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War and the Environment in Syria: An Interdisciplinary Approach to Biodiversity Conservation and Socio-Ecological Change

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Doctoral Dissertation Presented by

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For My Best Friend Mahmoud R.I.P

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"We don't inherit the land from our ancestors. We borrow it from our children"

Sitting Bull

Abstract

Over thirteen years of war in Syria have led to widespread human displacement and suffering, economic collapse, and ecological disruption. While most research has focused on the humanitarian toll, the environmental dimensions of the war remain poorly understood. This thesis addresses this gap by examining how war has reshaped ecosystems and human-nature relationships through three complementary studies, each highlighting different yet interconnected aspects of ecological degradation, community resilience, and species survival under war conditions. Firstly, Chapter 2 provides a nationwide overview of war-driven environmental conflicts in Syria, drawing on ten qualitative case studies based on interviews and desk research. The results show an extensive ecological fallout of war, including deforestation, water pollution, biodiversity loss, and the collapse of environmental governance. These impacts have undermined livelihoods, exacerbated public health challenges, and severed communities from ecologically and culturally significant landscapes. In response, grassroots environmental actions have emerged—rooted in everyday survival and justice struggles—though these are often neglected or repressed by centralized authoritarian institutions. The analysis builds on Joan Martínez-Alier's concept of *"environmentalism of the poor"* to argue for more inclusive, locally rooted environmental recovery strategies. Chapter 3 shifts to a more local scale to investigate how forest management and logging behavior have changed in response to war-induced violence, energy scarcity, and economic hardship. Based on household surveys in two Syrian coastal villages—Blouta and Nehel al Annaze—exposed to differing levels of violence, the study finds a substantial rise in logging activity post-2011. Days spent harvesting wood per week nearly tripled, and gender disparities in labor roles narrowed during the conflict. The amount of wood logged per month was not affected by the village's level of violence. However, it did vary with socioeconomic factors like gender and age: women logged less wood than men, and younger people logged more than older ones. The income from logging filled a critical gap between household needs and actual income—covering 46.94% and 84.83% of that gap in the two villages, respectively. These findings underscore the urgent need for post-war forest governance that balances ecological restoration with economic support for vulnerable communities. Finally, Chapter 4 presents a detailed case study on the wartime impacts facing *Iris nusairiensis*—a Critically Endangered, high-elevation endemic plant of western Syria—and supplies the first comprehensive baseline for its conservation. Extensive field surveys, habitat mapping, and statistical modelling documented five subpopulations of the species (four newly recorded) and an overall population of 13,651 individuals, of which only 2.24% are mature, indicating severely limited reproductive capacity. War-related pressures—

soil removal for military infrastructure, construction of fortifications and deployment of heavy machinery, together with intense overgrazing—are accelerating the species' decline. The study urges immediate action: a formal IUCN Red List reassessment, legal protection of key habitats, and establishment of long-term ecological monitoring.

Together, these chapters highlight how war reshapes not only political and social landscapes but also ecological systems and the ways communities interact with them. The findings reveal a recurring pattern: while environmental degradation is often treated as collateral damage, it is in fact central to the lived experience of war. At the same time, local resilience and ecological knowledge persist, offering valuable entry points for inclusive, justice-oriented recovery strategies. Integrating environmental concerns into post-conflict planning is not only necessary for ecological recovery—it is essential for sustainable peacebuilding and social reconstruction in Syria and other conflict-affected regions.

Resumen:

Tras más de trece años de guerra, Siria ha experimentado desplazamientos humanos y sufrimiento generalizados, colapso económico y una grave alteración ecológica. Si bien la mayor parte de la investigación se ha centrado en el coste humanitario, las dimensiones ambientales del conflicto siguen siendo poco comprendidas. Esta tesis aborda esa laguna examinando cómo la guerra ha remodelado los ecosistemas y las relaciones entre los seres humanos y la naturaleza mediante tres estudios complementarios, cada uno de los cuales destaca aspectos distintos pero interconectados de la degradación ecológica, la resiliencia comunitaria y la supervivencia de las especies en condiciones bélicas. En primer lugar, el Capítulo 2 ofrece una panorámica nacional de los conflictos ambientales provocados por la guerra en Siria, basada en diez estudios de caso cualitativos sustentados en entrevistas y revisión documental. Los resultados muestran amplias repercusiones ecológicas del conflicto —deforestación, contaminación hídrica, pérdida de biodiversidad y colapso de la gobernanza ambiental— que han socavado los medios de vida, agravado los problemas de salud pública y desconectado a las comunidades de paisajes de gran valor ecológico y cultural. En respuesta, han surgido acciones ambientales de base, arraigadas en luchas cotidianas por la supervivencia y la justicia, aunque a menudo son ignoradas o reprimidas por instituciones autoritarias centralizadas. El análisis se apoya en el concepto de «ecologismo de los pobres» de Joan Martínez-Alier para abogar por estrategias de recuperación ambiental más inclusivas y localmente enraizadas. El Capítulo 3 se traslada a una escala más local para investigar cómo la gestión forestal y las prácticas de tala han cambiado ante la violencia, la escasez energética y las dificultades económicas derivadas de la guerra. Con base en encuestas a hogares en dos aldeas costeras —Blouta y Nehel al Annaze— expuestas a distintos niveles de violencia, el estudio detecta un aumento sustancial de la actividad maderera tras 2011. Los días dedicados a recolectar leña por semana casi se triplicaron y las disparidades de género en las tareas laborales se redujeron durante el conflicto. La cantidad de madera extraída al mes no dependió del nivel de violencia de la aldea, pero sí varió según factores socioeconómicos: las mujeres cortaron menos madera que los hombres y las personas jóvenes más que las mayores. Los ingresos procedentes de la tala cubrieron una parte crucial de la brecha entre las necesidades y los ingresos reales de los hogares —46,94 % en Nehel al Annaze y 84,83 % en Blouta—. Estos hallazgos subrayan la necesidad urgente de una gobernanza forestal posbélica que combine la restauración ecológica con el apoyo económico a las comunidades vulnerables. Por último, el Capítulo 4 presenta un estudio de caso detallado sobre los impactos de la guerra en *Iris nusairiensis*, una planta endémica de alta montaña del oeste de Siria catalogada como En Peligro Crítico, y aporta la primera línea de base

exhaustiva para su conservación. Extensos muestreos de campo, mapeo de hábitats y modelización estadística documentaron cinco subpoblaciones (cuatro registradas por primera vez) y una población total de 13.651 individuos, de los cuales solo el 2,24 % son adultos, lo que indica una capacidad reproductiva muy limitada. Las presiones asociadas al conflicto —extracción de suelo para infraestructura militar, construcción de fortificaciones, despliegue de maquinaria pesada y sobrepastoreo intenso— están acelerando el declive de la especie. El estudio insta a una acción inmediata: reevaluación formal en la Lista Roja de la UICN, protección legal de hábitats clave y establecimiento de un monitoreo ecológico a largo plazo.

En conjunto, estos capítulos muestran cómo la guerra remodela no solo los paisajes políticos y sociales, sino también los sistemas ecológicos y las formas en que las comunidades interactúan con ellos. Los resultados revelan un patrón recurrente: aunque la degradación ambiental suele considerarse un daño colateral, en realidad es central para la experiencia vivida de la guerra. Al mismo tiempo, persisten la resiliencia local y el conocimiento ecológico, que ofrecen puntos de partida valiosos para estrategias de recuperación inclusivas y orientadas a la justicia. Integrar las consideraciones ambientales en la planificación posconflicto no solo es necesario para la recuperación ecológica, sino esencial para la construcción de una paz sostenible y la reconstrucción social en Siria y otras regiones afectadas por conflictos.

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Chapter 01

The General Introduction

Active Warfare Amidst Vegetation in Syria © Mahmoud Taha

1.1. Warfare And Ecosystems

We are living in an era marked by an alarming biodiversity crisis, driven by unprecedented rates of species loss. This issue is rapidly advancing toward what scientists have identified as the sixth mass extinction which differs from previous events because it is driven primarily by anthropogenic activities rather than natural causes (Ceballos et al., 2015; Cowie et al., 2022; IPBES, 2019). Among the many human activities driving the global biodiversity crisis, warfare plays a critical — yet frequently overlooked — role. As highlighted by Hanson et al. (2009), nearly 90% of armed conflicts between 1950 and 2000 took place within countries that form a part of the global biodiversity hotspots. These regions are known for their high concentrations of endemic and threatened species, such as the Amazon Basin, the Mediterranean Basin — of which Syria is a part — and several others (CEPF, n.d.).

In recent years, the number of armed conflicts and global military spending have steadily increased, reflecting a growing shift in priorities away from environmental protection and toward militarization (Escola de Cultura de Pau, 2024; SIPRI, 2024). In 2024 alone, 37 armed conflicts were recorded globally — the highest in over a decade — with many occurring in ecologically sensitive regions such as the Middle East and Africa (Escola de Cultura de Pau, 2024; SIPRI, 2024). At the same time, military emissions, estimated to account for between 1% and 5% of total global greenhouse gas emissions remain largely excluded from international climate policies and reporting frameworks (Rajaeifar et al., 2022). Redirecting resources toward militarization—while ignoring its environmental impact—intensifies both climate change and biodiversity loss.

Warfare contributes to species decline both directly and indirectly, mainly through habitat disturbance and wildlife exploitation. It can lead to habitat destruction, including deforestation, soil erosion, and water contamination, as well as increased hunting and illegal trade of wildlife. Forests, which are critical habitats for species biodiversity, are particularly vulnerable in conflict zones. A key example is the Vietnam War, during which the widespread use of the herbicide Agent Orange caused extensive and long-lasting forest degradation, a damage that continues to impact people and ecosystems to this day (Zierler, 2011). Similarly, recent conflicts like the ongoing war in Ukraine have led to significant deforestation and habitat destruction due to bomb-induced forest fires and military infrastructure development (Pereira et al., 2022; Rawtani et al., 2022).

In addition to forests, soil ecosystems also face substantial disturbance due to warfare activities. Military operations frequently lead to changes in soil physical and chemical properties such as soil sealing for infrastructure, soil compaction, excavation, and contamination with pollutants such as heavy metals and oil products. These activities negatively impact soil biodiversity, particularly the microbial communities essential for ecosystem functioning and soil fertility (Certini et al., 2013).

Aquatic ecosystems—both freshwater and marine—also suffer significant damages during armed conflicts. Freshwater bodies such as rivers and lakes can become contaminated with war-related pollutants, including toxins, heavy metals, and remnants of explosives. In some cases, warfare can also facilitate the introduction of invasive species. Bombing and shelling can directly kill aquatic wildlife and destroy critical habitats (Francis, 2011). Marine ecosystems face similar threats to species biodiversity. For example, during the ongoing Russian-Ukrainian war, the Black Sea has been affected by oil spills, the release of toxic substances, physical habitat destruction, and pollution from untreated sewage due to damaged wastewater treatment infrastructure (Kvach et al., 2025).

Moreover, species can be directly targeted during armed conflicts for trade or consumption. A study examining mammal populations during armed conflicts in southwestern Africa documented a dramatic 77% overall decline in mammal abundance, with some species experiencing reductions of up to 80% compared to pre-war levels (Braga-Pereira et al., 2020). The primary drivers identified by the authors included the collapse of conservation efforts and increased hunting during periods of instability.

Wars can exacerbate the risk of extinction for already threatened and endemic species; such species are highly vulnerable to habitat disturbance or population decrease. A notable example is the critically endangered Grauer's gorilla (*Gorilla beringei graueri*), the world's largest primate and a narrow-range endemic confined to the Virunga Volcanoes region mountainous regions of the Democratic Republic of Congo, Rwanda, and Uganda (Glew & Hudson, 2007; Kalpers et al., 2003; Thorne et al., 2013). During periods of armed conflict in Congo, the population of Grauer's gorilla declined drastically—from approximately 16,900 individuals to just 3,800—representing a 77% reduction in one generation. This dramatic loss has been directly linked to increased hunting pressure by armed militias and rebel groups operating in the region (Plumptre, 2003).

While the environmental impacts of war are overwhelmingly negative, it is important—purely for the sake of academic accuracy—to acknowledge that, in certain contexts, armed conflicts have led to temporary reductions in human activity that have allowed ecosystems or species to recover (Hanson, 2018; Lawrence et al., 2015).

This observation is not intended to justify or defend warfare, but rather to present a nuanced and complete understanding of its ecological consequences. Specifically, military conflicts can create de facto conservation zones, often termed "no-go zones," where human activities such as agriculture, logging, and poaching are restricted.

For instance, during and following the Korean War (1950–1953), the heavily fortified demilitarized zone (DMZ) between North and South Korea has inadvertently become a haven for numerous rare and endangered species, providing refuge and facilitating ecosystem recovery in the absence of human disturbances (Brady, 2020; Kim, 1997). Similarly, in Colombia, guerrilla warfare and related security concerns significantly restricted access by logging companies and other extractive industries, indirectly protecting substantial forest areas and biodiversity until peace negotiations commenced (Davalos et al., 2021; Negret et al., 2019).

1.2. Biodiversity and Species Conservation in Syria

Syria is an eastern Mediterranean country known for its ecological diversity and rich tapestry of ecosystems as it forms a part in the Mediterranean basin biodiversity hotspot, this diversity is shaped by its different climate, topography, and other environmental factors (Almasri et al., 2010; Anthony et al., 2012).

The predominant climate in Syria is the Mediterranean climate, which is marked by cool, wet winters and hot, dry summers, with precipitation concentrated between October and May (Abou Zakhem & Hafez, 2010). Rainfall patterns vary widely across regions: for example, the coastal mountain range receives over 800 mm of rain annually, forming humid areas, whereas the eastern and southeastern areas experience sub-humid to arid climates, with rainfall ranging from 400 mm to as little as 100 mm per year (Almasri et al., 2010). These climatic gradients significantly influence the distribution and composition of Syria’s natural habitats and species diversity (Figure 1.1).

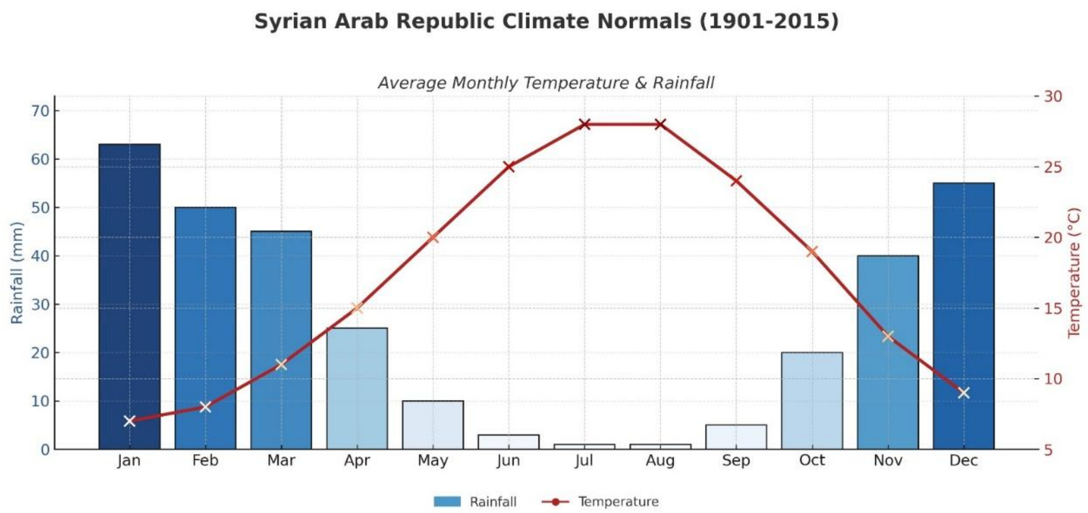

Figure 1.1 *Average monthly rainfall (blue bars, left axis) and temperature (red line, right axis) for the Syrian Arab Republic, 1901–2015 climatological mean. Note. Values are long-term means derived by Angham Daiyoub from the Climatic Research Unit, (2020) Time-Series (CRU TS v4.04) dataset, accessed via the World Bank Climate Change Knowledge Portal. climateknowledgeportal.worldbank.org.*

In addition to climate, the topography of Syria also influences this ecological variation. In the West, mountain ranges such as the Anti-Lebanon, Qalamoun, and the coastal mountains with highest elevation in mount Hermon 2814 m, while the East and central regions feature expansive plains like the Al-Jazeera plain and lowland basins including Al-Ghab and Al-Ghouta (Alsafadi et al., 2021).

These landscapes harbor a wide range of ecosystems, ranging from forests to semi-deserts. For example, forest cover formed approximately 1.26% of Syria's total land area before the war (CBD, 2009), those forests are mostly located in humid mountainous regions in the western part of the country and predominantly owned by the state. Although forests in Syria do not contribute significantly to the national economy, they are an important source of income and livelihood support for local and poor communities—particularly through non-wood forest products such as medicinal and aromatic plants, fruits like chestnuts and pinenuts, grazing, and other resources (Nahal & Zahoueh, 2005).

Forest management in Syria is overseen by the Forestry Department under the Ministry of Agriculture and Agrarian Reform, which focuses on conservation, protection, and afforestation. However, the country lacks a clear, long-term forest policy, comprehensive forest inventories, and structured management plans. This has resulted in weak enforcement, limited community involvement, and continued degradation (Nahal & Zahoueh, 2005).

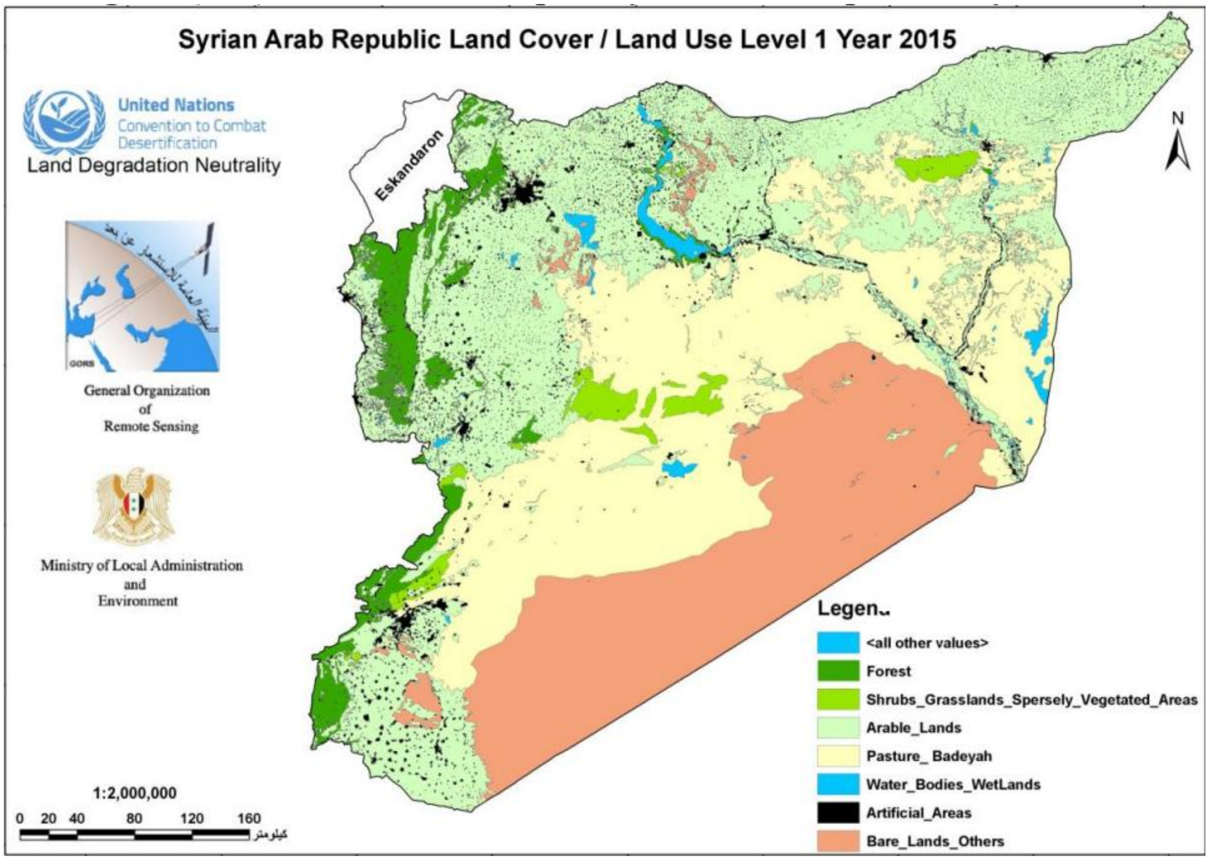

Figure 1.2 *Land cover map of Syria in 2015. (Source: Ministry of Local Administration and Environment, 2018).*

In terms of flora diversity, Syria hosts 3,077 documented species across 133 families and 919 genera, primarily from Mediterranean and Irano-Turanian phytogeographical zones. There is also notable representation from Euro-Siberian and Saharo-Arabian regions. Approximately 8% of Syria's flora is endemic, including 243 species primarily from the genera *Iris*, *Astragalus*, *Centaurea*, and *Allium* (CBD, 2009, 2022).

