Biodiversity and agriculture in the Mediterranean region

A species conservation perspective

Diego Juffe-Bignoli, Bea Maas, Nigel Maxted, Randall R. Jiménez, Thomas Cherico Wanger, Joe Gosling, José M. Herrera, Chris J. Kettle, Nicholas B. W. Macfarlane, Joana Magos Brehm, Pedro J. Rey, Manuel Toledo-Hernández, Mariana Yazbek, Faye M. Weaver, Mercedes Muñoz Cañas, Catherine Numa

INTERNATIONAL UNION FOR CONSERVATION OF NATURE

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Cover photo: *Lachnaia* cf. *cylindrica* in an almond tree, Malaga province, Spain.
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Table of contents

List of boxes

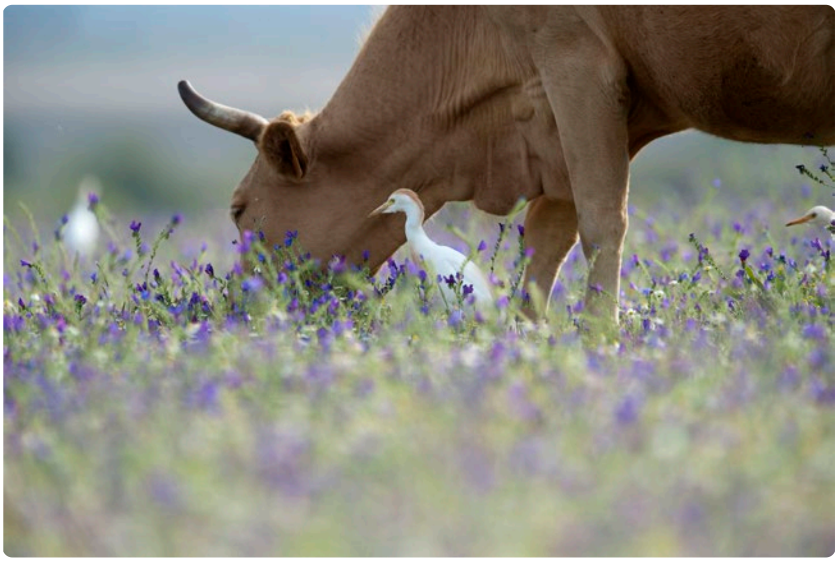
List of tables

List of figures

Black-eared wheatear (*Oenanthe hispanica*), Least Concern (LC) at the global and European level, pictured here in an olive tree in Lesbos, Greece (BirdLife International, 2021a; 2024a). © "Black-eared Wheatear - Lesbos Is - Greece_5P5A7639" by Francesco Veronesi is licensed under CC BY-SA 2.0.

Foreword

from the IUCN Director General



The cattle egret (*Bubulcus ibis*) is known for often associating with large grazing mammals, including domesticated livestock, and is typically found in open grassy areas, such as meadows and livestock pastures (BirdLife International, 2019). The species is listed as Least Concern globally, and is pictured here alongside a grazing cow in Doñana National Park, Spain.

Agriculture and biodiversity are fundamentally interconnected, shaping the landscapes that sustain life on Earth. For millennia, agricultural practices have provided food, livelihoods, and cultural heritage while coexisting with the natural world. Today, however, this relationship is under immense pressure. Unsustainable agricultural expansion and intensification are among the primary drivers of biodiversity loss, threatening ecosystems, species, and the very services that underpin food production and human well-being.

This report comes at a pivotal moment. It underscores the urgent need to transform agriculture into a force for biodiversity conservation. By presenting evidence-based solutions, such as agroecology, diversified farming systems, and sustainable land management, it shows that agriculture can be part of the solution to the biodiversity crisis. Importantly, this transformation is not just an environmental imperative but also an economic and social opportunity - one that builds resilient ecosystems, enhances food security, and supports local communities and cultures.

The findings and recommendations in this publication resonate with global goals, particularly the Kunming-Montreal Global Biodiversity Framework, which calls for halting species extinction, restoring ecosystems, and promoting sustainable production systems. Achieving these ambitions requires bold, collaborative action that unites policymakers, farmers, researchers, and conservationists.

This report serves as a valuable resource for IUCN Members and partners in the Mediterranean and beyond. It offers pathways to address the challenges of biodiversity loss in agricultural landscapes while recognising the diversity of contexts and solutions needed to achieve balance. By aligning agriculture with the needs of nature, we can ensure a future in which both biodiversity and human well-being flourish together.

I encourage stakeholders around the world to use the insights in this report to drive forward the transformative change our planet so urgently needs. Together, we can foster a new relationship between agriculture and biodiversity - one that ensures a sustainable, thriving future for generations to come.

Dr Grethel Aguilar

IUCN DIRECTOR GENERAL

Foreword

from the Director of the IUCN Centre for Mediterranean Cooperation

Agroforestry system featuring olive trees near Ghar El Melh in Tunisia

The Mediterranean basin stands as one of the most significant regions for biodiversity and cultural heritage worldwide. It is a global biodiversity hotspot, home to an extraordinary variety of ecosystems and species, many of which are endemic. For thousands of years, this region has also been shaped by agriculture, an integral part of its history, economy, and identity. Yet, today, the Mediterranean faces significant challenges: balancing the need to sustain human livelihoods through agriculture while preserving its unique biodiversity.

This report, *Biodiversity and agriculture in the Mediterranean region: A species conservation perspective*, is a timely and essential contribution to addressing this balance. It highlights both the threats posed by unsustainable agricultural practices and the opportunities for agriculture to be a critical partner in conservation. By examining species extinction risks, identifying priority areas for intervention, and proposing practical, science-based solutions, this publication demonstrates how agriculture and biodiversity can not only coexist, but thrive together.

The findings of this report contribute to the Convention on Biological Diversity (CBD) and its Kunming-Montreal Global Biodiversity Framework, supporting global and regional efforts to conserve and sustainably manage biodiversity. Furthermore, we hope that this work will assist IUCN Members and their partners across the Mediterranean in better understanding the biodiversity and complexity of its unique landscapes, enabling them to address threats in a targeted and effective manner.

I commend the authors, contributors, and collaborators who made this report possible. It serves as a valuable resource for policymakers, practitioners, and stakeholders, offering pathways to ensure that agriculture and biodiversity conservation can thrive together for the benefit of nature and people alike.

Maher Mahjoub

DIRECTOR, IUCN CENTRE FOR MEDITERRANEAN COOPERATION

Agriculture in the Mediterranean both relies on and helps to support a wide range of ecosystem services provided by biodiversity, including pollination.

Executive summary

The Mediterranean basin is a global biodiversity hotspot, home to a unique variety of ecosystems and species, where people have shaped the landscape for millennia. However, unsustainable agricultural practices have become one of the most significant threats to biodiversity in this region, driving habitat loss and species extinction.

This report, *Biodiversity and agriculture in the Mediterranean region: A species conservation perspective*, is designed to inform policymakers, conservation practitioners, and stakeholders across the Mediterranean region. Its purpose is to highlight the current challenges posed to biodiversity by intensive agricultural pressures, while identifying solutions and opportunities to reconcile biodiversity conservation and sustainable agriculture. It acknowledges that while certain unsustainable agricultural activities pose a key threat to species conservation in the Mediterranean, agricultural landscapes also provide habitat to numerous species - so considering agriculture as a threat requires a more nuanced approach, given its inherent linkages to nature.

The thesis of this report is that not all agricultural practices are negative for biodiversity conservation. For example, sustainable grazing systems, particularly in traditional pastoral landscapes, as well as agroecological approaches, can play a critical role in maintaining biodiversity and ecosystem functions. In addition, some species have adapted to certain types of agricultural practices and their resulting landscapes, on which they now depend. Finally, the Mediterranean is also a global hotspot for Crop Wild Relatives, wild plant taxa closely related to crops, which are key for the long-term sustainability of agricultural production and food security, and are again intimately linked to agricultural practices.

By presenting scientific assessments and recommendations, this report contributes to international frameworks, including the Kunming-Montreal Global Biodiversity Framework, and supports IUCN Members and partners in understanding and addressing the complex interactions between species conservation and agricultural practices.

Conclusions and Recommendations

In the Mediterranean, agriculture is both a threat and an opportunity for biodiversity. Certain agricultural practices, such as unsustainable overgrazing and overreliance on chemical fertilisers and pesticides, threaten species and habitats, while sustainable agricultural approaches, such as agroecology, crop diversification and sustainable grazing through traditional pastoral systems, can support biodiversity conservation and ecosystem services, including preserving the diversity of Crop Wild Relatives. Thus, the way in which agricultural practices are implemented is key to species conservation in the Mediterranean. For example, grazing, when managed at sustainable levels, can promote habitat diversity and maintain open ecosystems that are beneficial for pollinators and other species dependent on grassland habitats.

This report finds that one in four (26%) of species assessed on the IUCN Red List of Threatened Species™ in the Mediterranean are threatened with extinction (Chapter 2). Freshwater species face the highest risk, with 50% threatened. Similarly, 38% of assessed Crop Wild Relatives, critical for food security, are also at risk of extinction. According to species assessments on the Red List, which follow the fixed IUCN Threats Classification Scheme, the top three threats to terrestrial species in the Mediterranean are agricultural and aquaculture activities, biological resource use, and natural system modifications. On the other hand, the top three threats to freshwater species are pollution, natural system modifications, and biological resource use. At least 28% of all Mediterranean species assessed on the Red List, and 38% of all threatened species in the region, are considered to be threatened by unsustainable agricultural practices. In the Mediterranean, the land system type with the largest overlaps with species distributions is Agro-silvo-pastoral mosaic, followed by Open and bare grazing (Chapter 2). Moreover, for 18% of species included in this study, agricultural habitats were identified as suitable, and for 2%, agricultural lands are considered to be habitats of major importance (Chapter 2).

Priority large-scale areas for action to mitigate threats related to agricultural practices have been identified through the Species Threat Abatement and Restoration (STAR) metric (Chapter 3). The results reveal hotspots where agricultural threats could be mitigated through sustainable practices, including southern Spain, Greece, Türkiye, and parts of North Africa.

Regarding best practices, agroecology offers a path forward: practices such as agroforestry, diversified cropping, and sustainable grazing can enhance biodiversity while maintaining agricultural productivity (Chapter 4). Policy frameworks like the European Union´s (EU) Common Agricultural Policy must support these approaches (Chapter 5).

KEY MESSAGES

1 Agriculture affects biodiversity, but it can also be part of the solution

While agriculture is confirmed as a major threat to species in the Mediterranean, some species depend on agricultural landscapes. Sustainable agricultural practices can reduce threats to species while supporting food production and ecosystem resilience and, through certain agricultural practices, biodiversity can be maintained and even enhanced.

2 Immediate action is needed to prevent species extinction in the Mediterranean

One in four species in the Mediterranean is at risk of extinction, with freshwater species and Crop Wild Relatives being particularly threatened.

3 Strategic investments in high-risk areas can yield significant conservation gains

Targeted threat abatement actions in regions where unsustainable agricultural practices are a major threat to species can significantly reduce species extinction risks.

4 Agroecology provides practical, scalable solutions for biodiversity and agriculture to coexist

Policies and practices that promote crop diversification, sustainable grazing and agroforestry are key to achieving a sustainable balance between agriculture and species conservation. In certain places, this shift towards a more sustainable agri-food system may require a considerable transformation in the food market and consumer attitudes. However, the widespread and longstanding use of sustainable, traditional agricultural practices in the Mediterranean offers a basis for the upscaling of agroecological principles, if such practices and knowledge systems can be effectively conserved and promoted.

Acknowledgements

The preparation and publication of this report was made possible through the collective efforts, dedication, and collaboration of many individuals and organisations. This report would not have been possible without the generous support of our partners and collaborators. We sincerely thank the Spanish Ministry for Ecological Transition and the Demographic Challenge (MITECO) for their financial support through the programmatic agreement 2022-2025 contributions, which made this project a reality.

We would also like to acknowledge the reviewers and advisors, Pablo Manzano, John Garcia Ulloa and Helena Clavero Sousa, who provided critical feedback and guidance which greatly improved the quality and clarity of this publication.

Our appreciation also extends to the graphic designers, data analysts, and communication teams for their work in bringing this report to life. Special thanks to María Lasa Morales and Lourdes Lázaro Marín for ensuring the information in this report is accessible, visually engaging, and impactful.

Finally, we recognise the efforts of all stakeholders, local communities, and field researchers across the Mediterranean region who contributed their insights, knowledge, and lived experiences to this work. Their contributions reflect the shared commitment to achieving a sustainable future for agriculture and biodiversity in the Mediterranean.

This report is dedicated to all those working tirelessly to safeguard the Mediterranean's natural heritage, including farming communities across the region who actively recognise the importance of nature, and are ultimately a key part of the solution.

Wildflowers in an olive grove on the island of Zakynthos, Greece.

1

Introduction

Summary: The Mediterranean basin is a global biodiversity hotspot as well as one of the most modified regions in the world, as a result of thousands of years of human habitation. The biodiversity found in this region today has been shaped by that interaction. Agriculture has been a fundamental pillar of Mediterranean civilisations, but has also been a driver of significant biodiversity loss, especially in more recent decades. Crop Wild Relatives play an important role in this interaction, and are key for both conservation and the future of agricultural development. The main purpose of this report is to explore the complex relationship between agriculture and biodiversity in the Mediterranean basin through the lens of species conservation, and to identify the contexts under which agriculture has been and can be an ally for conservation.

1.1. Context and rationale

The biodiversity of the Mediterranean region

The Mediterranean basin stretches approximately 3,800 km from the tip of Portugal in the west to the shores of Lebanon in the east, and approximately 1,000 km from Italy in the north to Morocco and Libya in the south. It includes 23 states spread across three continents, historically connected by a common sea (Figure 1.1; CEPF, 2017). The region offers a diversity of landscapes, including high mountains, rocky shores, scrubland, semi-arid steppes, coastal wetlands, sandy beaches and a myriad of islands of various shapes and sizes. The region is one of the world's richest places in terms of animal and plant diversity, with an exceptionally high level of endemism (Myers et al., 2000). About one-third of the outstanding biodiversity of the Mediterranean region consists of endemic species, including 60% of its freshwater

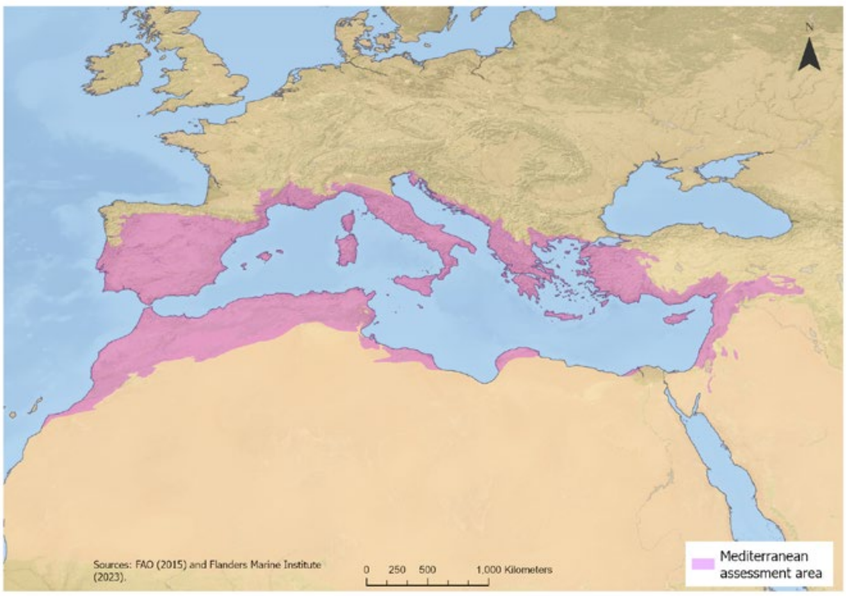


Figure 1.1. Geographical scope of this assessment adapted from the Mediterranean biodiversity hotspot as defined by Mittermeier et al. (2004)

mollusc species, almost half of its amphibians and freshwater fishes, 41% of its reptiles, 21% of its butterflies, 13% of its dragonflies, 12% of its mammals and 2% of birds inhabiting the region (CEPF, 2017). The Mediterranean´s rich biodiversity includes around 25,000 plant species, more than half of which are endemic to the region (Zohary & Hopf, 1993). In agricultural landscapes, the variety of life includes plants, vertebrates, invertebrates, fungi and algae among many other soil organisms and microorganisms – all essential for supporting ecosystem services and the health of those landscapes.

The Mediterranean is also one of the most intensely modified regions in the world. Its landscapes are a direct result of millennia of anthropogenic activities, such as forest fires, clearance, livestock grazing and cultivation (Zeder, 2008; Sundseth, 2009). These include long-term traditional agricultural practices which have gradually adapted to local contexts, as well as large-scale industrial approaches encouraged during the Green Revolution of the mid-20th century (Benton et al., 2021).

Agriculture in the Mediterranean region

Agriculture has been one of the key historical pillars of Mediterranean civilisations. The Mediterranean region is the historic homeland that gave rise to the origin of agriculture and associated civilisations, and still today its Eastern element includes the Fertile Crescent (from the Persian Gulf to the Mediterranean Sea, including parts of modern-day Iraq, Syria, Lebanon, Israel, Palestine, Jordan, and parts of Türkiye and Iran), which holds a unique global concentration of cultivated and wild progenitor agricultural diversity, or Crop Wild Relatives (CWR) (Box 1.1; Zohary & Hopf, 1993). As one of the oldest basins of agricultural development, the region has experienced a complex interaction between natural and human-managed landscapes, leading to both positive and negative impacts on biodiversity.

Agriculture and the domestication of animals and plants has transformed biodiversity, especially in the Mediterranean region, shaping ecosystems, economies and societies. In addition, natural disturbances such as fire and grazing have played a key role in shaping Mediterranean biodiversity, contributing

Agricultural landscape in the region of Axarquía, Andalusia, Spain. © Faye Weaver

to habitat heterogeneity and preventing woody encroachment (Bond, 2019; Pausas & Bond, 2020).

Although the management of plants in the Mediterranean is believed to have begun as late as 12,000 years before present (B.P.), evidence of agricultural economies reliant on a mix of domesticated crops and livestock does not appear until 9,500–9,000 B.P. (Zeder, 2008). Nevertheless, human expansion supported by agricultural economies over the past 10,000 years has brought important environmental impacts for Mediterranean biodiversity, including both losses and opportunities (CEPF, 2017), and the biodiversity found in the region is a direct result of those interactions. Today, the Mediterranean region is dominated by agricultural landscapes (Figure 1.2), which cover at least 82% of its land surface (Malek & Verburg, 2017) (see Chapter 2 for more details), including different types of agricultural systems: both intensive and extensive. Depending on their level of intensity, agricultural systems affect biodiversity and ecosystem functions to a greater or lesser degree (see Chapter 4 for more details about how agriculture impacts biodiversity and ecosystem services).

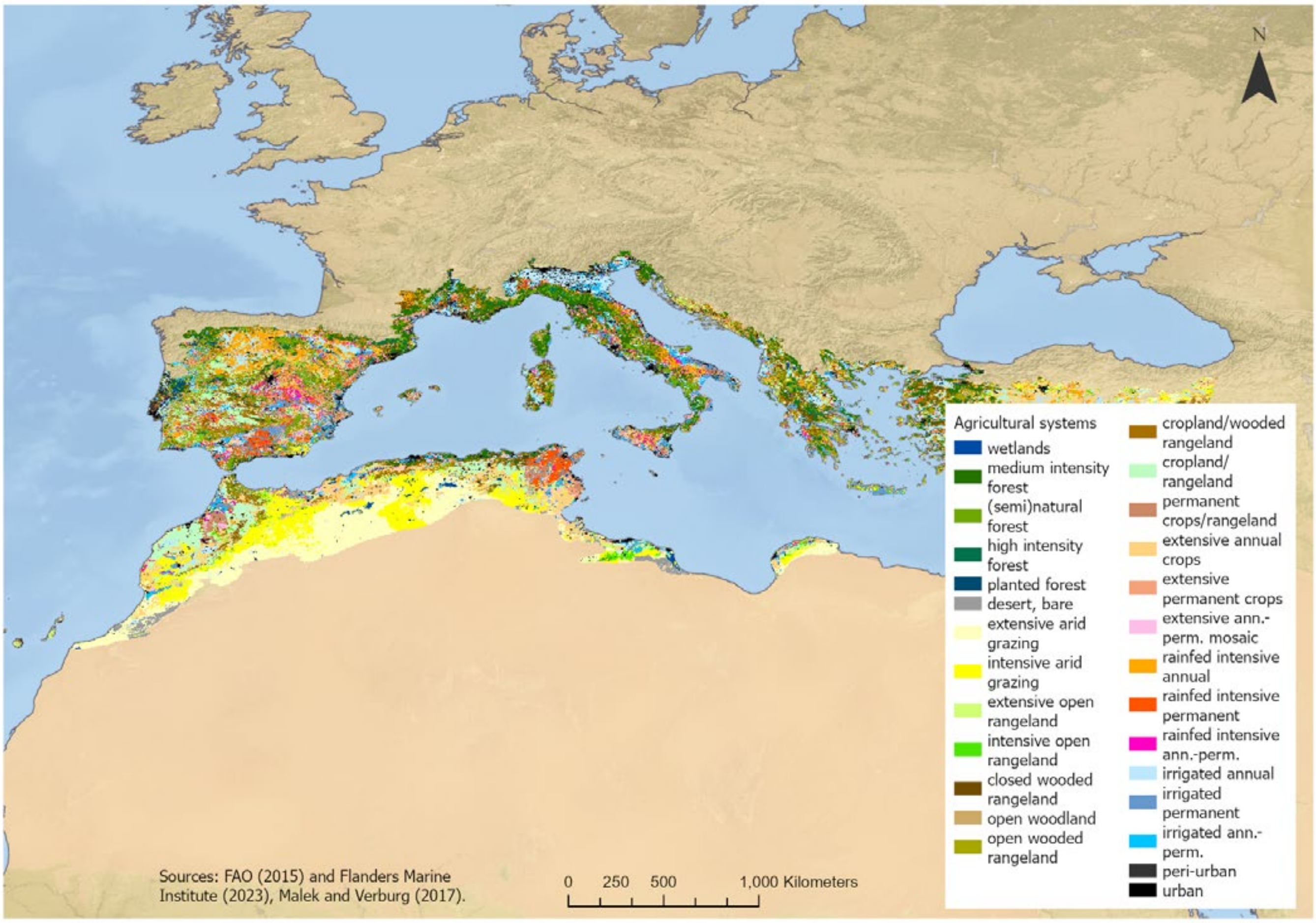


Figure 1.2. Map of agricultural systems in the Mediterranean. Source: Malek and Verburg (2017). For more details on how this map was developed see Section 2.5.2.

BOX 1.1. Crop Wild Relatives in the Mediterranean

The Mediterranean basin holds a key role in ensuring global food security in the face of climate change, which is critical for future human survival (Maxted et al., 2024). One potential solution is to use new climate-smart crop varieties created using the breadth of diversity inherent in CWR (Maxted et al., 2024): wild plant taxa closely related to crops that are relatively easily introgressed with crops to engender crop resilience (Maxted et al., 2006). CWR are defined by how readily their traits can be transferred to the related crops and have been increasingly used in plant breeding since the early 20th century to improve the characteristics of crops regarding resistance to pests and diseases, tolerance to environmental conditions, improved nutritional value and the colour and texture of food (Hajjar & Hodgkin, 2007; Maxted et al., 2007).

Despite their economic value, CWR are threatened, with 16-35% of these species at risk of extinction in Europe (Bilz et al., 2011) and Meso-America, and a significantly higher percentage suffering genetic erosion. Additionally, they are under-conserved: 95% requiring additional ex situ collections (Castañeda-Álvarez et al., 2016) and less than 1% actively conserved in situ (Maxted & Magos Brehm, 2023). They also often grow naturally in disturbed habitats lacking standard conservation measures. The urgent requirement for CWR use in crop breeding (Tanksley & McCouch, 1997) and active CWR conservation is widely recognised in the global policy context (e.g., the Convention on Biological Diversity (CBD), the United Nations (UN) Sustainable Development Goals, the Food and Agriculture Organization of the United Nations (FAO) Second Global Plan of Action of Plant Genetic Resources and the FAO Framework for Action on Biodiversity for Food and Agriculture) and breeders highlight that lack of CWR diversity is unnecessarily limiting crop improvement (Dempewolf et al., 2017).

Crocus hartmannianus, a crop wild relative endemic to Cyprus, is classified as Vulnerable (VU) at the Global, Europe & Mediterranean scale on the IUCN Red List (Bilz, 2011). © "Crocus hartmannianus" by Oron Peri is licensed under CC BY-NC-ND 4.0.

CWR are not spread evenly across the globe; they are focused in hotspots, with the richest region for CWR diversity being in West Asia and North Africa (WANA) (Vincent et al., 2013). This region has about 40% of global priority taxa as well as the top 17 countries with the highest numbers of CWR taxa per unit area (Maxted et al., 2024). Specifically, the Mediterreanen basin is home to priority CWR of cereals (Vavilov, 1926). Therefore, improved active conservation of CWR in the Mediterranean region is not only a regional priority but a critical global imperative to support the well-being and future of humankind, through for example, food security (see Figure 1.3 for examples).

Given the importance of CWR for agriculture and biodiversity, throughout this report there are several boxes opening a window into CWR conservation status, threats, and habitats in the Mediterranean.

