is regulated through collective agreement between different tribes in the High Atlas mountains

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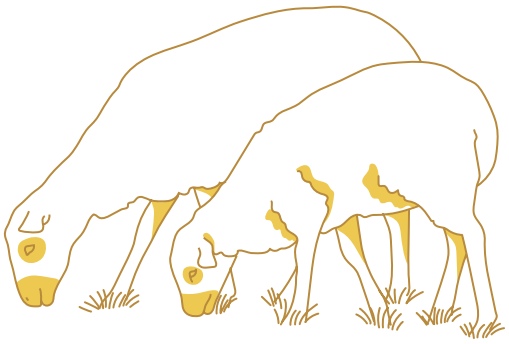
MAVA FONDATION POUR LA NATURE



Agdal sheep

1. OBJECTIVES

The general aim of the project is to document the cultural practices in the three different Amazigh communities in the High Atlas (Imegdal, Ait M´hamed, Oukaimeden) and to measure the impact of these cultural practices on biodiversity, community wellbeing and socioecological resilience in the High Atlas cultural landscape.

The project attempts to unravel the interrelated drivers that could halt the loss of the cultural landscape and biocultural diversity through ecological monitoring, specifically of the state of vegetation, in the different Amazigh communities sites that are also identified as Key Biodiversity Areas (KBA).

Three different cultural practices and project actions were monitored and studied:

1. **Pastoral *agdals* (Ait M´hamed & Oukaimeden):** vast areas of high-altitude rangelands that are normally used by Amazigh livestock herders for grazing, but are communally restricted during about 3 months per year in order to ensure plant growth, reproduction and seed dispersal. The impact of this communally restricted *agdal* practice will be measured with a number of vegetation indexes and butterfly monitoring.
2. **Enrichment planting areas (Boumagour):** Through this action that combines traditional practices and modern innovations, the wild populations of threatened, economically valuable and over-harvested plant species are protected and boosted for future generations. In a non-grazing plot, several valuable medicinal and aromatic plants are grown, with a current focus on lavender and thyme. The impact on plant biodiversity will be investigated through the comparison between an enrichment planting plot and a control plot.
3. **Agricultural terraces (Imegdal & Ait M´hamed):** This traditional agricultural practice permits crop production and occasionally seasonal grazing on the steep slopes of the High Atlas. The combination of local knowledge with innovative approaches could enhance productivity and biodiversity in these terraces. Soil-related indicators (and future butterfly biodiversity) were compared between agricultural terraces with and without regenerative agricultural practices.

SELECTED INDICATORS:

Three groups of indicators were selected:

- Plants/Vegetation
  - Species richness
  - Species density/abundance/frequency
  - Vegetation cover
  - Vegetation biomass
  - Vegetation structure
  - Biodiversity indices
  - Remote sensing
- Soil
  - Visual and physicochemical characterization of the soil
- Fauna
  - Abundance and diversity of Lepidoptera

2. METHODS

2.1. METHODS PHASE 1

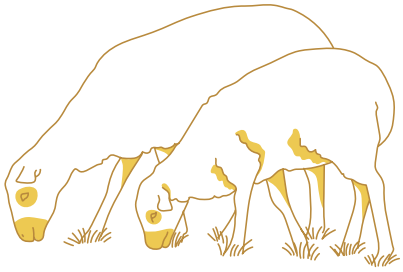
The methodology applied to High Atlas in phase 1 was mainly based on ecological monitoring. The methodological approach of the research includes four main parts: 1) baseline data collection; 2) sampling strategy & study area; 3) ecological monitoring (vegetation and soils); and 4) remote sensing. A total number of 48 plots were selected to be studied by a team of experts. Among them, 8 plots were targeted for the plant enrichment project (Boumagour), another 8 plots were targeted for the studying the effects of artificial enclosures (Imegdal), and the final 32 plots focused on the study of the *agdals* (Ait M´hamed & Oukaimeden).

