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KUNGL. VETENSKAPS-AKADEMIEN
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RESEARCH ARTICLE

Which plants matter? A comparison of academic and community assessments of plant value and conservation status in the Moroccan High Atlas

Irene Teixidor-Toneu, Soufiane M'Sou, Hajar Salamat, Hamid Ait Baskad, Fadma Ait Illigh, Touda Atyah, Hafida Mouhdach, Hassan Rankou, Rachid Ait Babahmad, Emily Caruso, Gary Martin, Ugo D'Ambrosio

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Abstract As interest in including local communities and their knowledge in biodiversity conservation increases, challenges to do so become clear. One of them is to harmonize local and academic assessments of conservation status. Here, we document the culturally valuable flora of two Amazigh communities in the Moroccan High Atlas Mountains and contrast local conservation observations with IUCN and other red-listing assessments. Our study reveals two levels of mismatch. Unsurprisingly, the species of interest of these two knowledge systems differ considerably. Moreover, species' availability and populations' trends of change and the conservation evaluations often diverge between local and academic assessments. Locally valuable species are rarely threatened, but a focus on locally prioritized species is essential to ensure the active participation of local communities in conservation initiatives. Given the salient role of IUCN Red Lists in guiding conservation action, a better understanding of the differences in plant value and conservation assessments between the two knowledge systems can help harmonize biodiversity conservation and community wellbeing goals.

Keywords Amazigh · Ethnobotany · Indigenous and local ecological knowledge · IUCN conservation assessments · Maghreb · Red lists

INTRODUCTION

The IPBES Global Assessment Report on Biodiversity and Ecosystem Services reports an alarming deterioration of nature and a rapid decline of biodiversity and ecosystem functions and services worldwide (IPBES 2019). As human actions threaten an ever-increasing number of species, non-material contributions of nature to human life are also in steep decline (IPBES 2019). Ecological and social systems are inextricably linked, and biodiversity extinction drives cultural decline as much as human action drives biodiversity extinction (Cámara-Leret et al. 2019). However, conservation scholars and practitioners struggle to recognize that biological and cultural diversity face similar pressures (Gorenflo et al. 2012). Top-down conservation strategies that ignore local communities and their needs are often the source of conflict and achieve limited success (Adams et al. 2004; Cernea and Schmidt-Soltau 2006; Ostrom 2009).

Mounting evidence shows that biodiversity conservation cannot be decoupled from indigenous and local knowledge (e.g., Berkes et al. 2000; Chapin 2004; Waylen et al. 2010; Andrade and Rhodes 2012; Garnett et al. 2012; Otto et al. 2013; Gavin et al. 2015). Indigenous and local ecological knowledge has been recognized by all global conservation organizations and agreements as key for biodiversity conservation (e.g., CBD 2012, 2020) as it contributes to improving livelihoods, sustaining biodiversity and ecosystem services, and building resilience in social-ecological systems (e.g., Gadgil et al. 1993; CBD 2012; Gómez-Baggethun et al. 2012). This knowledge is the base of human environmental modifications that result, for example, in the multifunctional, productive and diverse Mediterranean landscapes (Thompson 2005; Blondel 2006; Carvalho and Frazão-Moreira 2011). Indigenous and local communities across the world recognize, name, and manage ecological interactions with

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biodiversity, and their knowledge offers opportunities for biodiversity conservation (Berkes et al. 2000; Nabhan 2001; Carvalho and Frazão-Moreira 2011). For example, local knowledge about rare, threatened, and endemic species can guide the identification, management, protection, and recovery of habitats for these taxa (Nabhan 2001). However, integration of this knowledge into conservation strategies is not straightforward (Gruber 2010; Brooks et al. 2013; Tomasini 2018), and important regional, cultural, and environmental differences may hinder the formulation of global guidelines. As the IUCN red list database is internationally accepted as the most comprehensive global index of species conservation status, and as it is a primary resource used for conservation priority-setting and policymaking (Possingham et al. 2002; Trousdale and Gregory 2004; Hoffmann et al. 2008), how this database stands in relation to indigenous and local knowledge is key to biodiversity conservation. A protocol has been written to guide the integration of local knowledge into IUCN Red List Assessments (Cross et al. 2017), but its degree of implementation is unknown. Also unknown is how IUCN currently represents local conservation concerns and observations.

Using a case study from the Moroccan High Atlas Mountains, this study compares local conservation priorities with global IUCN, regional, and national red lists and evaluates the potential of local ethnobotanical information as a tool for biodiversity conservation. First, we document the useful flora in two rural Amazigh rural communities, and characterize perceived changes in plant use, habitat and availability. Second, we compare this information with global (worldwide), regional (Mediterranean) and national (Moroccan) conservation assessments of these plants. While academic assessments should not be expected to entirely match locally important plants because of geographic scale issues and discrepancies in how plants are assigned value, here we discuss the magnitude and implications of these differences. Finally, we highlight why ethnobotanical knowledge should be taken into account when selecting species for targeted conservation and suggest ways for integrating local and academic knowledge. A taxonomic focus on plants is justified given their key, but often overlooked, cultural, economic, and ecological roles (Sanders 2019). We discuss the challenges and opportunities of considering indigenous and local knowledge into conservation assessments and the strategies derived from them.