Figure 1.3. (**a**) Wheat CWR *Aegilops triuncialis* L. growing on a field margin in Meghri, Armenia © N. Maxted;
(**b**) First genetic reserve established for CWR in situ conservation in Latakia province, Syria in 2016 © N. Maxted

Intensive orchard monoculture on the Saiss Plain, Morocco. © "Intensive orchard farm, Saiss Plain, Morocco" by Water Alternatives Photos/Florence Malerbe is licensed under CC BY-NC 2.0.

Agricultural landscapes and biodiversity conservation

Agricultural development has been widely documented as the major threat to species conservation (Benton et al., 2021). However, labelling all agriculture as a threat is an oversimplification - not all agriculture is a threat to biodiversity. For instance, the maintenance of CWR diversity is largely associated with disturbed agricultural habitats and their margins (Jarvis et al., 2015).

Humankind could not exist without agriculture and its food production to sustain our livelihoods. Agriculture is needed to provide many essential resources on which human societies depend, including, but not limited to, food, spices, clothes, materials, and medicine. In addition to being the means of subsistence for billions of people around the planet, agriculture is also an important part of the cultural identity and heritage of indigenous peoples and local communities (FAO, 2022). Consequently, agri-food systems and nature conservation need to find ways to harmonise: producing agricultural products in ways that are less harmful to the environment while still meeting people's needs.

From a conservation perspective, agricultural biodiversity is also a fundamental part of conserving the benefits people obtain from nature, as exemplified by CWR diversity (Box 1.1), for which the Mediterranean basin is a global hotspot (Maxted & Vincent, 2021; Sajeev et al., 2023). Throughout this report, the conservation status, threats, and habitats of a subset of CWRs assessed for the Mediterranean is explored, through the CWR focus theme.

This report also introduces the concept of agroecology as one approach that can shape agricultural landscapes while supporting biodiversity conservation (Box 1.2), which is explored further in Chapter 4. Agroecology has been recognised for such role in previous years and is gaining momentum in global and national discussion on policy and funding. Examples include recognition in EU policy (European Commission, 2023), the FAO´s Agroecology Knowledge Hub (FAO, 2024), and the CBD´s Global Biodiversity Outlook, which states that the sustainable agriculture transition should include "…redesigning agricultural systems through agroecological and other innovative approaches to enhance productivity while minimising negative impacts on biodiversity" (CBD, 2020; p. 20).

BOX 1.2. Defining agroecology

In Europe and the United States of America, the term agroecology was first used in scientific publications in the late 1920s, when scientists started to combine principles from ecology and agronomy to better understand different agricultural systems. However, despite gaining momentum in the Global North in recent decades, the concept has roots in campesino and social movements and has long been championed by the Global South (Declaration of the International Forum for Agroecology, 2015).

Today, agroecology is a multifaceted and complex term. It takes a holistic and sustainable approach to solving one of the major problems faced by humanity: feeding a growing population while conserving natural resources (Biovision, 2019). Agroecology is mainly about applying ecological concepts, principles, and knowledge to agricultural production, rather than relying on external inputs. It combines local and scientific knowledge and considers the long-term impacts of farming systems. It is a principles-based approach to agricultural development that has been defined in various ways since the first principles were proposed by Altieri in 1995 and updated in 2016 (Nicholls Nicholls et al., 2016). In 2019, the High-Level Panel of Experts on Food Security and Nutrition (HLPE), a science-policy interface of the UN FAO Committee on World Food Security (CFS), published the **13 Principles of Agroecology**. These are grouped under three operational principles: strengthening resilience, securing social equity, and improving resource efficiency. Under these, 13 principles, shown in Figure 1.4, underpin the agro-ecological approach (Figure 1.4). In addition to these, several other frameworks on agroecology have been developed, including the FAO´s 10 Elements of Agroecology (FAO, 2018). How agroecology can support biodiversity conservation is further explored in Chapter 4.

Figure 1.4. The 13 HLPE Principles of Agroecology. © Biovision. An interactive tool is available here.

Old vineyard in the Marmara Region of western Türkiye. © "Gülfem Köseoğlu Vineyard" by Can Kırış is licensed under CC BY-SA 4.0.

1.2. Purpose of this report, target audience and objectives

The main purpose of this report is to explore the complex relationship between agriculture and biodiversity in the Mediterranean basin through the lens of species conservation, and to identify the practices through which agriculture has been or can be an ally for conservation. The geographical scope is the Mediterranean region according to the Mediterranean Basin Biodiversity Hotspot (Mittermeier et al., 2004) (Figure 1.1), with the exception of the Macaronesian islands, which have not been included in this study.

This report is targeted to policy makers in the Mediterranean region. Its aim is to inform the implementation of current agricultural policies and the formulation of new ones, and to ensure that these consider both the risks and opportunities that agricultural practices can pose to biodiversity, as well as the benefits they provide to people.

The report starts with Chapter 2, where a dataset of 4,409 Mediterranean species assessed on the IUCN Red List of Threatened Species is described. This dataset possibly represents only around 2% of the known species in the Mediterranean (CEPF, 2017). However, it is the most comprehensive compilation of species assessments for the Mediterranean to date and summarises over a decade of assessment work aimed at understanding and determining species extinction risk in the region. Chapter 2 also uses this dataset to explore the role of agriculture as a threat or a habitat for many of these species, and the nuances of making these associations. Strategies to mitigate and reduce threats to species from agriculture, and solutions to reconcile agriculture and biodiversity conservation, are discussed in Chapters 3 and 4. Chapter 3 presents the calculation of the first Species Threat Abatement and Restoration (STAR) metric focused on the abatement of agricultural threats in the region. Chapter 4 provides an overview of agroecology as a key approach that can support more sustainable and inclusive agricultural systems. It does this by introducing key concepts, principles, frameworks, and approaches of agroecology. The final Chapter builds on from the previous ones, putting forward policy recommendations to develop agriculture in the Mediterranean region in a way that can support species conservation while sustaining food production and local people´s livelihoods.

2

Over a decade of IUCN Red List species assessments in the Mediterranean

Summary: We compiled a subset of 4,409 species that have over 75% of their distributional range within the Mediterranean region and summarised their conservation status, patterns of distribution, major threats and major habitats. We found that one quarter (26%) of these species are at risk of extinction. The three top habitats for terrestrial species are shrubland, forest and grasslands, accounting for 66% of all major habitats recorded. Unsustainable practices in agriculture and aquaculture, biological resource use and natural system modifications are the major threats to Mediterranean species. Other notable threats include invasive species, pollution, and residential and commercial development. We then selected a subset of species assessments with enough information to further examine key threats and habitats, and assess the spatial overlap between the species distributions and a classification of land system types in the Mediterranean. We show that 38% of the Mediterranean´s land surface is covered by Croplands, 23% by Agro-silvo-Pastoral Systems and 10% by Open and Bare Grazing. 76% of the species distribution ranges overlap with the land use systems of Agro-silvo-pastoral mosaic (33% of species), Open and bare grazing (24%), and Croplands (20%). Agricultural habitats were identified as suitable for 18% of these species, and for 2%, agricultural lands are habitats of major importance.

2.1. Introduction

This Chapter reviews The IUCN Red List of Threatened Species™ assessments completed for the Mediterranean region over the past decades and further explores the information reported in a subset of terrestrial species assessments, in order to understand the role that agriculture plays in threatening or supporting their conservation.

2.2. The IUCN Red List of Threatened Species™

The IUCN Red List of Threatened Species™ (Red List) is widely recognised as the most comprehensive, scientifically based source of information on the global conservation status of plant, fungi and animal species (IUCN, 2001). IUCN Red List Categories and Criteria are applied to individual taxon assessments - which contain information on aspects such as ecology and life history, distribution, habitat preferences, threats, current population trends and conservation measures - to determine their relative threat of extinction (Figure 2.1). Taxa in Categories Extinct (EX) and Extinct in the Wild (EW) correspond to taxa that have disappeared at the global level or in their natural habitat, respectively. Threatened species are those listed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU). Taxa that are either close to meeting the threatened thresholds or would be threatened if it were not for ongoing conservation programmes are classified as Near Threatened (NT). Taxa evaluated as having a relatively low risk of extinction are classified as Least Concern (LC). Also highlighted within the Red List are taxa that cannot be evaluated due to insufficient knowledge, which are therefore assessed as Data Deficient (DD). This Category does not necessarily mean that the species is not threatened, only that its risk of extinction cannot be assessed from the currently available data (IUCN Standards and Petitions Committee, 2024).

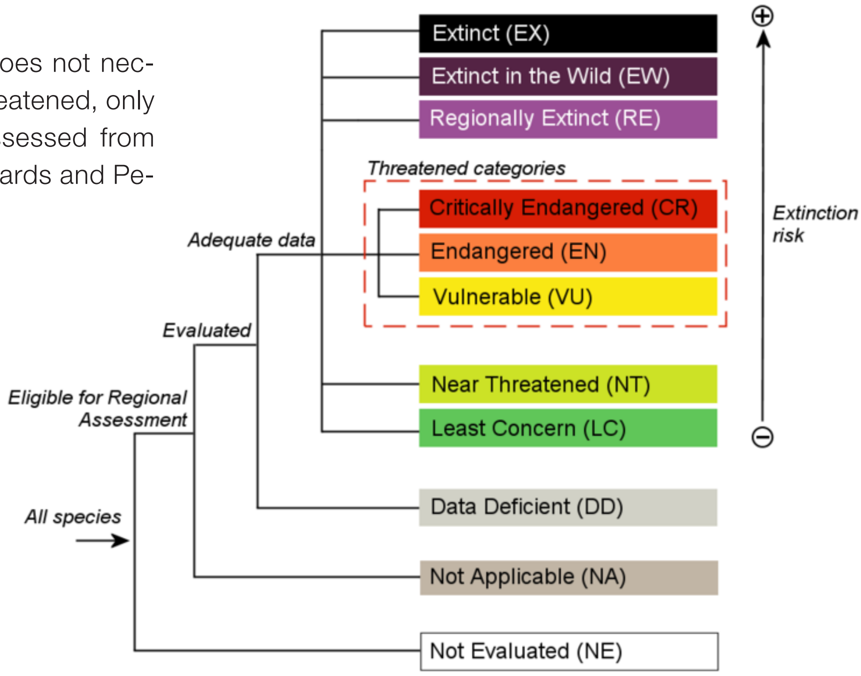


Figure 2.1. IUCN Red List Categories © IUCN

2.3. The IUCN Red List Mediterranean assessment initiative

In addition to a global assessment, the extinction risk of species can also be assessed at a national or regional level. For example, a given species could be simultaneously Least Concern (LC) at a global level, Endangered (EN) within Europe, and Critically Endangered (CR) in a European country when the Red List Criteria are applied, depending on the status of their populations in each of those geographical scopes. However, an endemic species should have the same Category at both regional and global level, as it is not present in any other part of the world. The guidelines for the application of IUCN Red List Criteria at the regional and national level (IUCN, 2012) are applied to avoid any over- or underestimation of the regional extinction risk of a species.

The Mediterranean Red List of Species is a compelling review of the conservation status of species at the regional level, identifying those that are threatened with extinction and the main threats they are facing. Thus, it is a powerful tool to lead, prioritise and monitor conservation action within the Mediterranean region.

The red-footed falcon (*Falco vespertinus*) is Critically Endangered CR) at the Mediterranean scale. It typically occurs in open lowland areas with trees and a plentiful supply of insects, including agricultural land with tall trees or hedgerows. The species is severely threatened by habitat loss due to unsustainable agricultural expansion, as well as reduced prey availability due to pesticide use (Westrip & BirdLife International, 2022).

2.4. Species distributions and agriculture

The impact of agricultural practices on species heavily depends on the specific agricultural practices and traditions where those species used to exist or are still present (see Chapters 1 and 4). It is important to understand which types of agricultural practices have the most significant impacts on species, so that actions to avoid or manage those impacts can be put in place. For example, while "overgrazing" has widely been considered a threat to biodiversity, a more nuanced approach is required, especially in the Mediterranean region, where grazing has historically shaped the ecosystems and land uses that are still characteristic of the region today (Perevolotsky & Seligman, 1998; Caballero et al., 2011). Well-managed extensive livestock systems contribute to ecosystem stability by maintaining species-rich grasslands, facilitating seed dispersal and preventing the overgrowth of shrubs that can alter Mediterranean ecosystems (Maestre et al., 2022), fire severity and rate of propagation (Lecomte et al., 2024).

Conversely, especially in the Mediterranean, many species which have coexisted with human activities for thousands of years may have colonised or used other habitats in addition to their natural habitats. The main questions here are: to what extent do terrestrial species in the Mediterranean use artificial habitats in general, and agricultural habitats in particular? For example, when specifically addressing CWR diversity, it is well established that priority CWR are almost always associated with disturbed anthropogenic habitats (Jarvis et al., 2015).

In Sections 2.6.6-2.6.8, we explore the answers to these questions. First, we use a Mediterranean land system map to refine the IUCN terrestrial species distributions in the Mediterranean to specific land systems as defined by Malek and Verburg (2017), who take an integrated social-ecological approach to classify land systems. Then, by examining information relating to threat and habitat classification reported in the Red List species assessments, we determine the extent to which agriculture is a threat as well as an important habitat type for the survival of species.

Sheep grazing in the Middle Atlas Mountains of Morocco. © "Herding sheep in Dayet Ifrah" by Hugo van Tilborg is licensed under CC BY-NC-SA 2.0.

2.5. Methods

This section describes the methods followed to compile, process, and analyse a dataset of species assessments and their associated spatial data relevant to the Mediterranean region (Section 2.5.1), and the approach used to further explore the role agriculture plays in threatening or supporting their conservation, using Red List data (Section 2.5.2).

2.5.1. Conservation status of species in the Mediterranean

Data compilation and processing

Thousands of species assessments have been conducted since the IUCN Centre for Mediterranean Co-operation started Red Listing work in 2010. The aim of this data compilation initiative has been to gather the most comprehensive list of species assessments for the Mediterranean region (as defined in this report) to date. This has involved compiling species assessments at a Mediterranean, European, and global level.

An initial Mediterranean species master list (hereafter Master List) and spatial dataset was compiled by the IUCN Centre for Mediterranean Cooperation. The Master List included 8,746 species known to occur in the Mediterranean and for which a Red List assessment has been completed. The date of assessments ranged from 1996 to 2020. The spatial dataset consisted of species range polygons submitted to the IUCN Red List Unit together with the corresponding assessments for publication at www.iucnredlist.org. This spatial dataset was completed by assessments and polygons of comprehensively assessed groups downloaded from the Red List website using the IUCN Red List API (IUCN, 2023). As the scope of this report was to explore the interactions between agriculture and species, all marine species were removed. In addition, any species for which there was no distribution range map were also excluded.

Taxonomic groups included in the initial dataset were amphibians, birds, bees, butterflies, dragonflies and damselflies, freshwater crabs, freshwater fishes, freshwater molluscs, grasshoppers, locusts, crickets, hoverflies, mammals, terrestrial molluscs, plants, reptiles and saproxylic beetles. All the available species ranges were then filtered by the ‘presence’ and ‘origin’ fields to remove extinct and introduced species. Table 2.1 shows which categories of species were excluded (categories marked in white were removed from the dataset). The species polygons were then clipped with the CEPF Mediterranean biodiversity hotspot polygon (see Figure 1.1).

Table 2.1. Values for presence, origin and seasonality fields in IUCN Red List spatial data for which associated geometries were included (in black) and excluded (in white) in the final Master List of species used in this report.

Presence	Origin	Seasonality
1 (Extant)	1 (Native)	1 (Resident)
2 (Probably Extant)	2 (Reintroduced)	2 (Breeding Season)
3 (Possibly Extant)	3 (Introduced)	3 (Non-breeding Season)
4 (Possibly Extinct)	4 (Vagrant)	4 (Passage)
5 (Extinct)	5 (Origin Uncertain)	5 (Seasonal occurrence uncertain)
6 (Presence Uncertain)	6 (Assisted Colonisation)	

Our aim was to only include species which have a significant proportion of their distribution range within the Mediterranean, and therefore not all species range polygons compiled were included in the final analysis. All species on the Master List for which spatial data was available were included in the analysis (see Appendix 1). Species that were not on the Master List were only included if 75% or more of their range was within the Mediterranean.

Red List Categories assignment

All species were assigned a Red List Category, where possible from Mediterranean level assessments, in order to ascertain their extinction risk. If these were not available, Red List Categories from European assessments were used, and where these were also not available, the Categories from global assessments were used. In some cases, for example European endemics, one or more assessments could have the same category.

Freshwater and terrestrial species

Species were split into terrestrial or freshwater categories. To create the freshwater species dataset, all species labelled as freshwater in the Master List and those that only had freshwater habitat affiliations in the respective species assessments were categorised as freshwater. For example, all of the wetland category (5) and artificial aquatic (15), apart from marine/saline categories (habitat categories 5.14, 5.15, 5.16, 5.17, 15.4, 15.11, 15.12, 15.13) from the IUCN Habitats Classification Scheme 3.1 (IUCN, 2024), were included. Plants with a freshwater habitat affiliation labelled as major importance in the Red List assessment and plants listed as 'freshwater' in the Master List biome column were also included in the freshwater group.

Crop Wild Relatives

To further explore the diversity of wild plants and their potential contributions to agriculture, we identified those CWR taxa that have been assessed, largely by members of the IUCN Species Survival Commission (SSC) Crop Wild Relative Specialist Group (CWR SG). So far, there is no comprehensive CWR inventory for the Mediterranean region. However, building on two sub-regional inventories for West Asia (Zair et al., 2021) and North Africa (Lala et al., 2018), together with those CWR taxa of global priority native to the Mediterranean, Vincent et al. (2013) produced a Mediterranean priority list of 491 human or animal food crops CWR taxa, as well as reviewing their conservation and threat status. This list was crosschecked with the plants included in the Master List to add a CWR label for further analyses (Appendix 2).

The Crop Wild Relative *Vicia esdraelonensis* is classified as globally Vulnerable (VU) on the IUCN Red List. It has a very restricted distribution comprising three isolated populations in Syria, Israel and Türkiye, and is highly threatened by unsustainable overgrazing (Rhodes, 2016).

IUCN Habitats and Threats Classification Schemes

During the species assessment process, IUCN Red List assessors code for each species the suitable and major habitats they use and the relevant known threats. The IUCN Habitats Classification Scheme (Version 3.1), which includes 17 major habitat types and over 100 subtypes, is used to code the suitable and major habitats and for each species. Similarly, the IUCN Threats Classification Scheme (Version 3.3; IUCN, 2022) uses standardised threat codes to document threats to species, and is divided into 12 threat codes that include over 100 subcodes. Both Schemes include definitions of all the categories and guidance on how to use them. The classifications are structured in 3 levels of detail: Level 1 (e.g., 2 Agriculture & aquaculture), Level 2 (e.g., 2.1 Annual & perennial non-timber crops) and Level 3 (e.g., 2.1.1 Shifting agriculture). Thus, IUCN Red List assessors follow standardised and hierarchical classification schemes to record which agricultural practices are considered as a threat and which agriculture-associated habitats are considered as suitable for a given species.

To determine which types of agricultural practices were coded as a threat and which agricultural habitats were coded as suitable or important for each species, we extracted the selections made by IUCN assessors from the IUCN Red List database and examined the attributions made at different levels.

Spatial analyses

Species richness maps based on Red List distribution ranges

All species range polygons were converted to 2 x 2 km rasters to match the resolution of the Malek and Verburg (2017) layer which would subsequently be used in the second part of this study (see Section 2.5.2). The resulting rasters, one for each species, were binary, with a value of 1 indicating that the species' range polygon overlapped that grid cell, and a 0 where it did not (i.e. any cell the range polygon overlapped was included in the raster). These rasters, and subsets of them to represent specific taxonomic groups, were summed together to produce the species richness maps. All analyses were performed in 2022 using a combination of ArcGIS Pro and R.

Caveats of this approach

As with any large-scale biodiversity assessment, results should be interpreted with caution, as the classification of agricultural impacts may reflect reporting biases rather than an absolute measure of impact severity. It is important to acknowledge that, while Red List threat and habitat code assignations are based on a value judgement of key experts on the species being assessed, the use of Red List data for assessing agricultural threats may introduce biases, particularly in how different land-use types are perceived. For example, grazing impacts may be overrepresented due to historical conservation narratives that focus on overgrazing rather than sustainable grazing benefits (di Virgilio et al., 2019). However, while unsustainable grazing remains a concern in certain contexts, extensive and rotational grazing systems have demonstrated ecological benefits by supporting landscape mosaics that sustain diverse species communities (e.g., Pinto-Correia et al., 2011). Moreover, the IUCN Threats Classification Scheme, especially at the broader levels of categorisation (i.e., Level 1), does not allow for distinguishing specific agricultural practices or their intensities. Thus, these assessments should be interpreted with caution, as the assignation of one of the agricultural threat categories to a given species does not necessarily mean that *all* agricultural practices or intensities are incompatible with the survival of the species.

There are other important limitations inherent in this approach that need to be clarified. First, these maps are derived directly from the distribution data provided by IUCN Red List assessments, and thus do not show confirmed species occurrence, but rather coarse, large-scale distribution patterns. Thus, these analyses do not allow to locate with certainly the presence of a given species in a particular location, nor its threats.

Alfilerillos de Sierra Nevada (*Erodium rupicola*) is a Crop Wild Relative endemic to the southeast of the Iberian Peninsula and listed as Vulnerable (VU) at the Global, Europe & Mediterranean scale. According to the Red List assessment, its primary threats include unsustainable overgrazing, firebreak maintenance and reforestation (Algarra Ávila et al., 2011).

2.5.2. Species distributions and agriculture

Mediterranean land systems distribution

As well as the species richness maps based on IUCN Red List distribution ranges, we also produced richness maps based on species ranges refined by suitable habitat. Each species range raster was refined using a Mediterranean land systems layer (Malek & Verburg, 2017). This land use layer was chosen as it has a good representation and breakdown of the systems that dominate Mediterranean landscapes. It also takes a social-ecological approach to map Mediterranean land systems, which seems more appropriate to the Mediterranean context. The dataset consists of a raster layer at 2 km^2 resolution representing 27 systems grouped into seven main systems: Agro-silvo-pastoral mosaic, Open and bare grazing, Croplands, Forest, Settlements, Bare and Wetlands (Table 2.2, Figure 2.1).

The land system classification developed by Malek and Verburg (2017) (Figure 2.2) shows that 38% of the Mediterranean is covered by Croplands, 23% by Agro-silvo-pastoral systems, and 10% by Open and bare grazing. This suggests that 82% of the Mediterranean land region is dedicated to some kind of agricultural activity, making it likely that species ranges overlap with agricultural habitats.

Table 2.2. Mediterranean land system types and assigned groups as mapped by Malek and Verburg (2017)

Land system type (Malek & Verburg, 2017)	Land system group (Malek & Verburg, 2017)
2 = (semi)natural forest	Forest
5 = desert, bare	Bare
0 = wetlands	Wetlands
1 = medium intensity forest	Forest
3 = high intensity forest	
4 = planted forest	
10 = closed wooded rangeland	Agro-silvo-pastoral mosaic
11 = open woodland	
12 = open wooded rangeland	
13 = cropland/wooded rangeland	
14 = cropland/rangeland	
15 = permanent crops/rangeland	
6 = extensive arid grazing	Open and bare grazing
8 = extensive open rangeland	
7 = intensive arid grazing	
9 = intensive open rangeland	
18 = extensive mosaic	Croplands
17 = extensive permanent	
16 = extensive annual	
21 = rainfed intensive mosaic	
20 = rainfed intensive permanent	
19 = rainfed intensive annual	
24 = irrigated mosaic	
23 = irrigated permanent	
22 = irrigated annual	
25 = peri-urban	Settlements
26 = urban	

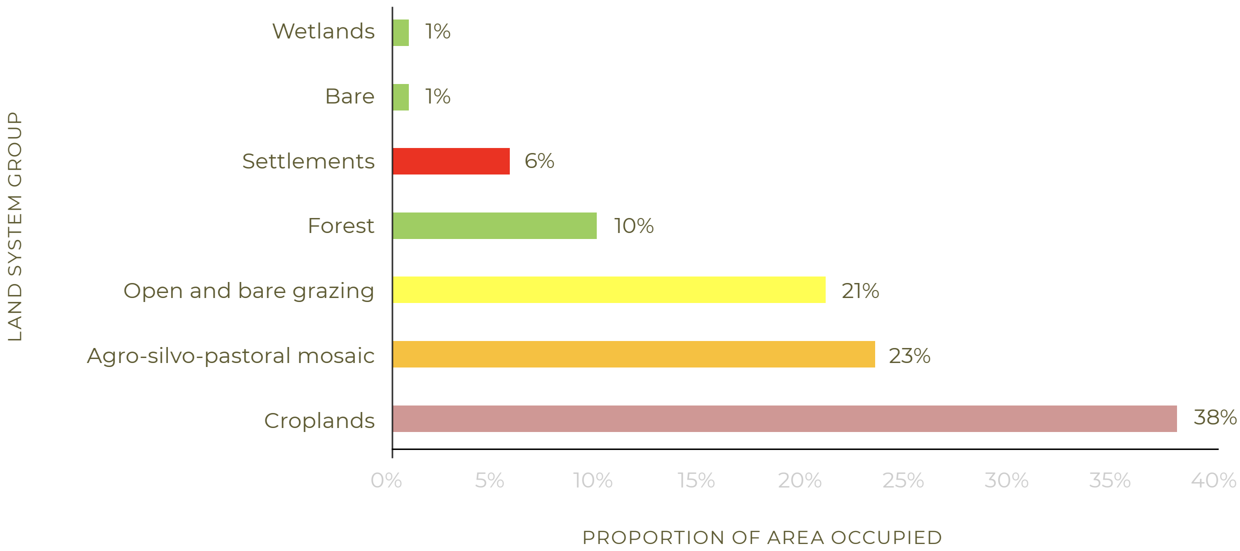


Figure 2.2. Proportion of area occupied by main Mediterranean land system groups as developed by Malek and Verburg (2017)

Grazing, when managed at sustainable levels, can promote habitat diversity and maintain open ecosystems that are beneficial for pollinators and other species dependent on grassland habitats.