2.1.1. PLANTS

METHODS FOR DATA COLLECTION

For most of the systematically chosen sampling plots, the Line Intercept Transect (LIT) was used as a sampling method to evaluate the plant biodiversity. The LIT sampling method consists in extending a 20m decametre in a straight line in a randomly selected direction from a randomly selected starting point within the area under study, and making 100 observations at regular intervals of 20 cm.

For the study on plant enrichment, the slower



Quadrat method was used as the main sampling method. This method consists in placing a wooden square of a $1m^2$ that is subdivided into 100 equal-sized squares using string (10x10), and recording and calculating the vegetation within the space.

For each sampling method, the following biodiversity indicators were calculated:

1. Species richness: The number of individuals per species and the corresponding family and genus were assessed at the level of each transects. It does not consider the abundances of the species.
2. Species density/abundance/frequency: For each transect, the number of individuals per unit area was reported. With this information the frequency, abundance and density were calculated with DAFOR indices for Raunkiaer´s vegetation classification.
3. Vegetation cover: The percentage of ground covered by vegetation expressed in units of percent.
4. Vegetation biomass: Biomass is the total weight of living plant material in an area at a given time.
5. Vegetation structure (habitat): This indicator allows us to assess the change in total area/ average size of a particular block of habitat
6. Biodiversity indices
    a. Simpson's diversity Index (D): measure of diversity which considers the number of species present and the relative abundance of each species. As species richness and evenness increase, so diversity increases. The value of D ranges between 0 and 1 With this index, 1 represents infinite diversity and 0, no diversity.
    b. Shannon diversity index (H): index that is commonly used to characterise species diversity in a community. The value of H ranges between 0, indicating low community complexity, and 4 and above, indicating high community complexity.
    c. Evenness index (E): measure of relative abundance of different species making up the richness of an area. The value for E ranges between 0 for no evenness, and 1 for complete evenness

Finally, the field-based sampling data were supported with remote sensing data, allowing for up-to-date and spatially detailed assessment on plant biodiversity. Through the use of remote sensors, data can be collected about areas on a large distance by detecting the energy that is reflected from Earth. The vegetation that is observed in remote-sensing data is usually described in terms of derived variables such as vegetation indices.

1. Normalised Difference Vegetation Index (NDVI): Indicator using satellite data, analysing the near-infrared reflected by the vegetation. It provides information about spatial distribution, health and growth of the plants.
2. Fractional Vegetation Cover (FVC): Fraction of ground covered by green vegetation. F VC is widely used to describe the quality of vegetation and ecosystem change.
3. Vegetation biomass data from satellite images: Total amount of living vegetation in a certain place. Through the use of remote sensing techniques and biomass data provided from the Centre for Spatial Study of the Biosphere, a full estimated mapping of biomass can be constructed.

SAMPLING

The vegetation was monitored for the plant enrichment area in Boumagour, with 4 sampling plots in the part of the area enriched with medicinal plants and 4 sampling plots in the control part. Furthermore, the vegetation was monitored for the 10 *agdal* sampling plots and 6 control plots in Oukaimeden and Igourdane (Ait M´hamed) respectively.

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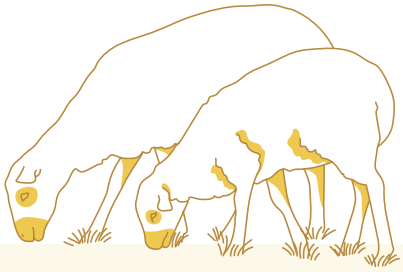


2.1.2. SOIL CHARACTERISTICS

METHODS FOR DATA COLLECTION

Soil samples were extracted from *agdals* and nurseries to get a preliminary idea of the soil quality and the physico-chemical properties. These extractions were performed on a yearly basis and through visual assessment or field-based using Hanna instruments (chemical agents).

SAMPLING

Soil quality and the physico-chemical properties were compared for agricultural terraces with and without regenerative agricultural practices in 2 KBAs (Imegdal, Ait M´hamed).