MATERIALS AND METHODS

Study area

The High Atlas Mountains are the highest mountain chain in North Africa, rising above 4000 m in Morocco. This mountain range is one of the major Mediterranean biodiversity hotspots (Fennane and Ibn Tattou 2012) and is mainly inhabited by Amazigh (Berber) populations, whose livelihoods depend to a large extent on subsistence agriculture and pastoralism. Amazigh people organize themselves in patrilineal and patrilocal tribal factions, subfactions, villages, lineages, and nuclear families, governed through traditional assemblies or councils of elders. They speak one of the Amazigh languages or dialects, but men and younger women are often fluent in Moroccan Arabic learnt through school, media, and in the case of men, professional relationships and interactions with the governmental administration. Small-scale agro-sylvo-pastoralism is the main economic activity of these populations and has shaped the High Atlas cultural landscapes. This activity is grounded in detailed and dynamic Amazigh knowledge of local plants' distribution, abundance, ecology, and utility (e.g., Teixidor-Toneu et al. 2016; Ouarghidi et al. 2017). Original Amazigh practices and techniques for resource management are embedded in a holistic vision of production systems (e.g., Domínguez et al. 2012; Teixidor-Toneu et al. 2020). Plant diversity is threatened in the High Atlas due to well-known pressures including weather-related phenomena, climate change, land-use transformations, plant overharvesting, changes in values and habits, market integration, and social inequalities, among others (e.g., Barrow and Hicham 2000; Domínguez and Benessaiah 2015). Rapid environmental, social and economic transformations also result in the loss of local knowledge and local agroecosystems. Customary governance traditionally guided access to natural resources, for example by regulating extractive activities and water management, but these institutions are weakening in the face of globalization (Domínguez 2017). Furthermore, while the local population may still effectively regulate resource extraction, non-local harvesters can drive resource depletion (e.g., Ouarghidi et al. 2017).

Fieldwork was conducted in two localities representative of the cultural and ecological diversity of the High Atlas (Fig. 1): the communes of Ait M'hamed (Central High Atlas) and Imegdal (Western High Atlas).

Imegdal (IME) is located 75 km south of Marrakech in the Al Haouz Province, and occupies an area of approximately 278 km^2, with altitudes ranging from 900 to 2500 masl. It has a population of 5 537 people (1 156 households) in 28 small villages (Haut Commissariat au Plan 2014), who are mainly speakers of the Western Amazigh dialect Tashelhit. Imegdal's climate is Mediterranean, with cold winters (temperatures can drop to − 2 °C) and hot and dry summers (maximum temperatures reaching 42 °C). Rainfall is around 300 mm/year. Imegdal is characterized by a diverse vegetation including sparse *Juniperus phoenicea*, *Quercus rotundifolia*, *Tetraclinis articulata*, and

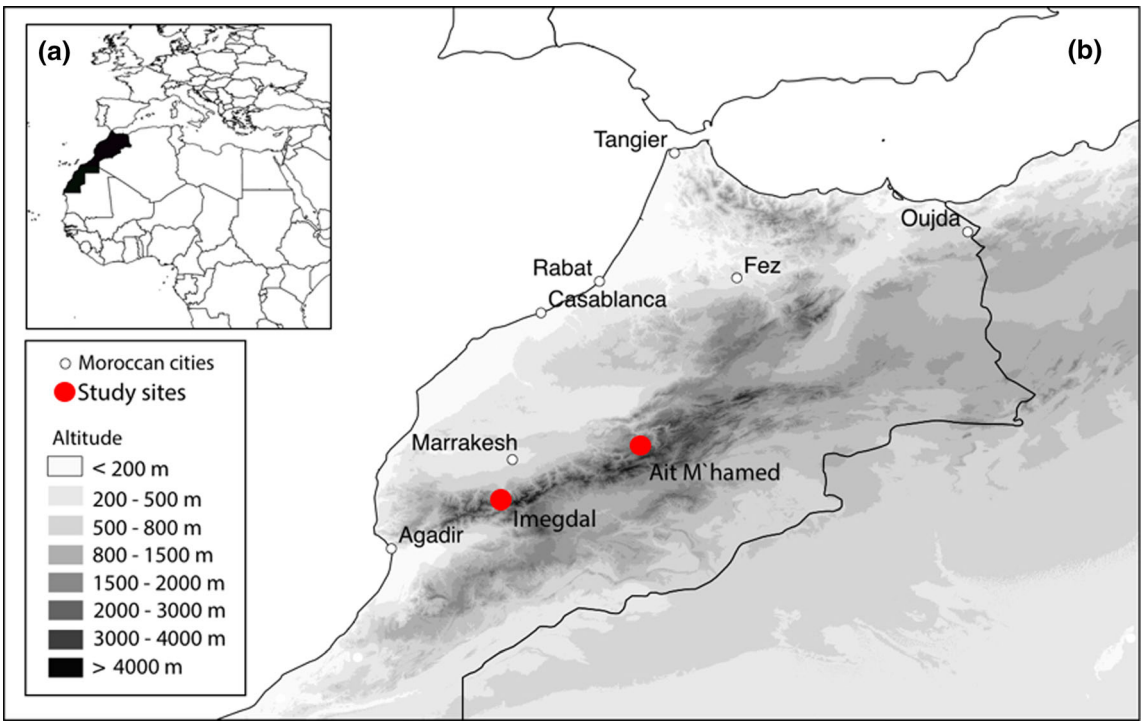

Fig. 1 Study sites Ait M'hamed and Imegdal in the Moroccan High Atlas

Juniperus thurifera woodlands in a mosaic of landscapes with different levels of intervention, resource use intensification or abandonment.