Species distributions by Mediterranean land systems

Each land system group from Malek and Verburg (2017) was linked to one or more IUCN habitat categories by creating a crosswalk table (Appendix 3). The land use layer was then used to remove parts of species ranges that were not classified as suitable habitat, based on the IUCN Red List habitat assessment of each species. This was only undertaken for terrestrial species, as the land use data was not detailed enough for freshwater habitats. Some species' ranges (957 species maps) could not be refined because either the range was too small, the habitat was too specific and did not match the landcover (e.g., IUCN habitat category 6. Rocky areas (e.g., inland cliffs, mountain peaks)), or the species ranges were restricted to islands not included in the landcover extent (Macaronesian islands and Cabo Verde). This left a total of 3,452 species that were included in the refined species richness map. These rasters were summed together to produce the species richness map refined by land use systems.

To estimate species richness in each land system, the refined species range rasters were first converted into polygons. The Mediterranean land systems layer was also converted into a polygon layer and then intersected with the species polygons. This was then processed using the "dissolve" GIS tool for all species names and land use systems to avoid double counting. The analyses consisted of counting the number of spatial overlaps of species range maps with land use systems to obtain two measurements: (i) species occurrences or number of times any species was found in a particular land system group, and (ii) total number of species found in each land system group.

Agriculture as both a threat and a habitat for species

Threats: The Level 1 threats to species in the Mediterranean are explored in Section 2.6.5. To understand in more detail what types of agricultural threats were recorded, we selected only the 1,119 of 3,568 terrestrial species for which the IUCN threat code "2. Agriculture & aquaculture" was used and was classified as "ongoing". These include the following subcodes (Table 2.3):

Table 2.3. Level 2 (e.g., 2.1) and Level 3 (e.g., 2.1.1) threat categories included under Agriculture & aquaculture (Level 1)

2.1 Annual & perennial non-timber crops
2.1.1 Shifting agriculture
2.1.2 Small-holder farming
2.1.3 Agro-industry farming
2.1.4 Scale Unknown/Unrecorded
2.2 Wood & pulp plantations
2.2.1 Small-holder plantations
2.2.2 Agro-industry plantations
2.2.3 Scale Unknown/Unrecorded
2.3 Livestock farming & ranching
2.3.1 Nomadic grazing
2.3.2 Small-holder grazing, ranching or farming
2.3.3 Agro-industry grazing, ranching or farming
2.3.4 Scale Unknown/Unrecorded
2.4 Marine & freshwater aquaculture
2.4.1 Subsistence/artisanal aquaculture
2.4.2 Industrial aquaculture
2.4.3 Scale Unknown/Unrecorded

Oak agro-silvo-pastoral system in central Italy.

Habitats: The major habitats for all terrestrial species included in this study are summarised in Section 2.6.4. To explore the extent to which other artificial habitats are used or are important for each terrestrial species in our sample, we investigated all IUCN habitat subcodes assigned to species under the code “14. Artificial - Terrestrial”, which include those listed in Table 2.4:

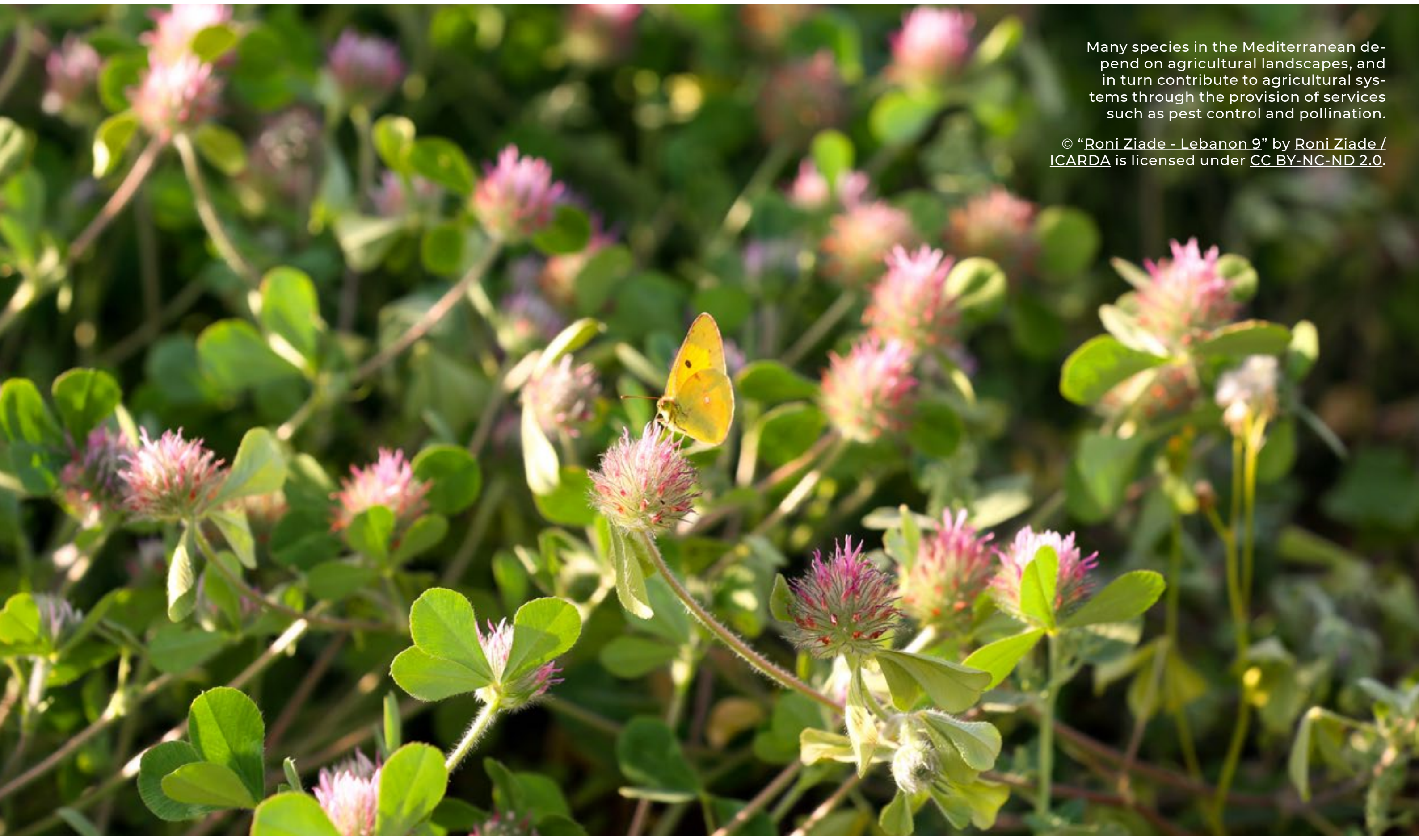
Table 2.4. Level 2 habitat categories included under 14. Artificial - Terrestrial (Level 1)

14.1 Arable Land
14.2 Pastureland
14.3 Plantations
14.4 Rural Gardens
14.5 Urban Areas
14.6 Subtropical/Tropical Heavily Degraded Former Forest

Caveats of this approach

The Malek and Verburg (2017) approach to classify land use systems is not a measure of human modification or naturalness of these systems. Instead, it is an expert-based classification aiming at representing landscapes as integrated social-ecological systems, focusing on agro-silvo-pastoral mosaic systems: multifunctional Mediterranean landscapes hosting different human activities that are not represented in common land cover maps (also see caveats in Section 2.5.1).

As noted in Section 2.5.1, the spatial data used are derived directly from the distribution data provided by IUCN Red List assessments, which do not show confirmed occurrence of species but rather coarse large-scale distribution patterns. This means that the resulting species distributions by land use types represent the relationship between species distribution and land use types rather than the confirmed presence of these species within those land use types.



Many species in the Mediterranean depend on agricultural landscapes, and in turn contribute to agricultural systems through the provision of services such as pest control and pollination.

2.6. Results

2.6.1. Species groups and taxonomic groups

The data compilation and processing described in Section 2.5.1 resulted in a dataset that included 4,409 species assessments, listed in Table 2.5. These represented 17 taxonomic groups of terrestrial and freshwater species. Most species (3,583; 81%) were terrestrial and included amphibians, birds, bees, butterflies, grasshoppers, locusts, crickets, hoverflies, mammals, terrestrial molluscs, reptiles, saproxylic and terrestrial plants. A total of 826 species (19%) were labelled as freshwater. These included dragonflies and damselflies, freshwater crabs, freshwater fishes, freshwater molluscs, and freshwater plants. These taxonomic groups were merged into 10 *species groups* to facilitate the synthesis of the results (Table 2.5).

Table 2.5. Number of species per species group and taxonomic group included in this study. See Appendix 1 for a full list and taxonomy.

Species group	Number of species per taxonomic group	Total number of species
Amphibians	103	103
Birds	525	525
Decomposers	Dung Beetles: 205 Saproxylics: 345	550
Freshwater Fishes	292	292
Freshwater invertebrates	Dragonflies and damselflies: 45 Freshwater crabs: 7 Freshwater molluscs (Bivalvia): 4 Freshwater molluscs (Gastropoda): 352	408
Mammals	249	249
Other terrestrial invertebrates	Grasshoppers, Locusts, and Crickets: 353 Terrestrial molluscs (Gastropoda): 284	637
Plants	Freshwater plants: 126 Terrestrial plants: 530	656
Pollinators	Bees: 177 Hoverflies: 60 Butterflies: 461	698
Reptiles	291	291
Total number of species included		**4,409**

CWR Focus: Types of CWR

Of the 4,409 species included in the present analysis, 656 were plants, of which 449 (68%) were labelled as Crop Wild Relatives (CWR) (see Appendix 2 for CWR data). This subset of CWR represents only 2% of plant species, 12% (111) of genus, and 31% (48) of families known to be CWR in the Mediterranean basin countries (IUCN SSC CWR SG, 2024), which means it is a small sample size. Most (90%) of these 449 species are related to species with medicinal and aromatic uses, but it is common to attribute various uses to the same species. Other uses include ornamental purposes, human food, forestry, and animal food (Figure 2.3).

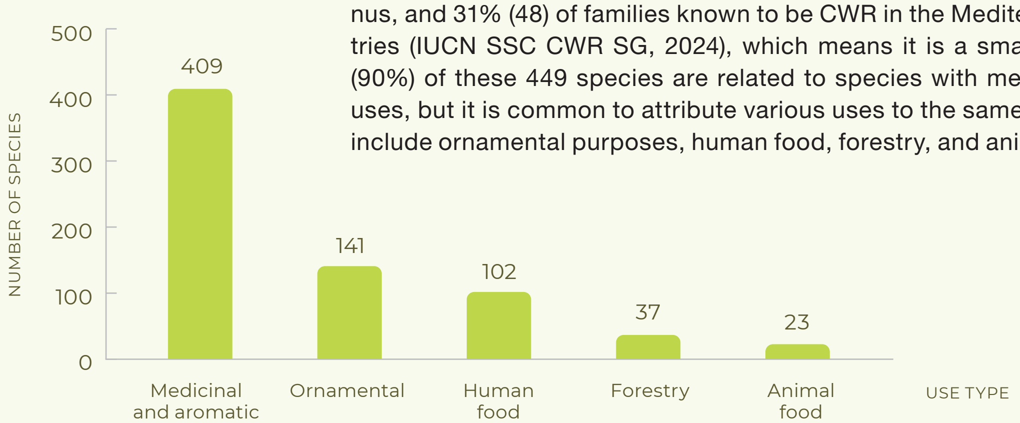


Figure 2.3. Number of species associated with each use type included in the CWR subset. Note that most species have been recorded for more than one use.

Farmer working in a peach grove, Lebanon. © "Lebanon: Agricultural Steering Committee activities 2022" by Prospects ILO/Elisa Oddone is licensed under CC BY-NC-ND 2.0.

2.6.2. Conservation status of Mediterranean species

Freshwater and terrestrial species

One in four (26%) of species included in the present Mediterranean dataset are at risk of extinction (CR, EN or VU) (Figure 2.4), while 9% are listed as Near Threatened (NT) and 14% as Data Deficient (DD). Half (51%) of species assessed are listed as Least Concern (LC) but for 53% of these, population trends were either unknown or showing a decrease (see Appendix 1 for full list of species).

This picture changes substantially when freshwater and terrestrial species are separated. Half of all the assessed freshwater species are threatened with extinction and only 30% are listed as Least Concern (LC), whereas 21% of terrestrial species are threatened and 56% listed as Least Concern (LC).

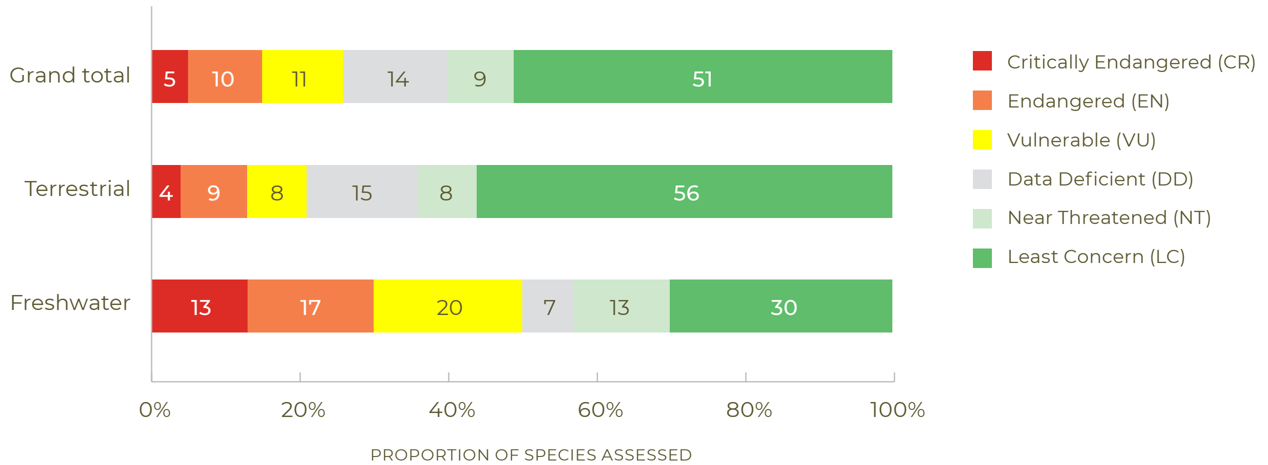


Figure 2.4. Red List Categories assigned to all species included in this analysis

When separating species by taxonomic groups, freshwater invertebrates and freshwater fishes are the most threatened, with over 50% of these species at risk of extinction (53% each), followed by plant species (39% threatened) and amphibians (34% threatened) (Figure 2.5). Decomposers and pollinators both have high proportion of species listed as Data Deficient (DD) (41% and 24% respectively), which highlights the importance of carrying out more research on population and distribution trends of these important species groups.

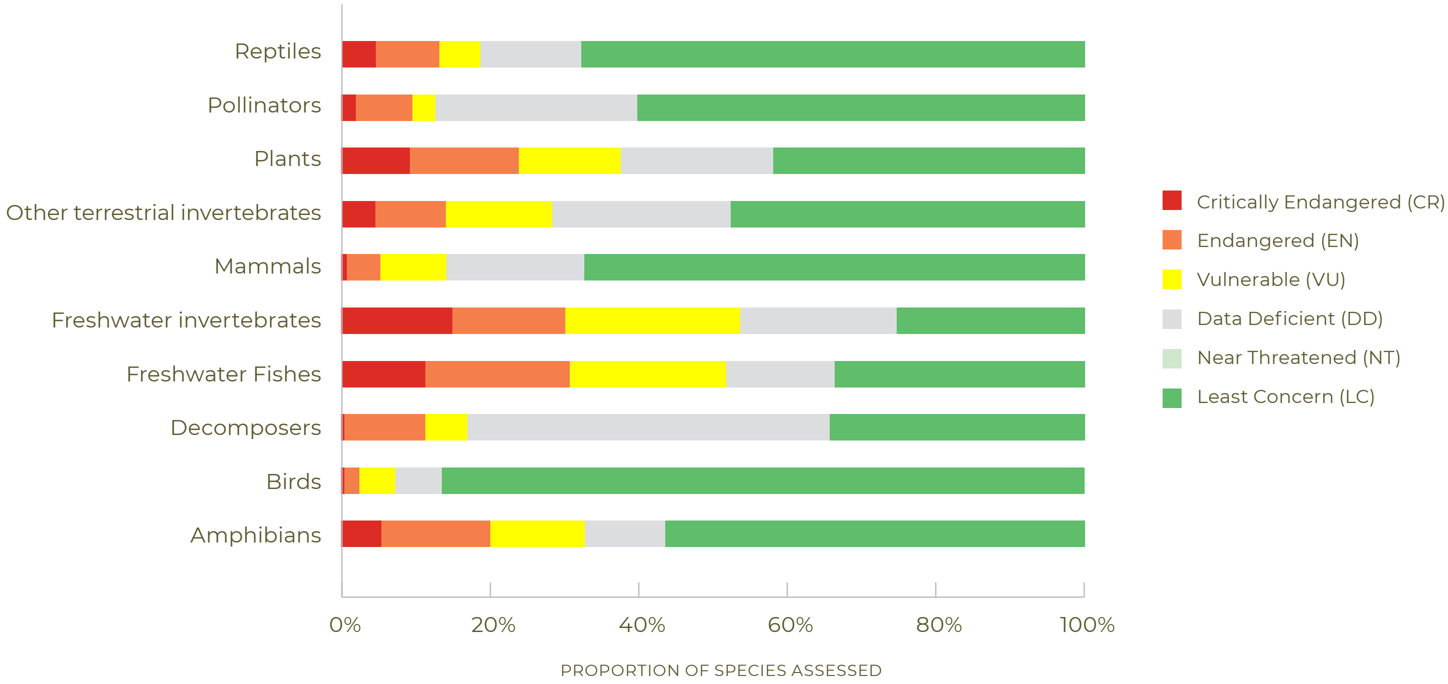


Figure 2.5. Red List Categories assigned to all species groups included in this study

The glittering demoiselle (*Calopteryx exul*) is endemic to the northern Maghreb, and is found in very fragmented, isolated populations across mountain streams in northern Morocco, Algeria and Tunisia. It is listed as Endangered (EN) at the Global, Mediterranean, Northern Africa & Pan-Africa scale and is principally threatened by water pollution, stream desiccation due to water abstraction for irrigation, overgrazing and drought, according to its Red List threat classification (Boudot, 2018).

CWR Focus: Risk of extinction

38% of plant species in the CWR subset are threatened with extinction (Figure 2.6), 7% are Data Deficient (DD), 12% are Near Threatened (NT), and 43% are listed as Least Concern (LC). Medicinal and aromatic and ornamental plant species are the most threatened, with 38% and 40% threatened respectively. Importantly, 34% of CWR related to species used for human food are also threatened.

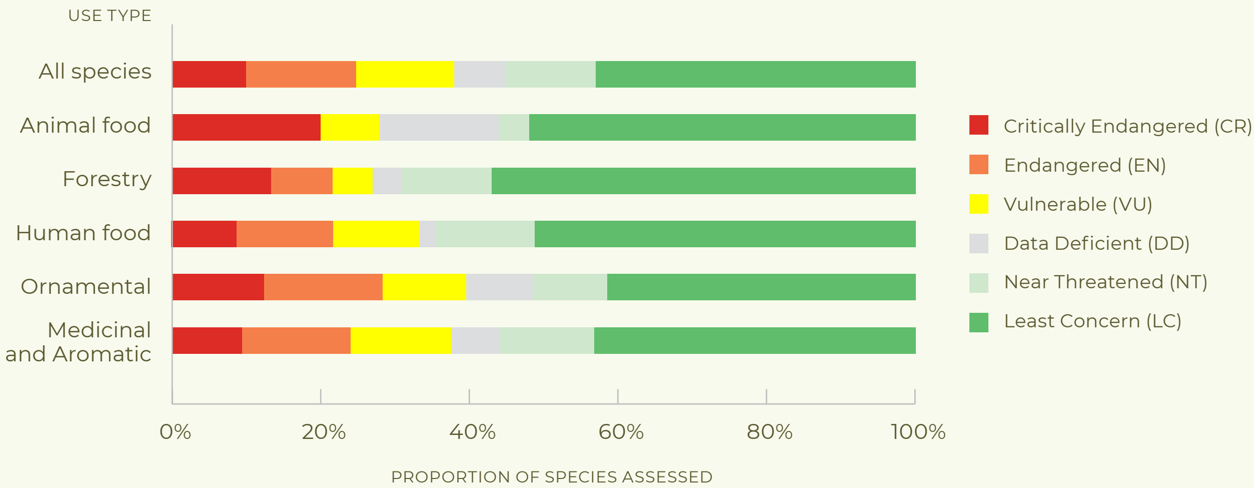


Figure 2.6. Proportion of CWR species in each Red List Category, according to type of use. Note that most species have been recorded for more than one use.

The full picture of the extinction risk of CWR in the Mediterranean is unknown, as there is no comprehensive regional Red List for CWR in the region. In addition to this analysis, another assessment of the threat status of plant diversity in the region identified a total of 3,408 plant assessments, of which 25% (852 species) were CWR of human or animal food crops (Maxted et al., 2024). Of the latter, 17.3% (148 species) priority CWR had been assessed, of which 7.4% (11 species) were threatened (three Critically Endangered (CR), five Endangered (EN), three Vulnerable (VU)), 4.7% (7 species) Near Threatened (NT; or Lower Risk), 77.0% (114 species) Least Concern (LC) and 10.8% (16 species) Data Deficient (DD). Further analysis identified that at least 10.7% (91 species) of the assessed CWR have declining populations, whereas 47.5% (405 species) are stable, 1.5% (13 species) are increasing, and the remaining 40.2% (343 species) have unknown population trends. Similarly, 10.1% (15 species) of the priority CWR have populations in decline, 56.1% (83 species) are stable, 1.4% (2 species) are increasing, and the remaining 32.4% (48 species) are unknown (Maxted et al., 2024).

A *Geotrupes stercorarius* dung beetle and *Lysandra coridon* butterflies on cattle dung in north eastern Spain, illustrating the diversity of decomposer fauna that depends on well-managed grazing systems. Sustainable livestock practices are essential to maintain the ecosystem services provided by these key species. © José Ramón Verdú Faraco

2.6.3. Patterns of distribution

Terrestrial species richness is highest in coastal areas and across key mountain ranges in most Mediterranean countries (Figure 2.7). Hotspots of threatened species (Figure 2.8) are found along the southern Mediterranean coast of Spain and the Baetic mountain system, the Morrocan Rif and High Atlas mountain ranges, the Central Peloponnese in Greece, and along the Mediterranean coasts of Türkiye, Lebanon and Israel. Data Deficient (DD) species, for which more research is needed to determine their risk of extinction, are predominantly found in Spain, Greece, Türkiye, Morrocco and Algeria (Figure 2.9).