2.2. METHODS PHASE 2 (SIMPLIFIED METHODS)

The methodology applied to High Atlas in phase 2 (2020-2022) is a simplification of the methods in phase 1 with the incorporation of butterfly monitoring. The methodological approach of the research included four main parts: 1) baseline data collection; 2) sampling strategy & study area; 3) ecological monitoring (vegetation, soils and butterflies); and 4) community-based approaches. A total number of 36 plots were selected to be studied by a team of experts and community researchers. Among them, 4 plots were targeted for the monitoring of agricultural terraces (Ait M'hamed and Imegdal), and the final 32 plots focused on the study of the *agdals* (Ait M´hamed & Oukaimeden). The advent of COVID-19 in early 2020 had a significant impact at the start of this phase.

2.2.1. PLANTS INDICATORS

METHODS FOR DATA COLLECTION

After selecting 11 bioindicator plant species in each site (totalling 29 different species for all sites), we measured, for each of them, the number of individuals (and density), their frequency and their abundance (DAFOR) and a visual estimation of the vegetation cover in each plot. A list of accompanying abundant plant species (beyond the bioindicators) was also included. Species were selected according to their indications for different preferences in soil and climatic conditions as well as for their high ethnobotanical relevance in the area.

SAMPLING

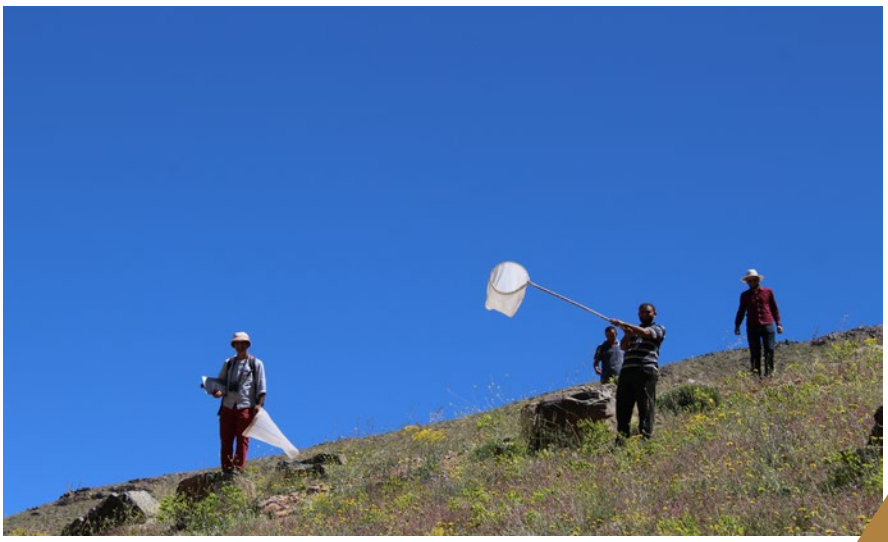
The vegetation was monitored for agricultural terraces, in 4 different sampling plots. Furthermore, the vegetation was monitored for the 10 *agdal* sampling plots and 6 control plots in Oukaimeden and Igourdane (Ait M´hamed).

2.2.2. SOIL CHARACTERISTICS

Following the visual soil assessment proposed by FAO (Shepherd et al. 2008) we monitored soil texture, structure, porosity, crust, compaction, root density and depth in 4 plots in agricultural terraces and 32 in *agdals*.

SAMPLING

Visual soil characteristics were measured in 2 agricultural terraces and 2 *agdals* (including sample plots and control plots).