Significant efforts to document Syria's plant biodiversity have been undertaken by Almasri et al. (2010) and Catullo et al. (2011), who identified 33 Important Plant Areas (IPAs) which are regions that are recognized for their high concentrations of endemic and rare plant species, making them critical for biodiversity conservation. Among these areas, three stand out as the most important hotspots. Kurd Dagh, located in the northern Levant, is a botanical hotspot hosting endemic species such as *Vaccaria liniflora*, *Ranunculus millefolius*, and *Astragalus antabicus*, many of which are shared with southern Türkiye. The Anti-Lebanon Mountains represent Syria's premier center of endemism and are unique for including subalpine and alpine habitats at elevations up to 2,600 meters. This area supports distinctive endemic species like *Phagnalon linifolium*, *Helichrysum pygmaeum*, and *Thymus alfredae* that thrive in its high-altitude environment. Lastly, Jabal al-Druze is notable for its basaltic volcanic landscapes and hosts a rich diversity of endemic flora, including rare species such as *Gagea procera*, *Allium drusorum*, and *Iris auranitica*, some of which are found nowhere else. Despite their ecological importance, these areas face significant threats from human activities, especially overgrazing, which damages vegetation cover and disrupts habitat integrity, putting the survival of these endemic species at risk (Catullo et al., 2011).

The terrestrial fauna alike is diverse consisting of 110 mammal species, 381 bird species, 40 snake species and eight amphibian species (Aidek & Eid, 2025). Syria's 183-kilometer coastline along the Mediterranean supports a rich marine ecosystem, home to over 1,700 identified species ranging from plankton to marine mammals. This biodiversity plays a crucial role in local livelihoods and food systems for the coastal communities (UNEP/MAP-SPA/RAC, 2021).

Despite Syria's rich biodiversity, conservation efforts remain limited and face numerous obstacles. While the 2016 Convention on Biological Diversity (CBD) report identified 31 protected areas, the UNEP-WCMC Protected Area Profile (2025) lists only 19, with just two having undergone management effectiveness evaluations (Anthony et al., 2012; CBD, 2022; UNEP-WCMC & IUCN, 2025). Many critical habitats remain unprotected—of the 33 Important Plant Areas (IPAs) identified in Syria, only seven fall under any form of protection (Catullo et al., 2011).

Additionally, the country is home to 50 officially recognized Key Biodiversity Areas (KBAs), including Mount Hermon, Sabkhat al-Jabboul, Buhayrat al-Assad, and Jabal Abdul Aziz. However, a national framework for threat assessments, species monitoring, and updated biodiversity inventories is still absent (KBA Partnership, n.d.).

Beyond gaps in formal protection, conservation knowledge in Syria is outdated and fragmented. The most comprehensive botanical reference remains the work of Mouterde (1966–1983), which still lacks clear taxonomic separation from Lebanon's flora. The absence of updated species lists, and a national red list severely limits effective conservation planning (Almasri et al., 2010). Scientific research remains underfunded, and institutional capacity is weak.

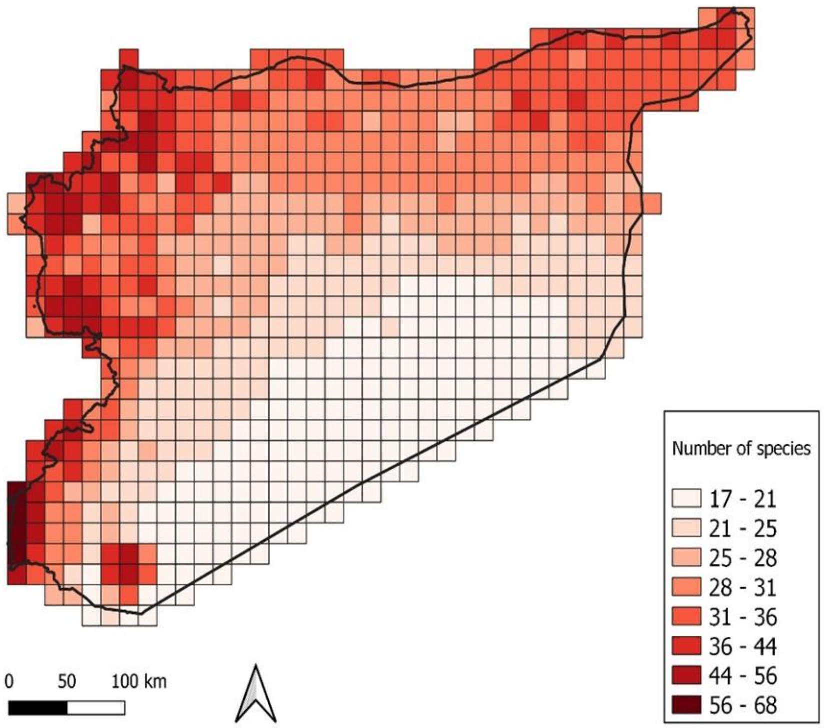

Figure 1.3 *Hotspots of threatened species biodiversity in Syria. Taken from* (Daiyoub, 2020)*, this map highlights regions with the highest concentrations of threatened species.*

1.3. The War and Environmental Impacts in Syria

The war in Syria, which began in 2011, is considered one of the most catastrophic humanitarian crises of the twenty-first century (UNHCR, 2024). The war began during the "Arab Spring" in 2011, and it was initially marked by peaceful demonstrations calling for economic and political reforms from the Assad regime. However, the government's violent repression of these protests sparked a broader national uprising. What started as a civil protest movement quickly escalated into a full-scale war and later evolved into a complex proxy war involving regional and global powers (Daher, 2022; Gürcan, 2019).

This prolonged and brutal war has claimed the lives of more than 500,000 Syrians and triggered a massive refugee crisis, displacing over 6.8 million individuals internally and forcing approximately 5.5 million people to seek refuge outside the country, primarily in neighboring countries such as Türkiye, Lebanon, and Jordan (UNHCR, 2024). In addition to the dire humanitarian consequences, the war has led to the large-scale destruction of vital services and infrastructure, including homes, schools, roads, hospitals, and essential water and electricity networks. Reports estimate that nearly 50% of the country's overall physical infrastructure has been destroyed, with key sectors such as agriculture suffering severe losses, including the destruction of half of its infrastructure, particularly damage to irrigation systems (World Bank, 2017).

The war also led to the collapse of the Syrian economy, with the country's GDP shrinking to less than half of its pre-war level in 2010 (World Bank, 2022) .This economic downturn resulted in severe inflation, drastically reducing people's ability to afford basic necessities for survival. Additionally, the economic collapse and the widespread loss of job opportunities have pushed 90% of the population below the poverty line. Out of Syria's total population of 23.7 million, approximately 16.5 million people now depend on humanitarian assistance for their basic needs (OCHA, 2021).

This war also left a legacy of destruction on Syria's ecosystems, contaminating the soil, air, and water and causing the degradation of various marine and terrestrial ecosystems, such as forests, grasslands, rivers, seas, and soils. The toxic remnants of the war include vast amounts of rubble produced from the aftermath of battles, resulting in more than 15 million tons of debris, threatening the health and lives of thousands of people (PAX, 2015). The World Bank (2022) estimated the environmental cost of the Syrian war to exceed hundreds of millions of dollars, including US$167.6 to US$269.0 million required primarily for rubble clearance from damaged housing and electronic waste management from damaged health facilities. Additionally, losses in ecosystem services alone were estimated at approximately US$36 million, further underscoring the extensive environmental damage resulting from the war (Aoun, 2022).

Additionally, unexploded ordnance scattered across the country requires removal as they represent an ongoing threats to human safety and ecosystem health (UNMAS, 2023). Furthermore, several reports documented the use of chemical weapons by the Syrian government against civilians, notably in the East Ghouta region in 2013. Investigations by Human Rights Watch confirmed the deployment of sarin nerve gas, a chemical agent with severe and long-lasting environmental impacts affecting plants and wildlife, in addition to its direct devastating humanitarian toll (Qandeel & Sommer, 2022).

Several studies have documented the impacts of the war in Syria on forests, highlighting a substantial decline in forest cover since the war began (CEOBS, 2021; Daiyoub et al., 2023; PAX, 2023; STJ, 2023). For instance, Daiyoub et al. (2023) estimated that approximately 20% of forest cover in western Syria was lost between 2010 and 2019. Deforestation was most pronounced near refugee camps and rural settlements, particularly in the northwestern coastal region (Figure 1.4). The study also found that over 50% of forest loss occurred in areas that experienced high levels of violence, including areas with intense shelling and bombing. In addition, a 2023 report by the Dutch peace organization PAX revealed that the governorates of Latakia, Hama, Homs, and Idlib saw more than 36% deforestation, with rates doubling in 2020 and tripling in 2021. The reports identified forest fires, illegal logging, and the erosion of forest conservation efforts as some of the most significant drivers of forest decline—factors that were further intensified by the war through both direct and indirect impacts (Daiyoub et al., 2023; Mohamed, 2021; PAX, 2023).

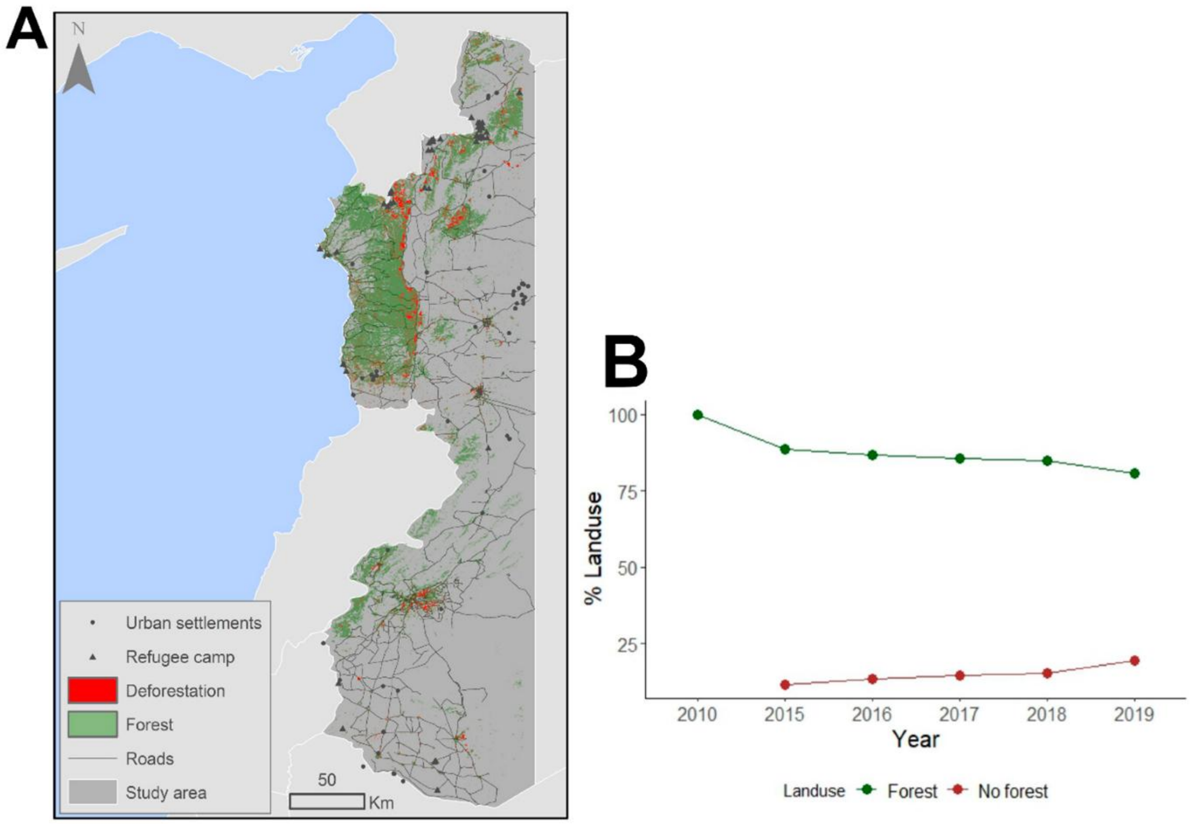

Figure 1.4 *Forest decline in Syria between 2010 and 2019. Produced by Daiyoub (2023), this map illustrates the spatial distribution and extent of deforestation during the conflict period, with significant losses concentrated in western and northwestern regions.*

Additionally, marine ecosystem conservation in Syria faced considerable challenges during wartime conditions, as funding and recruitment opportunities for researchers and conservation personnel declined sharply, weakening protected areas' ability to conserve vulnerable species. This situation has facilitated illegal activities, including overfishing and pollution, which further threaten marine biodiversity (UNEP/MAP-SPA/RAC, 2021).

1.4. Warfare and Socio-Ecological Perspectives

Warfare often results in widespread environmental destruction, disproportionately affecting the health and well-being of marginalized communities by intensifying pre-existing social and economic inequalities and creating new vulnerabilities—such as forced displacement, the collapse of livelihoods, and reduced access to clean water, arable land, and safe food (Williams et al., 2023).

While direct impacts such as bombings, deforestation, and the destruction of wildlife are often the most visible consequences of armed conflict, they represent only one facet of warfare's broader destructive capacity. Johan Galtung's influential framework on the typology of violence offers a useful lens for understanding the multifaceted nature of violence, distinguishing between direct, structural, and cultural forms. Direct violence involves immediate physical harm—such as injury, death —or in the case of our study focus— environmental degradation resulting from military actions.

In contrast, structural violence refers to systemic harm embedded within social, political, or economic institutions. In the environmental context, this can be seen in the collapse of environmental governance, the redirection of conservation funding toward military efforts, and the weakening of institutional capacity to manage natural resources (Galtung, 1996). Cultural violence legitimizes these forms by embedding militarism, inequality, and ecological disregard within dominant narratives and social norms, marginalizing affected groups—especially Indigenous and poor communities— normalizing and justifying their exclusion from decision-making processes (Galtung, 1990; Kyrou, 2007).

Environmental activism often emerges in response to such forms of violence and injustice, especially within effected communities. Historically, western environmentalism—often cantered on ideals of pristine, untouched nature—has been portrayed as a concern of affluent populations in the Global North (Comer, 1997). This narrative, however, ignores the lived realities and resistance of those whose survival depends directly on environmental integrity. Joan Martínez-Alier offers an alternative framework through the concept of the "environmentalism of the poor," which highlights how environmentalism is neither the product nor the exclusive domain of wealthy nations. Instead, it can be led by communities in the Global South and Indigenous groups whose activism is rooted in the defense of essential resources—such as water, forests, soil, and medicinal plants—upon which their lives and cultures depend (Guha & Alier, 1997; Martinez-Alier, 2002).

Recognizing the multilayered impacts of warfare on both people and ecosystems underscores the urgent need for stronger legal frameworks and accountability mechanisms. Although international agreements such as Additional Protocol I to the Geneva Conventions (1977) and the Environmental Modification Convention (ENMOD, 1977) seek to limit environmental harm during conflict, they suffer from vague language, limited enforcement, and inadequate integration of environmental justice principles (Okowa, 2009; Wunsch, 1980) . As a result, affected communities often remain unprotected and without legal recourse.

To address these gaps, there is growing momentum behind initiatives to classify ecocide—the large-scale destruction of ecosystems—as an international crime. Scholars and activists argue that such recognition would elevate the legal and moral status of environmental protection during war and peacetime alike, offering new pathways for accountability and redress (Higgins et al., 2013; Pereira, 2020). Strengthening these legal mechanisms is critical for ensuring both environmental justice and the long-term recovery of ecosystems and societies devastated by armed conflict.

In this context, I hope this thesis contributes—however modestly—to the ongoing movement for environmental accountability in war, shedding light on the underexplored effects of conflict on ecosystems, and amplifying the call for robust legal reform.

1.5. Thesis Aim and Objectives:

Aim:

In this thesis, I adopt an interdisciplinary approach to examine various causes and dimensions of war-induced environmental degradation in Syria. I investigate how the war has affected people's relationship with their environment concretely with forest management and the conservation of threatened species.

Chapter 2

This second chapter aims to contribute to the political ecology literature on Syria by presenting empirical evidence on how the war has impacted both ecosystems and human communities, drawing on ten case studies from various regions of the country. It then examines the forms of environmentalism that have emerged among the Syrian population, with particular attention to the rise of an "environmentalism of the poor" as a mode of protest and expression of grievance among marginalized groups. Finally, the chapter analyzes the deeper structural drivers of ecological harm, including governance failures under the Assad regime and the effects of foreign interventions—and how these have intensified environmental injustices.

Chapter 3

The third chapter investigates the socioecological impacts of the war in Syria, with a primary focus on how conflict has caused changes in logging practices among forest communities in two villages that were exposed to different levels of violence. The main objective is to identify changes in logging behavior during the war and to determine the key variables driving these changes. Specifically, the chapter addresses the following research questions: 1) Did the frequency of logging changed during the war? Are gender and violence intensity levels related to the frequency of logging days? 2) Do socioeconomic factors, such as gender, education level, age and others affect the amount of harvested wood? 3) How do people harvest wood during war? 4) What is the economic contribution of forest harvesting to people's survival during times of war?

Chapter 4

The fourth chapter focuses on species conservation in the context of the war in Syria, using the endemic and threatened plant *Iris nusairiensis* as a case study. The study aims to examine the impact of the Syrian war on the species' habitat and population, particularly as its limited habitat is confined to mountain peaks that were used by military forces during the conflict. Given the IUCN Red List's call for comprehensive research on its ecology and threats—especially those related to war—this chapter aims to address key knowledge gaps to support effective conservation planning.

Concretely, our study has three objectives: 1) Collect and analyze life history traits, distribution, abundance and ecological data of the taxon to improve conservation planning and stablish a baseline data for long-term monitoring and future comparative studies; 2) Detect and analyze threats and impacts to reassess the species based on IUCN Red List criteria and provide essential data for developing conservation strategies; 3) Study the hypothesis that Syrian war has had direct and/or direct effects on the conservation of this endemic plant.

Chapter 02

The War as a Driver of Syria's Socio-Ecological Conflicts

A Proud Hunter Posing in front of His Kills © Zawaya Media

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The War as a Driver of Syria's Socio-Ecological Conflicts

2.0. Abstract:

Since the outbreak of war in March 2011, Syria has experienced large-scale destruction, mass displacement, and immense human suffering. Amid these humanitarian and political crises, one critical yet under-researched consequence has been the war's impact on natural ecosystems and the communities that rely on them for survival. This research addresses that gap by presenting empirical evidence from ten case studies across the country, based on interviews and desk research. The findings show that the war's impact reaches far beyond human casualties, causing severe environmental damage such as deforestation, biodiversity loss, and pollution of water, air, and soil—which in turn undermines public health, livelihoods, and access to natural resources. In response, local communities have mobilized through informal, nonconfrontational, grassroots activism rooted in the defense of land, health, and dignity. These efforts reflect Joan Martínez-Alier's concept of the "environmentalism of the poor," calling for more inclusive, justice-oriented environmental policies. Yet such activism is often met with neglect, delay, or symbolic responses from an authoritarian regime focused on preserving elite interests and regime stability. Foreign military interventions and the collapse of environmental governance have further accelerated ecological decline through the weaponization of water, increased deforestation, pollution, and illegal wildlife trade. Beyond physical destruction, the war has also affected Syria's cultural and ecological identity, severing communities from landscapes that once held deep cultural and spiritual meaning. These findings suggest that environmental harm in Syria is not merely collateral damage—it is central to the lived experience of war and the broader struggle for justice, sovereignty, and resilience.

Keywords: War, Syria, Environmental justice, Environmentalism of the poor.

2.1. Introduction:

Syria has been experiencing large-scale destruction and displacement after the armed conflict has erupted in March 2011 (UNICEF, 2022). The origins and causes of the conflict in Syria are complex, multifaceted, and remain the subject of ongoing debate as they encompass a combination of economic, social, and political grievances. They cannot be attributed to a single factor, especially given the Syria's colonial legacy that stretches back to the Ottoman Empire and the French mandate both of which have left their lasting impacts on the Syrian society (Daher, 2018; Gürcan, 2019; Turner, 2018). However, the most agreed-upon narrative by scholars in the literature is that the conflict began with a series of peaceful demonstrations against the Assad regime during the "Arab Spring" demanding economic and political reforms which were met with violent repression. The crisis after that escalated into a nationwide armed conflict and eventually evolved into a proxy war (Daher, 2018; Gürcan, 2019).

Foreign interventions have further complicated the situation, reshaping power dynamics by involving both regional and international players. Since the war began, more than 20 states and hundreds of armed groups have been engaged in the conflict in Syria (El Abdi, 2021). These actors —motivated by a range of economic, strategic, and geopolitical interests—in Syria and the wider region have significantly shaped the course of the conflict (Adeyeye & Akinrinde, 2021; Gürcan, 2019). Key players in the Syrian war include the Syrian government, opposition forces, Gulf states, Islamist groups, Russia, Iran, Türkiye, the United States, among other states and non-state armed factions (UN Geospacial, 2022).