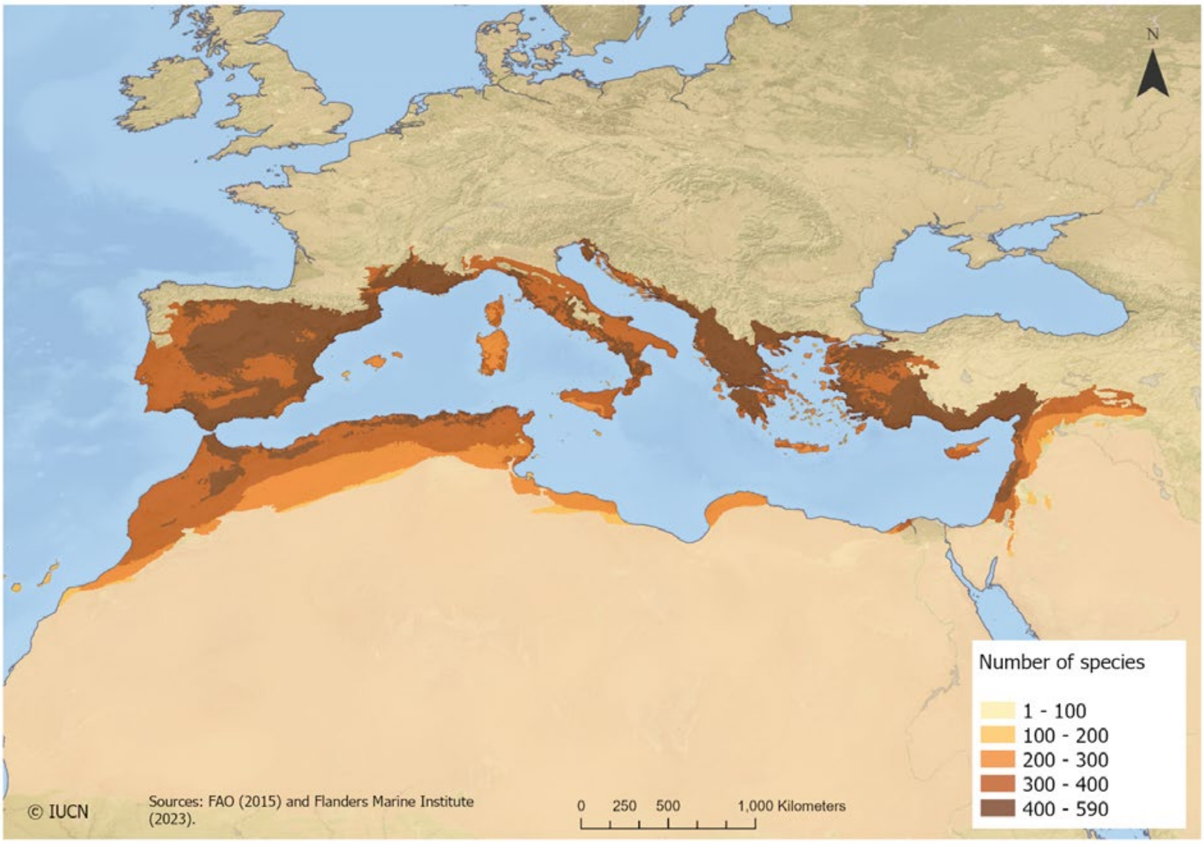


Figure 2.7. Terrestrial species richness in the Mediterranean land region

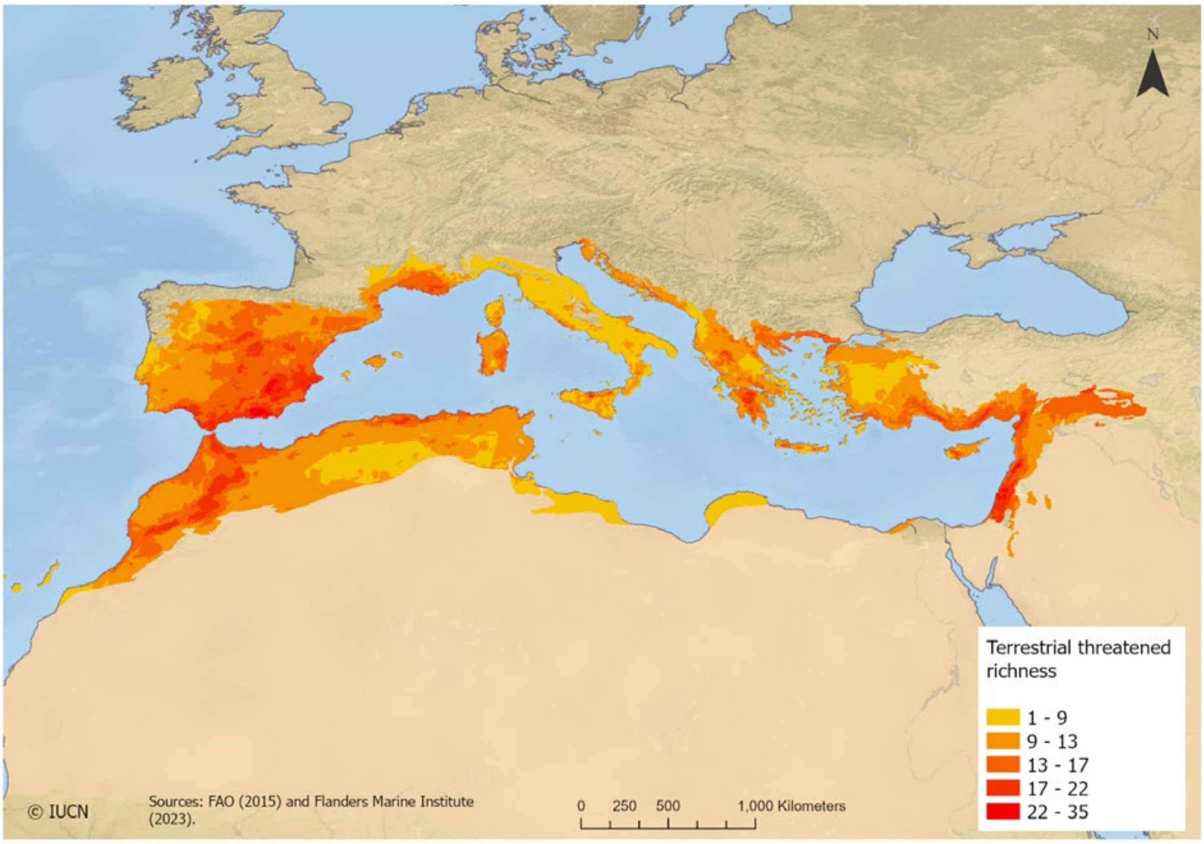


Figure 2.8. Richness of terrestrial threatened species (Categories CR, EN and VU) in the Mediterranean land region

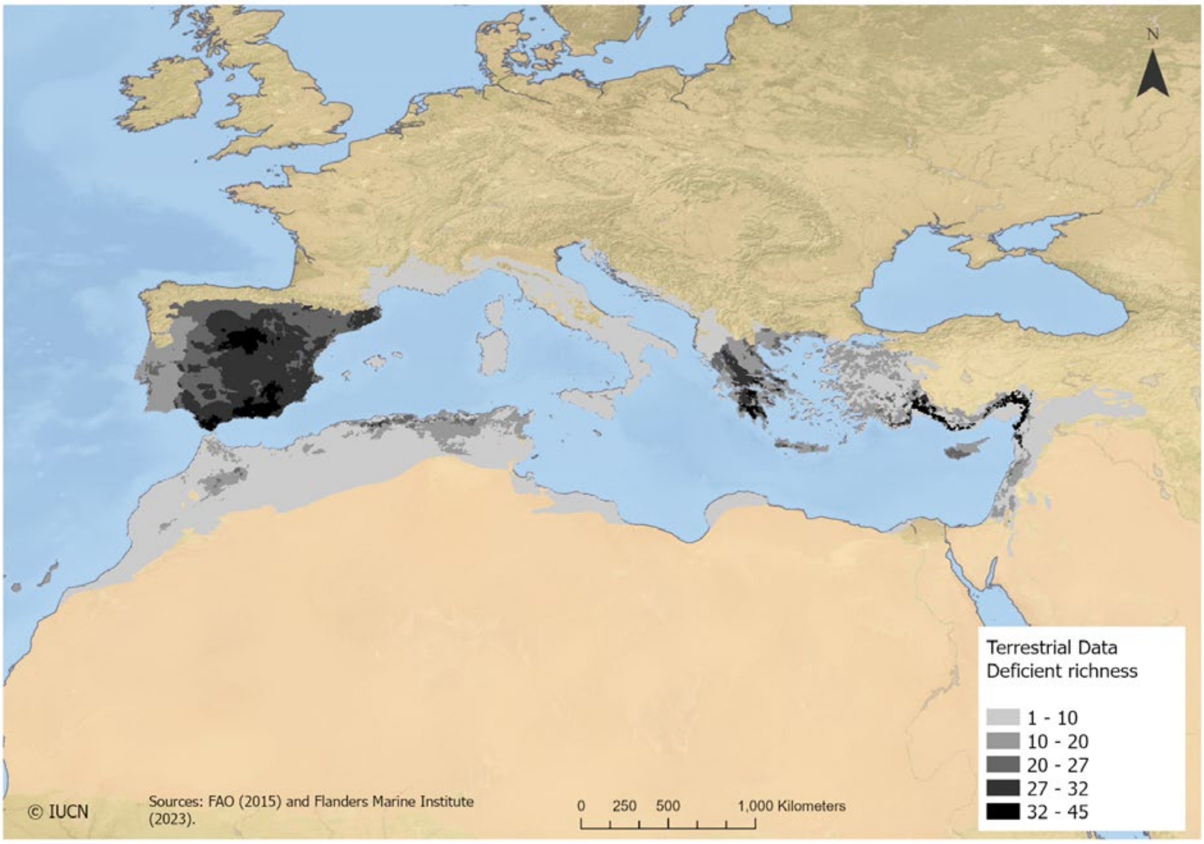


Figure 2.9: Richness of Data Deficient (DD) terrestrial species in the Mediterranean land region

Helicella stiparum is endemic to the province of Almería in Andalusia, southern Spain. It is listed as Endangered (EN) at the Global, Europe & Mediterranean scale and is threatened by agricultural intensification, particularly habitat loss and degradation due to the expansion of greenhouses, as well as groundwater extraction for irrigation, reducing water availability for the species and the vegetation it depends on (Gómez-Moliner, 2025).

The freshwater species richness maps (Figure 2.10) show a different pattern of distribution to the terrestrial species. In the Mediterranean, the main centres of freshwater species richness lie in the Guadiana and Tajo catchments in Spain and Portugal, coastal catchments of the Adriatic Sea in Croatia and Montenegro, northern Greece, the northwest coast of Morocco, and the area between the northern coasts of Algeria and Tunisia. The highest concentrations of threatened freshwater species are found in southern and central Spain, Croatia, and Montenegro (Figure 2.11), whereas the areas with the highest richness of Data Deficient (DD) species (Figure 2.12) include northern Greece, Croatia, Montenegro, northern Algeria and northern Tunisia, and parts of southern Spain.

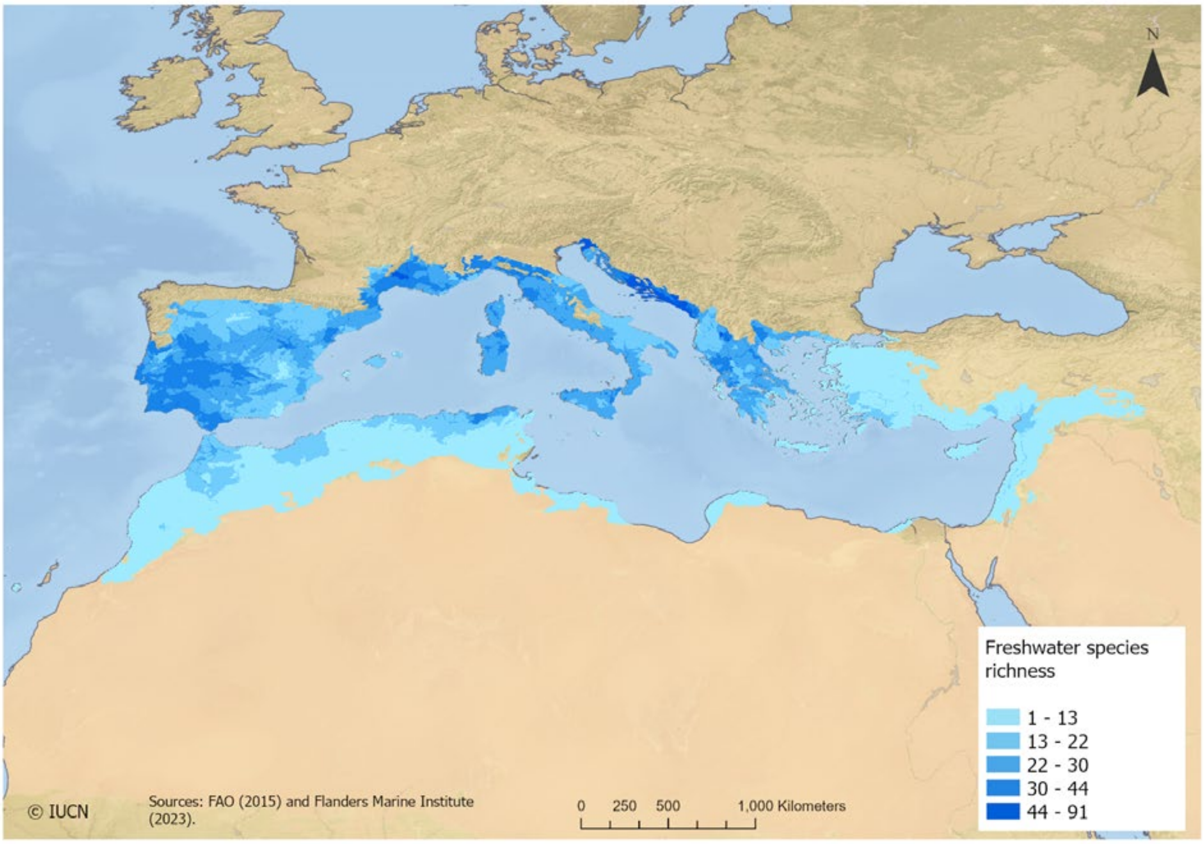


Figure 2.10. Freshwater species richness in the Mediterranean land region

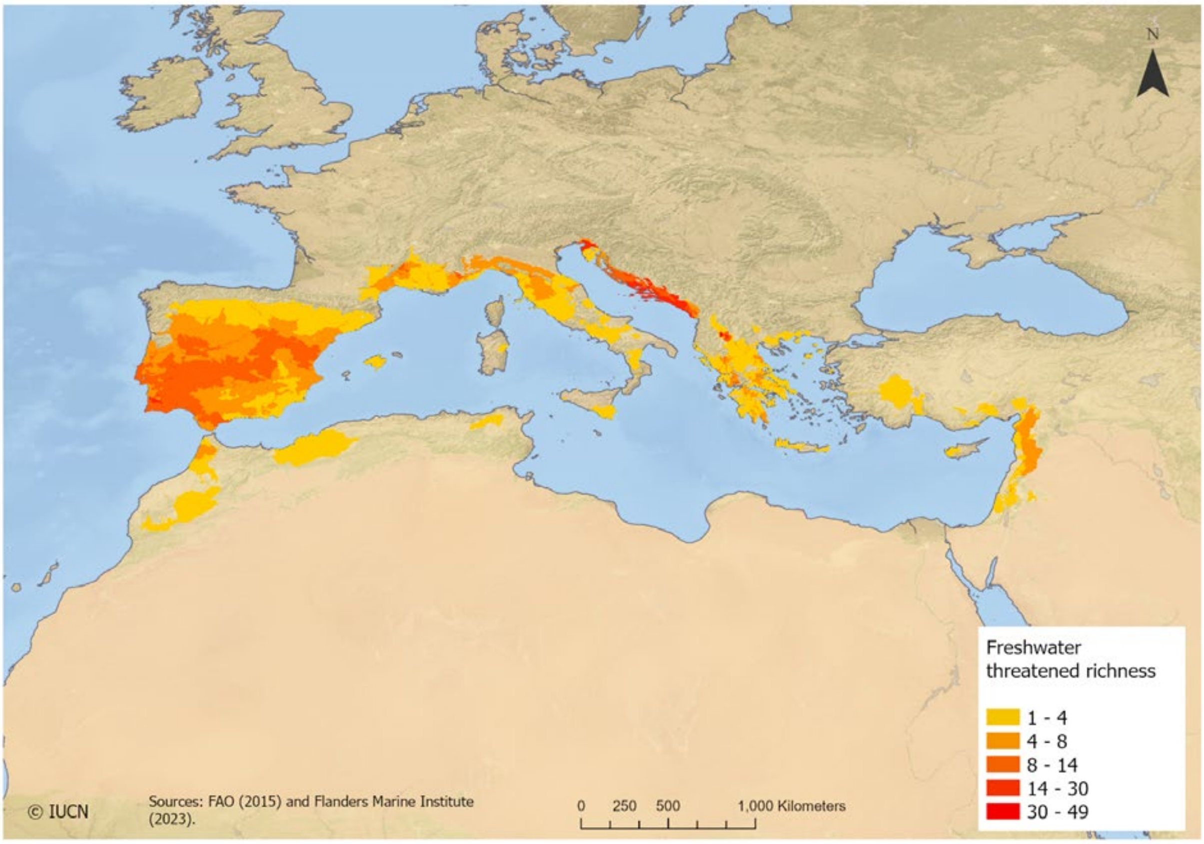


Figure 2.11. Richness of freshwater threatened species (Categories CR, EN and VU) in the Mediterranean land region

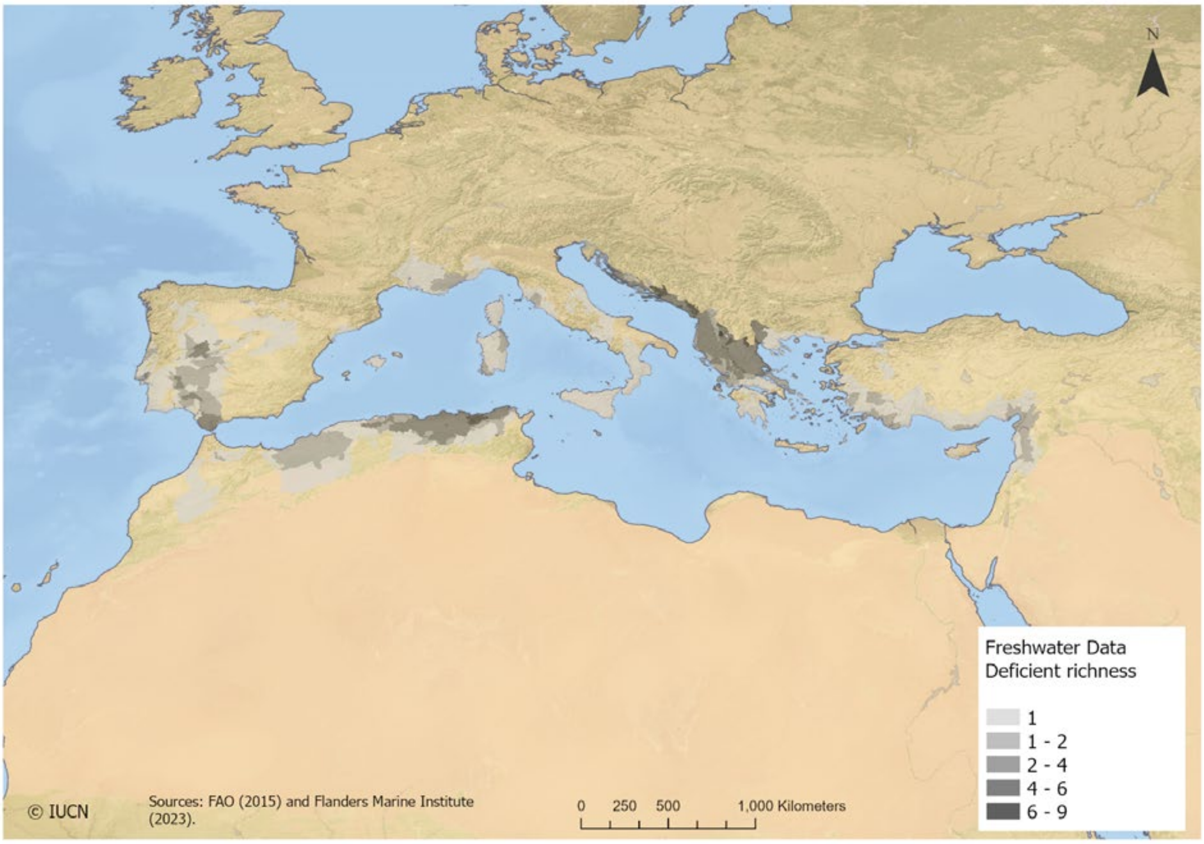


Figure 2.12. Richness of Data Deficient (DD) freshwater species in the Mediterranean land region

2.6.4. Major habitats

The top three habitats of major importance for terrestrial species were shrubland, forest and grasslands, together accounting for 66% of species for which habitats were coded (Figure 2.13). A similar pattern was found for CWR (Figure 2.14). Notably, artificial terrestrial habitats were among the top 10 habitats coded, which confirms what is expected of the Mediterranean basin, given the high degree of human modification this region has experienced over time.

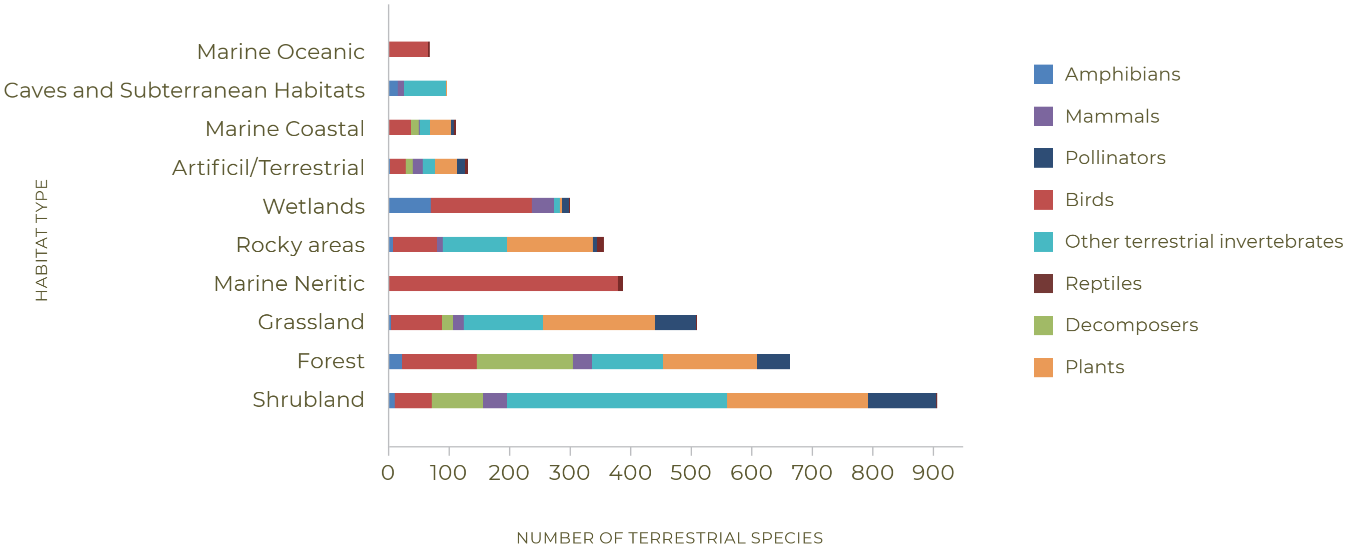


Figure 2.13. Top 10 IUCN Red List habitat types of major importance according to the number of terrestrial species the habitat has been coded for (by species group). Note that a given species might have more than one habitat of major importance.

CWR Focus: Major habitats

The habitats of major importance recorded for CWR in the Mediterranean region are shrubland (221 species), grassland (203 species), and forest (170 species) (Figure 2.14).

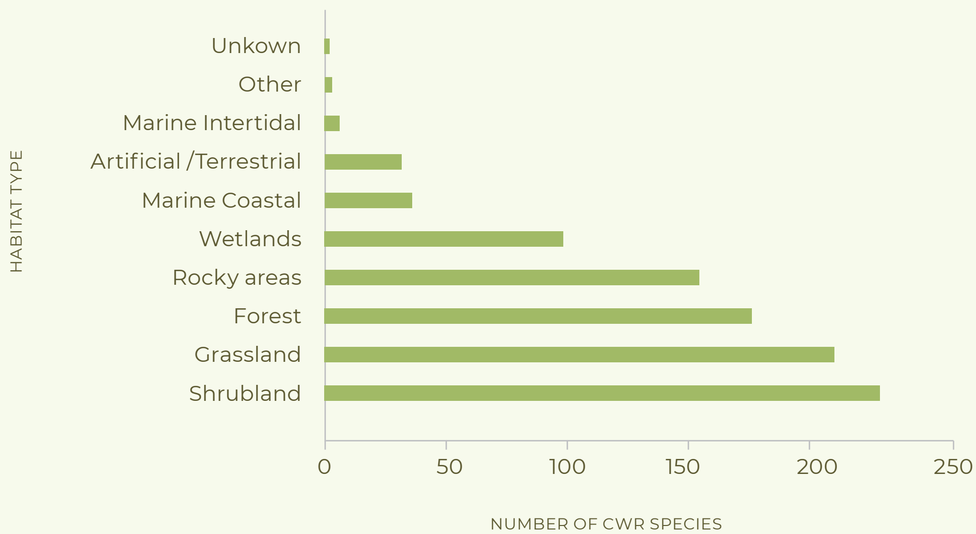


Figure 2.14. Top 10 IUCN Red List habitat types of major importance, by number of CWR species the habitat has been coded for. Note that a given species might have more than one habitat of major importance.

2.6.5. Major threats

The major threats recorded for terrestrial species were agricultural and aquaculture practices, biological resource use (e.g., direct extraction by humans) and natural system modifications (Figure 2.15). Other notable threats include invasive species, pollution, and residential and commercial development. For freshwater species, pollution and natural system modifications account for most threats reported (Figure 2.16). It is important to note that these represent the first level of threat codification which does not distinguish between different agricultural practices, nor their level of intensity. This further level of detail is discussed in Section 2.6.7, which aims to understand what types of agricultural practices are impacting a subset of these species for which there is sufficient information available.