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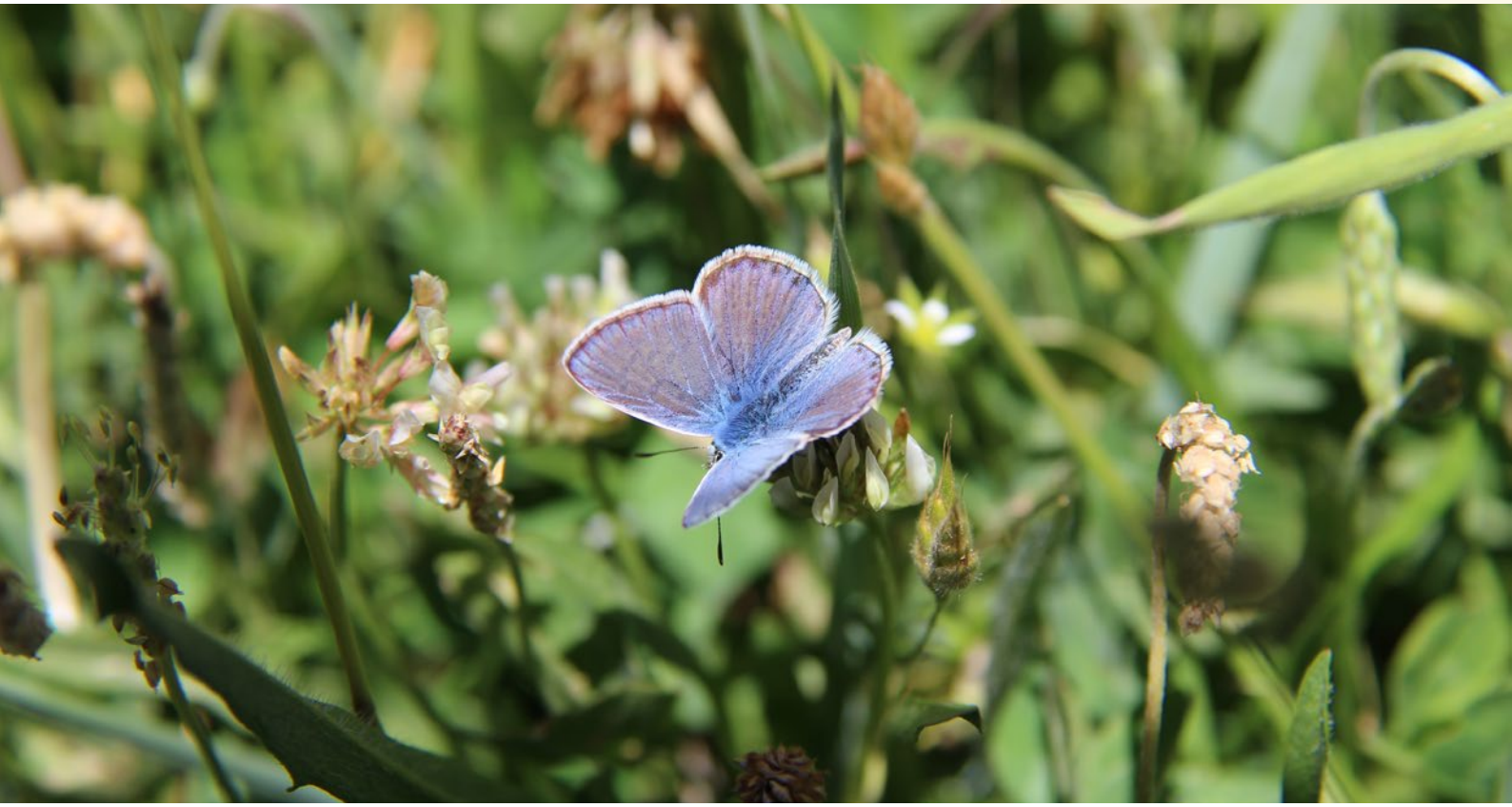


Butterfly monitoring © Pommelien Da Silva Cosme

2.2.3. BUTTERFLIES

METHODS FOR DATA COLLECTION

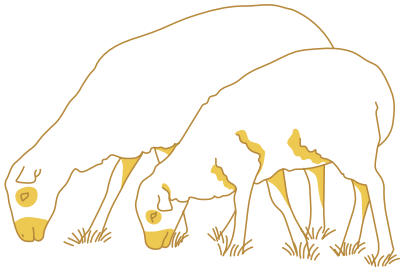
Butterflies have been added to the ecological monitoring in 2020. The data collection is conducted with a participatory science protocol for sampling butterflies using transects, the BMS technique. This technique is based on the visual counting of adult specimens of butterflies along a specific route. The data collection happened twice yearly, at a constant speed, and only butterflies at a distance of 5 m ahead and on the sides of the observer are counted. The 2 sampling moments were at the beginning of the summer (June-July), just before the opening of the *agdal*, and in the month of September, after the *agdal* opens.