In addition to political, social, and historical drivers, some scholars have theorized that environmental factors also contributed to the origins of the Syrian conflict (Gleick, 2014). Gleick argues that climate change played a role in fueling the war in Syria. He suggests that the mismanagement of droughts between 2006 and 2011, which caused higher unemployment rates, food insecurity, and displaced a significant number of people from rural areas to urban centers like Damascus and other cities, contributed to the political instability and the mobilization of the population. Other researchers, such as (Daoudy, 2020a) and (Selby et al., 2017), refute this theory, arguing that drought didn’t cause immigration at such a large scale, and that there is no evidence linking these displaced individuals to participation in the 2011 uprisings.

The repercussions of the war in Syria are devastating. Since 2011, over a total population of less than 24 million, the war has forced at least 6 million Syrians to flee the country and left 6.7 million internally displaced (United Nations, 2023). It has also caused immense suffering, leaving over 14 million people in need of humanitarian aid (United Nations, 2023).

The war did not only have negative impacts on the Syrian people but also took its toll on the environment. Environmental problems were not new to Syria, as the country was already suffering from a wide range of environmental crises, including water scarcity and drought, waste mismanagement, pollution, among others (Daher, 2022). However, environmental concerns grew as these issues were largely ignored under the Assad regime. Environmental policies were largely symbolic and failed to demonstrate any genuine commitment to environmental protection. Deep-rooted corruption within the regime further undermined environmental governance, and these issues have only been exacerbated by the ongoing conflict, leading to further degradation of multiple ecosystems (Daher, 2018).

The environmental consequences of the Syrian war have been addressed by multiple academic researchers and international peace organizations in the last years. For instance, Daiyoub et al. (2023) reported that forests in western Syria experienced substantial degradation due to both direct and indirect effects of the war. These included bombing and shelling near forested regions, as well as widespread logging by internally displaced persons and local communities who relied on wood for cooking and heating amid fuel shortages and rising poverty. As a result, approximately 20% of the region's forest cover was lost between 2010 and 2019. Moreover, the Dutch organization for peace PAX produced several reports indicating widespread environmental degradation of the forests, soil, air, and water pollution caused by rubble and waste, contamination from weapon residues and the collapse of the environmental services (PAX, 2015, 2023).

War-induced environmental degradation is not limited to Syria. Although underreported by media, examples can be found all across the Middle East, a region which is considered to be one of the most politically unstable regions in the world (Fukutomi, 2024). The Gulf war between Kuwait and Iraq serves as an important example, where oil fires and spills caused by Iraqi bombing of Kuwaiti oil wells led to severe contamination in the Gulf (Al-Damkhi et al., 2009; CEOBS, 2016). Similarly, the U.S. invasion of Iraq saw the use of weapons prohibited under international law, including depleted uranium and cluster bombs, which resulted in widespread contamination across much of Iraq (CCERF, 2010).

This destructive pattern of war on the environment can be seen worldwide and throughout history. For instance, during the Vietnam war, the herbicide Agent Orange was used by the U.S. forces to remove vast forested areas and improve visibility of the enemy positions. This tactic resulted in widespread ecological contamination, the effects of which persist today in the form of soil and water pollution, biodiversity loss, and severe health consequences for the Vietnamese population, including increased rates of cancer and birth defects (Frey, 2013; Young, 2009).

Today, the Russian invasion has caused large-scale deforestation and a significant loss of biodiversity in Ukraine (Rawtani et al., 2022), while in Gaza, the Israeli occupation has destroyed at least half of the area's trees, poisoned water sources, and left the ecosystems "unlivable," with some describing the damage as "an act of ecocide" (Ahmed et al., 2024).

Understanding how people respond to the degradation of their environments, whether due to war, mismanagement, or development pressure requires attention to the forms of environmentalism that shape these responses. In the context of environmental movements in the Middle East and North Africa (MENA), several scholars have emphasized that these forms of activism do not always fit western framings of environmentalism meaning that in Arab countries that fall under authoritarian regimes and face forms of state repression are less likely to engage in confrontational resistance to the status quo (Choucair Vizoso, 2025). For example, in Iraqi Kurdistan region, a new form of environmentalism has emerged as a response to climate change-related water scarcity, called "dutiful environmentalism" a grassroot form of environmentalism that focuses on non-confrontational activities like spreading awareness, education, campaigning among others (Wiktor-Mach et al., 2023).

Another framework that authors like (Sowers, 2018) leverage to understand the environmentalism in the MENA region is the environmentalism of the poor. This approach argues against a belief that has been prevalent in conservationist organizations and think thanks for decades, namely the idea that impoverished people were not (yet) concerned or could not be concerned for the environment because they have not met their basic needs, as if a healthy environment were a luxury feature of well-off societies Guha and Martínez Alier (1997). Such approach justified technological fixes towards the environment and the imposition of state-led conservation plans which often displaced, excluded and even criminalized traditional communities and dwellers. On the contrary, the environmentalism of the poor argues that these communities protect the environment they evolved with and depend upon. Their concern for the environment is not about conserving the "wild" or reaching more technological efficiency but about protecting and reproducing their relationships and co-dependence with the rest of nature (Guha & Alier, 1997; Martinez-Alier, 2002; Martínez-Alier, 2023).

Despite the importance of the framework of the environmental of the poor in the MENA region contexts, this region remains largely under-researched in global environmental debates (Sowers, 2018). Especially in recent years, this area experienced a rise in political activism in response to pressing environmental concerns (Hamouchene, 2023). Environmental movements have addressed urgent, everyday concerns linked to public health, survival, and access to basic resources—particularly waste management, water quality, and pollution (Moneer, 2024; Orrnert, 2020). Sowers argues that the environmental movements in the MENA region can be divided into the following three main types, ranging from informal grassroots actions to structured organizational efforts: 1. Informal protests demonstrations involve farmers, fishermen, and local residents, often using petitions, sit-ins, and roadblocks to address inadequate public services, resource access, and pollution. 2. Formalized efforts by environmental organizations and NGOs, led by professionals and experts 3. Popular resistance campaigns, involving activists, journalists, and sometimes political networks, blend direct action, media advocacy, and legal challenges to confront industrial land use, pollution, and systemic governance issues (Alibeli et al., 2018; Sowers, 2018; Zumbrägel, 2020).

State responses to environmental activism range from suppression to accommodation. Discrediting tactics frame activists as threats to national security, economic progress, or cultural identity, using state-controlled media and nationalist rhetoric to undermine movements. Harassment includes legal actions, arrests, and travel restrictions, increasing risks and discouraging participation (Sowers, 2018). Co-optation strategies selectively recognize or exclude NGOs, charge them with corruption, or manipulate planning processes to create divisions and weaken solidarity. On the other hand, negotiation and accommodation involve policy changes, service extensions, or canceling controversial projects, sometimes empowering activists and improving consultation practices. However, Syria has often been excluded from discussions on environmental activism in the MENA region due to the ongoing war, which has deprioritized environmental issues, a lack of reliable data, and the authoritarian nature of the regime that suppresses dissent and restricts civic mobilization (Orrnert, 2020; Sowers, 2018).

This paper seeks to contribute to the political ecology literature on Syria, by presenting empirical evidence on how the war has affected both ecosystems and human communities. It focuses particularly on the emergence of an environmentalism of the poor as a form of protest and grievance among marginalized groups. Finally, it explores how governance failures under the Assad regime, along with foreign interventions, have deepened environmental injustices.

2.2. Methodology:

Our study departs from the analysis of ten case studies of environmental conflicts from various regions of Syria (See Figure 2.1). To identify the cases, we used the environmental justice framework, which defines these as social conflicts tied to environmental concerns, such as the unfair distribution of environmental benefits (like clean water and fertile land) or impacts (such as pollution and health risks), lack of meaningful participation, and neglected recognition of the impacted people. We selected cases with a satisfactory amount of evidence from interviews, peer-reviewed research, social media, international organizations, and humanitarian reports from the Syrian conflict (2011-2022). All data was organized into the Global Atlas of Environmental Justice (ejatlas.org) and published online. The research, conducted from July to December 2022, involved collaboration with local communities, including online interviews with affected individuals, activists, and NGOs like Green Bridges, PAX for Peace, and the Human Rights Organization in Afrin-Syria. The 15 anonymous interviewees, many with environmental backgrounds, provided critical insights as front-line eyewitnesses (Table A.2 in appendixes). Interviewees were selected using purposive sampling. Participants were identified through searches of social-media platforms and websites of relevant environment organizations. Additional informants were located via snowball sampling, leveraging the authors' existing professional and personal networks.

Our methodology also included fact-checking, cross-referencing reports from various political sources such as Syrian government media (SANA) and opposition outlets (e.g., Syria TV). We also utilized nine reports from neutral organizations like the UN (UNDP, UNICEF, OCHA, FAO). We used social media platforms like Facebook, Twitter, and YouTube to localize environmental justice movements and campaigns. Additionally, 26 local and international peer-reviewed articles were used to contextualize our findings, searched using academic search engines like Google Scholar, Web of Science, and the Syrian research engine Shamra (شمرا). Data collection was carried out both in English and Arabic.

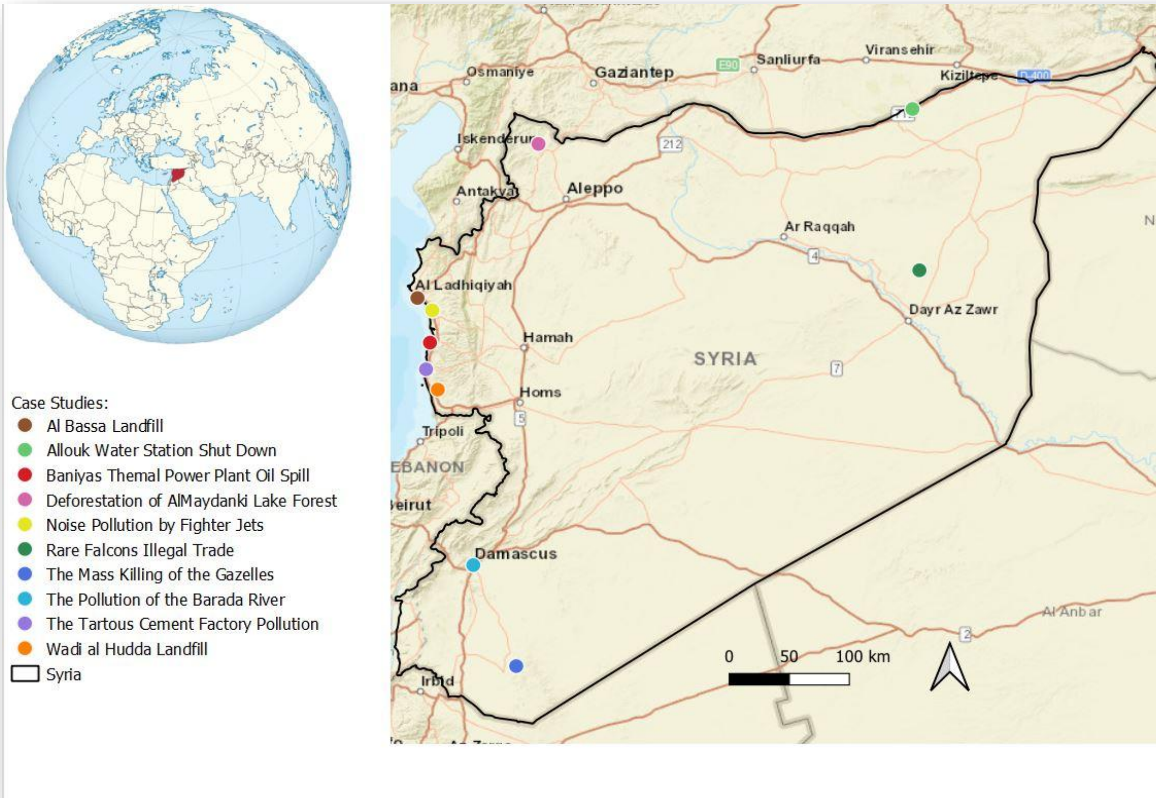

Figure 2.1 The study area.

2.3. Results:

2.3.1. Biodiversity Conservation Conflicts

2.3.1.1. Deforestation by Turkish-supported armed groups in Northwestern Syria

In 2018, the area of Afrin in northwest Syria and its surroundings were taken over by the Turkish-supported Syrian National Army (SNA) during a military operation called *"Operation Olive Branch"*. This operation was initiated by Türkiye with the aim of pushing back the influence of the PYD (Democratic Union Party) along the Turkish-Syrian border (Mauvais, 2022a).

The Maydanki Lake in Afrin was created by the Syrian government in the early 2000s to store drinking and irrigation water and generate electricity through the Afrin hydroelectric dam (Mauvais, 2022). The lake and its surrounding green forests were designated as a protected area in 2004 through Resolution No. 1849, with the aim of conserving the lake's water and the adjacent forest ecosystem (The government of the Syrian Arab Republic, 2005).

Many residents have fond memories of this area, and some local environmental activists describe it as "a place for leisure, known across the region". It was also a well-known gathering spot for Kurdish communities celebrating the Nowruz festival, a traditional new year celebration marking the arrival of spring. However, in 2018, the ongoing Syrian war and Turkish military operations led to the arrival of thousands of displaced people in Afrin. With few alternatives for shelter, many of them cleared some parts of the forest to establish makeshift settlements (Mauvais, 2022).

Moreover, on 31st of August 2022, large-scale logging of trees mainly pines (*Pinus brutia*) took place around Maydanki Lake forest (See Figure 2.2). The exact extent and duration of the deforestation are not clear. However, some reports indicated that armed groups cleared roughly 70% of the Maydanki forest, which spans an area of 74 hectares. Additionally, it was reported that the trees on the island in the lake and on the mountain were burned for unknown reasons (Mauvais, 2022a; Yek Dem, 2021). Local inhabitants and activists in Afrin blamed the Syrian opposition factions backed by Türkiye, who have control over the region, on the deforestation being carried out by the "Sultan Murad Division." The reason behind the cutting of the trees was said to be for the purpose of selling them to firewood dealers in anticipation of winter (Karkas, 2022; Mauvais, 2022a).

In light of the deforestation events, many activists blamed Türkiye and its proxies for the environmental destruction in Afrin, and accused it allowing, directly or indirectly, mass tree clearing to take place in Kurdish regions under its influence in Syria. Kurdish journalist, Nurhat Hesen, who was displaced from Afrin in 2018 said (Mauvais, 2022):

> *"The shores of the lake were radiant with greenery before Türkiye occupied the area. The same thing happened in Afrin city: there were hundreds of trees above the Mahmudiya neighborhood. Now they no longer exist, they have all been cut down"*

In response, residents and activists—along with the Syrian Observatory for Human Rights, other human rights organizations in Afrin, and the Rojava Information Center—called for accountability for those responsible for the deforestation. They also emphasized the need to raise public awareness and support organizations working to combat illegal logging.

Furthermore, they urged the implementation of laws against logging and advocated for afforestation campaigns to be launched across Northern Syria (Karkas, 2022; Mauvais, 2022a).

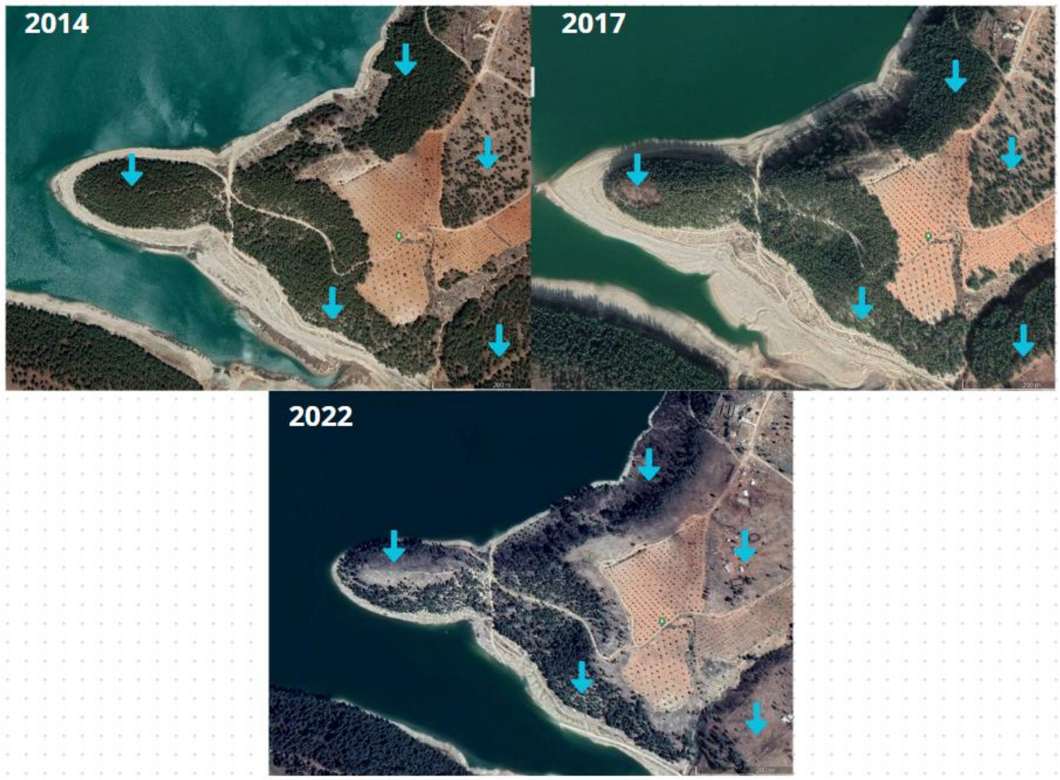

Figure 2.2 *Deforestation in the Maydanki lake forest (2014-2022). Created by Angham Daiyoub using Google Earth Pro historical imagery.*

2.3.1.2. The trapping and trading of falcons in the Syrian desert

Falconry in Syria is a traditional practice deeply rooted in the cultural fabric of the Levant, with evidence suggesting its origins may trace back to ancient times. It involves the trapping and training of falcons to hunt other bird species. In the Syrian desert—including the governorates of Deir Ez-Zor, Al-Hasakah, and Raqqa, as well as the Palmyra and Qamishli areas—falconry has historically played a significant role in both the cultural heritage and economic activities of local communities (UNESCO, 2009).

During the war in Syria, the illegal hunting and trade of rare wildlife escalated significantly, becoming what some have described as a "booming business"(Aidek & Eid, 2025; Mauvais, 2022b). Among the most affected species is the Saker falcon (*Falco cherrug*), which is listed as endangered globally by the IUCN Red List and critically endangered in the Mediterranean region, with its population in continuous decline (BirdLife International, 2021; Stretesky et al., 2018; Westrip, 2022). This is especially concerning because the Saker falcon is one of the most sought-after species for trapping and trade in Syria (Mauvais, 2022b).

According to a resident of a Syrian refugee camp near the Jordanian Syrian border, hunting falcons has become a "crazy obsession," despite the high costs involved up to $2,000 USD per person (Mauvais, 2022b). This amount is roughly 26 to 45 times greater than the average monthly salary in Syria in 2023, where workers earned approximately $44.2 USD in the public sector and between $46 and $77 USD in the private sector, based on the official exchange rate of 6,532 SYP/USD (Daher, 2023). Nevertheless, the lack of law enforcement and minimal penalties have facilitated the illegal falcon trade. Under Syrian hunting law No. 152 of 1970, falcon hunting is prohibited, with fines ranging from $1 to $5 USD only, and prison sentences from 10 days to two months (Abido, 2011; BirdLife International, 2014).

The illegal trade is facilitated by smuggling networks operating between Syria and Lebanon. Economic pressures caused by the war, such as widespread unemployment and poverty, have incentivized poachers to engage in falcon hunting, especially given the instability of governmental agencies responsible for nature preservation and the absence of effective law enforcement, Although Syria has approximately 3 million hunters, only around 300 possess official hunting permits, which further exacerbates the challenge of controlling illegal hunting activities (ARIJ, 2012; Mauvais, 2022b).

This illegal falcon trade has grown into a popular business, further facilitated by the rise of social media pages dedicated to hunting and selling these birds. These pages act as marketplaces, providing a simple platform for buyers and sellers to connect. Demand is largely driven by wealthy individuals from the Arab Gulf, with falconers seeking migratory species such as saker and peregrine falcons, which typically sell for between $6,000 and $60,000 USD (ARIJ, 2012). Traditional hunters have voiced concerns about what they call “hunting intruders,” arguing that this new wave of hunters lacks the ethics of the old tradition and shows no respect for established hunting rules. Moreover, a number of local Syrian and Arabic news agencies produced reports addressing this emerging issue and warned of the outcomes that would occur if the necessary conservational actions haven't been taken (ARIJ, 2012; Jamous, 2022).