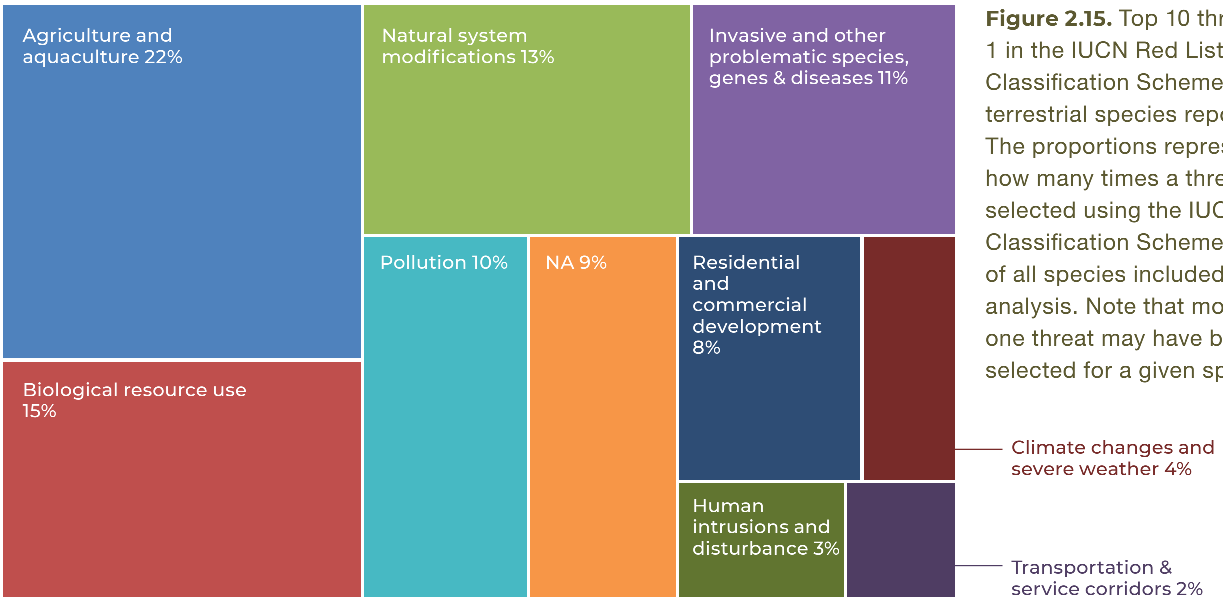


Figure 2.15. Top 10 threats (Level 1 in the IUCN Red List Threats Classification Scheme) for all terrestrial species reported. The proportions represent how many times a threat was selected using the IUCN Threats Classification Scheme, out of all species included in the analysis. Note that more than one threat may have been selected for a given species.

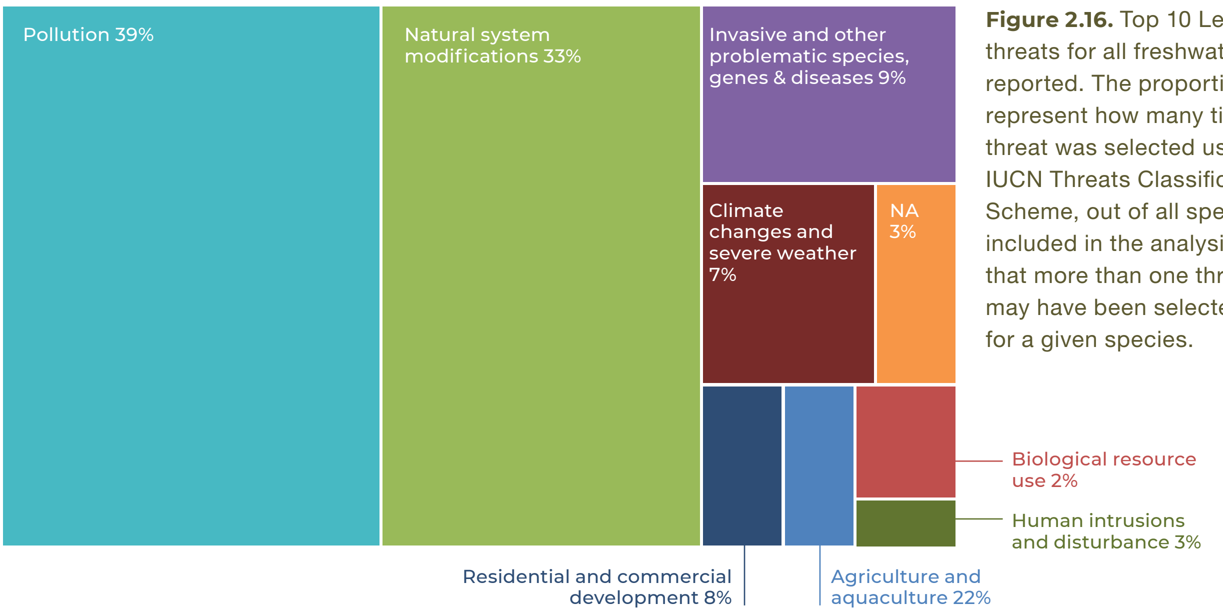


Figure 2.16. Top 10 Level 1 threats for all freshwater species reported. The proportions represent how many times a threat was selected using the IUCN Threats Classification Scheme, out of all species included in the analysis. Note that more than one threat may have been selected for a given species.

CWR Focus: Major habitats

Agricultural and aquaculture practices are the major threat reported for CWR, having been coded for 161 of the 449 species (36%) in the CWR subset. Residential and commercial development is the second most important, recorded for 139 species (31%). The third most recorded threat is natural system modifications, which was coded for 131 CWR species (29%) (Figure 2.17).

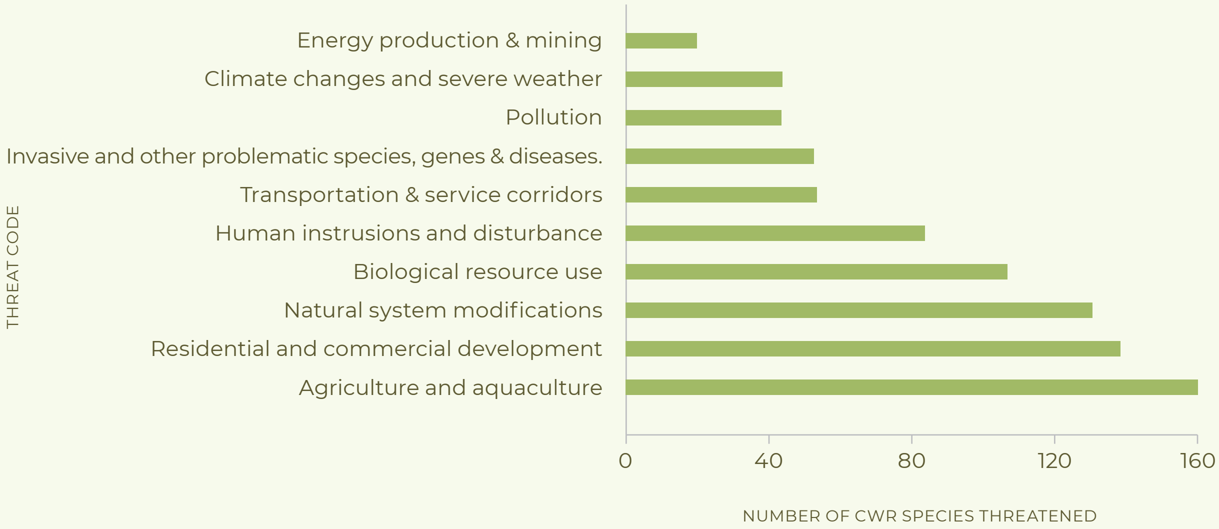


Figure 2.17. Top 10 threats by number of CWR species they have each been coded for, according to Level 1 of the IUCN Red List Threats Classification Scheme. Note that more than one threat may have been selected for a given species.

These results align with the top three main threats to CWR identified by Maxted et al. (2024). These are: (i) livestock farming and ranching, which affects 208 CWR species (of which 96 are threatened); (ii) housing and urban development, which affects 107 species (47 threatened); and (iii) agricultural practices, which affect 120 CWR species (40 threatened). Similarly, priority CWR in the Mediterranean region are most affected by (i) livestock farming and ranching, which affects 43 CWR (11 threatened); (ii) housing and urban development, which affects 17 species (three threatened); and (iii) both tourism and recreation and agricultural practices, each affecting 16 species, with no threatened CWR species being affected by tourism and recreation, and six threatened by agricultural practices.

Agroforestry system of oak trees intercropped with lavender in the south of France. © "Oak trees and lavender, AGROOF" by AGFORWARD project is licensed under CC BY-NC-SA 2.0.

2.6.6. Species distribution by land system groups

Data for 3,438 species of the 4,409 species in the original species dataset was adequate to refine their ranges by Mediterranean land system groups. The results are shown in two ways: (i) occurrences or number of times a species was found in one land use system (2 km^2 pixel) and (ii) number of species found in each land use system in total.

Agro-silvo-pastoral mosaic is the most common land system group overlapping with species range maps, both in total number of species and number of occurrences (Table 2.6; Figure 2.18). This is followed by Open and bare grazing, which is consistent with what is expected in Mediterranean land use systems. However, the croplands land system falls from the third most important category when counting species occurrences to the fifth when counting the total number of species. This means that while croplands are the third most common land use system overlapping with species range maps in the Mediterranean, it is only the fifth most important in terms of species richness. The same pattern is the case for threatened species.

Table 2.6. Number of species occurrences (i.e., number of times a species range overlaps with one land use system) and total number species occurring in each Mediterranean land system as mapped by Malek and Verburg (2017)

Main land cover categories	All species occurrences	Threatened species occurrences	Total number of species	Number of threatened species
Agro-silvo-pastoral mosaic	11,193	1,543	3,055	546
Open and bare grazing	8,159	881	2,786	408
Croplands	6,662	547	857	92
Forest	4,838	658	1,710	286
Settlements	1,567	89	800	48
Bare	988	131	988	131
Wetlands	650	64	650	64

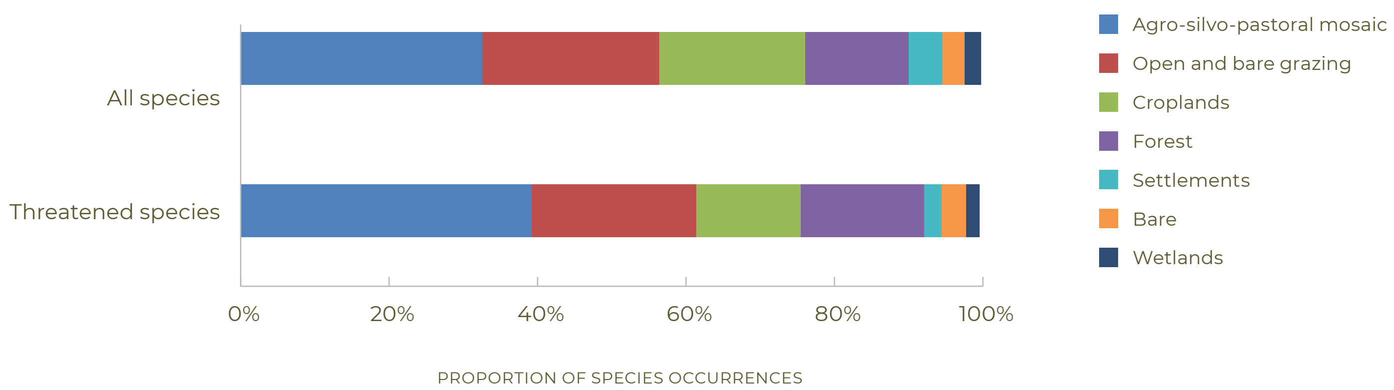


Figure 2.18. Proportion of times species range maps overlapped with the main Mediterranean land systems as mapped by Malek and Verburg (2017)

Assessing these results by taxonomic groups (Table 2.7) shows that species ranges overlap with Mediterranean land systems in different proportions. However, landscapes dominated by agricultural practices are still found to support the most species, with Agro-silvo-pastoral mosaic, Open and bare grazing and Forests remaining the top three land systems by species richness. Importantly, while croplands may appear to support lower species richness in our dataset, this result may be influenced to some extent by data availability and reporting biases, as well as the level of land-use intensification, rather than an inherent lack of ability of crop systems to retain biodiversity within agricultural landscapes. Moreover, it is important to note that these land use systems are not always mutually exclusive when it comes to agriculture; agricultural practices are not solely restricted to the explicitly "agricultural" land use systems and can be present and even potentially play an important role in other land systems, such as forest or wetlands (Malek & Verburg, 2017).

Cattle grazing in the region of Chefchaouen, Morocco.
© Catherine Numa

Table 2.7. Number of species per taxonomic group found in Mediterranean land systems as mapped by Malek and Verburg (2017). The colour gradient represents species richness, with yellow representing the highest species richness and dark blue lower species richness.

Land use system	Land use system group	Amphibians	Birds	Decomposers	Mammals	Other terrestrial invertebrates	Plants	Pollinators	Reptiles	Proportion of Total
11 = open woodland	Agro-silvo-pastoral mosaic	87	383	293	195	471	330	592	198	7.5%
12 = open wooded rangeland	Agro-silvo-pastoral mosaic	82	378	297	195	474	317	565	190	7.3%
9 = intensive open rangeland	Open and bare grazing	71	375	294	193	413	274	541	215	7.0%
10 = closed wooded rangeland	Agro-silvo-pastoral mosaic	81	322	436	181	384	258	486	163	6.8%
8 = extensive open rangeland	Open and bare grazing	68	383	256	196	295	210	534	211	6.3%
13 = cropland/ wooded rangeland	Agro-silvo-pastoral mosaic	82	331	240	193	438	246	417	200	6.3%
7 = intensive arid grazing	Open and bare grazing	58	324	220	199	268	250	410	205	5.7%
6 = extensive arid grazing	Open and bare grazing	54	329	194	196	160	186	388	189	5.0%
1 = medium intensity forest	Forest	85	240	397	144	181	184	290	133	4.9%
2 = (semi) natural forest	Forest	71	215	337	128	164	173	280	102	4.3%
3 = high intensity forest	Forest	70	222	344	130	98	142	235	114	4.0%
5 = desert, bare	Bare	18	222	88	133	140	104	141	142	2.9%
14 = cropland/ rangeland	Agro-silvo-pastoral mosaic	61	224	117	146	80	50	82	127	2.6%
22 = irrigated annual	Croplands	54	219	115	125	77	34	96	93	2.4%
15 = permanent crops/rangeland	Agro-silvo-pastoral mosaic	54	221	86	140	57	46	77	120	2.4%
25 = peri-urban	Settlements	48	176	132	103	67	14	148	107	2.3%
16 = extensive annual	Croplands	50	217	109	126	71	27	93	92	2.3%
26 = urban	Settlements	46	174	128	103	59	11	147	104	2.3%
18 = extensive mosaic	Croplands	53	206	110	122	81	33	77	85	2.3%
24 = irrigated mosaic	Croplands	54	210	105	125	76	31	78	86	2.2%
19 = rainfed intensive annual	Croplands	51	208	105	123	74	26	71	85	2.2%
21 = rainfed intensive mosaic	Croplands	51	206	93	120	67	26	71	86	2.1%
17 = extensive permanent	Croplands	49	197	96	115	62	25	71	83	2.0%
23 = irrigated permanent	Croplands	49	199	87	116	63	26	74	83	2.0%
20 = rainfed intensive permanent	Croplands	49	192	91	108	62	21	70	81	2.0%
0 = wetlands	Wetlands	65	276	70	79	33	23	65	39	1.9%
4 = planted forest	Forest	24	90	74	57	16	6	37	55	1.1%

2.6.7. Agriculture practices as a threat to species

2,869 of the 4,409 species assessed had a specific threat code attributed by IUCN Red List assessors. Among the 1,220 species with the Level 1 threat classification Agriculture & aquaculture (28% of all species, 43% of those with an attributed threat code), it was identified as an ongoing threat for 1,147 species. Moreover, 442 threatened species (38% of all threatened species) in the Mediterranean had Agriculture & aquaculture coded as a threat. Table 2.8 shows that, out of all the Red List assessments, Livestock farming and ranching was selected as a threat the most times (46%), followed by Annual & perennial non-timber crops (39%). Across all the different agricultural threat categories recorded, threats linked to large-scale and intensive agricultural practices were considerably more prevalent, with at least 42% of threats coming from these types of activities (Table 2.8; see caveats in Section 2.5.1). However, for 46% of the species assessed, the scale of the agricultural threat was unknown.

Table 2.8. Threat selection for Level 2 and Level 3 IUCN Threat Classification codes (see Section 2.5.2 in Methods for full details), showing the number of times each threat code was selected across all of the Red List species assessments. Marine & freshwater aquaculture was excluded as it only counted for less than 2% of coded threats.

IUCN Level 2 threat code	IUCN Level 3 threat code	Times selected	Proportion
2.1 Annual & perennial non-timber crops		**606**	**39%**
	2.1.1 Shifting agriculture	46	3%
	2.1.2 Small-holder farming	79	5%
	2.1.3 Agro-industry farming	368	24%
	2.1.4 Scale Unknown/Unrecorded	113	7%
2.2 Wood & pulp plantations		**212**	**14%**
	2.2.1 Small-holder plantations	23	1%
	2.2.2 Agro-industry plantations	122	8%
	2.2.3 Scale Unknown/Unrecorded	67	4%
2.3 Livestock farming & ranching		**720**	**46%**
	2.3.1 Nomadic grazing	169	11%
	2.3.2 Small-holder grazing, ranching or farming	199	13%
	2.3.3 Agro-industry grazing, ranching or farming	159	10%
	2.3.4 Scale Unknown/Unrecorded	193	12%

Little egret (*Egretta garzetta*), listed as Least Concern (LC) at the global and European scale, pictured here in a rice field in Doñana, Huelva, Spain (BirdLife International, 2021b, 2025b). © Antony Luque Montero

2.6.8. Agriculture as a habitat for species

A total of 3,568 terrestrial species assessed had a habitat code attributed. 822 (23%) of these had artificial terrestrial habitats considered as suitable habitats and 18% had (648 species) agricultural habitats (i.e., Plantations, Pasture Land, or Arable Land) as suitable. Of these, 85 species (2% of total) had agricultural habitats noted as habitats of major importance, mainly including species of plants, birds, mammals and invertebrates (Figure 2.19).

Marianne's bright bush-cricket (*Poecilimon mariannae*), Least Concern (LC) at the Global, Europe and Mediterranean scale, is endemic to Greece and heavily relies on agricultural land for its survival (Willemse et al., 2023).

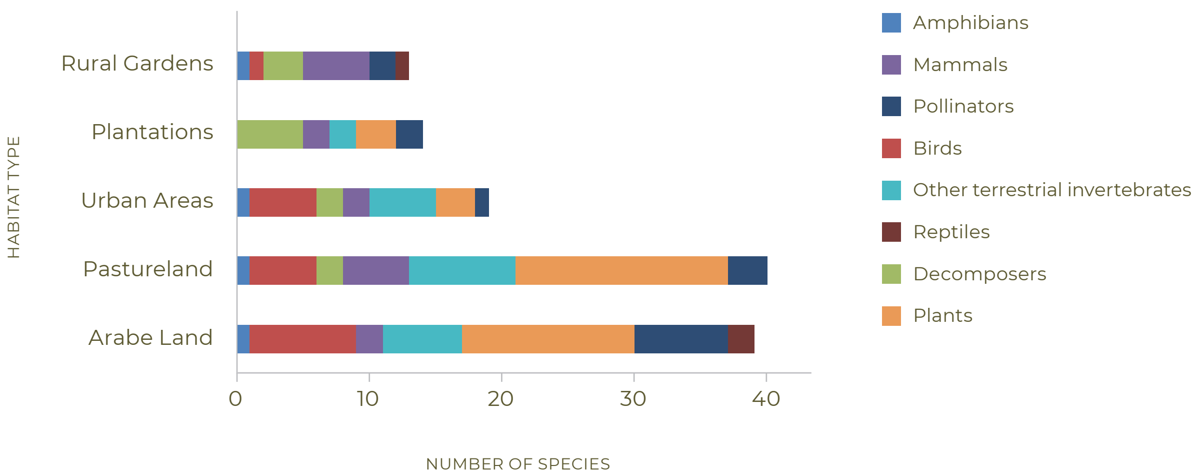


Figure 2.19. Number of species associated to each artificial terrestrial habitat type of major importance, by taxonomic group. Note that a given species may have more than one habitat type of major importance.

Regarding species at risk of extinction, agricultural habitats are considered to be of major importance for 25 threatened species, including plants, birds, invertebrates, pollinators and decomposers. Remarkably, for some species the *only* habitat of major importance selected was an agricultural habitat type, which means that these areas are fundamental for their conservation. For example, the Least Concern (LC) Marianne's bright bush-cricket (*Poecilimon mariannae),* endemic to Greece, is found mainly in roadsides and adjacent agricultural fields on the mainland (Willemse et al., 2023). Another example is the Endangered (EN) golden hamster (*Mesocricetus auratus)* which, as of 2022, is only known from "fertile, agricultural and densely populated Aleppinian plateau" in Syria and Türkiye (Kennerley & Middleton, 2022), as well as the Data Deficient (DD) rush *Juncus fernandez-carvajaliae*, which is only found in pastures on seasonally wet soils in the Guadiana River basin in Spain (Romero Zarco et al., 2018).

2.7. Key messages

- Of the 4,409 terrestrial and freshwater species included in these analyses, one in four (26%) are threatened with extinction (CR, EN or VU).

- Half of all Least Concern (LC) species report an ongoing population decline.

- Half of all freshwater species assessed are threatened with extinction and only one in three (30%) are listed as Least Concern (LC).

- The three top habitats for terrestrial species are shrubland, forest and grasslands, accounting for 66% of all major habitats recorded.

- Agricultural and aquaculture activities, biological resource use and natural system modifications are considered major threats to Mediterranean species. Other notable threats are invasive species, pollution, and residential and commercial development. However, these threat classifications correspond to Level 1 of the IUCN Threats Classification Scheme, where there is no distinction between the intensity of agricultural activities.

- The assignation of broad agricultural threat codes in tools such as the Red List may imply that such activities are inherently incompatible with the species´ survival; agriculture is therefore coded as inherently negative in such tools, and caution must be taken to analyse the results on a context-specific basis, paying particular attention to the characteristics and intensity of agricultural practices and how exactly they are affecting a given species.

- The sample of Crop Wild Relatives (CWR) shows that 38% of these species are threatened with extinction, with agricultural and aquaculture practices recorded as the major threats.

- 76% of the species included in this study have distribution ranges in human-modified land use systems, including Agro-silvo-pastoral mosaic (33% of species), Open and bare grazing (24%), and Croplands (20%).

- Species distribution ranges cover a wide variety of land use systems in the Mediterranean, with species using to some extent all land use systems included in this study.

- At least 28% of all Mediterranean species assessed on the Red List, and 43% of those for which a threat code has been attributed, are considered to be threatened by some form of agricultural activity. 38% of all Mediterranean threatened species are affected by unsustainable agricultural practices.

- The main threats to species from agricultural practices are related to Livestock farming & ranching (46%) and Annual & perennial non-timber crops (39%). Threats linked to large holder based and intensive agriculture were more prevalent, with almost half (47%) of all agriculture-related threats coming from these activities.

- More research is needed to better understand these results and determine specifically *which* agricultural practices are negatively impacting *which* species in the Mediterranean, and to explore alternatives to reduce these impacts.

- Agricultural habitats were coded as suitable for 18% of species, and for 2% agricultural lands are habitats of major importance. Moreover, for 24 species, agricultural lands are their only remaining major habitat.

Dehesa in Andalusia, Spain.

3

Opportunities to reduce regional species extinction risk through abatement of agricultural threats in the Mediterranean

Summary: The Species Threat Abatement and Restoration (STAR) metric is a tool that quantifies the potential opportunities to reduce species extinction risk through threat reduction in particular locations. Here, we combined the extinction risk, distribution and threats classification data documented through the IUCN Red List assessments in Chapter 2 and calculated the STAR metric specifically for species documented as threatened by agriculture. The highest opportunities to reduce species extinction risk by addressing agricultural threats are found in Western Greece, specifically in the Ionian area, southern Spain, the most oriental coast of the Mediterranean in southern Türkiye, Syria, Lebanon and Israel, as well as the island of Cyprus. Livestock farming & ranching and Annual & perennial non-timber crops are the largest contributors to the risk of species extinction. Plants (31.3%), terrestrial invertebrates (29.9%), and pollinators (15.9%) are the major contributors to the agricultural STAR metric, which means that these groups are in greater need of actions to mitigate threats from unsustainable agricultural practices.

3.1. Species Threat Abatement & Restoration (STAR) metric

The Species Threat Abatement & Restoration (STAR) metric, developed by Mair et al. in 2021, serves as a tool that quantifies the potential opportunities to reduce species extinction risk through threat reduction in particular locations. In addition, it aims to support science-based target setting for species conservation across various spatial scales. The metric relies on information sourced from the IUCN Red List of Threatened Species, specifically species distributions and habitats, documented threats to species (following the IUCN Threats Classification Scheme), and species extinction risk Category (NT, VU, EN and CR). The STAR methodology estimates the potential for reducing species extinction risk across a global 5 x 5 km^2 grid. Within this grid, STAR assesses the contribution of threats affecting species in each pixel, allowing values to be aggregated for larger polygons representing diverse areas, such as the Mediterranean region. To date, the metric has been applied to birds, mammals and amphibians assessed as globally Threatened (CR, EN or VU) or Near Threatened (NT) on the IUCN Red List. Importantly, the metric has the versatility to be applied to other datasets and taxa, as long as there is documentation of species' extinction risk, distribution, and encountered threats (Mair et al., 2023)

Here, we combine the extinction risk, distribution and threats classification data documented through IUCN Red List assessments using the methodology for derivation of the STAR metric (Mair et al., 2021), specifically for species in the Mediterranean documented as threatened by agriculture (classes 2.1, 2.2 and 2.3 in the IUCN Threats Classification Scheme). This analysis results in a variation of the Species Threat Abatement metric focusing on the impacts of agriculture in the Mediterranean region. The aim is to identify which agricultural threats have a greater contribution to STAR scores related, which can then be used to determine the most efficient actions to reduce those scores and therefore contribute to reducing species extinction risk in the region.