Instead of 2 km, like in the Catalan BMS method, in the High Atlas transects had a length of 500m to match the length of the plots. The data collection happened in the early morning in favourable climatic conditions. Specific butterfly sampling forms and an existing baseline were used for the data collection. Information on the ecology of the species and the environmental factors on transects could be filled in on the sampling forms.

SAMPLING:

During phase 2, butterflies were monitored in all 36 plots (agricultural terraces and *agdals*).

Additional work on biodiversity monitoring and documentation occurred at the species level, including IUCN Red List conservation assessments of a selection of High Atlas plants (Rankou et al. 2020) and ethnobotanical and conservation studies (Teixidor-Toneu et al. 2022), as well as using GIS techniques (Castangia 2022a and 2022b).



3. REFERENCES

Castangia, G. (2022a). Measuring impact in Cultural Landscapes of the M6 OAP/ AMNC. Available at: https://storymaps.arcgis.com/stories/07fb8a22edcd461f87eaf238596d422d

Castangia, G. (2022b). HACL GIS. GIS Mapping and Analysis of the High Atlas region and study areas of Igourdane, Oukaimeden and Znaga Valley (March 2020 - January 2022). Available at: https://storymaps.arcgis.com/stories/602ad1bf7e914d2bb9cb6a31369c43d4

Rankou, H., M'Sou, S., Diarra, A. & Ait Babahmad, R.A. (2020). *Capparis spinosa* (e.T137745831A139593491), *Mentha gattefossei* (e.T164184A72262769), *Thymus saturejoides* (e.T139600868A139601223), *Lavandula maroccana* (e.T139600541A139600544), *Cistus monspeliensis* (e.T73094084A139593829), *Salvia taraxacifolia* (e.T139603526A139603531). The IUCN Red List of Threatened Species 2020.

Shepherd, T. G., Stagnari, F., Pisante, M. and Benites, J. (2008). *Visual Soil Assessment. Field guides*. FAO, Rome, Italy. Available at: https://www.fao.org/3/i0007e/i0007e00.pdf

Teixidor-Toneu, I., Martin, G., M'sou, S., D'Ambrosio, U. (2020). Integrating Amazigh cultural practices in Moroccan high atlas biodiversity conservation. In: Thornton, T.F., Bhagwat, S.A. (Eds.). *The Routledge Handbook of Indigenous Environmental Knowledge*. Available at: https://www.routledgehandbooks.com/doi/10.4324/9781315270845-19

Teixidor-Toneu, I., M'Sou, S., Salamat, H., Baskad, H. A., Illigh, F. A., Atyah, T., Mouhdach, H., Rankou, H., Babahmad, R. A., Caruso, E., Martin, G., & D'Ambrosio, U. (2022). Which plants matter? A comparison of academic and community assessments of plant value and conservation status in the Moroccan High Atlas. *Ambio*, 51(3), 799–810. https://doi.org/10.1007/s13280-021-01584-0

4. CONTACT

Alliance for Mediterranean Nature and Culture
https://www.mednatureculture.org/

Global Diversity Foundation
https://global-diversity.org/

Moroccan Biodiversity and Livelihoods Association
https://www.mblaassociation.org/

IUCN Centre for Mediterranean Cooperation
https://www.iucn.org/our-work/region/mediterranean

Tour du Valat
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MAVA Foundation
https://mava-foundation.org/oaps/promoting-sustainable-land-use-practices-2/