2.3.1.3. The mass killing of the Arabian sand gazelle

Another example of hunting threatened species is the Arabian sand gazelle (*Gazella subgutturosa* spp. *Marica*) an antelope which is found in southwestern Syria. This gazelle inhabits the Black Desert region of As-Suwayda governorate, characterized by basalt soils, scarce water resources, and a population of nomadic people (Mallon & Kingswood, 2001). Globally, this mammal is classified as Vulnerable on the IUCN Red List (IUCN SSC Antelope Specialist Group, 2017). Although it was once declared extinct in Syria, the species was reintroduced in 1996 by the Syrian government using individuals from a captive population at the King Khalid Wildlife Research Center in Saudi Arabia, releasing them into the At Talila Reserve in central Syria (Mallon & Kingswood, 2001).

The Arabian sand gazelle was also listed as a rare species in the IUCN Antelope Report in 2001, with 101 individuals observed in the Al Harrat Desert of As-Suwayda in 1998 (IUCN SSC Antelope Specialist Group, 2017; Mallon & Kingswood, 2001). In an interview we conducted with a local environmental activist from the As-Suwayda region, he said that that during the period of Islamic State (IS) control over gazelle-inhabited areas (2013–2017), these regions became inaccessible to hunters. According to the activist, this temporary restriction contributed to a noticeable protection of the gazelle population. However, this protection was short-lived. After IS was defeated in 2018, illegal hunting of gazelles resumed—and even intensified. The activist emphasized that powerful individuals—mostly affiliated with the regime and equipped with weapons and off-road vehicles suited for desert terrain—have exploited their influence and access to protected or restricted areas in the As-Suwayda desert to engage in illegal hunting. These individuals, often coming from outside the region, have intensified the threat to the gazelle population.

Hunters targeted the entire gazelle population indiscriminately, showing no regard for young calves or reproductive seasons. Many posted photographs of the gazelles they hunted or captured on Facebook as a way to boast about their hunting skills (See Figure 2.3). Information from monitoring local Facebook hunter groups showed that at least 75 gazelles were reportedly killed in 2022; however, the actual number is likely higher, as not all hunters share their activities publicly (Bahhah, 2022a; Daw, 2022). The hunted gazelles were either consumed, sold alive, or mounted. Young calves were particularly valued and sold for approximately $600 USD (equivalent to 3 million Syrian pounds in 2022), while adult gazelles were typically sold for less.

Another activist and expert in wildlife conservation named Dr. Ahmad Aidek stated during an interview with him:

“The current hunting situation in As-Suwayda can be described as ‘extermination’; it is mainly caused by the economic crisis in the country and hunters bragging about killing the largest number of gazelles”

According to local reports, hunting in Syria was more respectful and less frequent before the war. Residents recalled enjoying the sight of gazelles roaming near their properties—an experience that has since vanished, as gazelles have developed a deep fear of humans. The gazelle holds long-standing cultural significance in Syria; it has inspired folklore songs, poetry, and music celebrating its beauty (Fakhri, 2022). The Arabic name for the gazelle, *Reem*, is also a popular female name in Syria and other Arab countries (Babynames, 2022). In response to the recent mass killings, several activist groups—such as The Syrian Wildlife Hobbyists, Oaks, the Group for the Protection of Syrian Wildlife, and Discover the Syrian Wildlife—have condemned the indiscriminate slaughter of gazelles, describing these acts as barbaric and destructive.

Illegal gazelle hunting continues despite the government hunting regulation law that prohibits all types of wildlife hunting in all Syrian Arab Republic territory for a year, beginning February 27, 2022, and ending February 26, 2023 (The Syrian Presidency Website, 2022).

Figure 2.3 *The illegal hunting of the threatened gazelles. Source Zawaya Media.*

2.3.2. Soil, Water, and Air Pollution Conflicts

2.3.2.1. The thermal power plant oil spill in Baniyas

The thermal power plant in Baniyas is one of the five power stations in charge of supplying the country with electricity, it is situated in the city of Baniyas in northwest Syria and provides around 20% of the country's electrical needs (ESyria, 2003).

On August 23, 2021, a massive oil leak was reported at the Baniyas power plant, caused by the deterioration of an oil tank due to wear and tear. This incident was largely attributed to inconsistent and insufficient maintenance of the power plant infrastructure—an issue exacerbated by the war, which significantly reduced the Syrian government's capacity to perform routine environmental monitoring and enforce regulations on energy infrastructure (PAX, 2021). The leak released approximately 15,900 tons of TTP oil into the Syrian Mediterranean coast (PAX, 2021). Despite efforts by the Syrian government to minimize the disaster, satellite images revealed that a strong oil stream extended northwest from Baniyas to Cyprus and Türkiye (REMPEC, 2021) (See Figure 2.4).

Dawoud Darwish, the head of the Tartus electricity workers union claimed on the 24th of August 2021 that the fuel leak had been contained. He also stated that some fuel from one of the thermal station's fuel tanks flowed into the sea due to wear and tear, and that the tank contained only 15,000 tons of fuel (Jazaeri, 2021). Darwish's statement was followed by another statement on 30th of august by Ghassan el-Zamel the Syrian minister of electricity told Alwatan newspaper that (Alwatan, 2021):

> *"What happened cannot be described as pollution, but the incident was noticeably hyped through social media, the fuel that reached the sea does not exceed 4,000 tons"*

The oil spill had a direct and severe impact on local fisherfolk and their livelihoods. Reports indicated that fish sales in the nearby city of Tartus dropped by 60% following the spill, accompanied by a significant decrease in fish prices (Alwahda, 2007; SyriaTV, 2021). Fisherfolk along the Syrian coast refuted official claims downplaying the disaster's effects, stating that they were forced to relocate their fishing areas to avoid the spread of oil slicks (Baz News, 2022; REMPEC, 2021). Khalid, a local fisherman said to Daraj Media. (2021):

> *“From the very first hours of the spill, the Syrian government downplayed its severity through a counter-media campaign claiming it was a minor issue, while locals could clearly see the dark oil slicks staining the sea water black"*

Syrian officials responded to the oil spill with outright denial, relying on familiar conspiracy-driven narratives to deflect attention from underlying issues of corruption and mismanagement. Instead of addressing the crisis with transparency, the Ministry of Oil refrained from making any public statements and distanced itself from accountability (Daraj Media, 2021). In contrast, a technical expert emphasized that a rupture of such magnitude would not have occurred suddenly. Given the metallic composition of the tank, structural failures would have developed gradually over time. Notably, maintenance teams had detected signs of cracking nearly two weeks before the incident, yet no action was taken to address the issue — raising serious questions about the oversight, accountability, and safety protocols in place at the facility.

Despite local denial of the disaster, international organizations highlighted the severity and extent of the oil spill. For instance, the Regional Marine Pollution Emergency Response Center for the Mediterranean (REMPEC) produced a report detailing the causes and timeline of the incident. The report also documented Cyprus’s monitoring and response efforts and offered support to affected countries, including Syria, Cyprus, and Türkiye. REMPEC proposed assistance and training for local authorities to help manage the consequences of the spill and to build capacity for future emergency response efforts, underscoring the transboundary nature of marine pollution in the Mediterranean (REMPEC, 2021).

The World Wildlife Fund (WWF) also issued a written statement along with satellite imagery, expressing serious concern over the ecological and socioeconomic impact of the leak. The WWF warned of both immediate and long-term consequences for marine life, coastal communities, and local livelihoods. They urged affected nations to raise funds and act quickly to clean up the contaminated areas to prevent further habitat degradation, protect biodiversity, and reinforce oil and gas infrastructure to minimize the risk of future disasters (WWF, 2021).

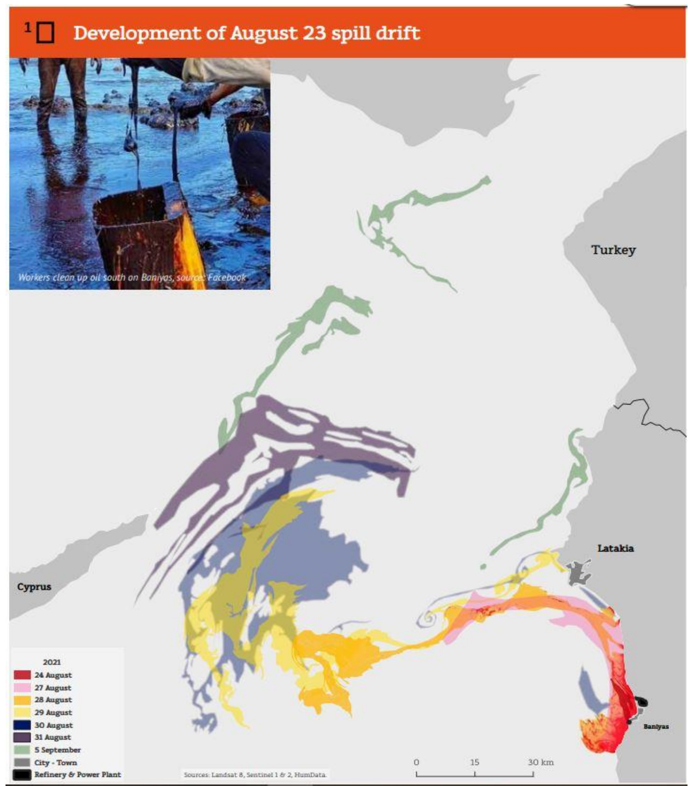

Figure 2.4 *The oil leak from Baniyas thermal power station captured by satellite images. Source: [PAX For Peace](#).*

2.3.2.2. Air pollution by the Tartus cement factory

The Tartus cement factory is one of the largest state-owned cement factories in Syria. It is located in the governorate of Tartus, western Syria, and about 1.5 kilometers away from the Mediterranean Sea. The area of the factory is surrounded by agricultural lands that are mainly cultivated with olive trees and greenhouses (Kayyal, 2005). For decades, Tartus residents and people who are living nearby the factory have been concerned about the pollution coming from the city's cement industry. The daily exposure to cement manufacturing dust threatens people's lives and livelihoods as it can travel over 10 kilometers before precipitating on land and sea (Kayyal, 2005).

In the vicinity of the factory, average dust particle concentrations range from 115 to 486 $\mu g/m^3$, exceeding the World Health Organization's recommended limit of 150 $\mu g/m^3$. Data from the National Environmental Action Plan (NEAP) indicate that levels of total suspended particles (TSP), PM_{10}, and PM_3 in the surrounding air surpass both international and Syrian air quality standards (Kayyal, 2005). Research conducted by the Ministry of Health in 2005, found that the towns and villages near the Tartus cement factory had higher incidences of bronchitis and respiratory illnesses than similarly situated clean areas (Kayyal, 2005).

Many residents of the villages surrounding the plant stressed that the amount of falling dust is unbearable and some of them said that if the situation continues as it is they will have no choice but to leave their homes for a more suitable living area (Al-Bashir, 2022). They also pointed out that the demand for a solution to stop the pollution rose in 2016 but was never answered (Al-Bashir, 2022).

According to the Ministry of Justice, dozens of lawsuits are filed annually against the factory by nearby property owners seeking compensation for damages caused by dust emissions from the factory's kilns (Al-Thawra Newspaper, 2020). In Husayn al-Baher—the village most affected by the cement dust—the head of the agricultural association and a local agricultural engineer expressed their concerns to the local media, stating:

> *"Tartus Cement Factory's compensation is far less than the real damage to our properties and agricultural income"*
>
> *"We can't breathe, and we can't even sit outside of our houses"*
>
> *"Our food, clothes, and land are contaminated with the dust that is coming from the factory"*

The factory does not only have an impact on people's health, livelihood, and agriculture, but it has also reduced the value of their properties. As with any property for sale, the square meter is valued at less than half of its true value because it's location near to the factory (Alsameh, 2022).

The factory´s filters needed to be replaced but the current economic hardships and the western blockades made it harder for the company to get new filters. The company's general manager, Hilal Omran, who took over in mid-May 2020, confirmed that the technical situation is bad, and that work is being done by its cadres to improve it as much as possible, indicating that the company is serious about improving the performance of the company. He also stressed that the current filters used to cut down on pollution are old. The supply and installation of new cloth filters to end pollution is linked to the economic feasibility, as well as the wear and ageing of equipment, and the difficulty of obtaining replacement parts of foreign origin (mechanical, electrical, electronic equipment) due to the country's economic blockade due to the ongoing war (AlMashhad, 2020). As of March 2022, Syria ranked as the third most sanctioned country globally, following Russia and Iran, according to statista.com. Various countries, including the European Union (EU), the United Kingdom (UK), United States (US), Canada, Switzerland, Australia, and others have implemented targeted individual and sectoral restrictive measures, on Syria (Leclerc, 2023)

While international sanctions significantly impact the Syrian economy and its institutions, they are not the sole catalyst for the pollution attributed to the factory. The authorities often use the economic situation as an excuse for their shortcomings. Media reports extensively highlight corruption within the factory, ranging from neglecting the health of workers to directors and procurement departments enriching themselves through embezzlement. This corruption underscores its persistence and links it to a systemic issue rooted in a nepotistic appointment system embedded in the Syrian governmental institutions (Krayem, 2023).

Ziad Haidar, a well-known journalist and writer from the village of Husayn al-Baher, authored the novel *Awaiting the Northern Winds*, which portrays the daily lives of those living near the Tartus cement factory highlighting a complex relationship between the community and the factory. Haidar notes the dependency of many residents on the factory for employment, which complicates their stance on its contamination: *"The factory is poisoning us, true… but in return, it feeds us. Our children work there, and if they didn't have that opportunity, they wouldn't have any other place to earn their living."* The narrative also explores the intersection of war and environmental degradation, showing how pollution—especially cement dust—permeates every aspect of life. In addition, the novel critiques corruption within the factory's management and subtly attributes responsibility to the broader political regime in Syria (Haidar, 2024).

In response to the prolonged pollution issue and delayed action, the people of the affected areas demanded to relocate the factory and use its location for residential and tourist installations. They stressed that the location of the factory has a lot of tourist potential, and the building of this factory was hampering it (OSJ News, 2021). Despite all the complaints to the authorities, some people from Husayn al-Baher village said that they have been promised a solution to this situation for 3 decades while the authorities promised to install smoke filters, but it was never implemented (OSJ News, 2021).

2.3.2.3. Wadi Al-Hudda landfill in Tartus

Residents of the Tartus governorate have suffered for decades from the pollution caused by the Wadi Al-Hudda solid waste treatment plant. Established in 2004 near the city of Tartus, the facility spans approximately 10 hectares and processes municipal solid waste from across the governorate. It was originally designed to handle around 400–450 tons of waste per day, which matched the estimated daily waste production of the region at the time (Shaheen et al., 2013).

Following the outbreak of conflict in Syria, the Tartus governorate experienced a significant influx of displaced individuals, leading to a notable rise in population. According to UNHCR data, by 2021, internally displaced persons made up approximately 19.47% of the governorate's population—around 180,735 people (UNOCHA, 2021). As a result, the total population grew to 929,366 people, and daily waste generation increased to 800 tons (Ahmad, 2022). This surge placed considerable strain on the Wadi Al-Hudda waste treatment plant, which struggled to manage the escalating volume of waste. By 2019, the plant was receiving between 500 and 600 tons of waste per day and required a new landfill to accommodate the rejected materials from the treatment process (Ahmad, 2022).

Residents of villages surrounding the Wadi Al-Hudda landfill have faced serious environmental and health consequences due to pollution. In Al Zarkat village, for instance, over 100 wells have reportedly been contaminated, with several cases of poisoning linked to the consumption of polluted water. As a result, residents are forced to rely on bottled water, which costs around 2,000 Syrian pounds per bottle—an enormous burden given that the average monthly salary in Syria was just 100,000 pounds (approximately $23 USD) in 2022 (Haid, 2022). More than 15,000 people became affected by the pollution, and there was a growing concern that the area's drinking water may soon become entirely unsafe. Beyond water contamination, the landfill has also contributed to other public health issues, such as increased mosquito populations and widespread garbage accumulation along the Safita–Tartus road (Cancer – Wadi Al-Hudda Landfill, Together We Will Shut It Down, n.d.; Nisafi & Al-Jubaili, 2018). Public concerns were confirmed by a 2013 study, which identified significant bacterial contamination in water sources within the Wadi Al-Hudda area. The study reported elevated levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD), indicating serious pollution. This contamination was attributed to the leaching of waste and asphalt aggregate from the landfill (Shaheen et al., 2013).

Despite residents raising concerns and complaints with their governmental representatives, there has been a noticeable lack of action. The issue of the Wadi Al-Hudda landfill has neither been taken seriously by the relevant authorities nor addressed by members of Syria’s People’s Assembly, the legislative body in parliament. The landfill continues to pose a significant threat to the local community, with residents deeply worried about its harmful impact on their health and well-being.

In response to such inaction, an online campaign called *"Cancer – Wadi Al-Hudda Landfill, Together We Will Shut It Down"* has emerged to advocate for the landfill's closure. The Facebook page, which has gathered around 3,000 followers, raised public awareness and encouraged action by locals. Campaigners have also organized public events to highlight the issue and mobilize community support, urging local authorities to close the landfill and adopt alternative waste management practices.

On August 15, 2021, the movement escalated its efforts by organizing a street protest that blocked access to the landfill, preventing trash trucks from entering. Protesters condemned the ongoing operation of the Wadi Al-Hudda landfill, which they consider the largest environmental disaster on the Syrian coast (Enab Baladi, 2021; Scoop, 2021).

Despite reaching its maximum capacity in 2017 and the expectation that it would cease receiving waste, garbage from the Tartus governorate continues to be dumped there daily causing ongoing harm to residents and with no clear solution in sight.

2.3.2.4. Al Bassa landfill in Latakia

Al Bassa landfill in Latakia was opened in the beginning of the 1970s. It was under the supervision of the Latakia city council, and it was supposed to be closed by 2009 (Nisafi & Al-Jubaili, 2018). By 2011, the landfill had reached full capacity, yet it continued to receive 800–1000 tons of waste daily from Latakia city and its countryside. The garbage was dumped without soil cover or treatment, creating massive, uncontrolled mounds—estimated at 1 million tons of uncovered waste by 2019 (Nisafi & Al-Jubaili 2018).

During the ongoing war in Syria, the volume of waste dumped at the landfill increased significantly as Latakia's population grew due to an influx of refugees (UN-Habitat, 2014). The site also posed serious environmental and health risks, with an estimated 5–7 m^3 of leachate per day seeping into the soil, groundwater, and eventually the nearby sea, thereby contaminating water, air, and soil quality (Nisafi & Al-Jubaili, 2018).

Nasser and Ahmad (2019) found that nitrate and phosphate levels in groundwater near the Al-Bassa landfill often exceeded safe drinking water standards, indicating contamination from solid waste. Additionally, soil samples revealed elevated levels of heavy metals such as nickel, lead, and cadmium (Nisafi & Al-Jubaili, 2018). The uncontrolled burning of trash mounds also posed other health risks on the surrounding communities, while the landfill became a breeding ground for disease-carrying animals like mosquitoes, rodents, and stray dogs. Waste pickers searching for recyclable materials also contributed to further waste dispersion (Nasser & Ahmad, 2019; Nisafi & Al-Jubaili, 2018).

In response to the lack of effective waste management and the authorities' inaction, residents protested through various means—including blocking roads leading to the landfill, filing formal complaints, and voicing their concerns via television, newspapers, and radio. They also leveraged social media platforms like Facebook and YouTube to raise awareness and demand accountability (Ninar, 2018; SyriaUntold, 2019).

Residents living near the Al-Bassa landfill voiced deep frustration over the long-standing environmental and health impacts. One resident lamented:

> *"The situation is bad; there are garbage piles everywhere, and smoke is spreading too. The landfill is located on one of the most beautiful beaches in the Mediterranean, which could have been a national treasure before the landfill was built"*

Despite repeated government promises over six years to relocate the site, the issue persists:

> *"Every time we ask, they say they will relocate it within the next six months"*
>
> *"The dump has harmed our farmers and agricultural lands, and our groundwater has been poisoned"*

Another farmer stated the crisis has also devastated local agriculture:

> *"A huge portion of our citrus-planted lands was damaged, and the cost of pesticides on our seasonal crops exceeds the total amount of money we earn from producing them"*

Beyond environmental degradation, health concerns are expressed by local doctors:

"The effects are not limited to our agriculture. People are also suffering from the health effects—we had some cases of leishmania"

On January 27, 2022, the Syrian Arab News Agency (SANA) announced the closure of the Al Bassa landfill following the establishment of a new site in Qasieh, in the Al Haffa region of Latakia. The report claimed that the new landfill would resolve the long-standing environmental pollution caused by Al Bassa, which had exceeded its design life and become a major concern due to ongoing waste incineration and resulting smoke emissions (SANA, 2022).