Ait M'hamed (AMH) is 180 km east of Marrakech in the Azilal Province and covers 560 km^2 from 950 to 2 600 masl. It hosts 23 696 inhabitants in 3 493 households and 45 villages (Haut Commissariat au Plan 2014), mostly speakers of the Central Amazigh dialect Tamazight. AMH is thus larger than IME, with a higher population and higher number of services, while IME is more geographically isolated and smaller in size and population. The climate of AMH is predominantly oro-Mediterranean, with annual rainfall between 450 and 600 mm, a minimum temperature of − 3.5 °C, and a maximum of 40 °C. Vegetation is also a typical Mediterranean mosaic, with patches of evergreen oaks (*Quercus rotundifolia*) and *Fraxinus dimorpha* at lower elevations, and areas with *Juniperus phoenicea*, *Juniperus thurifera* and introduced *Pinus halepensis*. Scrublands with spiny xerophytes are also present at higher elevations (Emberger 1939).

Data collection, plant identification, and data analyses

We used an inductive, participatory research approach with methods designed by a research team composed of nine national and international researchers and community members from the two studied sites. We drew insight from co-enquiry methods (Caruso et al. 2015) combined with conventional ethnobotanical data collection techniques (Martin 1995). The form and content of the questionnaires and semi-structured interviews were co-created with community members. Research took place between May 2016 and April 2018. Three types of interviews were conducted consecutively in three research phases, carrying out regular team workshops to evaluate and improve methodologies and discuss preliminary results (Table 1). Since we focused on non-cultivated species, crops, especially vegetables, are underrepresented in our results. Results were discussed with community members during two focus group discussions with 25 (IME) and 33 (AMH) participants.

We followed the code of ethics of the International Society of Ethnobiology (ISE 2006) to ensure the highest possible ethical standards for our research. Community members were part of the research team, actively contributed to the design and implementation of the methodology and co-author this publication. Research took place after meetings with local authorities and we communicated our work to the wider community.

In total, 184 people were interviewed in Ait M'hamed (106 men, 58%; 78 women, 42%), and 134 in Imegdal (64 men, 48%; 70 women, 52%; Table 1). Interviewees were identified through snowball sampling. All interviews occurred following a free, prior and informed consent process during which we described the aims and expected outcomes of the project. Interviews were conducted by

Table 1 Type and number of interviews conducted in each of the three consecutive research phases

Phase	Type	Number of interviews
Phase 1	Semi-structured interviews focusing on local practices relevant for the conservation of the environment and the plants related with them	221
Phase 2	Herbarium-based questionnaires supported by 62 (Ait M'hamed) to 120 (Imegdal) herbarium specimens to gather basic information about plant use of a wide range of plants	39
Phase 3	In-depth semi-structured interviews focusing on a small set of single high-value plants	100
	Total	360

local community researchers in the local Amazigh dialects, Tashelhit in Imegdal and Tamazight in Ait M'hamed. Interviews were conducted with either the male or female head of the household and took place in their houses or nearby, according to interviewee preference. Most participants had little or no formal education and were mostly employed in subsistence agriculture and pastoralism. We aimed to interview roughly the same number of men and women in each community across age groups, given that ethnobotanical knowledge is known to be gendered and often age dependent. We made sure to include people with specific occupations of interest (e.g., shepherds, traders, community employees) in order to have the widest overview of community knowledge as possible.

Phase 1 of the study generated in a list of culturally valued plants and their uses. Use Reports (URs; a Use Report is one mention of a specific plant use by one participant) were calculated per species. For Phase 2, we chose herbarium specimens based on the useful flora mentioned in Phase 1 interviews as well as species documented as culturally valuable in previous studies. Prior to conducting the interviews, community members and a conservation biologist from our team revised the list and added rare and endemic taxa.

Based on the results of Phases 1 and 2, we identified specific high-value plants as the focus of in-depth semi-structured interviews in Phase 3. Species were selected according to their importance for local practices of conservation, the diversity of their uses, and high numbers of URs. These in-depth interviews asked: What is this plant used for, by whom and how often? Where does the plant grow and is it abundant? When is the plant harvested and how much is harvested? Has the plant population changed over time? Are there any local practices to manage or maintain the plant's population? We asked each participant about four to five plants that they chose from a shortlist of ten high-value plants that grew in and around their community. This allowed gathering information on all high-value plants from multiple participants in a manageable amount of time, while allowing the participant to choose species of their own interest. Interviewees reported on perceived plant availability, changes in availability over time, and causes of change.

Herbarium specimens in local herbaria were used to identify vernacular names provided during interviews, which were later confirmed in herbarium-based interviews (Phase 2). Data from all interviews were archived in a digital database. Plants were identified using the *Flore Pratique du Maroc* (Fennane et al. 1999, 2007, 2014), and plant nomenclature follows The Plant List (2013) and botanical families of the Angiosperm Phylogeny Group IV (APG 2016). Duplicates of the voucher specimens were deposited at the Marrakech Regional Herbarium (MARK) as well as local community herbaria.