3.2. Methods

3.2.1. Species selection for analyses

We used the species dataset described in Chapter 2 and used the following species information: distribution range maps, documented threats, and extinction risk category.

We selected species from the Mediterranean region that are (i) comprehensively assessed on the IUCN Red List, (ii) documented as threatened by agriculture (classes 2.1, 2.2 and 2.3 of the IUCN Threats Classification Scheme) and (iii) categorised as Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) on the IUCN Red List version 2021.3 (IUCN, 2021).

3.2.2. STAR-t scores calculation

We used the threat abatement component of the STAR metric (referred to as STAR-t), which quantifies the opportunity for reducing species extinction risk through reducing threats to species in their current habitats (Mair et al., 2021). STAR-t scores were computed at a given location following the formula provided by Mair et al. (2021). Here, "location" refers to any defined area, with the maximum extent covering the Mediterranean territory and the minimum practical size determined by the spatial resolution of the species range maps, set at 50 km² (see spatial data processing details below). The 50 km² resolution aligns with the inherent uncertainty in species range maps and ensures that threat assessments are based on robust data rather than assumptions at finer scales. Additionally, while agricultural practices indeed vary within these areas, the use of Red List data allows us to assess species-level impacts consistently. Future analyses incorporating Area of Habitat (AOH) data will enhance spatial precision, but this study provides an essential first approximation to understand broad-scale threat patterns.

We calculated STAR-t scores for a location and its threats across all species as follows:

$$T_i = \sum_s P_{s,i} W_s C_{s,t}$$

where $P_{s,i}$ is the range size of each species s within location (expressed as a proportion of the species range in our study area), W_s is the EU Red List category weight of species s (Near Threatened = 100; Vulnerable = 200; Endangered = 300; Critically Endangered = 400) and C is the relative contribution of threat t to the extinction risk of species s.

We assessed the relative contribution of all recorded threats (including agricultural threats and other categories) to the extinction risk of each species. This contribution was calculated as the percentage population decline attributed to each threat, determined by the product of severity and scope for that threat from the species' European Red List assessment, divided by the total percentage population decline from all threats to the species, following Mair et al. (2021).

For species lacking specific information on the severity and scope of their threats, median values were applied, as outlined by Mair et al. (2021). In accordance with Mair et al. (2021), we excluded threats that were: (i) recorded as having occurred in the past and unlikely to return, and (ii) not expected to cause a population decline. As a result, threats with no anticipated impact on population size were omitted from the analysis.

Threat scores were initially calculated using the most detailed threat classification available, then aggregated to Level 2 of the Threats Classification Scheme by summing the scores.

To calculate STAR-t scores for agriculture threats across the Mediterranean region, we focused specifically on the three major agricultural threats reported for species in the Mediterranean region (Chapter 2, Section 2.6.5): 2.1 Annual & perennial non-timber crops, 2.2 Wood & pulp plantations and 2.3 Livestock farming & ranching. For species impacted by these threats, we calculated the proportion of the STAR-t score attributed to agriculture, relative to the total STAR-t score, which reflects all threats affecting the species. This approach highlights the contribution of threats 2.1, 2.2 and 2.3 to the overall STAR-t score for each species.

Potential opportunities to reduce species extinction risk from addressing agriculture threats across the Mediterranean region

We calculated the proportion of the STAR-t score from agricultural threats (2.1, 2.2, and 2.3 from the IUCN Threats Classification Scheme Version 3.3) relative to the STAR-t score with combined agriculture threats (hereafter Agri STAR-t) for the Mediterranean region. Next, we generated maps for the Agri STAR-t scores, as well as separate maps for each individual threat (threats 2.1, 2.2, and 2.3), across the Mediterranean territory at a 50 km^2 grid cell resolution. This fine-scale mapping allows for the identification of specific areas where efforts to mitigate agricultural threats can most effectively contribute to reducing species extinction. To do this, we used species distribution range maps by extracting GIS spatial data (polygons) from the European Red List assessments via the Red List website and filtered these polygons following the methodology of Mair et al. (2021). Specifically, we retained only the areas of each species' range where the origin was classified as native, reintroduced, or present due to assisted colonisation, while excluding areas labeled as introduced, vagrant, or of uncertain origin. Additionally, we omitted polygons where the species' presence was coded as extinct, possibly extant, or uncertain. The remaining species polygons were then cropped to the Mediterranean region and rasterised at a 50 km^2 resolution. Then, for each species threatened by agriculture, we calculated the STAR-t score attributed to these threats per grid cell by multiplying each species' STAR-t score from the combined or individual agricultural threats by the proportion of the species' range in the grid cell. Finally, we generated the maps for the Mediterranean region by summing the STAR-t score maps across all species. In addition, we investigated the STAR-t scores from agricultural threats at Level 3 of the IUCN Threats Classification Scheme (Appendix 4.3).

3.2.3. Caveats of this approach

While Level 3 of the IUCN Threats Classification Scheme offers finer distinctions, such as smallholder versus industrial farming, data limitations make its broad-scale application challenging. We recommend further refinement of threat assessments by integrating higher-resolution land use data. Similarly, the scale (50 km^2 resolution) at which this analysis was conducted is likely to exacerbate caveats noted in Sections 2.5.1. and 2.5.2. This level of detail is not captured in Levels 1 and 2 of the Threats Classification Scheme, which may in some cases represent an over-generalisation of the different threats. Thus, it should be noted that the broad threat categories discussed in the Results are not necessarily *inherently* incompatible with the conservation of a given species, as the degree to which an agricultural activity threatens a species is very context-specific, depending on factors such as location, spatial extent, duration, and intensity. However, these broader threat categories are useful in providing an overall indication of the types of agricultural activities that are being conducted in a way that is harmful for biodiversity, and therefore have potential for threat abatement.

3.3. Results

A total of 567 of 588 species had all the available data (i.e., agriculture threats expected to cause a population decline and available species distribution data) to be included in the STAR analyses (Appendix 4.1).

Potential opportunities to reduce species extinction risk from addressing agriculture threats in the Mediterranean region

The Agri STAR-t score for the study area was 56,983.77 STAR units (i.e., aggregation of STAR-t scores which accounts only for weighted threats 2.1 Annual & perennial non-timber crops, 2.2 Wood & pulp plantations and 2.3 Livestock farming & ranching). Figure 3.1 shows the potential opportunities that could be met by abating all agriculture threats in each grid cell in the Mediterranean region. The highest scores highlight southern Spain, including the Sierra Nevada mountain range, most of Greece and the coast of southern Türkiye, Cyprus and Israel. These are places where threatened and restricted range species trigger high Agri STAR-t scores.

Threats 2.1, 2.2 and 2.3

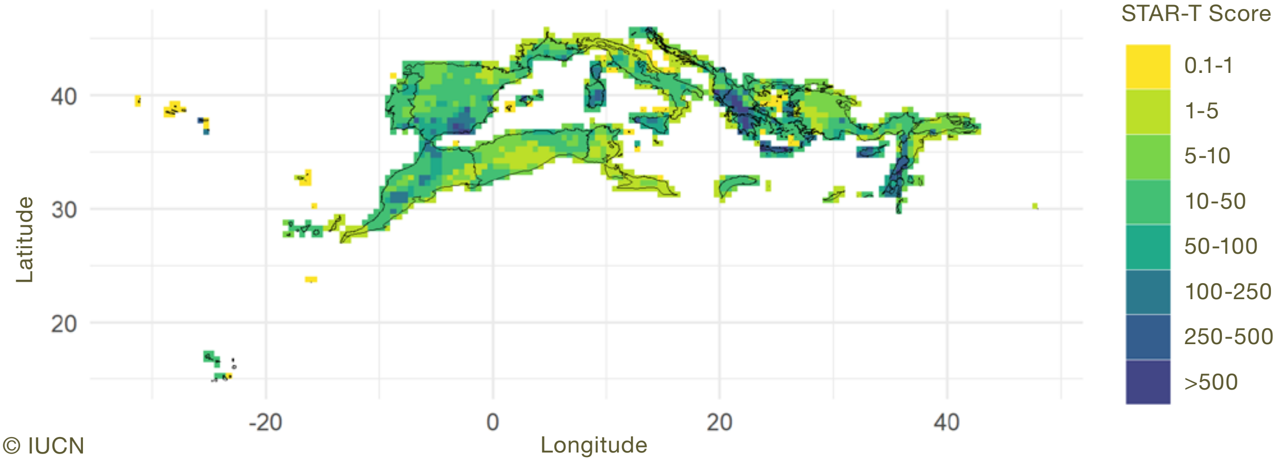


Figure 3.1. STAR-t scores attributed to agriculture threats (Agri STAR-t) at a 50 km grid cell resolution for the Mediterranean region. The total STAR-t attributed to agriculture threats for the Mediterranean region is 56,983.77 STAR units. STAR-t values of threats 2.1 Annual & perennial non-timber crops, 2.2 Wood & pulp plantations and 2.3 Livestock farming & ranching are aggregated per grid cell to generate the Agri STAR-t scores. Note that low scores do not necessarily mean that there are no threatened species present.

Table 3.1 shows the potential opportunities to reduce species extinction risk that could be met by acting to abate each agricultural threat across the Mediterranean region. Figures 3.2 to 3.4 show the potential opportunities that could be met by abating each agricultural threat in each grid cell in the Mediterranean region. Livestock farming & ranching represents the threat with highest potential to reduce regional species extinction risk through threat abatement (Table 3.1). The Sierra Nevada mountain range in Spain, central Sardinia, most of Greece and the coast of southern Türkiye, Cyprus, Israel, and southern Morocco are the areas with the highest opportunities to contribute to reduced species extinction risk by mitigating negative impacts of Livestock farming & ranching (Figure 3.2).

Table 3.1. STAR-t score per agriculture threat type in the Mediterranean region. STAR-t scores represent the potential opportunities to reduce species extinction risk that could be met by acting to abate each agricultural threat in the Mediterranean region. The percentage of contribution shows the proportion of the total Agri STAR-t score contributed by each threat type.

Rank	Threat type	STAR-t score	Percentage of contribution (%)
1	2.3. Livestock farming & ranching	37,034	55.7
2	2.1 Annual & perennial non-timber crops	15,143	33.1
3	2.2 Wood & pulp plantations	4,807	11.2

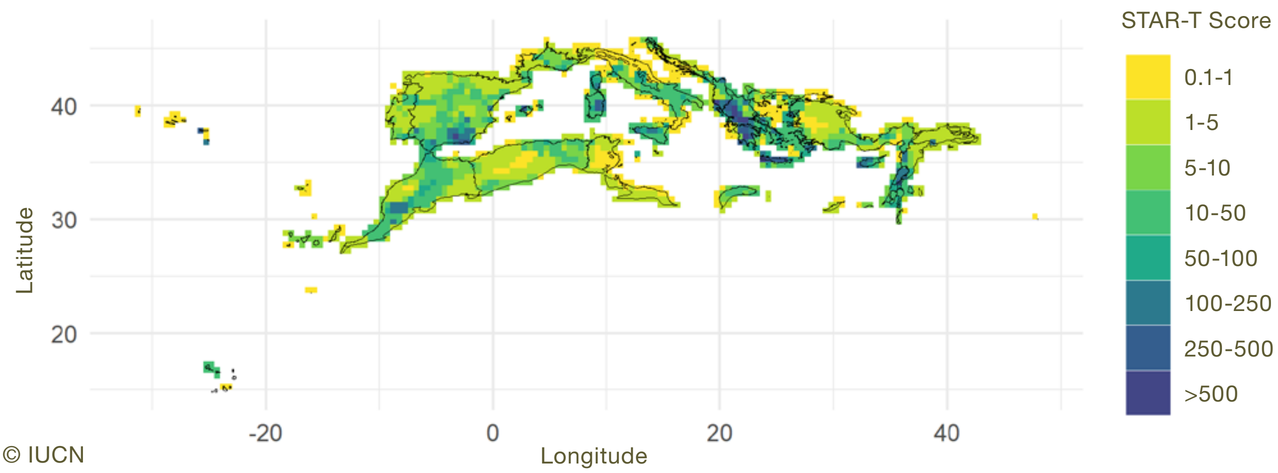


Figure 3.2. STAR-t scores attributed to threat 2.3 Livestock farming & ranching at a 50 km grid cell resolution for the Mediterranean region. Note that low scores do not necessarily mean that there are no threatened species present.

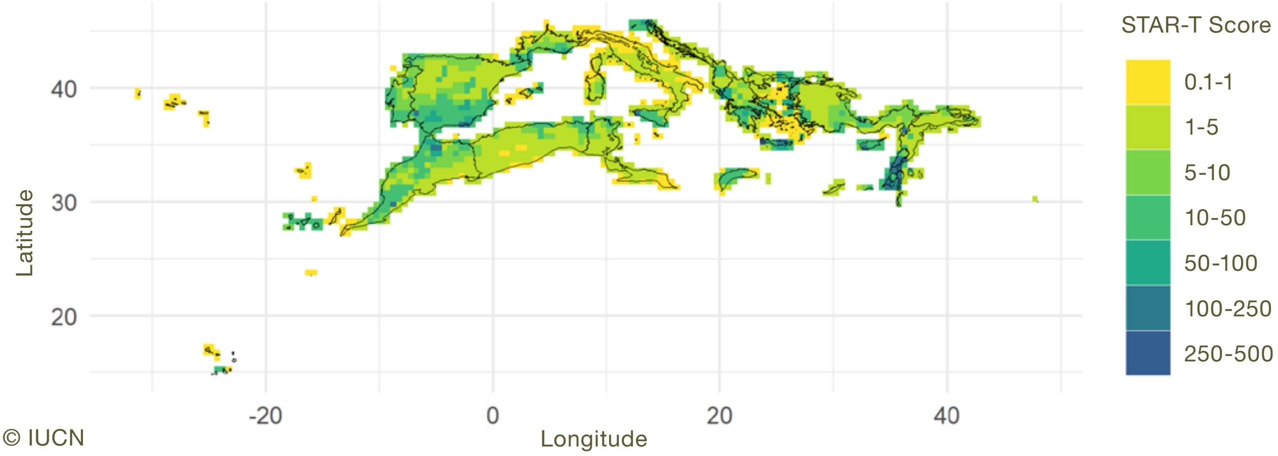


Figure 3.3. STAR-t scores attributed to threat 2.1 Annual & perennial non-timber crops at a 50 km grid cell resolution for the Mediterranean region. Note that low scores do not necessarily mean that there are no threatened species present.

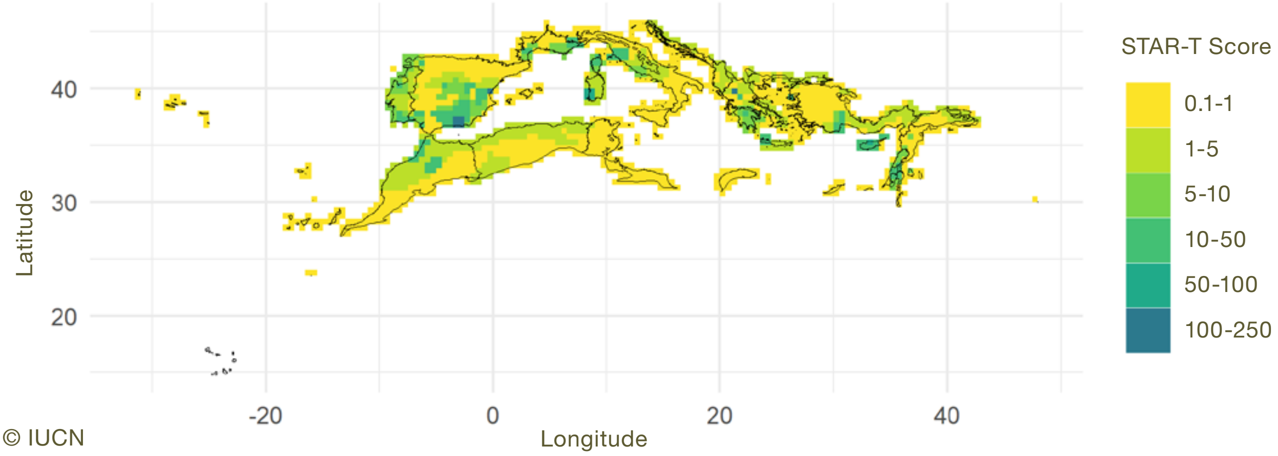


Figure 3.4. STAR-t scores attributed to threat 2.2 Wood & pulp plantations at a 50 km grid cell resolution for the Mediterranean region. Note that low scores do not necessarily mean that there are no threatened species present.

Sheep grazing in the Sierra Nevada mountains, Andalusia, Spain.

The species groups contributing to most of the Agri STAR-t score, responsible for 77% of the score, are mainly plants (31.3%), terrestrial invertebrates (29.9%) and pollinators (15.9%) (Table 3.2). This indicates that addressing agricultural threats affecting these groups could result in a substantial reduction in the overall Agri STAR-t score, thereby significantly lowering the overall species extinction risk in the Mediterranean region.

Most of these species have small global ranges and are restricted to very specific habitats. Two examples of species that drive these high STAR scores are the Critically Endangered (CR) plant Akamas centaury (*Centaurea akamantis*) and Triandafilia mountain grasshopper (*Oropodisma lagrecai*), endemic to Cyprus and Greece respectively. Species with STAR-t scores of 400 (only three species showed this score) are highly threatened by illegal local grazing, primarily from goats owned by landowners who disregard the protection measures prohibiting grazing in the respective areas. This pattern also applies to the 14 species with STAR-t scores of 300. Appendix 4.2 includes the STAR-t scores of each species per agricultural threat type included in this analysis.

Table 3.2. Disaggregated STAR-t score attributed to agricultural activities (Agri STAR-t score) per species group in the Mediterranean region.

Rank	Group	STAR-t score	% of Contribution
1	Plants	17822	31.28
2	Other terrestrial invertebrates	17039	29.90
3	Pollinators	9030	15.85
4	Decomposers	4001	7.02
5	Reptiles	3244	5.69
6	Mammals	2552	4.48
7	Birds	2007	3.52
8	Amphibians	821	1.44
9	Freshwater invertebrates	468	0.82
Total Agri STAR-t score		56984	100.00

Akamas centaury (*Centaurea akamantis*) is a Crop Wild Relative endemic to Cyprus. It is classified as Critically Endangered (CR) at the Global, European & Mediterranean level on the Red List, and it is primarily threatened by illegal goat herding, as well as soil erosion (Kadis & Eliades, 2015).

3.4. Key messages

- The greatest opportunities to reduce species extinction risk by addressing agricultural threats are found in southern Spain, Western Greece (specifically in the Ionian area), the most oriental coast of the Mediterranean in southern Türkiye, Syria, Lebanon and Israel, as well as the island of Cyprus.

- Threat 2.3 Livestock Farming & Ranching is the largest contributor to the risk of species extinction, accounting for 54.2% of the total impact in this context. Addressing unsustainable farming and ranching practices is therefore very relevant for biodiversity conservation in the region.

- Threat 2.1 Annual & perennial non-timber crops contributes 34% to the overall species extinction risk, followed by Threat 2.2 Wood & pulp plantations with 11.8%.

- Plants (31.3%), terrestrial invertebrates (29.9%), and pollinators (15.9%) are the major contributors to the agricultural STAR-t.

- Most species with a STAR-t score of 300-400 STAR units are invertebrates and plants with very restricted ranges, threatened by illegal local grazing. By setting actions to abate agricultural threats across different areas of the Mediterranean, particularly those with high STAR-t scores, and by taking into consideration these groups and species, we can significantly contribute to reducing regional species extinction risk in the region.

- The use of the IUCN Level 2 Threats Classification ensures consistency across species and provides a robust starting point for identifying key areas where agriculture poses significant threats. While Level 3 offers finer distinctions, such as smallholder versus industrial farming, data limitations make its broad-scale application challenging. We recommend further refinement of threat assessments by integrating higher-resolution land-use data and methodologies such as Area of Habitat (AOH) mapping. This will improve the precision of species distribution and threat identification and support more targeted conservation and mitigation strategies.

Grey heron (*Ardea cinerea*), listed as Least Concern (LC) at the global and European scale, pictured here in a rice field in Valencia, Spain (BirdLife International, 2019, 2021c).
© Antony Luque Montero

4

Biodiversity conservation and agriculture in the Mediterranean

Summary: The relationship between agriculture and biodiversity is complex and dual-faceted, as shown in the previous Chapters. With unsustainable agricultural practices representing the leading driver of global biodiversity loss, agriculture faces the challenge of feeding a growing human population while achieving biodiversity conservation goals. While unsustainable agricultural practices drive habitat destruction and biodiversity decline, agroecological approaches offer a pathway for integrating biodiversity conservation, and the management of associated ecosystem services, with agricultural productivity. Agroecological practices, such as diversification and agroforestry, supported by adaptations of the EU´s Common Agricultural Policy, have proven effective in mitigating biodiversity impacts. The benefits of diversified systems for yields and ecosystem services - pollination, pest control, and soil health - must be translated into regional biodiversity targets and supported by tailored, landscape-specific policies. This Chapter presents strategies to align agricultural systems with biodiversity goals through agroecology, illustrated by case studies.

4.1. Introduction

Chapters 1, 2 and 3 provide a broad overview of the interaction between biodiversity and agriculture in Mediterranean landscapes. Chapter 2 assesses agricultural practices as both a threat and a habitat for species, while Chapter 3 uses the STAR metric to identify how and where interventions could achieve the most benefit for biodiversity, with the importance of CWR being highlighted throughout. In the previous Chapters it was highlighted that at least 28% of all Mediterranean species assessed on the Red List, and 38% of all Mediterranean threatened species, are considered to be affected by unsustainable agricultural practices, while simultaneously over 18% of species depend on agricultural landscapes to survive. Unsurprisingly, most of these species occur in traditionally and extensively-managed agricultural habitats. These results highlight the opportunity that lies before us for aligning agricultural landscape planning with biodiversity conservation.

These findings point to agroecology as an important tool to provide the necessary agricultural shift in areas highlighted by the STAR metric, or landscapes of importance for CWR. Agroecology could provide the answers to the most dominant threats, such as reinforcing extensive, rotational grazing in areas where unsustainable overgrazing is detected.

Tools such as the STAR metric and the IUCN Red List, despite having inherent biases and limitations which must be taken into account, are very useful for evaluating biodiversity outcomes and selecting the most appropriate agroecological practices in order to reduce risks and enhance biodiversity in priority areas. By linking scientific analysis and assessments like the ones used and performed in this report with the design of agroecological strategies, we could build agri-food systems that actively contribute to halting or even reversing biodiversity loss, while improving the resilience and sustainability of agricultural landscapes.

This Chapter will delve into how agroecological practices could help to address the identified challenges and opportunities for biodiversity conservation, providing specific solutions to reduce biodiversity loss while maintaining, and potentially even enhancing, the resilience of Mediterranean agricultural landscapes.

Bridging conservation priorities with agroecology

The global agricultural sector is at a crossroads, facing three major challenges: ensuring reliable access to affordable, nutritious food (food security); reducing its contribution to climate change; and maintaining biodiversity, which is critical to supporting ecosystem services, such as pollination for maintaining food production from pollination-dependent crops (Semenchuk et al., 2022; FAO, 2023; Le Provost et al., 2023; Wanger et al., 2024). The Mediterranean is well-positioned to benefit from agroecological strategies that integrate biodiversity conservation with agricultural productivity, given its rich biodiversity and longstanding agricultural dependency. For example, in Andalusia, Spain, the intensification of olive farming has significantly reduced plant diversity and impaired pollination services, demonstrating how unsustainable agricultural practices can undermine ecosystem functions (Rey et al., 2019; Tarifa et al., 2021). If managed unsustainably, the ways in which we use land for agriculture can be a major contributor to biodiversity loss, weakening nature's functions as well as the benefits we receive from ecosystems (Gerten et al., 2020).

Fields of wheat in El Krib, Siliana, Tunisia.

The intersection of agriculture and biodiversity calls for policy interventions that address both conservation goals and socio-economic needs. Agroecological approaches bridge the gap between conservation and productivity, offering solutions to reconcile biodiversity goals with agricultural needs at a landscape scale.

In recent years, a strong body of evidence has emerged showing that adopting less intensive, more sustainable agricultural practices not only conserves biodiversity, but also enhances the ecosystem services we depend on, thereby increasing resilience to future changes (Wanger et al., 2020; Magrach et al., 2023; Vasconcelos et al., 2024; Zou et al., 2024). While we have a good scientific understanding of the ecological foundations needed to slow or even reverse biodiversity loss, this knowledge has not yet been fully translated into farmer-based approaches that truly incorporate biodiversity-friendly agricultural practices (Kreitzman et al., 2022; Pe'er et al., 2022).