2.3.3. Noise Pollution Conflicts

Hmeimim Airbase, located in Syria's Latakia governorate along the Mediterranean coast, serves as the primary hub for Russian military air operations in the Syrian war. The base's legal status was formalized through a bilateral agreement signed between Russia and Syria in 2015, which granted the Russians the right to use of the facility (Hamilton & Miller, 2020).

According to an article published by *Al-Quds Al-Arabi*, a civil engineer from the area explained that Russian military jets taking off at low altitudes near residential areas and produce intense sonic boom, white exhaust clouds, and powerful air pressure. These forces can compromise the structural integrity of nearby buildings by disturbing their foundations and increasing load stress, which may cause cracks, shorten building lifespans, and potentially lead to collapse. The engineer warned that continued low-altitude flights could have "disastrous" consequences for both the town's infrastructure and its residents (Al-Quds Al-Arabi, 2015).

A real estate office owner in the town also confirmed that the price of buildings has fallen by a quarter and that the town's urban movement has come to a complete halt due to the displacement of more than half of its population that is estimated at 15,000 people (Al-Quds Al-Arabi, 2015). The situation in Hmeimim has been described as catastrophic by locals due to the loud noises made by planes. Children in the area have reportedly been terrified, and some residents have even reported damages to their sense of hearing (North press agency, 2021). The residents of Hmeimim and the surrounding villages have also reported that the residential buildings in the town are experiencing cracks on their walls and rooftops that are getting wider every day. The rental of houses has stopped, and the town is said to be falling apart (Al-Quds Al-Arabi, 2015; North press agency, 2021).

Some residents have also raised concerns about the safety risks posed by the base, including the potential for accidents or missiles falling from military aircraft. While these concerns have been expressed cautiously, there is no clear evidence of organized public mobilization in response to the issue.

2.3.4. Water Management Conflicts

2.3.4.1. The stoppage of Allouk water station on Al-Khabur river

The Al-Khabur River originates in southeastern Türkiye and flows into northeastern Syria, spanning a total length of 388 kilometers—308 of which lie within Syrian territory. It is the largest of the three tributaries feeding into the Euphrates River and has the highest annual water flow among them (UN-ESCWA & BGR, 2013).

In 2019, with the approval of U.S. President Donald Trump, Türkiye launched a military operation in northeast Syria known as Operation Peace Spring. The offensive displaced over 200,000 people and relied on Syrian non-state armed groups acting as Türkiye's ground forces, who have since been accused of committing war crimes. Turkish president Recep Tayyip Erdoğan has declared his intent to extend control over a broader swath of Syrian territory to establish a so-called "safe zone" for resettling Syrian refugees currently in Türkiye. However, Human Rights Watch and other international observers have raised serious concerns about the potential for demographic engineering and human rights violations in these zones, particularly by Türkiye-backed militias (Human Rights Watch, 2022; OCHA, 2019).

2.3.4.1.1. The Impact of the Allouk Water Station Shutdown on Northeast Syria:

The Allouk water station, located on the Al-Khabur River and described by the United Nations as "the primary source of clean drinking water for 460,000 people," has faced repeated disruptions since November 2019 due to Turkish military strikes, totaling 24 recorded stoppages (OCHA, 2019). On June 23, 2019, the station ceased operations due to restricted access for maintenance and repairs, compounded by power shortages—leading to a severe water crisis across the Al-Hasakeh Governorate. It was again shut down by Turkish airstrikes in October 2019. The ongoing disruptions have affected up to 1 million people, including displaced families in refugee camps and informal settlements, who are especially vulnerable (UN, 2021). Türkiye has been accused of acting as an occupying power in parts of northeast Syria and of using the closure of the Allouk station as a bargaining tool in negotiations with the Kurdish-led autonomous administration. (PAX, 2022).

2.3.4.1.2. Water Shortages and Disease Outbreaks

The repeated shutdowns of the Allouk water station have exacerbated a critical water shortage, significantly hindering public health efforts—particularly in controlling the spread of COVID-19. Limited access to clean water for essential hygiene practices, such as handwashing, has placed children and families at heightened risk of infection. In addition to the pandemic-related risks, the drought of the Al-Khabur River has created favorable conditions for the proliferation of sand flies, which transmit Leishmaniasis, contributing to a rise in disease cases in nearby villages. In September 2022, the Syrian Ministry of Health declared a cholera outbreak, described by the former UN Humanitarian Relief Coordinator as a "serious threat" to the Syrian population and the wider Middle East region (UN, 2022).

2.3.4.1.3. Water Shortages and Agriculture loss

Local farmers in the Al-Khabur Valley have reported that reduced water flow from the river has led to significant losses in both agriculture and livestock. They noted that the declining river levels have increased the concentration of pollutants, making the water unsafe for animals to drink. As a result of the water shortage, farmers are unable to irrigate their fields as they once did. Land that was previously used to cultivate cotton, barley, wheat, and rice has now become barren (Al Jazeera, 2022).

In addition to its impact on agriculture, the water shortage has also severely affected the fishing industry, with local fisherfolk reporting significant declines in their livelihoods due to reduced water levels (ANHA, 2022). The Director of Water Resources within the Shaddadi Agriculture Committee has issued warnings about an imminent disaster, citing the collapse of agriculture and livestock—both of which are vital pillars of the region's economy and essential to residents' survival (ANHA, 2022). Local estimates suggest that at least three million people became at risk of food insecurity due to disrupted irrigation systems, a crisis expected to persist unless rainfall levels increase. Moreover, the shortage is also compromising the availability of clean drinking water across the region, exacerbating an already fragile humanitarian situation (Sadaa alwaqie alsuri, 2021).

The worsening water crisis has not only devastated agriculture, livestock, and public health—it has also galvanized strong grassroots and civil society responses across northeast Syria. In reaction to Turkish airstrikes on the Allouk Water Station and the systematic denial of water, local residents organized protests to denounce these actions. In Al-Hasakah, students and teachers, led by the General Activities Committee of the Educational Complex, marched in protest against the water cuts, carrying banners that read, “Even if we die of thirst, you will not kill our free will.” Similar protests erupted in Kobani, where civilians and civil society groups disrupted planned joint Russian-Turkish patrols in defiance of ongoing violations (North Press Agency, 2020). (See Figure 2.5)

In addition to local demonstrations, 124 organizations—including GAV Relief and Development, the Class Peasant Union, and multiple professional unions from North and East Syria—have jointly called on the international community to demand that Türkiye uphold international norms regarding transboundary water sharing. Major international actors, such as PAX for Peace, UNICEF, Human Rights Watch, OCHA, and the UN, have echoed these concerns, issuing reports that document the humanitarian consequences of the water blockade. The UN has explicitly urged all parties to restore the water supply, ensure humanitarian access, and protect civilians—a clear recognition of the urgency and scale of this man-made water crisis (PAX, 2022; Violations Documentation Center, 2021).

Figure 2.5 *Shows the damages on the Allouk water station pipes (Syrians for Truth and Justice), Student protests (North Press), and People collecting water in barrels due to the shortages (Sewar Magazine)*

2.3.4.2. The Barada river pollution and water infrastructure destruction

The Barada River is a vital resource for the city of Damascus, stretching 84 kilometers in length. It provides drinking water to a large portion of the population and irrigates vast agricultural lands in the al-Ghouta region. Beyond its practical uses, the river forms a lush oasis in the otherwise arid landscape surrounding Damascus, serving as a space for recreation and tourism. Overall, the Barada River plays a crucial role in supporting the social, economic, and environmental well-being of the region (Al Haddad, 2008; Kattan, 2006).

The pollution of the Barada River has been a longstanding issue that has only gotten worse over time (See Figure 2.6). Once a symbol of natural beauty, the river has become a serious concern for the residents of Damascus. Many now avoid walking near its banks for fear of disease or mosquito bites. The Barada has long suffered from multiple sources of pollution. With over 4 million residents, Damascus and its surrounding areas produce more sewage than the city's outdated treatment facilities can handle. As a result, untreated sewage is frequently discharged directly into the river, contaminating it with harmful bacteria and pathogens. Industrial waste also contributes significantly, as many factories release chemicals and toxins into the water. In addition, agricultural runoff—from fertilizers and pesticides used on nearby farms—further degrades water quality. These various forms of pollution pose significant threats to the health and well-being of the local population and the environment (Al Haddad, 2008; Awad, 2014).

This crisis has been further exacerbated by the ongoing conflict in Syria, which has led to a large influx of internally displaced people into Damascus. As of 2022, more than 600,000 people—about 33% of the city's population—had settled in the capital (UNICEF, 2022). This significant population increase has placed additional strain on the city's already overburdened water infrastructure, resulting in a rise in domestic wastewater discharge into the Barada River and intensifying the existing pollution problem.

During the Syrian war, control of the Barada River was used as a weapon of war by both the government and opposition groups. In 2017, the battle of Wadi Barada took place between the Government and opposition, with the government accusing the opposition of dumping large quantities of diesel into the source of the city's water supply, leading to the shutdown of the water supply to Damascus (OCHA, 2017). The opposition, on the other hand, claimed that they cut the water supply as a pressure tactic to prevent the government from overrunning the area (OCHA, 2017).

In addition to the weaponization of water, the war also caused significant damage to critical water infrastructure. In 2016, the Assad government dropped a number of barrel bombs on the Ain al-Fijeh spring—one of the main water sources feeding the Barada river and supplying drinking water to Damascus. The attack partially destroyed the facility, leading to water contamination and cutting off access to clean water for thousands of residents in the capital (SNHR, 2017).

The pollution crisis of the Barada River has mobilized activists, NGOs, and academic institutions to raise awareness and advocate for restoration, but their efforts were hindered by limited resources and ongoing political instability. The pollution of the Barada River raises significant environmental justice concerns, exposing local communities to serious health risks and the erosion of cultural heritage. In response, grassroots initiatives—such as Bedayat and the

Friends of Damascus Association's campaign, *"Let's wash the fatigue away from Barada"*—have mobilized volunteers for clean-up efforts, even amid the dangers of ongoing conflict (Al-Omar, 2019; Bahah, 2025; ESyria, 2010). These actions reflect a deep-rooted community commitment to reviving the river. As Soulaima Jabi, chairwoman of the nonprofit Bedayat Foundation, stated:

"The war will one day end. But the Barada River must not"

While Syrian government authorities have officially acknowledged the problem—conducting pollution assessments and allocating funds for cleanup and treatment projects—the actual efforts have not been translated into significant, lasting improvements on the ground. (Al-Omar, 2019; Bahah, 2025; ESyria, 2010).

The river's condition continues to deteriorate, and public complaints often go unresolved, reflecting a persistent governmental neglect of both the environmental and social impacts of the crisis.

Figure 2.6 *Pollution in the Barada river (Raseef22, Golan times, Dam press) and the destroyed water infrastructure in the aftermath of the war (The new humanitarian).*

2.4. Discussion:

In this section, we identify recurring patterns in the war related drivers of environmental impacts that emerged from the case studies. We first discuss people´s response to the environmental injustices caused by the war by exploring the specific forms and drivers of the environmentalism that rose in Syria. Next, we analyze two prominent war-related drivers of environmental degradation in Syria, namely the foreign military interventions and the weakened governance of the Syrian government. Finally, we discuss the cultural consequences of the war as an unseen and underreported result of violence.

2.4.1. The Environmental Activism in The Context of War in Syria

2.4.1.1. Reasons to protest

Environmental activism in Syria—and across the broader MENA region—cannot be meaningfully analyzed in isolation from the entrenched socio-economic struggles that shape it. These movements are not driven solely by ecological or conservationist concerns; rather, they are deeply embedded in local communities' resistance to exploitative, neoliberal, and extractive state agendas (Choucair Vizoso et al., 2021). In these contexts, environmental degradation is inseparable from political marginalization and systemic inequality.

Syria has long suffered from the structural injustices faced by many MENA countries, including economic marginalization, authoritarian governance, and environmental mismanagement. However, the eruption of war drastically exacerbated these conditions, intensifying pre-existing inequalities while producing new forms of dispossession. By 2021, over 90% of the population was living below the poverty line, and nearly half had been forcibly displaced from their homes (OCHA, 2021). In this context of extreme deprivation, reliance on land and natural resources has become a crucial means of survival for impoverished and marginalized communities. Their struggles to defend access to clean water, air, and arable land increasingly take the shape of environmental justice claims—expressed not through conservationist language, but through appeals to dignity, survival, and the right to remain safely and autonomously on their land.

This context calls for a rethinking of how environmental action is framed especially in regions like Syria. The grassroots mobilizations of farmers, fisherfolk, and rural residents—in areas like Al-Hasakah, Wadi al-Hudda, and Bassa—show that communities have responded to toxic landfills, poisoned water, declining agricultural yields, and polluted air not as environmentalists in the conventional sense (as many of them do not identify as environmental activists), but as people defending the very means of their survival. Here, environmental activism assumes a form radically different from elite conservation-centered models often seen in the Global North. Instead, what emerges resonates with Joan Martínez-Alier's (2002) concept of the "environmentalism of the poor": a form of resistance where environmental defence is inherently tied to material struggles over land, livelihood, and dignity. This framing challenges narrow definitions of environmentalism and demands a broader, more inclusive understanding rooted in justice and equity.

The similar struggles can also be observed across the region. Lebanon's "You Stink" movement, though more overtly political and urban in character, emerged in response to the government's mismanagement of waste and its direct impact on public health on the struggling and impoverished Lebanese population (Kraidy, 2016; Orrnert, 2020). Like Syria's local mobilizations, it illustrates how environmental injustice is a lived experience for the poor and marginalized—one that prompts collective action not as a matter of ideology, but necessity.

Finally, we suggest that further research is needed to examine how wartime conditions catalyze and intensify grassroots environmentalism of war affected communities, and to expand the framework of the environmentalism of the poor to account for conflict-affected contexts—where environmental action emerges not from ideological commitment, but from the socio-ecological adaptations of communities navigating extreme precarity.

2.4.1.2. Forms of protest

To better understand the nature of environmental activism in Syria, we applied the framework developed (Sowers, 2018) (as presented in the introduction section), which categorizes environmental activism in the MENA region into three primary forms: 1) Informal protests, 2) Formalized efforts, 3) Popular resistance campaigns.

Our analysis revealed that informal protests constitute the most common form of environmental activism in Syria. These typically emerge as grassroots, reactive responses to acute environmental harm, especially when it threatens public health and livelihoods. Communities—including farmers, fisherfolk, and residents—mobilized independently of formal organizations, often through spontaneous or loosely coordinated actions. For instance, in the villages surrounding the Wadi al-Hudda and Al-Bassa landfills, as well as the cement factory in Tartus, residents organized road blockades and online campaigns in response to years

of unregulated dumping and hazardous emissions. Their protests were sparked by state neglect and broken promises to address the issues, and were often framed as direct appeals to local authorities (e.g., governors or municipalities) rather than confrontations with the national ruling elite.
Despite their persistence, these actions remained cautious—reflecting the fragile political environment and fear of repression—and were aimed at achieving specific, tangible improvements such as landfill closures, relocation, or pollution mitigation. While residents used tools such as Facebook campaigns, petitions, and legal complaints (in the case of the cement factory).

The role of civil society, NGOs, and journalists remained limited, characterized by a lack of direct action. Their involvement was primarily symbolic, expressed through public statements, media coverage, social media posts, news articles, and calls for participation in reforestation campaigns to raise awareness.

The popular resistance campaigns that is more structured and organized environmental activism, though less common, was observed particularly in regions with relatively more political openness—most notably in Kurdish-controlled northern Syria and especially after the withdrawal of the Syrian state forces in 2012 (Hamelink et al., 2025). Here, formalized efforts took shape through coordinated mobilization by teachers, students, and civil society organizations who protested the Turkish military's targeting of water infrastructure. These organized marches and campaigns were characterized by planned events, public statements, and coordinated outreach, often backed by local institutions that enjoy greater civic space. The existence of functioning local governance structures and a somewhat protected freedom of expression in these areas has allowed for more sustained and visible activism. As a result, new ecological movements have emerged in Kurdish areas to campaign against dam construction, oil extraction, and deforestation. Groups like the Mesopotamian Ecology Movement have played a key role in raising awareness, mobilizing communities, and advocating for environmental justice (Hunt, 2019).

2.4.1.3. State's response

The state's response to environmental degradation and activism that we showed in our case studies reflects a broader pattern of denial, deflection, empty promises, and delayed action, prioritizing regime stability and elite interests over people's well-being. We did not find evidence of arrests among those who voiced environmental complaints. This may be because protesters deliberately avoided criticizing the ruling elite, choosing instead to negotiate cautiously with local authorities without crossing political red lines. Also, it could be because of heavy media censorship, which limits public reporting on repression.

When the oil spill off the Syrian coast raised serious concern, the Minister of Electricity downplayed it as social media exaggeration, minimizing the disaster despite visible impacts. This tactic of downplaying crises recurs in elite state narratives that suppress accountability and scientific truth to preserve regime image and counter environmental activism (Jacques et al., 2008). In Tartus, authorities have long ignored community complaints about pollution from the cement factory. Despite legal action and promises to install filters or relocate the facility, no real progress has occurred. Compensation is only granted after lawsuits, and endemic corruption within the factory highlights deeper governance failures tied to nepotism and impunity.

The regime often cites economic hardship and sanctions as excuses, yet reports suggest systemic corruption and weak institutions are the real barriers to effective environmental governance. Similarly, the state's 2022 ban on wildlife hunting has failed to curb illegal gazelle killings, revealing a disconnect between law and enforcement.

Even when action is taken—like the closure of the al-Bassa landfill in 2022—it comes after years of protest and damage, while other landfills such as Wadi al-Hudda remain active despite exceeding capacity. These examples demonstrate that environmental issues are addressed only when political pressure becomes unavoidable and public outcry demands action—yet responses remain largely symbolic, relying on superficial measures and rhetoric instead of meaningful structural reforms, functioning more as performative governance (Ding, 2020). In essence, environmental protection in Syria remains subordinated to regime preservation, selective enforcement, and performative governance.

2.4.2. The Environmental Cost of the Foreign Military Interventions in Syria

Syrians are grappling with the consequences of foreign intervention, as various regions of the country fall under the control of different states and armed groups. This has resulted in a fragmented environment within Syria's borders. These foreign entities often disregard the environmental impact of their military activities, significantly affecting local communities. One prominent example from our results is the Russian intervention, which led to the establishment of the Hmeimim air base near residential areas. This has introduced significant health risks, particularly in the form of noise pollution. The resulting disturbances have forced some residents to leave their homes, led to a decrease in property values, and disrupted livelihoods by restricting access to their land. Studies confirm that living near military airports not only harms people's quality of life but also has serious health repercussions. It undermines the sense of safety and contributes to increased psychological disorders, including anxiety and chronic stress (Hiramatsu et al., 1997; McKnight & Youmans, 1972).

Moreover, water has been used as a weapon of war in Syria, this tactic was also observed by other researchers (Abbara et al., 2022; Daoudy, 2020b). Our findings confirm this pattern, as critical water infrastructure—such as the Allouk water station in Kurdish-held areas—was subjected to bombing and shelling by Turkish forces and their allied militias. Such actions have had severe consequences, leaving the people of Al-Hasakah critically deprived of water for extended periods which led to the preventable spread of diseases like cholera and displaced large numbers of people. The tactic of weaponizing water underscores its vital importance as a source of life, as shortages or contamination can cause irreparable harm to communities; there is no substitute for this essential resource (Del Giacco et al., 2017).

In addition to these direct effects, it is crucial to highlight the indirect effects of foreign interventions on environmental degradation in Syria during the war. The lack of energy resources was exacerbated by ISIS's control over the country's oil and gas fields, which they exploited to finance their operations (Le Billon, 2023). After the defeat of ISIS, control over Syria's major oil and gas fields shifted to the U.S.-led coalition and Kurdish forces (Kukushkin, 2021). This transition led to an acute and abrupt disruption in energy access for millions of Syrians—particularly those in already vulnerable rural areas—who were cut off from the state's primary sources of fuel. The sudden deprivation of electricity, heating, and cooking gas forced communities to turn to forests as an immediate and accessible alternative. While this shift was driven by survival, the consequences have been ecologically devastating deforestation accelerated at an unprecedented rate, with over 20% of Syria's forest cover lost between 2010 and 2019 (Daiyoub et al., 2023).

2.4.3. The Socio-political Impacts of Weakened Governance, Failing Statehood, and Collapsing Borders

The war in Syria has significantly diminished the quality of government institutions. According to Bakkour & Sahtout, (2023), the institutional environment during the conflict became increasingly:

> *"Exclusionary, rent-seeking oriented, and distortionary, leading to substantial declines in government effectiveness, a widespread weakening of the rule of law, and heightened corruption"*

Moreover, Syria has a score of 13 out of 100, ranking 177 out of 180 countries in the Corruption Perceptions Index (CPI) report in 2023 (CPI, 2023). As shown in our case studies, government institutions largely ignored the public's pleas for solutions to contamination issues, particularly in relation to overflowing landfills exacerbated by the influx of refugees and a lack of preparedness on the part of the government.