Data on the conservation status of all documented plants were collected from all available resources for the study area including: "Elements for a Moroccan Red Book" (Fennane 2016–2018), conservation assessments and Red Listing of the endemic monocotyledon Moroccan flora (Rankou et al. 2015a, b), the IUCN Red List of threatened species database (IUCN 2019a) and the IUCN Mediterranean regional assessment initiative database (IUCN 2019b). We first compared the overlap between our species lists and the species included in these conservation assessment sources. For plants of high cultural value, we compared academic conservation status and population trends with local conservation considerations, including plant availability and availability changes over time.

RESULTS

Brief ethnobotanical description of the High Atlas locally valuable biodiversity

In total, interviewees provided 3 630 URs for 211 taxa (122 in AMH and 151 IME) belonging to 66 plant families (43 in AMH and 58 in IME) and including wild, semi-wild and cultivated plants (Electronic Supplementary material- ESM S1). Of these taxa, 189 were identified to the species level and 22 to the genus level. The vascular flora of the High Atlas (excluding cultivated species) consists of

approximately 1916 plant species according to the *Flore Pratique du Maroc* (Fennane et al. 1999, 2007, 2014), thus the useful flora reported in this data represents approximately 10% of the total flora of the High Atlas.

The families with the greatest diversity of plants mentioned (47% of the total number of species) were Lamiaceae (27 species), Asteraceae (21 spp.), Fabaceae (16 spp.), Poaceae (14 spp.), Rosaceae (12 spp.) and Apiaceae (10 spp.). These are also the most common families in the region (Fennane et al. 1999, 2007, 2014). These families, with the addition of Cupressaceae, account for over half the URs (58%; Lamiaceae with 801 URs; Asteraceae with 406 URs; Poaceae with 262 URs; Rosaceae with 198 URs; Cupressaceae with 171 URs; and Fabaceae with 130 URs). The most cited plant species were *Thymus saturejoides* (162 URs, 4.5% of total URs), *Mentha suaveolens* (89 URs, 2.5% of total URs), *Juglans regia* (84 URs, 2.3% of total URs), *Artemisia herba-alba* (73 URs, 2% of total URs), *Juniperus phoenicea* (68 URs, 1.9% of total URs) and *Thymus willdenowii* (67 URs, 1.8% of total URs). These species were mentioned mostly due to their medicinal and aromatic properties along with their use as food or as fuel.

Women provided a higher number of plants than men (ESM S2), a trend observed repeatedly in the region and linked to women's role as household food and care providers. We did not observe striking differences in ethnobotanical knowledge across age groups (ESM S2), showing that younger generations continue to engage in agro-sylvo-pastoral livelihoods and maintain the necessary ethnobotanical knowledge to undertake these activities.

The 59 plant taxa (four genera and 55 species) of high cultural value (43 found in AMH and 32 in IME; data collected in Phase 3) are listed in the Fig. 2 and ESM S3. Plants with high cultural value are harvested from the diverse environments surrounding mountain Amazigh villages and homesteads or are cultivated in fields and home gardens. Two thirds of these plant species are collected in forest and mountainous areas. Other species are collected in riverine environments (ca. 10%) or from irrigated or non-irrigated fields (ca. 10%). Only 21% of reported high-cultural-value plants are cultivated. Importantly, over half of these plants are commercialized in some way (ESM S3). Overharvesting is mentioned by our participants as one of the causes of plant population decline for commercialized species (e.g., *Anacyclus pyrethrum*, *Quercus rotundifolia* and *Capparis spinosa*), and various resource access limitation strategies and cultivation are often mentioned as a means for preservation and management of wild populations. Interviewees reported that availability of wild populations is decreasing for over a half (56.4%) of the plant species (Fig. 2). The most common threats perceived by participants in the study area are overharvesting (35.7%), drought (21.4%), erosion (21.4%), habitat lost due to agricultural expansion (14.3%), and overgrazing by livestock (7.2%).

Ethnobotanical knowledge and plant conservation assessments

A very low proportion of the total number of studied plants has been evaluated through academic assessments (ESM S1). Less than a third of the total documented useful plants (21.7%; ESM S1) and less than half of the plants with high cultural value (43.6%; ESM S3; Fig. 3) are part of the global IUCN Red List database. Most of those assessed at the global level are considered of Least Concern (LC; Table 2). Very few useful plants are academically assessed as threatened. Only five locally valuable species, of which two are of high cultural value, are considered threatened and three are vulnerable (Table 2).

Beyond a lack of assessments for high-cultural-value plants, global IUCN assessments of plant conservation status and population trends do not often coincide with local perceptions of plant availability and change over time (Fig. 2, ESM S3). As many as 22 species that are perceived locally as decreasing in the High Atlas are not assessed or considered of least concern. These range from aromatic *Thymus* and *Artemisia* species, fruit and other trees such as *Ficus carica, Quercus rotundifolia*, and various juniper species, to wild greens like *Nasturtium officinale*. The remarkable example of watercress is a case in point. This plant has a history of cultivation in Europe and, globally, there are no important conservation threats (Akhani and Zehzad 2014). However, watercress is not cultivated in the High Atlas and wild populations suffer enormously from flash floods, drought, and soil erosion. The loss of this species locally would represent a loss of biodiversity and gastronomic practices and could increase food insecurity.