The Mediterranean region, known for its distinctive biodiversity and ecological characteristics (Medail & Quezel, 1997; Thompson, 2005), is particularly sensitive to these environmental changes. While agriculture has been an integral part of Mediterranean landscapes and livelihoods for 11,000 years, the over-intensive agricultural production of the past 60 years has significantly reduced species richness, as a result of fewer types of land cover and more intensive management (Newbold et al., 2020). Conversely, traditional agricultural practices and conservation farming, which are still prevalent in some areas, support high levels of biodiversity (Ponti et al., 2016; Lee et al., 2019).

In non-European Mediterranean countries, traditional farming systems, such as those found in the Fertile Crescent and North Africa, have been integral to maintaining biodiversity (Balkrishna et al., 2021). These regions often employ age-old agricultural practices that are inherently sustainable and biodiversity-rich. Policies and initiatives in these countries also play a crucial role in shaping sustainable agricultural practices tailored to local contexts. For example, the implementation of national agro-ecological policies in Morocco and Tunisia supports biodiversity conservation while promoting sustainable agriculture (Houssni et al., 2023).

Extensive cattle grazing in a traditional dehesa landscape in Cáceres, Spain - a centuries-old silvo-pastoral system that supports biodiversity and maintains resilient Mediterranean ecosystems. © Vieyle Cortez Gallardo

Additionally, shifts in temperature and precipitation patterns are altering the climate in many agricultural areas, which is in turn affecting Mediterranean biodiversity, especially farmland species (Newbold et al., 2020; Rigal et al., 2023). In this region, diverse farming practices and landscapes can help restore and maintain ecosystem services and hence contribute to the conservation of species and agricultural biodiversity, as well as enhancing climate resilience (e.g., Rey et al., 2019; Herrera et al., 2021). Agroecology serves as a key climate change adaptation strategy, enhancing resilience through diversified cropping systems, water conservation, increased carbon sequestration, and enhanced landscape connectivity (FAO, 2023). However, adopting these practices requires a deep understanding of local conditions and the unique ecological characteristics of a given area (Carpenter et al., 2009).

Both within and beyond Mediterranean agricultural systems, experts in agroecology, agronomy, and agricultural policy stress the importance of moving towards sustainable land use that balances biodiversity conservation with sustainable agriculture and food production (Zaccari et al., 2023). Beyond local food demands, the Mediterranean region's agricultural sector must also respond to the pressures of tourism-driven consumption, which affects land use, resource availability, and biodiversity conservation (García-Nieto et al., 2018). This requires a fundamental change in approach, based on a detailed understanding of local, landscape and seasonal variables that influence environmental, economic, social outcomes (Tscharntke et al., 2021; Lombardo et al., 2022) as well as consumer behaviour.

Effective policy frameworks, such as national and regional adaptations of the EU CAP (2023-2027), are crucial in shaping these sustainable practices, ensuring that both EU and non-EU countries can implement strategies tailored to their specific needs (Díaz et al., 2021). In addition to the CAP, policies from non-EU Mediterranean countries, such as the Tunisian National Strategy for Sustainable Development and the Moroccan Green Plan, are essential in shaping these sustainable practices to fit diverse Mediterranean contexts (El Bilali et al., 2020).

In this Chapter, we provide a brief overview of agroecological approaches and evidence-based strategies to reduce the negative impacts of agriculture on Mediterranean biodiversity and related ecosystem services. We begin by exploring the effects of land use on biodiversity and ecosystem services in the Mediterranean. This is followed by an examination of how agroecology can reconcile agricultural production with biodiversity conservation. Two case studies illustrate how sustainable agriculture and biodiversity conservation can be combined in olive groves (Box 4.1) and the use of technological innovation for biodiversity monitoring in an international context (Box 4.2). We conclude with an outlook on policy directions for the region.

4.2. Effects of land use on biodiversity and ecosystem services in the Mediterranean

Agricultural landscapes in the Mediterranean region may be considered as social-ecological systems that are important for biodiversity conservation and contribute to a wide range of ecosystem services that benefit local communities. However, these landscapes are facing numerous pressures that are consistent with issues identified globally: (i) intensive agricultural practices such as monoculture and excessive use of chemical inputs; (ii) demographic and socio-economic changes driven by urbanisation and migration; (iii) climate change impacts, such as altered precipitation patterns and rising temperatures; and (iv) habitat loss due to land conversion and infrastructure development (sensu Balzan et al., 2020). These pressures are adversely impacting biodiversity in the Mediterranean: as mentioned in Chapter 2, 38% of threatened species in the region are affected by unsustainable agricultural practices, and the increasing need to feed the Mediterranean´s growing population further intensifies these pressures.

Agroforestry and multi-cropping systems can help to enhance biodiversity and related regulating services such as pollination and pest control, water purification, carbon storage, and climate regulation in this context (Balzan et al., 2020). For instance, the 'Olivares Vivos+' initiative in Spain demonstrates how integrating agroforestry practices into agricultural systems can significantly increase regional biodiversity, serving as a replicable model across the Mediterranean (Box 4.1). Moreover, the STAR analysis in Chapter 3 showed that these agroecological strategies can be particularly relevant in priority areas where actions to abate agriculture-related threats could provide greater benefits. However, the current trend towards agricultural intensification and abandonment poses risks to the sustainability of these systems. Notably, urbanisation, industrial, and coastal tourism development, as observed in regions such as Barcelona (Spain), Emilia-Romagna (Italy), and coastal areas of Tunisia and Lebanon, have led to significant losses in food provisioning and regulating services (Clavé et al., 2011; García-Nieto et al., 2018). These challenges must be viewed through an interdisciplinary lens that encompasses biophysical, sociocultural, and economic perspectives and involves all stakeholders along the agricultural value chain (e.g., Balzan et al., 2020; Ruckelshaus et al., 2020; Maas et al., 2021).

Intensive olive groves in the province of Jaen, Andalusia, Spain.

4.2.1. Effects on biodiversity

The impacts of intensive agricultural activities on biodiversity extend across various taxonomic groups, including birds, bats, arthropods, and plants (Rey et al., 2019; Morgado et al., 2020; Cano et al., 2022; Tarifa et al., 2021, 2024; Vasconcelos et al., 2024), leading to biodiversity losses within both cultivated and protected areas. Such biodiversity declines in homogenised landscapes compromise vital ecosystem services, increasing susceptibility to pests and invasions (Costa et al., 2020; Herrera et al., 2021; Martinez-Harms et al., 2021; Solomou & Sfougaris, 2021; Vasconcelos et al., 2022).

Agricultural intensification in the Mediterranean exacerbates these challenges, particularly in permanent croplands like olive groves and almond orchards, unless they are managed using traditional and more sustainable approaches. For example, the shift towards high-density plantations demands higher water and chemical inputs, eradicates resource competition from 'weed' populations, harms soil health and reduces agroecosystem resilience (Morgado et al., 2020; Guerrero-Casado et al., 2021). In turn, this can have an adverse effect on soil biodiversity, which includes microbial communities and invertebrates and plays a fundamental role in maintaining agro-ecosystem functions such as nutrient cycling, soil

European hare (*Lepus europaeus*) on agricultural land, Po Delta, Italy. The European hare is Least Concern (LC) with a decreasing population trend at the Mediterranean scale according to the IUCN Red List (Smith et al., 2010).

structure formation and plant health (Zuazo & Pleguezuelo, 2009; Lal, 2018). This trend, coupled with land consolidation, also threatens local livelihoods by undermining smallholder viability and rural economies (Morgado et al., 2022).

Additionally, unsustainable overgrazing remains a significant threat to biodiversity in some parts of the Mediterranean, with impacts including exacerbating soil degradation and habitat loss (Quaranta et al., 2020). In Chapter 3, the STAR metric results highlighted overgrazing as one of the top threats to species in the Mediterranean, especially in priority areas. However, sustainable grazing systems, particularly in traditional pastoral landscapes, can play a critical role in maintaining biodiversity and ecosystem functions by preventing shrub encroachment, enhancing habitat heterogeneity, and supporting pollinators and seed dispersers (Maestre et al., 2022). Moreover, recent studies indicate that transhumance fosters pollinator diversity by maintaining floral resources along migratory routes, thereby supporting ecosystem services which are crucial for agriculture (García-Fernández et al., 2019; Ubach et al., 2023). Sustainable agricultural practices such as these represent opportunities for addressing conservation objectives while using the land, especially if aligned with priorities identified through tools and analyses such as the STAR metric.

4.2.2. Effects on ecosystem services

Ecosystem services, also referred as Nature's Contributions to People, encompass the contributions of ecosystems to human welfare, and range from tangible benefits like food and water to intangible benefits such as stress alleviation and spiritual and cultural values (Carpenter et al., 2009). The concept of ecological resilience, defined as an ecosystem's capacity to withstand disturbances while retaining its functions (Walker et al., 2004), is vital for safeguarding these services.

The complexity of Mediterranean social-ecological systems arises from interactions between historical human endeavours and the spatio-temporal dynamics of biodiversity and ecosystem processes. These interactions result in both seasonal and long-term shifts in ecosystem services, further shaped by synergistic drivers and pressures that pose risks to the region's future provision of ecosystem services (Doblas-Miranda et al., 2017; Balzan et al., 2020). For example, the structural simplification of Mediterranean olive orchards through increased tree density has been reported to significantly reduce the diversity and foraging activity of insectivorous bats, thereby compromising the provision of pest control services in such structurally simple olive orchards (Herrera et al., 2024). However, the growing adoption of Nature-based Solutions (NbS), such as those involving agroforestry and crop diversification practices, has demonstrated measurable benefits for both biodiversity and human well-being. For example, the occurrence of flower strips has been widely reported to increase pollinator richness, leading to higher pollination services in nearby crop fields (e.g. Gardner et al., 2021). However, despite progress, critical gaps remain in understanding the socio-economic trade-offs of sustainable land-use changes, particularly in the region's most intensive cropping systems (Díaz et al., 2021). This is particularly relevant when taking into account that 18% of the species assessed in Chapter 2 depend on agricultural landscapes, and many of these species in turn contribute to agricultural systems through the provision of services such as pest control and pollination.

While the provisioning services of Mediterranean agricultural landscapes are well documented, there is a gap in understanding their contributions to regulating and cultural ecosystem services, which are crucial for promoting their sustainable development. There is a need for integrated approaches that weave together biophysical, socio-cultural and economic perspectives in the valuation of ecosystem services (Nieto-Romero et al., 2014; Ruckelshaus et al., 2020). Strengthened empirical field research is needed to address critical knowledge and implementation gaps in agroecological research and agricultural policy, while considering synergies and trade-offs with other objectives (see Box 4.1). Advances in ecosystem monitoring technologies to quantify provisioning services can be coupled with socio-cultural approaches to standardise long-term and high-resolution data collection (see Box 4.2).

The intensity of agricultural management often inversely correlates with the delivery of certain services, suggesting potential trade-offs between food provisioning and other ecosystem services (Raudsepp-Hearne et al., 2010). These trade-offs are particularly important in regions with high potential for the abatement of agricultural threats, as identified in Chapter 3 through the STAR metric. In these areas, not only biodiversity but wider ecosystem functions are at risk, due to agricultural intensification and unsustainable agricultural practices. Moreover, there remains a scarcity of research on the structural and functional ecosystem traits crucial for ecosystem service provision. A deeper understanding of how agrobiodiversity and ecosystem services interconnect is essential for predicting the impacts of agricultural management, as well as other factors, on ecosystems and the services they support (Nieto-Romero et al., 2014; Cole et al., 2020).

2.3. Agroecology for sustainable agriculture and biodiversity conservation

Agroecology offers a comprehensive framework for reconciling biodiversity conservation with agricultural production (see discussion on Agroecology in Chapter 1, Box 1.2). This approach integrates strategies like organic farming, agricultural diversification, and agroforestry, challenging the notion that agriculture is inherently detrimental to biodiversity. Organic agriculture, while representing a growing market that evolved from 51 billion Euros in 2012 to 135 billion euros in 2022 and is currently present in 188 countries, is still a niche production that covers only 2.0% of all agricultural land globally (Willer et al., 2024). Given the limited scope of organic agriculture, there is a pressing need for broader agroecological approaches that effectively integrate agriculture and biodiversity conservation across diverse landscapes.

Agroecology provides a holistic approach that extends beyond individual farming practices to encompass the entire food system, integrating environmental, socio-economic, and cultural dimensions (Aguilera et al., 2020; Carlile & Garnett, 2021; Zeng et al., 2023). As a holistic discipline, agroecology is based on a set of principles that can be applied in a decentralised and adaptable manner, making it a horizontal, knowledge-driven approach that integrates ecological, social, and governance dimensions. In contrast, organic farming is generally a top-down certification-based system, primarily focused on compliance with specific practices that reduce external inputs, rather than fully integrating agroecological principles. While organic farming contributes to sustainability, agroecology fosters systemic transformations, emphasising biodiversity-friendly landscapes, food sovereignty, and ecosystem resilience (Tscharntke et al., 2021; FAO, 2023). Agroecological practices such as intercropping, use of legumes, and restoration of native vegetation can optimise soil health and water retention, while promoting biodiversity at both field and landscape levels (Zeng et al., 2023). Agroecology also contributes to curbing the alteration of freshwater habitats by reducing the export of materials (e.g., soils, nutrients, microplastics, pollutants) from agricultural lands to watersheds, thereby preventing clogging, contamination, and eutrophication (Boutagayout et al., 2025). By reducing agrochemical use, soil erosion, and enhancing buffer zones (e.g., hedgerows, vegetated field margins), agroecology can help maintain freshwater ecosystem integrity and biodiversity (e.g., Haddaway et al., 2018; Giagnocavo et al., 2022). Moreover, incorporating landscape elements and other conservation and restoration actions, such as the establishment and sustainable management of ponds, can increase habitat heterogeneity and enhance species richness in agricultural landscapes (Cannucci et al., 2025; Hill et al., 2025).

Projects like 'ECO-OLIVES' in Italy exemplify this integration by demonstrating how biodiversity-friendly practices in olive orchards can align productivity with conservation (Box. 4.1). Emerging technologies, such as artificial intelligence (AI)-based monitoring systems (Box 4.2), provide scalable tools to evaluate and adapt agroecological strategies in real time, offering solutions to align productivity with biodiversity goals (Darras et al., 2024). This comprehensive approach is essential for addressing the complex challenges of modern agriculture, particularly in the context of global issues like food security, climate change, and resource depletion (Altieri et al., 2015; Lal, 2018). By managing landscape processes through less intensive, more ecologically sensitive approaches, agroecology contributes to the maintenance of ecosystem services, the conservation of species, and the promotion of sustainable land use (Tscharntke et al., 2021, 2022). These practices are crucial for conserving agricultural biodiversity as well as supporting Nature's Contributions to People (Balzan et al., 2020; Lombardo et al., 2022). In the Mediterranean, where diverse landscapes and traditional farming practices have coexisted for millennia, agroecology provides a critical framework for aligning agricultural productivity with the conservation of species and ecosystem services (Tscharntke et al. 2021).

A dehesa in the province of Salamanca, Castile and León, Spain. This traditional silvopastoral system integrates trees and livestock grazing; in this case holm oak forest is combined with pig farming for the production of acorn-fed ham.

BOX 4.1. Empirical field research in Mediterranean olive cultivation landscapes for biodiversity conservation and sustainable agriculture

The Mediterranean biomes, with their unique ecological landscapes, offer significant opportunities for sustainable land-use transformation. Small-scale, traditional farming systems prevalent in the region provide a framework for biodiversity-friendly agriculture. Olive orchards, integral to the region's ecology and economy, exemplify the complex relationship between agriculture and biodiversity. Despite the challenges posed by intensive farming, these systems also have significant potential to enhance ecosystem services and biodiversity through sustainable management practices (Costa et al., 2019; Rey et al., 2019; Morgado et al., 2020; Cano et al., 2022; Tarifa et al., 2021, 2024; Vasconcelos et al., 2022).

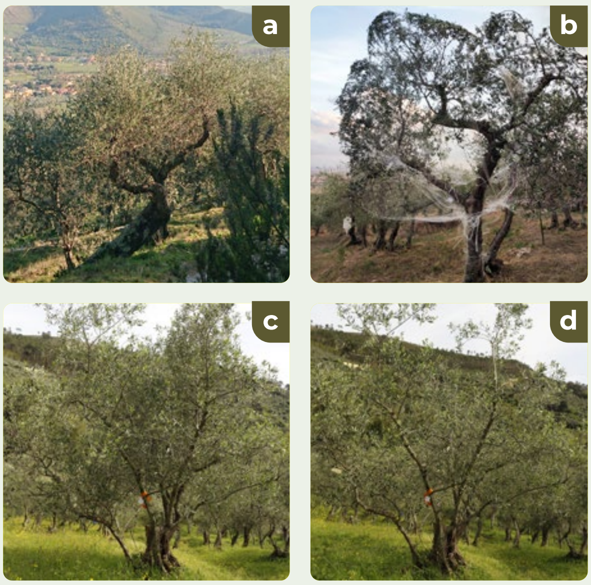
Over the past decade, international researchers have evaluated how shifting from intensive to biodiversity-friendly and agroforestry practices in olive orchards can enhance biodiversity through active ecological restoration. This approach has been exemplified by the LIFE project "Olivares Vivos" in Andalusia, whose measures have boosted short-term biodiversity and led to a scientific validation of biodiversity recovery and an ecolabel for olive oil. Building on this success, the "Olivares Vivos +" project is expanding these practices to olive groves across Spain, Portugal, Italy, and Greece, continuing to promote biodiversity with recognised ground cover and agroforestry strategies.

Simultaneously in Portugal, the "ECOLIVES" project has been evaluating the roles of birds and bats in natural pest control, specifically investigating how changes in olive tree density affect their insectivory and pest control services. This project aims to refine biocontrol services by applying distinct pest management strategies that maximise the ecological benefits of these insectivorous species. Meanwhile, the "OLE-Adapt" project is advancing these concepts by developing a climate-smart pest management strategy. By integrating fine-scale ecological assessments with economic analysis, OLEAdapt seeks to understand the impacts of climate change on key olive pests and to enhance farm resilience through informed crop variety selection and innovative biocontrol practices.

The "ECO-OLIVES" project in Tuscany, Italy, further exemplifies the integration of biodiversity conservation with agricultural productivity through its focus on the impacts of insectivorous birds and bats on pest control in organic olive orchards. With its transdisciplinary approach, ECO-OLIVES serves as a model for future research, offering actionable insights that help bridge knowledge and implementation gaps in sustainable agriculture while promoting a comprehensive view that includes scientific, socioeconomic, and cultural dimensions of agroecosystems (Maas et al., 2019; Pe'er et al., 2022; Nori et al., 2023).

In addition to these ongoing efforts, the proposed "EU-OLIVES" initiative seeks to further upscale and share ecological knowledge, innovations, and best practices in sustainable agriculture and biodiversity conservation across the olive sector on a continental level. By fostering cross-border collaboration and integrating ecological and socio-economic perspectives, this initiative aims to build on the successes of previous projects and address the broader challenges faced by the Mediterranean olive industry (Maas et al., 2019, 2021).

Together, these projects underscore the critical importance of integrated field research in advancing sustainable agricultural practices that support biodiversity conservation. Lessons from these projects provide a roadmap for upscaling similar biodiversity-friendly practices across Mediterranean agroecosystems. By merging scientific research with practical applications, these efforts not only enhance our understanding of complex ecological interactions in olive agroecosystems, but also promote the implementation of innovative farming techniques that benefit both nature and farmers in the Mediterranean region.



a) Study area of the ECO-OLIVES project in Tuscany, Italy, **b)** Vertebrate exclusion nets on an olive tree, **c)** Olive tree before pruning, **d)** Olive tree after pruning

Agroforestry system comprising intercropped olive trees, near Ghar El Melh, Tunisia

The Mediterranean region, with its diverse ecological and socio-economic landscapes, presents both unique challenges and opportunities for agroecological practices. Despite the region's complexities, its shared agroecological characteristics provide a foundation for cross-regional cooperation, which is crucial for addressing pressing international issues such as food security, climate change, and resource scarcity. Diverse practices tailored to local conditions significantly enhance the resilience and sustainability of cropping systems in the Mediterranean (Gallardo-López et al., 2018; Migliorini et al., 2018).

A key strategy within the agroecological framework is agricultural diversification, which has been shown to significantly increase biodiversity and ecosystem services while maintaining or even improving crop yields (Tamburini et al. 2020; Zaccari et al. 2023). This approach involves integrating functional diversity - such as different crops, crop varieties, and diversity-enhancing farming practices - into agricultural systems to create a more dynamic and robust framework. The Mediterranean's diverse climates and ecosystems are particularly well-suited for such practices, offering opportunities to enhance biodiversity conservation alongside agricultural production (Aguilera et al., 2020; Kamau et al., 2023).

Diversification practices, including traditional farming systems in the Eastern Mediterranean and North Africa, not only support rich biodiversity but also provide farmers with a more stable economic base by better responding to market fluctuations (Navarrete, 2009). These practices take many forms, including crop rotation, intercropping, the inclusion of legumes, and the establishment of flower strips, all of which contribute to a richer, more balanced ecosystem (Kleijn et al., 2019; Tamburini, 2020; Kamau et al., 2023). Legumes, for instance, enrich soil nitrogen levels, support subsequent crops, and enhance biodiversity, while flower strips boost pollinator populations and biological pest control agents, reducing the need for chemical pesticides (Gurr et al., 2016; Peñuelas et al., 2020). For instance, a recent synthesis which included all available data on global rice production showed that diversification can enhance both socioeconomic and environmental conditions in rice production (He et al., 2023). Similarly, socioeconomic and environmental benefits have been confirmed in field experiments globally (Rassmussen et al., 2024). Furthermore, integrating extensive livestock management within agroecological frameworks can enhance biodiversity, reduce soil erosion, and maintain traditional landscape structures (FAO, 2024). Market-based incentives, such as biodiversity-friendly product certification, public procurement policies, and consumer awareness campaigns, can also facilitate the transition towards sustainable agri-food systems (Zaccari et al., 2023).

Another critical element of agroecology is agroforestry, which integrates trees and shrubs into agricultural landscapes, enriching biodiversity, enhancing resilience, and boosting productivity (Jose, 2009; McAdam et al., 2009; Torralba et al., 2016; Damianidis et al., 2021; Nair et al., 2021; Pantera et al., 2021). Agroforestry has been comprehensively evaluated and shown to increase productivity by up to 40% compared to monoculture systems (Graves et al., 2007). In the Mediterranean, agroforestry contributes to soil conservation, water management, and the overall ecological balance of farming landscapes (Zuazo & Pleguezuelo, 2009; Torralba et al., 2016) Furthermore, it plays a crucial role in reducing wildfire risks by minimising flammable undergrowth (Damianidis et al., 2021; Kaloudís et al., 2021).

The multifunctionality of agroforestry is recognised under various international and national frameworks, such as the Natura 2000 Directive (European Union, 1992) and the designation of High Nature Value farmlands (Paracchini et al., 2008). These frameworks underscore the importance of protecting agroforestry areas for their biodiversity and ecosystem services, particularly in the Mediterranean.

In summary, agroecology in the Mediterranean integrates ecological, socio-economic, and cultural dimensions, advocating for diverse and resilient agricultural landscapes. By embracing traditional knowledge, fostering community involvement, and emphasising diversification and ecological practices, agroecology offers a sustainable path forward in the face of climate change and resource depletion. Specific policies and traditional practices in non-European Mediterranean countries, such as those in Egypt, Lebanon, and Türkiye, further emphasise the importance of sustainable land use aligned with the region's cultural and ecological characteristics. Moreover, agroecology offers a response to the results of this report: it addresses key threats to threatened species (Chapter 2) and, if implemented across priority areas for agricultural threat abatement indicated by the STAR analysis (Chapter 3), while including traditional systems, agroecology can be a pathway towards sustainability - a concrete opportunity to foster productive and biodiverse agricultural landscapes.

4.4. How can agriculture and biodiversity coexist in the Mediterranean?

4.4.1. Changing management practices

Practical measures such as implementing diversified crop systems and fostering habitat connectivity in agricultural landscapes are crucial (e.g., flower strips boosting pollinator populations). The effective management and diversification of farming systems can significantly benefit biodiversity, especially in regions like the Mediterranean where traditional agricultural practices have long supported diverse ecosystems (Lombardo et al., 2022). For instance, CWR in the Mediterranean show a clear preference for disturbed anthropogenic environments, illustrating how well-managed agricultural systems can maintain high biodiversity levels (Jarvis et al., 2015). In fact, as discussed in this report, the Mediterranean hosts a richness of traditional agro-silvo pastoral systems which support a diversity of CWR, thus providing a solid foundation for agroecology. However, it is crucial to recognise that even the most well-managed agricultural landscapes cannot fully replicate the biodiversity found in natural ecosystems, which are increasingly scarce in Europe and the Mediterranean compared to other regions, such as the tropics (Aguilera et al., 2020; Massante et al., 2021; Kreitzman et al., 2022).