The economic collapse and international sanctions further crippled Syria, severely hindering the maintenance of critical infrastructure. Resource shortages have led to the deterioration of facilities, particularly the thermal power plant in Baniyas and the Tartus cement factory, which have resulted in significant pollution along the Syrian coastal area.

Although sanctions had a significant effect on the Syrian economy, government officials often use them as a scapegoat to justify their own shortcomings, corruption, neglect, and the lack of alternative solutions. This is particularly evident in the cases concerning the cement factory and the Barada River, where officials concealed deep-rooted corruption within institutions, despite public calls for solutions that predated the conflict and became more urgent due to it.

The armed conflict has also resulted in ungoverned areas and uncontrolled borders, making law enforcement nearly impossible (like the hunting ban law by the Syrian government). In these regions, hunting and trapping of threatened species not only occur without oversight but are also facilitated by the chaotic spread of weapons, which has contributed to the increase in poaching of species like the sand gazelle (CEOBS, 2020; Syrian Network for Human Rights, 2022). Similarly, (Braga-Pereira et al., 2020) found that armed conflicts in southwestern Africa led to declines in mammal populations due to the proliferation of weapons and military bases within protected areas. Their study indicates that the socioeconomic and institutional changes resulting from armed conflicts have a more pronounced impact than direct war effects.

The power vacuum and fragmented governance have diminished the effectiveness of protected areas, while uncontrolled borders have facilitated the smuggling of threatened species, including falcons in Syria. According to (Nowrot, 2020), the challenge of combating illegal hunting is exacerbated during armed conflicts globally, particularly due to the exploitation of threatened bird and mammal species for consumption or trade. This situation is further worsened by the diminished capacity of conflict-affected nations to enforce laws aimed at preventing illegal wildlife trade. The emergence of uncontrolled spaces during conflicts fosters environments conducive to illegal activities.

2.4.4. The Ecocultural Impacts of the War: Syria's Unseen Precipice

The consequences of the war in Syria go beyond environmental destruction—they have also affected cultural and spiritual values, weakening people's sense of place. 'Place' is more than just a physical location; it represents the emotional and cultural bonds people form through lived experiences (Brown & Perkins, 1992), the war breaks down this connection in multiple forms and dimensions. For example, the Barada River in Damascus, once a symbol of inspiration and life, has transformed into a burden for residents due the unbearable level of pollution. Rania Qataf describes in her article, "Stranger in My City," how the pollution of the river has altered residents' relationships with the city of Damascus, forcing many to relocate to the suburbs, and making them feel that the city is no longer theirs (Qataf, 2021).

Another example can be found in Afrin, where the Kurdish population has faced significant hardships due to the Turkish invasion. The destruction of the Maydanki lake forest not only eliminated a leisure area but also a crucial site for the Nowruz festival, deeply tied to Kurdish identity and tradition. The interplay between environmentalism and cultural identity is evident not only among Syrian Kurds but also seen in regions like Rojhelat in Kurdish Iran, where environmental activism has emerged as a means to preserve and elevate Kurdish national identity and culture. The connection between Kurdish identity and the natural environment—forests, mountains, and rivers— shows how ecological preservation is inseparable from cultural survival of such marginalized groups like the Kurds (Hassaniyan, 2021).

Biodiversity significantly benefits the community's well-being by shaping the environmental qualities and physical characteristics of places that contribute to identity, sense of attachment and belonging. The decline of iconic species weakens the sense of place and diminish cultural connections (Hausmann et al., 2016). Thus, the declining populations of wildlife species like the saker falcon and the Reem gazelle not only disrupts ecological balance but also erodes cultural ties and shared identities for Syrians.

Research limitations:

Due to the ongoing nature of the war, limited access to reliable data, the authoritarian nature of the Assad regime, and the underreporting of environmental issues in warzones have all restricted the scope of this research. Further interdisciplinary studies covering wider regions of the country—drawing from ecology, political ecology, ecofeminism, conflict studies, and human rights —are urgently needed to fully understand the scale and complexity of wartime environmental damage in Syria.

2.5. Conclusions

This study presents preliminary yet critical empirical evidence of the environmental consequences of the ongoing war in Syria. Our findings reveal that the conflict has not only introduced new forms of environmental degradation but has also exacerbated long-standing ecological challenges. These effects are deeply entangled with the collapse of governance, the erosion of institutional capacity, foreign military interventions, and the fragmentation of territorial control across the country. As a result, Syria's ecosystems—along with the communities that rely on them—have been subjected to severe and compounding harm.

In the wake of this environmental crisis, activism has emerged as a powerful, if constrained, response. In many cases, these movements are informal, grassroots efforts rooted in local necessity and survival. Operating under an authoritarian regime, such actions tend to remain cautious, avoiding direct political confrontation. However, in areas with relatively greater political openness—such as regions controlled by the Kurdish-led Autonomous Administration—more organized and visible forms of environmental activism have taken shape. The Syrian state, by contrast, has responded with symbolic or dismissive gestures, primarily aimed at preserving its legitimacy rather than addressing the root causes of environmental harm.

These forms of environmental resistance align with Joan Martinez-Alier's concept of the "environmentalism of the poor"—a framework that emphasizes struggles not for abstract ecological ideals, but for basic human rights, health, livelihoods, and dignity. The Syrian case highlights how environmental justice movements can emerge not from elite advocacy, but from people's direct confrontation with material loss and injustice. In this sense, environmental activism in Syria is less about the preservation of nature in the abstract, and more about resisting systems of exploitation and marginalization that threaten survival itself.

In conclusion, Syria's environmental crisis cannot be disentangled from its political and social collapse. As our findings suggest, ecological harm in Syria is not merely collateral damage—it is central to the lived experience of war and the broader struggle for justice, sovereignty, and resilience. Addressing this crisis requires rethinking environmental protection not only as a technical or scientific issue but as a fundamentally political one—deeply tied to questions of governance, accountability, and the rights of communities to live in dignity on their land.

Chapter 03

The Impact of War on Forest Logging: Changes in Logging Practices in Syrian Rural Communities

Rural Women Bringing Firewood Home © Haitham al Khatib

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The Impact of War on Forest Logging: Changes in Logging Practices in Syrian Rural Communities

3.0. Abstract:

Syria has been struggling with a prolonged and brutal war for over a decade, leaving much of the country in devastation and its forests severely degraded. While many studies have identified logging for firewood as a significant driver of deforestation during the war, there is a notable absence of research specifically addressing logging behavior within the context of war. This research seeks to address this gap by examining the changes in logging behavior among local communities, the effects of violence and socioeconomic variables on wood harvesting, and finally the contribution of wood income to people's survival during the war. To do that, we conducted survey questionnaires in two coastal villages in Syria—Blouta and Nehel al Annaze—which experienced high and low levels of violence, respectively. Our findings reveal that logging activities increased once the war began, with more people involved in forest harvesting and average days spent logging per week significantly increasing from 1.5 to 4. Additionally, the war appeared to reduce the gender disparity in logging activities: before the war, women in Blouta engaged in logging significantly more frequently than men, but this difference became insignificant during the war. The amount of wood logged per month was not affected by the village's level of violence. However, it did vary with socioeconomic factors like gender and age: women logged less wood than men, and younger people logged more than older ones. Furthermore, earnings from wood harvesting significantly narrowed the gap between families' regular salaries and the income required to meet basic needs, covering 46.94 % of the shortfall in Nehel al Annaze and 84.83 % in Blouta. These results highlight the crucial role of forest resources in supporting rural livelihoods during times of war. Post-war effective forest management will be vital to ensure the sustainable use and recovery of forests, supporting both ecological restoration and economic stability for the rural communities.

Keywords: Warfare; Energy poverty; Syria; Firewood harvesting.

3.1. Introduction:

Mediterranean forests are highly diverse ecosystems that provide a wide range of ecological, social, and economic benefits that are crucial for the development of rural communities (Palahi et al., 2008; Scarascia-Mugnozza et al., 2000). According to Croitoru (2007), the average monetary value of non-timber forest products (NTFPs) such as firewood, cork, mushrooms, and others in the Mediterranean area was about €39 per hectare in 2005.

Croitoru (2007) also found that the collection of firewood was the most common practice in the forests of eastern and southern Mediterranean countries, accounting for 80-100% of the total wood collected in countries like Tunisia, Morocco, and Lebanon, with a significant portion (69% in Morocco) being collected illegally. The reliance on firewood as an energy source is not only prevalent in the Mediterranean area but also vital for the survival of rural communities globally. Furthermore, it is considered the most important product from local forests for rural populations in the developing world (Timko & Kozak, 2016). In sub-Saharan Africa, over 70% of rural communities depend on fuelwood to meet their energy needs for cooking and heating due to the absence of affordable alternatives (Matsika et al., 2013; M. G. Pereira et al., 2011). Similarly, in northern rural China, despite the country's economic growth, firewood consumption still accounted for 47.2% of total energy consumption in 2005 (Démurger & Fournier, 2011).

Consequently, the high demand and reliance on firewood as a primary source of energy could lead to unsustainable forest use, causing significant forest degradation that can negatively reflect on the well-being of poor rural communities (Kyaw et al., 2020). Globally, unsustainable wood fuel harvesting contributes to deforestation, forest fragmentation, loss of biodiversity, and increased greenhouse gas emissions (Bailis et al., 2015; Kyaw et al., 2020; Specht et al., 2015). The effects of unsustainable wood harvesting are well-documented, with a large body of literature identifying poverty and the lack of alternative energy sources, such as liquid gas, as the main drivers of this unsustainable use of forests (Agoramoorthy & Hsu, 2008; Cerutti et al., 2015; Soe & Yeo-Chang, 2019).

During times of war, the demand for energy resources becomes critical as wars often lead to rising oil prices and limits its availability for local populations (Asif & Muneer, 2007), this issue is especially true in rural areas, where access to services and energy is already limited (Cabello-Vargas et al., 2021). The impact of warfare on natural environments is evident across various global examples. In Kosovo, extensive forest degradation occurred due to logging activities during and after the 1998-99 war, leaving protected areas severely damaged (Bouriaud et al., 2014). Similarly, South Korea's mountains suffered severe defoliation during, and after the Korean War, driven by bombing, shelling, and illegal wood harvesting due to fuel shortages (Martin, 2023). In the Democratic Republic of Congo (DRC), two decades of violent conflict and increased mining activities have significantly contributed to deforestation in one of the world's largest tropical forests (Butsic et al., 2015). The rapid expansion of refugee camps in Sudan led to drastic depletion of local vegetation (Hagenlocher et al., 2012), while in Pakistan, the influx of Afghan refugees caused extensive deforestation due to the demand for agricultural land, fuelwood, and construction materials (Allan, 1987).

The war induced environmental degradation can also be seen in Syria, which has been grappling with armed conflict since 2011. The effects of this war have been catastrophic on the Syrian population, resulting in thousands of deaths, millions of displacements, and widespread destruction (UNHCR, 2024). The conflict has also caused extensive damage to the energy sector, depriving Syrians of the means to meet their basic energy needs (Alhaj Omar et al., 2023).

The critical demand for energy during the war in Syria forced people to use firewood as an alternative source, which had a negative impact on the forests. Numerous studies have been conducted to evaluate the war's effects on Syria's forests (Aldakhil et al., 2023; CEOBS, 2021; Daiyoub et al., 2023; Mohamed, 2021; PAX, 2023; STJ, 2023). The results of those studies showed a dramatic decline in forest areas since the onset of the war. For instance, Daiyoub et al. (2023) found that around 20% of the forests in the western region of the country were lost from 2010 to 2019. Additionally, a report by the Dutch peace organization PAX for peace in 2023 showed that the governorates of Latakia, Hama, Homs, and Idlib witnessed deforestation of over 36%, with deforestation rates doubling in 2020 and tripling in 2021 (PAX, 2023).

This deforestation is thought to be driven mainly by legal and illegal logging by forest communities and refugees, in addition to the impact of forest fires (CEOBS, 2021; Mohamed, 2021; PAX, 2023). The logging of forests was in demand for domestic and commercial firewood and charcoal for cooking and heating (Daiyoub et al., 2023; STJ, 2023). Access to fuel by locals and refugees was severely limited, with gas prices unaffordable for most of the population. This situation was worsened by the monopolization of the fuel and energy sectors and the fragmented control of the country (PAX, 2023). Most oil fields are not under the control of the Syrian government, further complicating the energy supply for Syrians (Alhaj Omar et al., 2023).

Although firewood logging is a significant contributor to deforestation in Syria during the war, there is a lack of research addressing this specific issue. The existing body of literature primarily focuses on broader deforestation trends like the change of forest area without isolating the specific role of firewood harvesting. Additionally, comprehensive, quantitative data on the extent of firewood harvesting in Syria is scarce to non-existent, even from the period prior to the war. For these reasons, this study aims to understand the changes in logging behavior of forest communities during the war in Syria and focuses on two villages that experienced different levels of violence.

The primary objective of this research is to examine how the war has influenced changes in forest logging behavior among two villages and to determine variables of impact. Concretely, we address the following questions: 1) Did the frequency of logging changed during the war? Are gender and violence intensity levels related to the frequency of logging days? 2) Do socioeconomic factors, such as gender, education level, age and others affect the amount of harvested wood? 3) How do people harvest wood during the war? 4) What is the economic contribution of forest harvesting to people's survival during times of war?

3.2. Methodology:

3.2.1. Study Area

The study area includes two villages: Blouta and Nehel al Annaze (Figure 3.1). Blouta is located about 50 km from the city of Latakia in the Latakia governorate. The village sits at an altitude of 750 meters above sea level, has an average annual temperature of 17°C, and an average annual precipitation of 1058 mm with the coldest month's minimum temperature at 3.8°C (Fick & Hijmans, 2017). The natural vegetation of the village is predominantly a Mediterranean *Maquis,* that is very rich in plant species, mainly composed of oaks such as *Quercus calliprinos (Al-sindian al adi) and Quercus infectoria (Al-sindian al ballouti)* as dominant species, and associated with shrubs including *Pistacia palestina,(Bitm falastini) Myrtus communis (Al-as), Phillyrea media (Zarroud), Rhamnus palaestina (Swaid),* and *Styrax officinalis (Al-estark)* (Nahal & Zahoueh, 2005).

Village residents mainly practice agriculture and cultivate crops, namely tobacco, olive trees, citrus trees and others (Y. Maarouf, personal communication, June 22, 2024). We encountered challenges in determining the village's total population number due to the violent terrorist attacks that led to significant loss of lives and displacement of residents. As a result, accurate data on the current population is unavailable.

The second village is Nehel al Annaze, located about 18 km from the city of Baniyas in the Tartus governorate. It is situated at 620 meters above sea level and shares Blouta's average annual temperature of 17°C but receives slightly more precipitation at 1081 mm. The minimum temperature during the coldest month in Nehel al Annaze is 3.9°C (Fick & Hijmans, 2017). The population in 2020 was around 2000 inhabitants that work mainly with agricultural crops including tobacco, olives, legumes, and vines (SANA, 2020). The natural vegetation of Nehel al Annaze is also a mediterranean *Maquis* of mainly oak species like *Quercus calliprinos (Al-sindian al adi)* and *Quercus infectoria (Al-sindian al ballouti)* and associated shrubs like *Pistacia palestina ,(Bitm falastini), Myrtus communis (Al-as), Phillyrea media (Zarroud), Rhamnus palaestina (Swaid), Styrax officinalis (Al-estirk)* (Nahal & Zahoueh, 2005).

The village's vegetation also includes a planted pine forest with species such as *Pinus brutia (Snawbar bruti)* and *Pinus pinea (Snawbar thamari)*, which burned in the 2020 forest fires. The fires resulted in the removal of a significant part of the forest area and cultivated olive groves in the village (SANA, 2020).

We chose those two villages to obtain data from different safety levels during the war (site status variable or SS). Blouta experienced a high intensity level of violence (HLV); in 2013 this village was attacked by armed terrorist groups that belong to the Islamic State of Iraq and Sham (ISIS) and Jaish al-Muhajireen wal-Ansar. This resulted in deaths and taking hostages of a number of the inhabitants, of which those violent events rose to the level of war crimes according to the Human Rights Watch report (Human Rights Watch, 2013).

Nehel al Annaze, however, wasn't directly affected by the war. The effects here are mainly represented by the economic hardship and the lack of essential resources for survival, such as gas, electricity and fuel. We consider this village as an area with a low intensity level of violence (LLV).

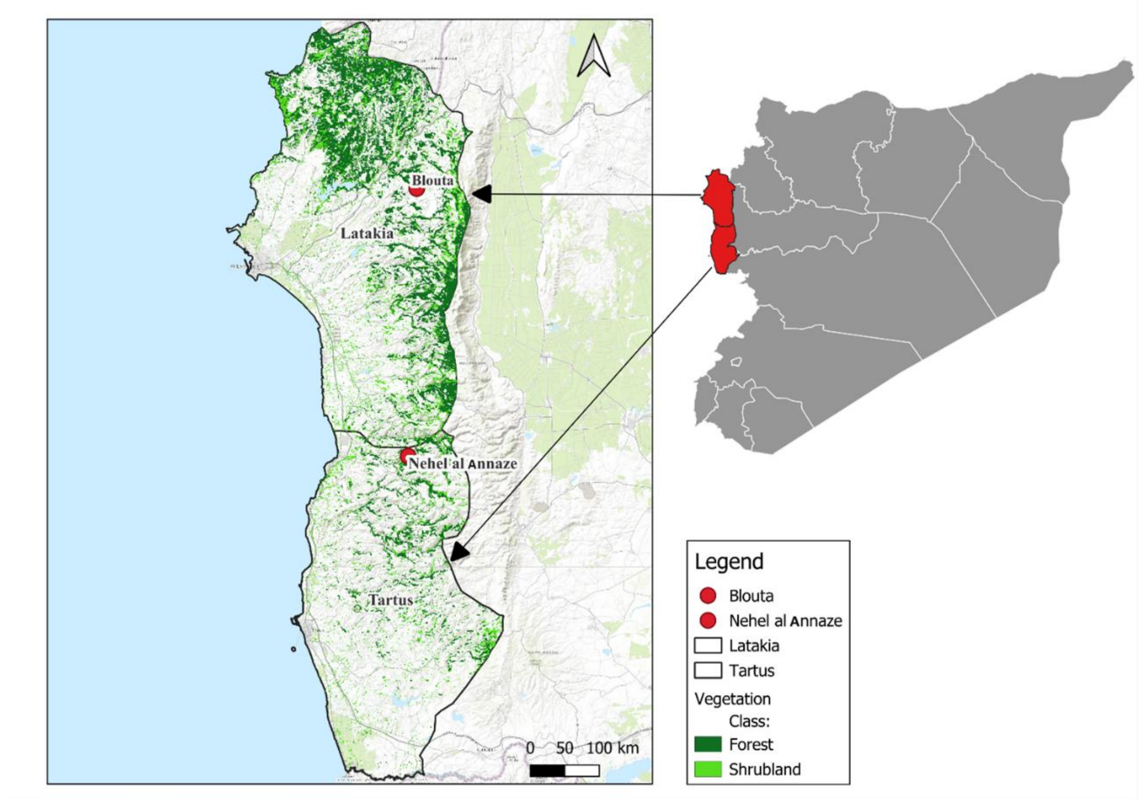


__Figure 3.1__ The study area. Vegetation classes were adapted from the global map of terrestrial habitat types (Jung et al., 2020).

3.2.2. Data Collection

The experimental design for data collection included 80 participants, consisting of 20 men and 20 women from each site, identified through snowball sampling. Initially, we contacted key individuals within our network, who then referred us to other people involved in logging activities. This approach ensured a gender-balanced representation and maintained confidentiality due to the sensitive nature of logging activities during the war. The design of the questionnaire included information on socioeconomic data like gender (GR), age (AG), monthly income (MI), number of household members (NM), and education level (EL). The second part of the questionnaire focused on logging activities. We asked participants first if they practiced logging before the war and if they practice it now, we also asked them about the number of days they go logging before and during the war (DL), the amount of wood harvested each month (LAT), and the price per ton of harvested wood they sell.

The final part of the questionnaire focused on logging methods. We asked participants how they cut trees and what tools they used, whether they allowed time for tree regeneration, the species of trees harvested (conifers or broadleaved), and the transportation methods used for the logged wood. We conducted the questionnaires during three-month period, from March to May

2021.

3.2.3. Data Analysis

Our analysis used two logging metrics as response variables: (1) the monthly amount of wood harvested, in tons (LAT), and (2) the number of logging days per week (DL). Because the war has persisted for more than 13 years, respondents could not recall their pre-war harvest amounts, so LAT data are available only for the wartime period, whereas DL was recorded for both pre- and during-war periods.

3.2.3.1. The Descriptive Statistics of Sampled Population and Harvesting Methods:

Firstly, we summarized the socioeconomic data of the participants by calculating frequencies, percentages, means, and standard deviations for age, gender, income, education level, and number of household members. Using the descriptive approach, we calculated the percentages of responses for each logging method identified in the questionnaires. These percentages were then visually represented in stacked bar plots to illustrate the frequency of the various logging methods reported by respondents.