A smaller number of useful plants have had their conservation status assessed at a regional level than globally (Fig. 3). These regional assessments almost always coincide with global assessments and local perceptions (Fig. 2, ESM S3). For example, the populations of *Chamaerops humilis* and *Anacyclus pyrethrum* are considered to be decreasing both by local populations and in IUCN regional assessments. *A. pyrethrum* is known to be severely endangered by both (ESM S3). This is also the case of the two most important tree species in AMH, *Quercus rotundifolia* and *Fraxinus dimorpha*, classified as Near Threatened and Endangered, respectively. While these plants are locally abundant, local communities are well aware of the need for sustainable use of these species and management strategies are in place accordingly (Fig. 2, ESM S3). However, discrepancies also exist between local perceptions and IUCN regional assessments. *Juncus acutus* and *Pistacia lentiscus* are locally perceived as decreasing, but

Species of high cultural value	L	G	R	N
Fraxinus dimorpha	↓	EN↓	EN↓	NT
Anacyclus pyrethrum	↓	VU↓	EN↓	VU
Lavandula maroccana	↓	VU	VU	NT
Thymus saturejoides	↓	VU	VU	VU
Quercus rotundifolia	↓	LC	NT	LC
Ceratonia siliqua	↓	LC↓	NT	LC
Chamaerops humilis	↓	LC↓	LC↓	LC
Cladanthus scariosus	↓	NA	NA	NT
Juniperus thurifera v. *africana*	↓	LC↓	NA	VU
Pistacia lentiscus	↓	LC→	NA	LC
Populus alba	↓	LC↓	NA	LC
Juniperus oxycedrus	↓	LC→	NA	LC
Juniperus phoenicea	↓	LC→	NA	LC
Drimia maritima	↓	LC	LC	LC
Nasturtium officinale	↓	LC	LC	LC
Juncus acutus	↓	LC	LC	LC
Fraxinus angustifolia	↓	LC	NA	LC
Crataegus monogyna	↓	LC	NA	LC
Ficus carica	↓	LC	NA	NA
Foeniculum vulgare	↓	NA	NA	LC
Dittrichia viscosa	↓	NA	NA	LC
Cistus creticus	↓	NA	NA	LC
Lavandula dentata	↓	NA	NA	LC
Thymus willdenowii	↓	NA	NA	LC
Rumex papilio	↓	NA	NA	LC
Ruta chalepensis	↓	NA	NA	LC
Ziziphus lotus	↓	NA	NA	LC
Artemisia herba-alba	↓	NA	NA	DD
Artemisia arborescens	↓	NA	NA	NA
Capparis spinosa	↓	NA	NA	NA
Rubia tinctorum	↓	NA	NA	NA

Species of high cultural value	L	G	R	N
Populus nigra	→	LC	NA	LC
Silene vulgaris	→	LC→	NA	LC
Herniaria hirsuta	→	NA	NA	LC
Euphorbia nicaeensis	→	NA	NA	LC
Marrubium vulgare	→	NA	NA	LC
Papaver roheas	→	NA	NA	LC
Rubus ulmifolius	→	NA	NA	LC
Pistacia atlantica	NA	NT↓	VU↓	LC
Mentha suaveolens ssp. *timija*	NA	VU	VU	LC
Tetraclinis articulata	NA	LC↓	NA	LC
Stipa tenacissima	NA	VU↓	NA	NT
Juglans regia	NA	LC	NA	LC
Punica granatum	NA	LC	NA	NA
Rosmarinus officinalis	NA	NA	NA	NT
Echinops spinosissimus	NA	NA	NA	LC
Inula montana	NA	NA	NA	LC
Olea europaea	NA	NA	NA	LC
Peganum harmala	NA	NA	NA	LC
Rosa canina	NA	NA	NA	LC
Micromeria hochreutineri	NA	NA	NA	DD
Prunus dulcis	NA	NA	NA	NA
Vicia ervillia	NA	NA	NA	NA
Lawsonia inermis	NA	NA	NA	NA
Salvia officinalis	NA	NA→	NA	NA

Fig. 2 Conservation assessments for the 55 plant species of high cultural value according to: (L) local observations, (G) IUCN global, and (R) regional assessments, and (N) the national Red List (Fennane 2016–2018). Local observations of declining populations are represented by a descending red arrow and stable populations by a horizontal green arrow. Red list categories are used for academic assessments (G, R, N). The four genera of high cultural value unidentified at the species level have not been included in this figure. Red list categories: DD: Data deficient; LC: Least concern; NT: Nearly threatened; VU: Vulnerable; EN: Endangered; NA: Not assessed