The impacts of intensive agriculture on biodiversity can be mitigated through management practices that consider interactions between species groups, ecosystem functions, and environmental factors. For example, integrating traditional silvopastoral systems like *montados* and *dehesas* with modern agroecological approaches offers sustainable solutions that enhance biodiversity while maintaining agricultural productivity (Pinto-Correia et al., 2011). Moreover, mobile pastoralism can play a crucial role in maintaining landscape connectivity and ecosystem resilience, particularly in Mediterranean drylands where habitat fragmentation is a major concern (Yilmaz et al., 2019). The Mediterranean's major crops, including fruits, vegetables, and cereals, present distinct challenges and opportunities for biodiversity-friendly production systems (Díaz et al., 2021). The management of these different crops varies significantly, with annual and biannual crops often requiring more intensive management than perennial crops like olives or vines, which can typically support higher biodiversity due to their less frequent disturbance and longer lifespan. Notably, a food systems approach is essential to fully integrate biodiversity conservation with agricultural practices, considering not only ecological aspects but also socio-economic drivers, market dynamics, and governance structures (FAO, 2023). In some places, achieving a shift in management practices may necessitate a transformation of the food market and consumer attitudes, However, given the prevalence of sustainable traditional practices in the Mediterranean, there already exists a considerable opportunity to implement, upscale and adapt agroecological strategies, if such practices and knowledge systems can be effectively conserved and promoted.

Sustainable land-use transformations in the Mediterranean require a deep understanding of these complexities. Evidence-based strategies must account for the various environmental, economic, and societal factors that influence biodiversity outcomes (Cole et al., 2020; Caro et al., 2022; Riva et al., 2023). The region's diverse agricultural landscapes present unique opportunities for biodiversity conservation but also face modern challenges, such as climate change and land degradation, which threaten traditional agricultural systems (Aguilera et al., 2020). While traditional systems in parts of the Eastern Mediterranean and North Africa have fostered biodiverse landscapes, they are increasingly threatened by modernisation and environmental stressors. Conversely, European Mediterranean countries are gradually adopting biodiversity-friendly practices, driven by policies like the CAP and the European Green Deal, though full integration of these practices into broader land-use policies remains a challenge (Pe'er et al., 2022).

A key element of harmonising agriculture and biodiversity in the Mediterranean involves identifying the types of biodiversity that should be supported within agricultural landscapes. Many of these landscapes, shaped by millennia of human activity, are recognised for their high biodiversity value, classified as High Nature Value (HNV) farming systems (Paracchini et al., 2008). However, comparisons with natural and semi-natural systems reveal that while agricultural lands can support significant biodiversity, they do not replicate the diversity found in untouched ecosystems, which are rare in the Mediterranean. This distinction is crucial for species like farmland birds and pollinators, which may find more suitable habitats in diversified agricultural lands than in certain natural woodlands. Biodiversity patterns in these landscapes depend heavily on the proportion of farmland area and the intensity of agricultural management, with larger, more intensively managed fields in less heterogeneous landscapes tending to support lower biodiversity (Herrera et al., 2015; Martin et al., 2019; Rey et al., 2019).

A nuanced understanding of the relationship between biodiversity and farming systems is essential for designing and implementing policies that foster biodiversity and ecosystem services in targeted landscapes (Costa et al., 2019; Lombardo et al., 2022). For instance, the Italian olive oil industry could benefit significantly from sustainability certifications that protect local varieties and link product quality to environmental stewardship (Lombardo et al., 2022). Similarly, Vizinho et al. (2021) propose a detailed framework for adapting agricultural and forestry landscapes to climate change, emphasising the need to integrate diverse data and local insights to tailor effective strategies. Additionally, agroforestry, as discussed by Pantera et al. (2021), offers a sustainable agricultural model that can address environmental challenges and bolster biodiversity across different climatic regions of the Mediterranean. Finally, while certification schemes can support sustainable agriculture, additional mechanisms such as public procurement policies, regulatory frameworks, and financial incentives for biodiversity-friendly practices may provide more inclusive and scalable solutions (Zaccari et al., 2023).

4.4.2. Implementing biodiversity-friendly policies

Agricultural goals and targets outlined in frameworks like the Kunming-Montreal Global Biodiversity Framework (GBF) and the UN Sustainable Development Goals advocate for biodiversity-friendly practices that conserve ecosystem services and ensure food security. To meet these ambitious goals, it is essential to adapt and design policies, such as the EU CAP, to reflect the unique characteristics and specificities of farming systems across the Mediterranean. Promising proposals based on ecological knowledge aimed in this direction already exist, such as those proposed by Díaz et al. (2021) for the eight main farming systems of Spain. The EU's Green Deal and the CAP's eco-scheme framework offer mechanisms to incentivise biodiversity-friendly practices like crop rotation and agroforestry. Similarly, North African policies, such as Morocco's Green Plan, can integrate agroecological research to inform localised solutions.

Implementing more effective, biodiversity-friendly policies involves recognising the complex history of land use in the region, addressing the specific agricultural practices that contribute to biodiversity loss, and understanding the market and consumer demands that drive overproduction (Zaccari et al., 2023). Additionally, the economic realities and other challenges faced by farmers must be acknowledged (Kreitzman et al., 2022; Pe'er et al., 2022). Furthermore, training land-use planners, government agencies, and civil society organisations in holistic agroecological approaches will enhance their ability to design policies that integrate biodiversity conservation with agricultural sustainability (FAO, 2023). In certain places, a paradigm shift is required that encompasses not just agricultural production but also consumption patterns, urging a reconsideration of our food demands within the Mediterranean context and beyond (Moreira et al., 2019). At the same time, a basis for agroecology already exists in the Mediterranean, with many sustainable agricultural practices widely used for centuries. This offers potential for shifting away from intensive, environmentally harmful agricultural practices, if we establish policy mechanisms which foster the upscaling and integration of traditional knowledge and sustainable practices at a broader scale.

Recent shifts towards sustainable farming practices, such as the EU's financial incentives for agroforestry development (initiated in 2005), underscore a growing recognition of the need for environmentally harmonious agricultural methods (EU, 2013). The transition to sustainable practices, as demonstrated by Lombardo et al. (2022) in the Italian olive growing sector, showcases the potential for aligning economic viability with environmental sustainability. This alignment is essential for meeting the objectives of the EU's Green Deal and the UN 2030 Agenda.

The insights from the 2021 Second International Agrobiodiversity Congress emphasise the crucial role of agrobiodiversity in creating resilient and equitable food systems (Zaccari et al., 2023). In fact, given the increasing need for and political obligations to adapt to climate change, there exists an opportunity to make the most of the synergies between climate change and biodiversity strategies, as many agroecological practices simultaneously offer an array of benefits for climate mitigation

Montado in the region of Portalegre, eastern Portugal. Cork is extracted from the cork oak (*Quercus suber*) trees, while the undercover is managed for cereal production.

and adaptation (Altieri et al., 2015; Bohan et al., 2022). In the Mediterranean, there is a pressing need for clear regional biodiversity objectives, alignment of the CAP's Green Architecture with landscape-specific measures, enhancement of farmers' knowledge, investment in biodiversity monitoring, and a strong commitment to the internalisation of biodiversity within farming practices (Díaz et al., 2021). This comprehensive approach aims to foster agricultural landscapes that support both biodiversity and productive farming by reducing chemical use and irrigation while increasing landscape heterogeneity and crop diversification (Díaz et al. 2021).

Achieving these goals requires bridging knowledge gaps, enhancing biodiversity monitoring, and fostering interdisciplinary collaboration between farmers and researchers to promote sustainable land-use transformations (Maas et al., 2019, 2021). Such efforts are crucial for balancing biodiversity conservation and agricultural sustainability in the Mediterranean (Pe'er et al., 2022; Cuadros-Casanova et al., 2023; UN, 2023). However, achieving coexistence requires a nuanced understanding of the trade-offs between yield-focused practices and ecosystem service provision, with research highlighting potential synergies through mixed farming systems (Tamburini, 2020; He et al., 2023).

In conclusion, realising the potential of biodiversity-friendly policies in Mediterranean agriculture will depend on the integration of ecological knowledge, including traditional knowledge systems, with tailored policy adaptations. Through a coordinated effort across various sectors, the Mediterranean can develop agricultural landscapes that are both productive and support biodiversity.

BOX 4.2. Computer vision-based environmental monitoring to promote biodiversity conservation and agricultural productivity

Global food systems require a transformation towards securing food and human wellbeing, while curbing human-induced biodiversity decline (Pendrill et al., 2022). Agricultural diversification positions in the forefront for this global transformation through the integration of biodiversity conservation principles into agriculture (Chaplin-Kramer et al., 2023; Zaccari et al., 2023). As the post-2020 GBF highlights, integrating biodiversity conservation and agricultural productivity requires monitoring capabilities to build reproducible assessments of (agro)biodiversity based on high resolution field data (CBD, 2022). Acoustic monitoring has been widely used to track species movement and occurrence. Radar and LiDAR are applied for insect-related energy and biomass flux quantification, molecular methods such as eDNA can help to better understand species interaction networks, and computer vision can provide high resolution information on ecosystem services such as pollination and pest control (van Klink et al., 2022).

Computer vision-based technologies are slowly replacing traditional biodiversity monitoring methods such as camera traps. While embedded AI-based methods that process data in real-time with limited power consumption exist, most commercial devices are still in early development stages. A recently developed portable, low-power, modular, embedded vision camera system provides high-resolution, long-term, real-time data based on standardised sampling methods (Darras et al., 2024). This system can: (i) non-invasively monitor various taxa for different applications across disciplines; (ii) reach high temporal resolution and coverage with solar power and be scaled up spatially due to its moderate cost and size; (iii) analyse images in real-time using established computer vision algorithms and performance assessment workflows that standardise observation results, and thus (iv) link specific detections to real-time reactions for intervening in environmental processes. The system is well-suited to reveal new species interactions and benefits in well-established crops, linking biodiversity conservation and agricultural productivity (see www.econect.biz for more details). It specifically aids biodiversity conservation, as standardised methods and data integration are needed to document the status quo and assess impacts from environmental pressures.

Cocoa (*Theobroma cacao* L.), a multi-billion USD crop grown in global biodiversity hotspots by over 5 million smallholder farmers, offers a good example of how this system can be used. Although pollination enhancement can increase yields and farmer profits in emerging and leading cocoa producing regions by up to 700% (Toledo-Hernández et al., 2023), little is known about cocoa´s small pollinators including diptera and thysanoptera, and how agricultural diversification helps to protect them and their habitats (Toledo-Hernández et al., 2017). Recent monitoring of cocoa pollinators with the aforementioned AI-based camera devices has allowed tracking in real time for a wide range of previously unknown pollinators (Darras et al., 2024; Figure 4.1). AI-based monitoring thus offers opportunities to enhance crop yields in sustainable production systems that can protect biodiversity and improve livelihoods of farmers while securing supplies of an important commodity crop. Intuitively, these benefits are not limited to tropical tree crops such as cocoa but can also be applied to monitor agricultural systems in the Mediterranean, such as rape seed oil pollinators and production or biodiversity benefits of olive orchards. Ultimately, methods and case studies like this can help to develop standardised, quantitative, and high-resolution indicator-based monitoring metrics for the post-2020 GBF, which will also support advancing COP27 commitments towards climate-resilient and sustainable agri-food systems in the future (Wanger et al., 2020).

Figure 4.1. Embedded vision cameras (**a**) recorded in real time the cocoa pollination process carried out by midge flies (Ceratopogonid, Diptera) © Manuel Toledo Hernández; (**b**) by previously unknown cocoa flower-visiting arthropods and interactions in agroforestry systems of China and Brazil © Wenxiu Xu

4.5. Key messages

- Well-managed, diverse agricultural production landscapes can support biodiversity. However, the expansion of homogenised landscapes through monocultures and the loss of natural habitat remnants pose significant threats to biodiversity and ecosystem services. Intensive production methods exacerbate these threats by further reducing landscape diversity.

- Addressing the coexistence of agriculture and biodiversity in the Mediterranean requires a multifaceted approach that considers historical land use, modern agricultural developments, and cross-disciplinary perspectives on the desired state of biodiversity.

- A balanced integration of agriculture and biodiversity conservation is essential for sustainable development in the Mediterranean region. Achieving this balance necessitates coordinated efforts across various sectors and disciplines to support agro-ecological research, practice, and policy, thereby overcoming existing gaps in knowledge and implementation.

- In order to move towards a future where biodiversity conservation and agriculture are reconciled, three critical aspects must be prioritised: including stakeholders in decision-making, mainstreaming sustainable practices and protecting biodiversity.

- By involving local communities in agricultural landscapes, mainstreaming sustainable farming strategies and traditional practices, and addressing threats to biodiversity, the Mediterranean can continue to be a region where agriculture and biodiversity conservation coexist harmoniously.

Olive groves intercropped with mixed vegetables in Axarquía, Andalusia, Spain. © Faye Weaver

5

Conclusions and recommendations

5.1. Overview of this report

This report has explored the relationship between species conservation and agriculture in three ways. First, by providing a review of the conservation status, threats and habitats of species assessed on the IUCN Red List in the Mediterranean, and the role of agriculture as both a threat and a habitat for those species (Chapter 2). The IUCN Red List assessment of over 4,400 Mediterranean species reveals that 26% are threatened with extinction (CR, EN or VU). The outlook is even more worrying for freshwater species (50% threatened) and Crop Wild Relatives (38% threatened). The results confirm agriculture as a key threat to species, while at the same time providing suitable habitat for 18% of species. Specifically, intensive practices such as monocultures and unsustainable overgrazing impact habitats and threaten species survival. However, the Red List data does not provide high-enough resolution information to determine which specific agricultural practices are better or worse for species conservation. A land systems analysis shows that, in particular, Agro-silvo-pastoral mosaic and Open and bare grazing landscapes support a wide variety of species (Chapter 2).

In Chapter 3, we explored large-scale opportunities to reduce regional species extinction risk through the abatement of agricultural threats in the Mediterranean, by calculating the first Species Threat Abatement and Restoration (STAR) metric for the region. This analysis identifies large-scale areas with high agricultural impact where the mitigation of agriculture-related threats would yield the most significant conservation gains. High STAR scores in regions like southern Spain, Greece, and Türkiye emphasise the need for targeted actions against threats such as intensive livestock farming, which alone contributes over 55% to species extinction risk in the region. Finally, we provide an overview of how agroecology can support biodiversity conservation in the Mediterranean. Agroecological practices, including crop diversification and agroforestry, as well as sustainable grazing and pastoralism, are highlighted as essential tools for sustainable agriculture (Chapter 4). Case studies on biodiversity-friendly olive grove management (Box 4.1) and AI-based monitoring for pest control (Box 4.2) provide tangible examples of how agroecology can support both biodiversity and agricultural production.

This final Chapter explores synergies between biodiversity conservation commitments acquired by countries through international and regional policy and sustainable agricultural policies (Section 5.2) and provides some final conclusions and recommendations emerging from the work presented in this report (Section 5.3).

5.2. Conservation commitments and sustainable agriculture policies in the Mediterranean

Approaches to develop a more sustainable agriculture that can support biodiversity conservation in the Mediterranean will vary depending on the socio-economic and political context within each country of the region. To strengthen, for example, the implementation of the CAP and EU Nature Restoration Regulation, measurable biodiversity objectives and regionally tailored incentives should guide agricultural practices, with lessons drawn from successful models like Olivares Vivos in Spain (Box 4.1). North African initiatives, such as Tunisia's Sustainable Development Strategy, should integrate biodiversity monitoring systems (e.g., AI-based tools in Box 4.2) to scale up conservation efforts efficiently. The STAR metric results highlight high-priority areas for conser-

Wildflower border along the edge of an agricultural field in the province of Ciudad Real, Castile-La Mancha, Spain.

vation actions and investments, bridging the CAP's Green Architecture goals with action in high-biodiversity areas (Chapter 4).

Integrating agroecological principles into National Biodiversity Strategies and Action Plans (NBSAPs) and other biodiversity policies will enhance alignment between conservation and food production goals (Tscharntke et al., 2021; FAO 2023, 2024). A coherent approach is needed to integrate biodiversity conservation goals with agricultural policies, ensuring that agroecological principles are embedded in biodiversity funding, research, and monitoring frameworks, and allowing them to permeate into the food market through increased awareness among consumers. To support such policies, accountability measures for agricultural impacts on biodiversity should be complemented by subsidies, financial incentives and technical support for producers adopting biodiversity-friendly practices, such as those promoted by agri-environmental schemes (Batáry et al., 2015; Pe'er et al., 2022). Moreover, agri-environmental policies and agroecological strategies can simultaneously help to achieve climate goals and obligations, and such synergies should be explored (Hodge et al., 2015).

Finally, developing robust biodiversity indicators that can track the impacts and benefits of various agricultural systems - including agroecology, organic farming, and conventional agriculture - will provide a clearer understanding of their role in species conservation and ecosystem services (Muñoz Cañas, 2025).

European Mediterranean

In EU countries, CAP offers mechanisms to support biodiversity. Policies such as the CAP's "Green Architecture" encourage agroecological practices, like agroforestry and habitat corridors, which align well with findings on species-specific needs in agricultural landscapes (Chapter 4.4). Additionally, the EU Biodiversity Strategy and the European Green Deal aim to enhance conservation within the agricultural sector, focusing on climate resilience, ecosystem services and species conservation - goals that align closely with the STAR metric results identifying high-priority areas for threat abatement. In particular, the EU Nature Restoration Regulation (2024) sets out specific targets for agricultural ecosystems, which also provide a good framework to target more sustainable practices in priority areas.

North Africa

In non-EU Mediterranean countries, frameworks like the GBF provide a foundation for integrating biodiversity conservation with agricultural development. North African policies, such as Morocco's Green Morocco Plan and Tunisia's National Strategy for Sustainable Development, prioritise sustainable agriculture and climate adaptation, aligning with agroecological recommendations from Chapters 3 and 4. These policies can further benefit from targeted actions in areas with high STAR scores to support biodiversity in critical hotspots, particularly within agro-silvo-pastoral systems that dominate these regions.

5.3. Recommendations

→ **Encourage biodiversity-friendly agriculture:** Promote the adoption of agroecological practices that support biodiversity, such as crop diversification, integrated pest management, and sustainable grazing. Policies like the CAP should prioritise these practices to enhance ecosystem services and species conservation across agricultural landscapes (Chapter 4). Box 5.1 provides a strategic road map to integrate biodiversity conservation into sustainable agriculture.

→ **Align policy frameworks across regions:** Facilitate coordination between the EU's CAP policies and North African agricultural strategies to ensure a consistent approach to biodiversity across the Mediterranean. Emphasising agroecology within CAP's Green Architecture and actions to implement the GBF could enhance resilience and sustainability in both EU and non-EU countries of the Mediterranean (Section 5.2). Moreover, there exists an opportunity to seek and take advantage of synergies between climate and biodiversity strategies. Collaborative frameworks between EU and North African countries, supported by cross-border research initiatives, can align conservation priorities with agricultural reforms (Maas et al., 2019).

→ **Strengthen local knowledge, capacity and engagement:** Support knowledge-sharing networks for farmers and stakeholders to access best practices in biodiversity-friendly farming. Programmes that enhance farmer education and engagement, particularly in remote areas, can help to build long-term capacity for sustainable agriculture (Box 5.1). At the same time, it is necessary to integrate local and traditional knowledge into wider agricultural strategies and policies, and where necessary establish measures to ensure the viability and resilience of traditional practices and protect livelihoods (Aguilera et al., 2020). Capacity-building programs that integrate traditional knowledge with modern practices are vital for fostering local ownership of biodiversity-friendly farming initiatives (Pantera et al., 2021).

→ **Address monitoring gaps through technology:** Implement real-time biodiversity monitoring systems, such as AI-based environmental monitoring, to track changes in biodiversity and ecosystem health. Such tools can support adaptive management in agricultural landscapes, improving responsiveness to biodiversity pressures (Box 5.2). Regional investments should prioritise monitoring infrastructure, enabling real-time biodiversity assessments. AI technologies can standardise data collection and inform adaptive management in dynamic agroecosystems (Wanger et al., 2020).

→ **Prioritise action in high-risk areas:** Focus conservation resources on areas with high STAR scores to effectively address species extinction risk. Regional conservation funds should prioritise threat abatement actions tailored to specific agricultural practices, particularly in regions like southern Spain, the Eastern Mediterranean, and North Africa's agro-silvo-pastoral landscapes, where biodiversity is most at risk (see STAR findings in Chapter 3).

→ **Future research on biodiversity conservation and sustainable agriculture in the Mediterranean** should focus on integrated land-use planning and maximising specific opportunities in the Mediterranean (Box 5.2).

BOX 5.1. A strategic roadmap to integrate biodiversity conservation with sustainable agriculture in the Mediterranean (modified from Wanger et al., 2020)

Protect biodiversity

1. Promote active conservation measures within agricultural landscapes, such as establishing ecological corridors, restoring and protecting key habitats, and implementing species-specific conservation programmes to ensure that biodiversity conservation is directly integrated into agricultural planning and practice.
2. Build agri-food systems that internalise negative externalities and spillover effects affecting biodiversity, to make producers accountable for costs.
3. Develop mechanistic models and indicators that integrate ecological, socio-economic, and cultural dimensions, emphasising the multifunctionality of landscapes benefitting biodiversity and associated ecosystem services. Enhance these models through data integration from research networks for systematic biodiversity inventories.
4. Use technological innovations for active biodiversity conservation, including real-time monitoring and adaptive management strategies, to assess, avoid, minimise, and mitigate environmental impacts.
5. Establish long-term experiments to study interactions between farm and landscape diversification effects on socioecological systems with biodiversity benefits.

Include people

6. Consider socio-economic links between farm-level biodiversity and food security, particularly including Crop Wild Relatives, wild harvested plant and crop landrace conservation as a foundation for future sustainable agricultural practices.
7. Ensure effective communication with farmers and provide incentives for them to implement agroecological production, while facilitating the wider integration of traditional knowledge and practices.
8. Build on existing diversification research to further improve the relationships between sustainability and productivity in diversified systems through effective land-use planning.
9. Quantify the trade-offs in agroecological practices and include aspects of good quality of life (e.g., health, happiness, and profitability).
10. Review options for adding value and niche market creation for crop landrace production to promote more sustainable agricultural practices.

Mainstreaming implementation

11. Determine effects of eco-certification encouraging agroecological production on biodiversity and socioecological systems.
12. Understand social, power, and value barriers to facilitate a transition from conventional to agroecological production systems.
13. Use and improve indicators to measure comprehensive agricultural systems performance, beyond production.
14. Quantify diversification effects on supply chain actors and identify obstacles for implementation.
15. Understand links between traditional agroecological production and local and global markets.

BOX 5.2. Future research needs for biodiversity conservation and sustainable agriculture in the Mediterranean

(modified from Maas et al., 2021 and Zaccari et al., 2023)

Integrated land-use planning:

1. **Agroecological practices:** Investigate the ecological, economic, and social outcomes of agroecological practices, focusing on their scalability and adaptability across different contexts.
2. **Biodiversity-friendly farming systems:** Examine the effectiveness of biodiversity-friendly practices across various agri-food systems, from intensive to extensive, and their impact on different taxonomic groups.
3. **Climate adaptation strategies:** Explore the resilience of agroecological and diversified farming systems to climate variability, emphasising water conservation and soil health.
4. **Socio-economic impacts:** Assess the socio-economic implications of transitioning to sustainable agricultural practices, including the viability for smallholders and the role of policy incentives.
5. **Habitat connectivity and landscape integrity:** Incorporate strategies for maintaining and enhancing habitat connectivity within agricultural landscapes in order to prevent biodiversity loss. This includes preserving landscape integrity by avoiding further fragmentation and integrating conservation goals into land-use planning processes.

Specific opportunities in the Mediterranean:

6. **Traditional knowledge integration:** Leverage the region's rich history of traditional agricultural practices to inform modern agroecological methods.
7. **Policy innovation:** Utilise the Mediterranean's varied policy landscapes to pilot and upscale effective biodiversity conservation strategies within agricultural policies.
8. **Cross-border collaboration:** Foster collaboration among Mediterranean countries to share knowledge, innovations, and best practices in sustainable agriculture and biodiversity conservation.
9. **Community engagement:** Engage local communities, farmers, and stakeholders in co-creating solutions that address local biodiversity and agricultural challenges.
10. **Conservation of endemic and threatened species:** Focus on the conservation of endemic and threatened species unique to the Mediterranean region by integrating species-specific management plans into agricultural practices. This ensures that biodiversity conservation efforts are tailored to the unique ecological context of the region.

Savi's warbler (*Locustella luscinioides*), listed as Least Concern (LC) at the global and European scale, pictured here in an agricultural field in Albufera Natural Park, Valencia, Spain (BirdLife International, 2021d, 2024b). © Antony Luque Montero

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Common pheasant (*Phasianus colchicus*) on agricultural land in the Po Delta, Italy. © "Common Pheasant (*Phasianus colchicus*) on agricultural land in the Po Delta, Italy" by Gregoire Dubois is licensed under CC BY-NC-SA 2.0.

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Appendices

All the appendices listed below are available for consultation and download in the IUCN Library System, under the following link: **here**.

Appendix 1:

List of species included in this report

The list of species included in this report and their corresponding Red List Categories and and main biome.

Appendix 2:

List of Crop Wild Relatives in the Mediterranean

The list of Crop Wild Relatives included in this in this report.

Appendix 3:

Crosswalk table to refine species ranges using Mediterranean land systems data

The correspondence between IUCN habitat classifications and Malek and Verburg (2017) land use types used to undertake the analyses in Chapter 2.

Appendix 4: STAR Supplementary materials

Appendix 4.1: STAR analysis data and maps

The list of species included in the STAR analysis.

Appendix 4.2: STAR-t scores of each species per agricultural threat type

The STAR-t scores of each species per agricultural threat type included in this analysis.

Appendix 4.3: Level 3 STAR scores and maps

The STAR scores for Level 3 agricultural threat types and the Level 3 maps.

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