3.2.3.2. The Analysis of Logging Behavior in the War Context

Participants were asked whether they engaged in logging activities before and during the war, with response options of "Yes" and "No." Descriptive analysis was conducted on these responses, calculating percentages for each category. The results were then visually represented using bar plots to illustrate the distribution of logging practices before and during the war among the respondents.

3.2.3.2.1. Number of Logging Days (DL) Analyses

We used the Wilcoxon rank sum test for paired samples test for nonparametric data analysis to examine differences in the number of wood logging days per week (DL) before and during the war among all participants. This test was chosen due to its suitability for non-normally distributed data.

To explore the relation between the number of days per week spent logging among sites, genders, and their interactions we used Generalized Linear Models (GLMs) with a Poisson distribution. This model allowed us to examine the combined effects of different variables and their interactions, considering the number of days per week spent logging as a predictor across both periods (before and during war (DLB and DLD, respectively)), gender, and site status (HLV, LLV). Analysis was conducted using the glm function from the stats package in R.

3.2.3.2.2. Amount of Logged Wood Analysis

We examined the relationship between the amount of logged wood per month in tons (LAT) and socioeconomic variables (Such as gender, age, income, and household members) and site status (HLV, LLV). For this analysis, we also used GLM models with a Gaussian distribution, considering LAT as the response variable.

In both GLM analyses, for the logged wood and days of harvesting we used the Akaike Information Criterion (AIC) to compare and select the best-fitting models. The emmeans package was used to perform pairwise comparisons of the estimated marginal means, providing insights into the interactions between socioeconomic variables and site status. The statistical analysis was performed using RStudio version 2022.02.0+443 ("Prairie Trillium").

3.2.3.3. Measuring the Economic Contribution of Forest Harvesting to Poverty Alleviation

We conducted a descriptive analysis to determine monthly wood income by multiplying the amount of wood harvested each month by the price per ton. This monthly income from wood was then compared to the average salary needed to meet basic needs, as specified in the 2021 United Nations report (OCHA, 2021). To convert both salaries and wood income into US dollars, we used the official exchange rate between Syrian pounds and US dollars for 2021 (UN, 2024).

3.3. Results

3.3.1. Socioeconomic Information of the Sample Population

The analysis of socioeconomic data from 80 respondents showed an average age of 43.96 years. The largest age group was between 45 and 59 years, comprising 41.2% (n=33) of the participants, while those aged 60 and older made up just 11.2% (n=9). In terms of education, 25% (n=20) of respondents had no formal education, and 55% (n=44) had received basic education. Regarding monthly income, 60% (n=48) earned less than US$30, whereas only 7.5% (n=6) earned more than US$90. (See Table 3.1).

Table 3.1 *Summary of the socioeconomic data of the sample population.*

Variable	Items	N	M (SD)	%
Gender	Man	40	50	50
	Woman	40	50	50
Education level	None: No formal education	20	25	25
	Basic education: 9 years duration, from age 6 to 15	44	55	55
	Secondary education: 3 years duration, from age 15 to 18	8	10	10
	University education	3	3.8	3.75
	Vocational education	5	6.2	6.25
Monthly income (US$)	< 30	48	60	60
	30-60	21	26.2	26.25
	60-90	5	6.2	6.25
	> 90	6	7.5	7.5
Number of household members	80		3.92 (1.90)	
Age (years)	80		43.96 (12.36)	
Age Group	15-29	10	12.5	12.5
	30-44	28	35	35
	45-59	33	41.2	41.25
	60+	9	11.2	11.25

3.3.2. Forest Logging Practices Before and During the War Among Sites and Genders

Before the war, 46.2% (n= 80) of the respondents did not participate in logging, while 53.8% (n= 80) were already involved in it. When comparing pre-war logging activities by site and gender, the data shows that in Blouta, women made up 54.5% (n= 40) of those involved in logging before the war. While in Nehel al Annaze, a higher proportion of women (57.1%) (n= 40) engaged in logging compared to men (Figures 3.2 and 3.3).

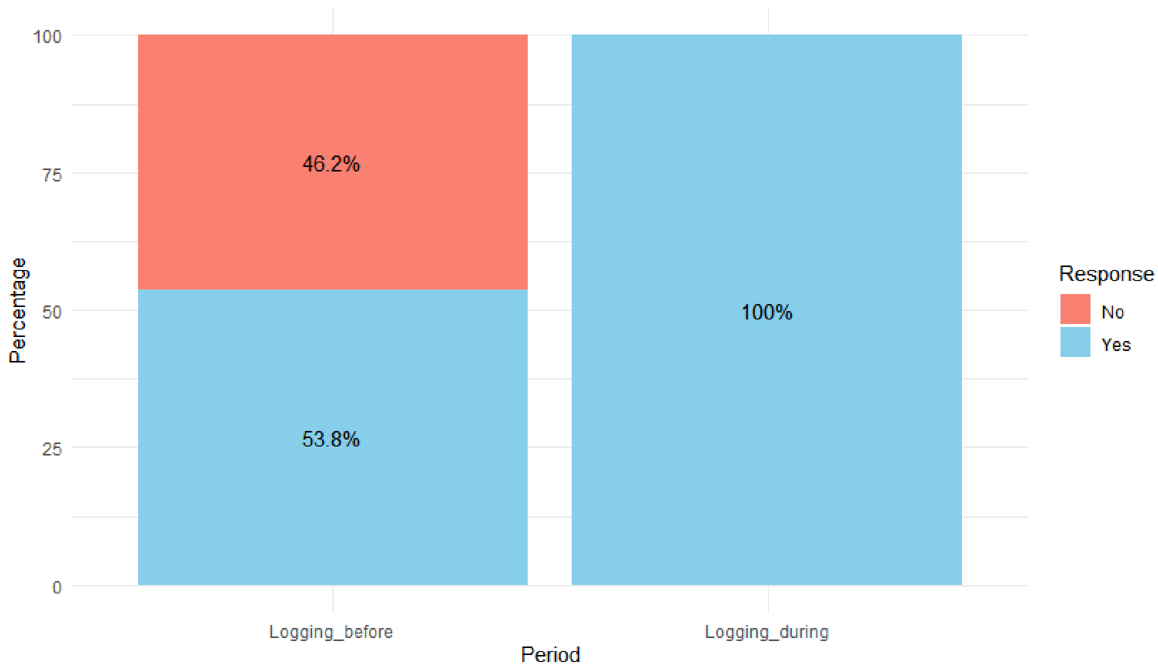


Figure 3.2 *Logging practice reported before and during the war periods.*

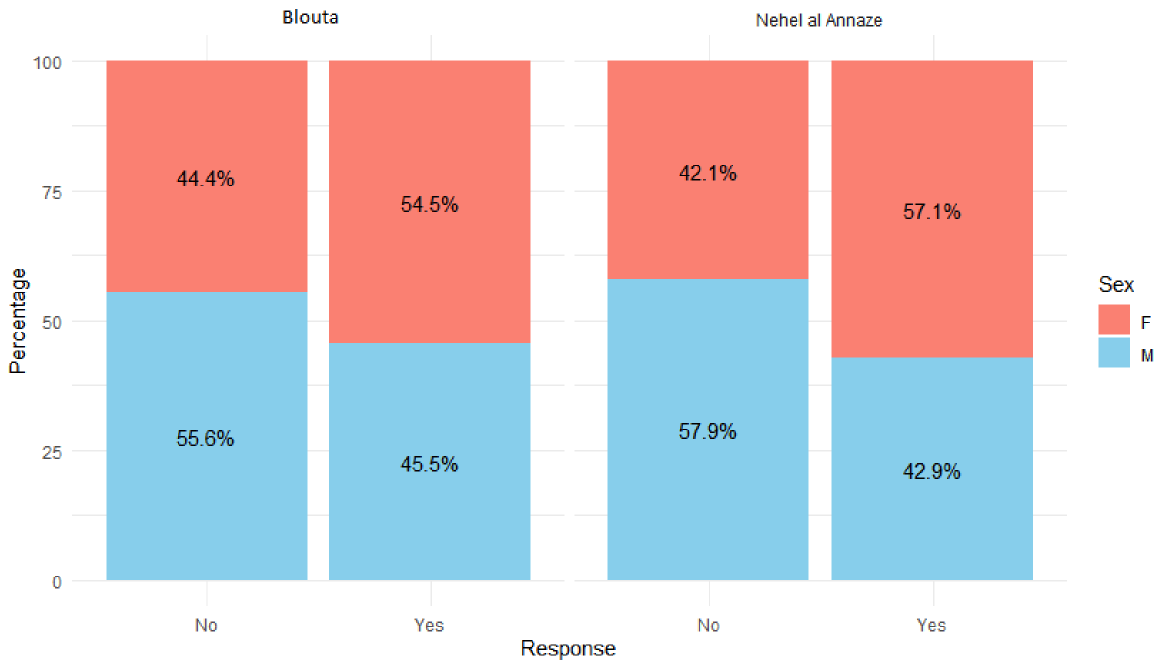


Figure 3.3 *Logging practise among gender and sites.*

3.3.3. Logging Frequency Before and During the War in Relation to Genders and Violence Intensity

The results of the Wilcoxon rank sum test for paired samples showed a significant increase in the average number of logging days (p = <0.0001), rising from 1.5 days per week before the war to 4 days per week during the war (Figure 3.4).

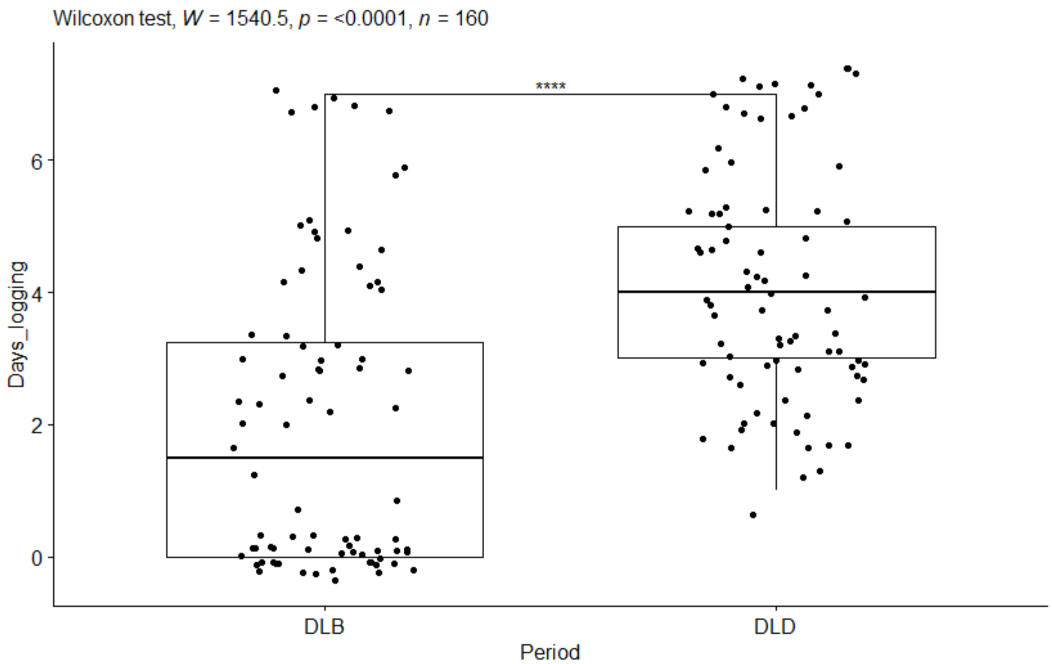


Figure 3.4 *Boxplot displaying the results of the Wilcoxon test, illustrating the distribution of Days of logging (DL) before (DLB) and during the war (DLD).*

We fit six models and selected the best one using the corrected Akaike Information Criterion (AICc) and AICc weights (Table A.3.1 and A.3.2 in appendixes). The model *interaction.mod2 (~ Period + SS + GR + GR*SS*Period)* was chosen because it had the lowest AICc value (686.71) and the highest AICc weight (0.54) which suggests that it has the best fit and highest performance among all the other fitted models.

Results from the selected model showed that the effect of gender alone, the interaction between gender and site status, as well as the interactions between period and gender were statistically significant ($p = <0.05$). The site status effect alone was marginally significant with ($p = 0.0618$), (Table 2.3). To further understand those significant interactions, we used the emmeans pairwise comparisons of the different combinations of the variables.

We found that before the war, women significantly logged more days than men in Blouta (HLV), while in Nehel al Annaze (LLV) there were no significant differences in logging days between men and women. In contrast, during the war there was no significant differences in logging days among men and women in both villages (Figure 3.5). For full interactions values refer to (Table A.3.3 in appendixes).

Table 2.3 *Results of the Generalized Linear Model (GLM) interaction analysis for logging practices (interaction.mod2), showing coefficient estimates, standard errors, z-values, p-values, and significance levels.*

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	Significance
(Intercept)	-1.8293	0.9338	-1.959	0.05011	.
PeriodDLD	3.3544	1.0834	3.096	0.00196	**
SS	1.0625	0.5689	1.868	0.0618	.
GR	1.6633	0.5327	3.122	0.00179	**
SS:GR	-0.7142	0.3323	-2.149	0.03163	*
PeriodDLD:GR	-1.5992	0.6334	-2.525	0.01157	*
PeriodDLD:SS	-1.2435	0.6709	-1.854	0.06379	.
PeriodDLD:SS:GR	0.7411	0.3993	1.856	0.06349	.

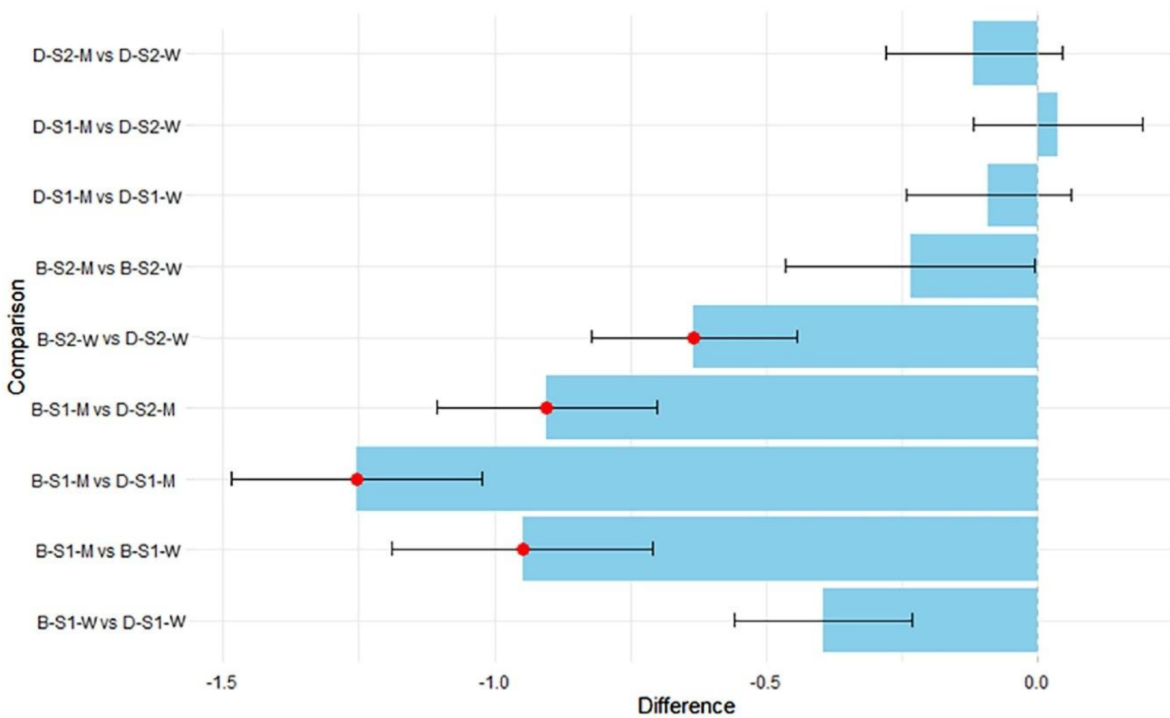


Figure 3.5 *Graph of estimated marginal means showing interaction effects of gender and sites on logging practices before and during the war (B-D: Before, During; M-W: Men, Women; S1-S2: Blouta Site, Nehel al Annaze Site).*

3.3.4. Amount of Harvested Wood in Relation to Socioeconomic Variables

To explore the relationship between the amount of harvested wood and socioeconomic factors, we evaluated 28 models (That include the combination of the variables and their interactions) and identified the most suitable ones based on their AIC scores (Full models detailed in Table A.3.4 appendixes). Our findings highlighted a significant relationship between the amount of harvested wood (LAT) and gender (GR). The emmeans analysis showed that during wartime women harvest an average of 0.47 tons less wood than men. Additionally, age variable (AG) was found to significantly influence wood harvesting, with the 30-44 age group harvesting 0.7 tons more compared to those aged 45-59. Generally, wood harvesting tends to decrease with age. We also found that across all fitted models, site status had no significant effect on the amount of wood harvested wood (See A.3.4 appendixes).

Additionally, variables such as monthly income, number of household members, and education level did not demonstrate a significant impact on the amount of harvested wood (Table 3.3).

Table 3.3 *Summary of Generalized Linear Model (GLM) results for various predictors of amount of logged wood in tons (LAT).*

Variable	Model	Estimate	Std. Error	t value	Pr(>|t|)
Number of household Members (NM)	LAT ~ NM	0.03547	0.06288	0.564	0.574
Age (AG)	LAT ~ AG	-0.02248	0.008956	-2.51	0.0142*
Gender (GR)	LAT ~ GR	-0.4698	0.2225	-2.111	0.0379*
Education Level (EL)	LAT ~ EL	0.09624	0.11812	0.815	0.418
Monthly Income (MI)	LAT ~MI	-8.429e-08	1.468e-06	-0.057	0.954

3.3.5. Methods of Forest Logging

Our results show variations in logging methods (LM), revisiting the logged site (RLS), and type of exploitation (TE) across both sites and gender. In Blouta, the predominant logging method among women was cutting all the branches and leaving the trunk (55%), whereas half of men cut the main trunk (50%). In Nehel al Annaze, we sound that women (50%) and men (65%) engaged in cutting a few branches (Figure 3.6).

Regarding the practice of revisiting logged sites (RLS) in Blouta, a higher percentage of women (65%) gave trees time to regenerate compared to men (45%), who tend more towards harvesting without allowing regeneration. Whereas in Nehel al Annaze, both women and men

(70%) predominantly gave trees time to regenerate. The type of exploitation (TE) also showed notable differences: in Blouta, women largely engaged in selective cutting (55%), while men showed more balanced distribution between selective cutting (45%) and clear cutting (35%). Conversely, in Nehel al Annaze, men preferred selective cutting in a higher percentage (85%) compared to women (55%) (Figure 3.6).

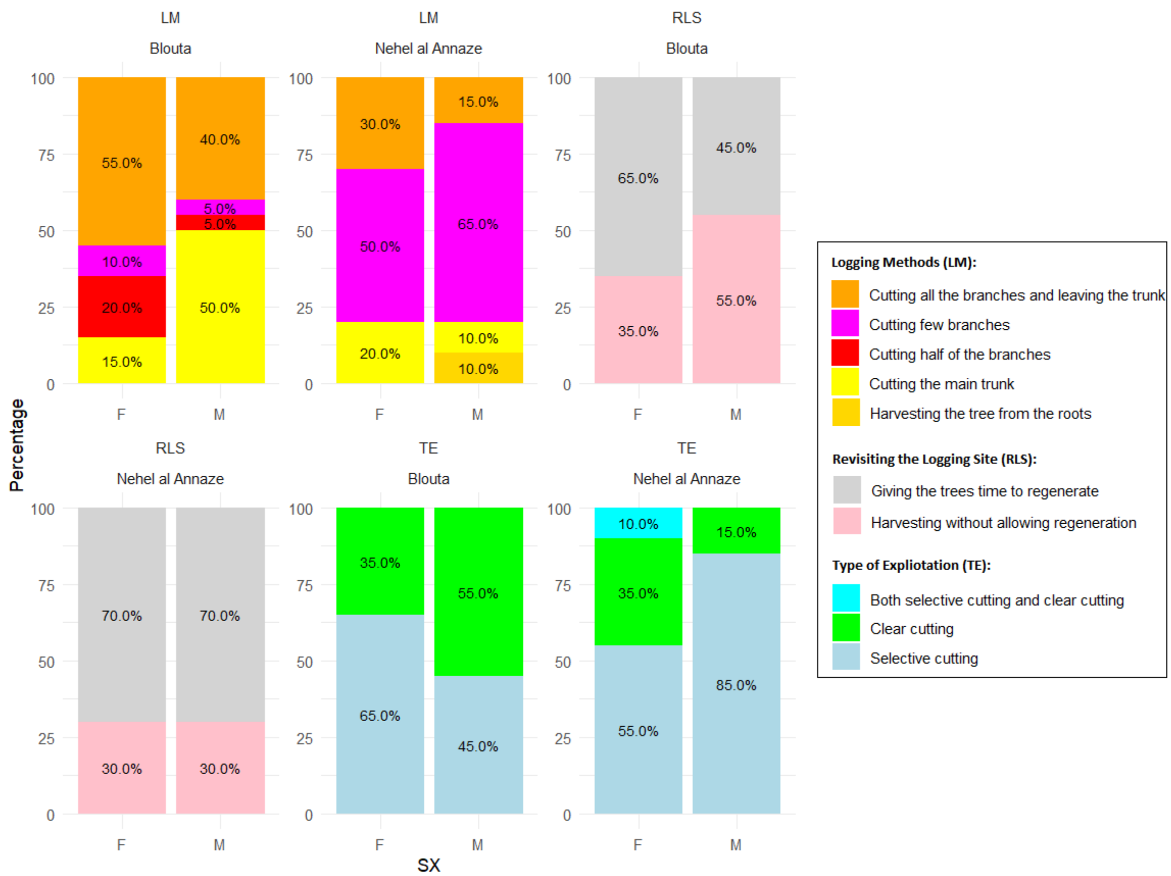


Figure 3.6 *Stacked bar plot showing the percentages of logging methods (LM), revisiting the logged site (RLS), and type of exploitation (TE) among respondents in Blouta and Nehal al Annaze.*

Our results showed distinct patterns in the use of logging tools (LT) and transportation methods (TM). In Blouta, the primary logging tools for women were the axe and handsaw (55%), whereas men utilized a wider variety of tools, but also preferred axe and handsaw (40%). In Nehel al Annaze, both women (90%) and men (70%) predominantly used the handsaw and sickle (Figure 3.7).