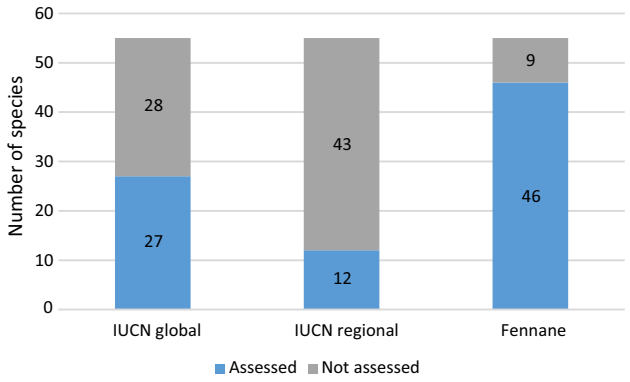

Fig. 3 Number of conservation assessments available for 55 high-cultural-value plant species by IUCN global, IUCN regional, and the national initiatives (Fennane 2016–2018). The four genera of high cultural value unidentified at the species level have not been included in this figure

of Least Concern according to the IUCN. The aromatic species *Mentha suaveolens* is not perceived to have conservation issues locally, but is considered Vulnerable by the IUCN (Fig. 2, ESM S3). A similar scenario exists when comparing local perceptions with Fennane's Red Book, which provides assessments at a national level. In the Red Book, *Quercus rotundifolia* and *Pistacia atlantica* are considered of Least Concern. This does not only contradict local observations, but also IUCN regional conservation assessments.

Other than providing evidence of a mismatch between the local and academic assignment of value and conservation considerations, our results also show that local populations rarely overuse threatened and endemic species (Fig. 2, ESM S3). Of 55 plant species of high cultural value, only five were vulnerable at a global scale and two were in some way threatened (Fig. 2, ESM S3). For most of these species local communities have management systems that strive for their sustainable use, such as the harvest of wood of *Pistacia atlantica* only from dead or very big trees, and local enrichment planting strategies for the highly valuable roots of *Anacyclus pyrethrum*.

Table 2 Number and proportion of the plants documented in this study that are red-listed according to the available resources: the national initiative *elements for a Moroccan red book* by Fennane (2016–2018), the global *IUCN Red List of threatened species database* (https://www.iucnredlist.org/), and the regional *IUCN Mediterranean assessment initiative database* (https://www.iucnredlist.org/regions/mediterranean)

	All documented plants- Global	Plants with high cultural value (29.1% of total)		
		Global	Regional	Fennane (2016–2018)
Assessed	60 (21.7%)	27 (49.1%)	12 (21.8%)	46 (83.6%)
Data deficient	5 (8.3%)	0 (0%)	0 (0%)	2 (4.3%)
Least concern	47 (78.3%)	20 (74.1%)	4 (33.3%)	36 (78.3%)
Nearly threatened	3 (5%)	1 (3.7%)	2 (16.7%)	5 (10.9%)
Vulnerable	4 (6.7%)	5 (18.5%)	4 (33.3%)	3 (6.5%)
Endangered	1 (1.7%)	1 (3.7%)	2 (16.7%)	0 (0%)
Critically endangered	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Not assessed	129 (68.2%)	28 (50.9%)	43 (78.2%)	9 (16.4%)
Total	189 (100%)	55 (100%)	55 (100%)	55 (100%)

DISCUSSION

Our study reveals two levels of mismatch between IUCN and national Red List conservation assessments. Firstly, it is clear that the species that are of interest to the IUCN and other academic red-listing processes—i.e., those considered most important for conservation—are often not the same as plants of interest to local communities. Secondly, we also found differences between community perceptions of plant availability and change over time and IUCN (and other academic) assessments of the conservation status and population trends of key cultural species.

These two levels of mismatch are to be expected. The differences between the perspectives of community members and conservation actors regarding what constitutes a plant species of interest are rooted in differences regarding the assignment of value to that species. Indigenous and local knowledge systems value plants for the practical uses they make of them (medicine, food, shelter, fuel, and so on), as well as for cultural, spiritual or symbolic reasons (Garibaldi and Turner 2004). These species are often—though not always—common, possibly as a result of human management over the millennia (Thompson 2005). The perceived value of a species in regard to conservation is assessed regarding its extinction risk, thus the IUCN red list database, national red-listed species or other academic assessments tend to concentrate on endemic, rare, and wild plant species that often have small areas of distribution. Domesticated or semi-domesticated plants, key to local agro-sylvo-pastoral livelihoods and the maintenance of agrobiodiversity, are most often not rare or endangered at the species level, and yet local or traditional varieties may be critically endangered at the infraspecies level (Thrupp 2000). However, Red Lists are not designed to address the loss of genetic diversity and these species may be overlooked. On the other hand, while all Moroccan endemic species have been red-listed and tend to be at the heart of national plant conservation programs, local communities are not often aware of their particular geographical status. While the IUCN red-listing process encourages consultation of local experts and the possibility of including local knowledge, selection of assessed species remains within the domain of natural science academia (Tomasini 2018). Given the two intrinsically different ways of conferring value to plants, red-listed species have little overlap with those considered locally important.

We found that a large number of locally valued plants remain unassessed (Figs. 2 and 3, ESMs S1 and S3), and are therefore overlooked by conservation programs even when local communities perceive them as vulnerable and declining. The large number of species, and the time required to carry out individual IUCN conservation assessments are obvious limitations to assessing the status of the world's plant diversity. In particular, the rigorous multi-stakeholder process established for data collection and review of conservation assessments according to IUCN categories and criteria is highly time-consuming and often results in long lag times between data collection and publication. This results in many species remaining unassessed or 'in the pipeline' and thus not attended to by conservation programs. Le Breton et al. (2019) have suggested a more agile assessment methodology that would help overcome current time and resource limitations, enabling assessors to clear the backlog of species yet to be assessed for extinction risk.

In cases where locally valued species are academically assessed, issues emerge when species that are locally perceived to be declining or vulnerable receive the status of

'Least Concern', thus not featuring as priorities in national or local conservation interventions. Plant populations may be perceived as declining due to local overharvest, as mentioned during interviews regarding commercialized plants (Fig. 2, ESM S3), or other local conservation threats that don't pose an extinction risk to the species. Yet, these locally threatened plants are those that will hold the highest conservation value among community members. As local communities and their traditional knowledge and practices are fundamental to the success of conservation initiatives (e.g., Berkes et al. 2000; Chapin 2004; Cernea and Schmidt-Soltau 2006; Waylen et al. 2010; Andrade and Rhodes 2012; Garnett et al. 2012; Otto et al. 2013; Gavin et al. 2015), it becomes clear that their concerns and observations should be adequately represented in conservation priority-setting.

In practice, the IUCN red list database is the primary source used for worldwide conservation priority-setting (Possingham et al. 2002; Hoffmann et al. 2008) and policymaking (Trousdale and Gregory 2004), whereas IUCN assessments are internationally accepted, and improvements are regularly suggested and implemented to keep them up to date with parallel scientific and paradigmatic advances in other fields (e.g., Holdaway et al. 2012; Trull et al. 2018). Currently, IUCN assessments describe interactions between the species of interest and humans in three sections: use and trade, threats, and conservation actions in place. There is no requirement to include local observations of a species' availability changes and conservation threats, nor have we come across any academic assessments that do so. Local sustainable management practices are equally not often included. Assessments must include all the available and existing data on plant use, yet a clear methodology on how to gather, evaluate, and present data from indigenous and local communities has only recently been proposed (Cross et al. 2017). Cross et al. (2017) argue that indigenous and local knowledge can improve estimates of species distributions, abundance, seasonal patterns, drivers of change, and threats, and provide practical considerations to guide engagement with local communities and the use of local knowledge. However, this advice is not yet included in common practice: the selection of methods for collecting and analyzing ethnobotanical data is fully in the hands of the academic assessor.

Over the past two decades, evidence has mounted that community engagement in conservation initiatives is essential to their success, although research on what precisely constitutes successful 'engagement' is not conclusive (Sterling et al. 2017). A recent review of research on community engagement in conservation programs shows that communities are "almost never involved in conservation initiatives until the implementation phase or as recipients of outcomes" (Raschke et al. 2019). Including community priorities and perceptions upstream, when decisions on the focus of conservation interventions are being made, is a rare practice in Morocco and elsewhere, yet it may be an essential ingredient for conservation success (e.g., Müller and Dan Guimbo 2010). It would be difficult, for example, to convince communities to engage in conservation actions for species that are locally perceived as abundant unless the species were of high value to them. Conversely, a conservation intervention that includes actions related to locally valued species that are perceived by community members as vulnerable or threatened, regardless of their academically assessed conservation status, will likely benefit from active community participation.

Roe and Booker (2019) argue that there is still a need for comprehensive research and evidence on how community engagement affects conservation initiatives. Through our co-constructed research process and conservation action, we observe that community-based conservation programs that address plants of high cultural value can have direct and indirect positive impacts on non-utilized, endangered species. The High Atlas Cultural Landscapes program (GDF 2019), which is managed by the communities referred to in this article in collaboration with the Global Diversity Foundation and the Moroccan Biodiversity and Livelihoods Association, exemplifies how to bridge local ecological knowledge with biodiversity conservation, by taking into consideration plants that are culturally relevant for local communities. The program began by establishing a constructive collaborative relationship with local communities and becoming acquainted with their ethnobotanical knowledge and conservation priorities. IUCN assessments were carried out to evaluate the conservation status of plants of five high cultural value (Rankou et al. 2015a, b, 2017a, b, c, 2018). Local community members were consulted to gather information and their observations included in the assessment. The principal focus of the program's conservation actions—which include growing plants in community nurseries, enrichment planting in designated areas, and seed conservation in community seed banks—is on species that are highly valued by partner communities. In some cases, these coincide with plants academically assessed as Threatened (e.g., *Lavandula maroccana, Thymus saturejoides, Anacyclus pyrethrum*), or Near-threatened (e.g., *Quercus rotundifolia, Ceratonia siliqua*). Plants that are threatened but not directly important to communities are not necessarily grown in the community nurseries, although seeds may be conserved in the community seed banks. However, other direct and indirect benefits to these species are expected as a result of the ecological and structural roles of the project-targeted plants in the ecosystem. For example, emerging research suggests that *Thymus saturejoides* and *Lavandula*

maroccana—both planted out in forest and semi-domesticated areas as part of the program's ecological restoration actions—may act as potential "plant nurses" for the critically endangered *Cupressus atlantica* in the High Atlas, through enhancing mycorrhizal networks (Hafidi et al. 2013).

Recently, it has been argued that effective conservation policies and programs need to recognize cultural differences and take a pluralistic approach (Kohler et al. 2019). The 2019 report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) underscores, once again, that active collaboration with indigenous and local communities is necessary to the success of conservation initiatives and programs, as confirmed by the research cited above. Engaging with these communities requires finding common ground for communication and action, including, in the context of plant conservation, prioritizing species that are of importance and concern to both scientific and local knowledge and value systems. However, decisions on what species to prioritize and what projects to fund are often based on the IUCN red list database, and in particular global assessments. It may be challenging for local conservation projects and programs to obtain funding for conservation actions for species that are locally highly valued or perceived as of concern, but not globally assessed as Threatened or Critically Endangered. Our research shows that local perceptions of value and conservation status can, in some significant cases, be at odds with these global assessments and, occasionally, with regional assessments, as expected given the differences of geographic scope and epistemological orientation between local and academic assessments. Our experience in the High Atlas Cultural Landscapes program suggests that in order to ensure the active participation and collaboration of local communities in conservation initiatives, a focus on species that are local priorities is essential. Expanding priority-setting for conservation interventions beyond the IUCN Red List to include species of local priority and concerns would be an excellent first step in this direction.

CONCLUSION

In this article, we bring to light the gap between local and academic conservation assessment of plants. We first evidence that Amazigh communities retain and continue to produce new knowledge about their environment. Plants that are important for local communities are not always those considered by research and conservation bodies. Local observations of plant conservation status and population trends may not coincide. While these mismatches are in part explained by the systemic differences between the two kinds of knowledge compared and issues of scale, some important considerations stem from our results. First, fine-tuning of academic assessments is recommended by including local perceptions. Second, conservation action that seriously takes the role of local communities into account is hampered conceptually and financially because plants with high cultural value are often not assessed or have little extinction risk. As many plants of high cultural value are tree species, their sustainable management and conservation may have a systemic impact for whole habitats and ecosystems. These and other biocultural keystone species could become the heart of successful and sustainable community-based conservation programs that integrate ecological health with community wellbeing. While it is not our aim to recommend that IUCN and other processes categorically include local perceptions of population trends and conservation status in academic assessments, we do believe it is necessary that conservation priority-setting processes are expanded beyond strict reliance on the IUCN red list to include local observations and priorities. We suggest that conservation action and its funding should not only rely on academic conservation assessments, but also be guided by local perceptions of conservation status. By focusing plant conservation efforts on plants of high cultural value, conservation efforts can ensure the integration of conservation and indigenous and local knowledge, as well as active community involvement and 'buy-in'. This approach would facilitate reaching the Aichi targets in a holistic way.

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AUTHOR BIOGRAPHIES

Irene Teixidor-Toneu is a postdoctoral fellow at the Natural History Museum, University of Oslo. Her research spans from evolutionary ethnobiology to biocultural diversity conservation.
Address: Natural History Museum, University of Oslo, Blindern, Postboks 1172, 0318 Oslo, Norway.
Address: Naturalis Biodiversity Centre, Leiden, The Netherlands.
e-mail: i.t.toneu@nhm.uio.no

Soufiane M'Sou is Project and Field Coordinator for Global Diversity Foundation (GDF). His interests range from communal governance systems to policy and conservation.
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: msousoufiane@gmail.com

Hajar Salamat is Morocco Field Researcher (Social Science) at GDF. Her research focuses on participatory action and community engagement.
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.

Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: slmt.hajar@gmail.com

Hamid Ait Baskad is a farmer and local community researcher from Imegdal. His interest range from gardening to conservation and cultural preservation.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: hamidaitbaskad14@gmail.com

Fadma Ait Illigh is a geographer and local community researcher from Imegdal. Her research is linked with field methodologies and local culture.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: fadmaaitiligh@protonmail.com

Touda Atyah is a community researcher from Ait M'hamed. Her interests include local development and Amazigh culture.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: atyatouda@protonmail.com

Hafida Mouhdach is a local community researcher from Ait M'hamed studying law. Her research interests are Amazigh culture and biocultural conservation.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: mohdach.hf@protonmail.com

Hassan Rankou is Biodiversity Conservation Consultant for GDF. His research focusses on conservation assessments and biodiversity of local plants.
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: h.rankou@gmail.com

Rachid Ait Babahmad is GDF's Project and Field Coordinator and MBLA Team Coordinator. His interests revolve around biodiversity conservation and cultural practices.
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.
Address: Moroccan Biodiversity and Livelihoods Association (MBLA), Av. Prince Moulay Abdellah 15, Marrakech, Morocco.
e-mail: rachid.aitbabahmad@gmail.com

Emily Caruso is Director of the Global Diversity Foundation in the UK. Her interests include nurturing and restoring people's relationships with nature.
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.
e-mail: ecarusogdf@gmail.com

Gary Martin is GDF Founder and Mediterranean Programme Lead Consultant. His interests span from ethnobotany to conservation and socioenvironmental leadership
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.
e-mail: gary@global-diversity.org

Ugo D'Ambrosio (✉) is Scientific and Technical Advisor for GDF in the Mediterranean. His interests revolve around theory and practice in ethnobiology and participatory methodologies
Address: Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK.
Address: Etnobiofic Research Group- Universitat de Barcelona and Institut Botànic de Barcelona (IBB-CSIC-ICUB), Barcelona, Spain.
e-mail: ugotopia@yahoo.com; ugo@global-diversity.org