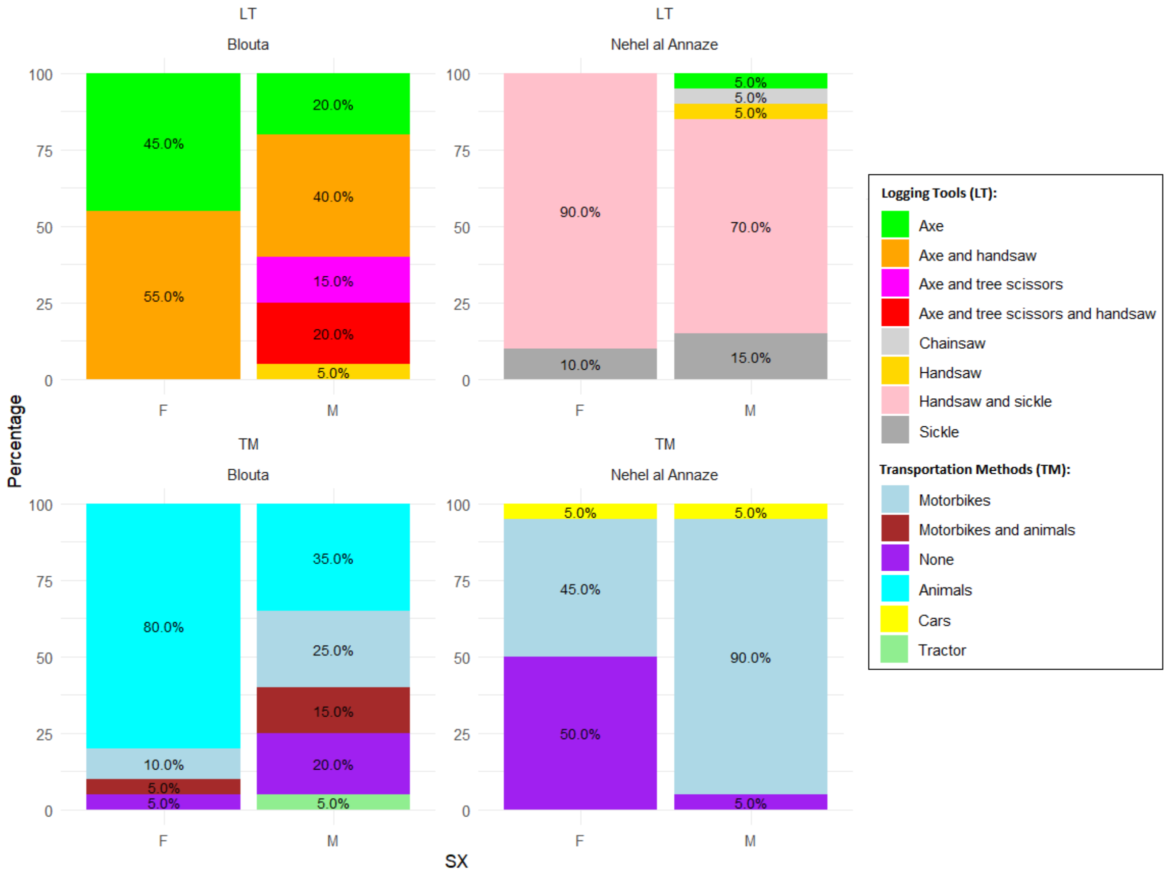


Figure 3.7 *Stacked bar plot showing the percentages of logging methods (LM), revisiting the logged site (RLS), and type of exploitation (TE) among respondents in Blouta and Nehal al Annaze.*

Regarding transportation methods (TM) in Blouta, women predominantly used animals (80%), while men have a more diverse range of methods, with (35%) using animals, motorbikes (25%), and a combination of motorbikes and animals (20%). In Nehel al Annaze (90%) of men relied on motorbikes for transportation, and (50%) of women responded that they did not use any type of transportation to move the harvested wood (Figure 3.7).

When we asked the respondents about their preferred species for wood harvesting between broadleaved species (mainly oaks), or pines. Clear patterns emerged between the two villages. In Blouta, both women (100%) and men (95%) predominantly logged broadleaved species, with women exclusively logging broadleaved species. In Nehel al Annaze, the majority also preferred broadleaved species, with 90% of women and 75% of men logging these species. However, a higher proportion of men (25%) in Nehel al Annaze logged both broadleaved and pine species compared to women (10%).

3.3.6. Economic Contribution from Forests to Sustaining People During the War

In 2021, the average price per ton of wood was US$100 in Blouta and US$63 in Nehel al Annaze, with average wood harvests amounting to 1.48 tons in Blouta and 1.44 tons per month in Nehel al Annaze. We assessed the income from commercial wood harvesting and compared it to the average monthly income required for a family to meet basic needs, which was US$180 according to 2021 UN estimates. Interviewees reported an average monthly salary of US$31.80, excluding wood income, while their average earnings from wood amounted to approximately US$150.60. Combining both sources, their total average monthly income was around US$182.40. Among the 16 interviewees (20% of the sample) who depended solely on wood profits, the average monthly earnings from wood were US$191, with half working full-time as loggers. In Blouta, the average income from wood was US$152.70, compared to US$84.50 in Nehel al Annaze. Salaries averaged US$31 in Blouta and US$33 in Nehel al Annaze. Income from wood harvesting helped reduce the income gap by 46.94% in Nehel al Annaze and 84.83% in Blouta.

3.4. Discussion:

3.4.1. The Change in Forest Logging Behavior During War

The earliest instance of anthropogenic deforestation in history was recorded in Syria, with evidence of deciduous forest clearing in Al-Ghab valley by pre-pottery neolithic people around 9000 years before present (BP) (Yasuda et al., 2000). Since then, forested areas have steadily declined, from 35% of the country's land cover at the beginning of the last century to just 3% in 2010 (Meslmani, 2010). Before the war, rural Syrians relied on firewood as source of energy, driven by minimal public services, harsh winter conditions, and high poverty rates (Meslmani & Ali, 2009). Firewood was used for heating, cooking, and producing charcoal. Annually, 3239 tons of firewood were extracted from Syrian forests (Nahal & Zahoueh, 2005). This demand led to significant forest degradation (Meslmani & Ali, 2009).

Our results confirm this pre-war reliance on forests, with more than half of our respondents (53.8%) reporting logging activities before the war, averaging 1.5 days per week of wood logging. However, during the war, logging increased significantly, with more people engaging in this practice and the average logging days rising to 4 days per week. Notably, 46.2% of those who started logging after the war began had not logged before. This change can be attributed to the war-induced poverty, which increased poverty rates in Syria to 90% of the population by 2021 (OCHA, 2021). Additionally, limited access to energy resources such as electricity, diesel, and butane gas exacerbated the situation.

The war caused extensive damage to the power infrastructure and oil pipelines throughout the country due to attacks, sabotage, and vandalism, severely restricting electricity supplies. Although the electricity sector in Syria was already struggling before the war, the conflict drastically worsened the situation, reducing per capita consumption to less than 10% of pre-war levels (Hatahet & Shaar, 2021). Furthermore, the Syrian government lost control of oil fields, which were captured by various armed groups and foreign states (Alhaj Omar et al., 2023).

In 2021, Syrians received less than eight hours of electricity per day, with some areas getting only three hours. Rural areas, in particular, had even less access since the war began, making cooking and heating using electricity as unavailable solution (UNDP, 2022). The villages where interviews were conducted, located at elevations of 750 and 620 meters, deal with harsh winters and had an average January minimum temperature of 4 degrees Celsius in 2021 (Fick & Hijmans, 2017). Thus, firewood remained the cheapest and most accessible energy source for them.

Similar patterns of increased reliance on firewood and consequent forest degradation during conflicts can also be observed globally. In the Democratic Republic of Congo, the civil war led to greater dependence on forests for firewood, exacerbating forest degradation (Draulans & Krunkelsven, 2002). Another example can be drawn from the Gishwati forest reserve in Rwanda, which suffered a significant loss of forest cover due to extensive logging activities during the armed conflict. The conflict led to a decline in conservation efforts in the reserve and increased use of forest resources near refugee settlements, leading to forest degradation (Ordway, 2015). The armed conflict in Tigray (Ethiopia) caused severe ecosystem disturbances, reversing restoration efforts and increasing dependence on natural resources such as firewood and charcoal due to service suspensions like electricity, especially in areas with many internally displaced persons (Negash et al., 2023). Angola's woodlands within the miombo ecoregion have faced major changes over the driven by increasing urban demand for agricultural products, firewood, and timber. The Angolan civil war intensified these pressures leading to deforestation and canopy opening, with widespread unemployment forcing many into informal jobs collecting firewood and trading in small markets (Andrews et al., 2024).

3.4.2. Logging Behavior Change by Genders and Violence Intensities

3.4.2.1. Pre-War Logging

In both villages we surveyed, women accounted for more than half of the "Yes" responses regarding logging activities before the war. Our results also showed that the average number of logging days was significantly higher for women than for men in Blouta village. This indicates that women were more involved in logging activities before the war. This trend can be attributed to the traditional role of women in collecting wood for cooking and heating. Collecting firewood is a gendered issue in many developing regions, where women are responsible for household chores, including firewood collection (Njenga et al., 2021; Tabuti et al., 2003). For instance, women in Kenya work more days and longer hours collecting wood compared to men (Njenga et al., 2021).

3.4.2.2. Logging During the War

During the war, we found no significant differences between women and men in the number of days spent logging in both villages. It seems that the war narrowed the gap in gender roles, with more men becoming involved in logging activities. Increased economic difficulties for rural communities during the war drove both men and women to collaborate in supporting household survival. This was evident in Syria, where not only did men take on more responsibilities, but the war also pushed women to adopt new roles and challenge long-standing gender norms. Women began participating more in various economic activities, often becoming the breadwinners for many households during the war (Buecher & Aniyamuzaala, 2016).

3.4.2.3. Violent Intensities and Logging Activities

The differences of logging days between Blouta and Nehel al Annaze were marginally significant, suggesting that the violence itself wasn't enough to trigger changes in logging activities. We conclude that the primary driver of forest use was economic motivation rather than the intensity of violence. In Blouta, the village that was under armed attack, residents were forced to flee to other areas. Upon their return, they resumed using the forest. We also found no evidence of forest use by armed groups in Blouta after it was recaptured.

3.4.2.4. Amount of Harvested Wood and Socioeconomic Variables During the War

The results of our model estimating the amount of logged wood (LAT) and the socioeconomic variables, only gender and age were found to have significant impacts on the amount of the harvested wood. Although the differences in logging days between men and women weren't significant during the war, women harvested significantly less wood (0.47 tons) than men. One explanation of this could be that women in rural areas are in charge of the domestic work at home in addition to the collection of the wood, which gives women less time to harvest wood than men. Studies show that women in rural areas especially in developing countries carry the burden of the domestic housework in addition to collecting firewood and agricultural activities, and they spend approximately about (14-16) of working hours everyday (Nagbrahmam & Sambrani, 1983). Unfortunately, our study didn't consider wood collection per hour, only the frequency of visiting the forest every week. This factor could help elucidate wood collection comparison by hours harvesting between men and women and help explain the result described above.

The gender is not the only variable affecting the amount of harvested wood, age also has a significant relationship to the amount of harvested wood. We found that LAT decreases by 0.02 tons for each additional year of age, suggesting that older individuals harvest less wood. Among age groups, the difference between the age groups of 30-44 and 45-59 years was statistically significant. These results suggest that younger individuals are more likely to harvest larger amounts of wood than older ones as younger people are more physically fit to carry out the logging and also capable of walking longer distances (Godoy et al., 1997; Mushi et al., 2020).

3.4.3. Wood Harvesting Methods During the War:

3.4.3.1. Preferred Tree Species for Logging

The majority of respondents reported a preference for broadleaved species in logging, particularly oak trees (*Quercus calliprinos and Quercus infectoria*). Oaks are a popular choice for forest loggers because they regenerate well after harvesting and they also have excellent combustion properties making them ideal for firewood and producing charcoal (Aguilar et al., 2012).

3.4.3.2. Logging Methods

In Blouta, women primarily used a logging method where they cut all the branches and left the trunk, while half of men cut the main trunk. In Nehel al Annaze, both women and men mainly engaged in cutting a few branches. Larger trunks are typically sold as firewood, while smaller branches are preferred for charcoal production (Bahhah, 2022). This charcoal is used for cooking and shisha consumption, especially with shisha smoking becoming increasingly popular among younger generations since the onset of the war in Syria (Bahhah, 2022b; Kakaje et al., 2021).

Most respondents in both villages preferred selective cutting for harvesting wood, the practise decreases tree species biodiversity, tree density and basal area, leading to potential long-term ecological impacts (Lulandala et al., 2023; Ndegwa et al., 2016).
A smaller percentage employed clear cutting, mainly for land conversion to crops, a similar pattern that also can be found among rural communities that practise logging Africa (Kutsch et al., 2011; Zulu & Richardson, 2013). This method, involving the removal of most or all trees in an area, can have varying negative effects based on the cleared area size, with large-scale forest removal significantly reducing soil organic content and affecting hydrology more than smaller cleared areas (Lulandala et al., 2023).

Most respondents, except for men in Blouta who favour clear cutting, indicated they would allow trees time to regenerate after harvesting. However, the lack of data on the harvest rotation period makes it difficult to determine whether these trees can mature or will be maintained as coppices for firewood. Given the ongoing conflict in Syria, it is more likely that trees will be maintained as coppices, potentially harming the sustainability of oak forests. (Nocentini et al., 2022) found that intensive use of oak forests for firewood in Mediterranean areas could lead to soil degradation and a decline in landscape quality.

3.4.3.3. Wood Transportation Methods

In Blouta, women predominantly used animals (80%), while in Nehel al Annaze 50% of women said that they didn't use any type of transportation to move the harvested wood. The wood transportation methods can be controlled by the social and cultural traditions and vary in every country, for example, in Kenya it is normal for women to transport wood carrying them in bundles on their back, a practise which is considered feminine and opposed to men who usually use donkeys and wheelbarrows to transport the wood (Njenga et al., 2021). In Syria it is uncommon for women to ride motorbikes which and considered a masculine transportation method (UNFCCC, 2018). We see this reflected in our results where 90% of men in Blouta use motorbikes for transporting the harvested wood.

Using motorbikes is not only influenced by the cultural norms but it is also affected by the availability of fuel during the war. In Nehel al Annaze, men rely on a variety of transport options, likely due to the high cost and limited availability of motorbikes and fuel. The average price for the subsidized diesel in 2021 for transportation was 376 SYP /litre (or 0.15 US$) while the informal (black market) average price was 1,612 SYP /litre (0.6 US$) (UNDP, 2021). While the minimum wage in 2021 was 71.515 SYP per month (28.6 US$ at the current official exchange rate of 2.500 SYP to one US dollar).

3.4.3.4. Logging Tools

Our results show a preference to using traditional logging tools like, handsaw, axe, sickle by both gender and in both sites. These results are similar to a study conducted in rural Nepal where informants found the traditional logging tools more familiar and easier to use, while modern tools like chainsaws were costly and more complex to use (Pahari & Bhattarai, 2020). Also, the use of modern tools like chainsaws although more effective but it requires sources of energy that are scarce and unaffordable by the rural communities, especially during the war.

3.4.4. Wood Income and Poverty Alleviation

The war in Syria has led to a significant economic collapse, with 90% of Syrians living below the poverty line compared to pre-war poverty overall rates in 2007 of 3.6% (Hamati, 2019; OCHA, 2021). The value of the Syrian pound plummeted against the US dollar (from 1 US$ = 46 SYP in 2010 to 1 US$ = 2500 SYP in 2021) (UN, 2024) . War also caused the collapse of key sectors like industry, agriculture, and tourism that were essential for the economic stability of the country (World Bank, 2017).

It is important to note that, although Syria was not an oil-rich country, its oil demands were met by refining crude oil domestically, with the surplus being exported to Türkiye and other European countries (Alhaj Omar et al., 2023). After the war began, the government lost access to the oil and natural gas fields primarily located in eastern Syria. This loss severely impacted the country's energy supply, increasing energy poverty and leaving the population with limited to no access to energy resources due to high costs and scarcity (Alhaj Omar et al., 2023; Nofal, 2023; Seifan & Alhosain, 2021).

Energy poverty is defined as a 'situation where a household is unable to meet its domestic energy needs', often due to low income, high energy costs, and inefficient energy use in buildings (Agnieszka, 2023). Wars can significantly exacerbate the energy poverty, as seen in countries like post-war Lebanon, where the conflict severely damaged energy infrastructure, leading to daily power outages of up to 8 hours (Abi Ghanem, 2018). Similarly, post-war Sri Lanka faced significant challenges in reducing poverty and providing affordable energy, with the lack of access to modern cooking fuels contributing to around 57% of the Multidimensional Energy Poverty Index (MEPI) (Jayasinghe et al., 2021). Beyond physical destruction, factors such as international economic sanctions, particularly by the USA, Europe, and the UN, can also exacerbate energy poverty in developing countries like Syria by reducing energy consumption and limiting access to clean cooking energy (Moteng et al., 2023).

These economic and political struggles made firewood an invaluable alternative energy source for rural communities, not only for meeting their energy demands, but also to generate extra income. Our results showed that income from wood harvesting reduced the gap between the required monthly income and the actual income by 46.94% in Nehel al Annaze and 84.83% in Blouta. People in Blouta earned more from wood harvesting by primarily selling it as charcoal, which commands higher prices compared to Nehel al Annaze where people sold the wood without any processing for lower prices. Revenues from firewood have become an essential source of income, especially when 20% of interviewees had no other sources of income, and firewood became critical for their survival.

In the Mediterranean countries, notably the southern Mediterranean, forests play an important role in poverty alleviation and development of rural communities (Bleu, 2018). This role also extends beyond the Mediterranean area to form as an essential source of income for rural communities all over the developing world. Many studies show how forests help reduce poverty by providing vital support to poor people, as they became a safety net for communities especially during emergencies like natural disasters and wars (Miller et al., 2022; Soaga & Kolade, 2013; Sunderlin et al., 2003; Wiersum & Ros-Tonen, 2005).

Limitations and Challenges of the Study:

Despite the significant findings, this initial study is intended to establish a baseline for future research and has several limitations. The sample size was limited to two villages, affecting generalizability. Data collection using the snowball sampling method poses limitations for statistical inference due to its non-random nature and inherent biases. The study's limited timeframe may not capture seasonal variations in logging practices. The lack of comprehensive ecological data and detailed information on harvest rotation periods limits the assessment of logging's environmental impacts. Additionally, the study did not fully explore broader economic and social factors influencing logging practices.

Future research should expand the sample size, use mixed-method approaches, conduct longitudinal studies, include detailed ecological assessments, and explore socio-economic dynamics to address these limitations.

3.4.5. Recommendations

Reliance on forests is crucial for rural Syrian communities to meet their energy needs and alleviate poverty during the war. However, this dependence poses significant risks to the health and integrity of the forest ecosystem. If unsustainable logging continues at current rates, the long-term consequences could be irreversible, especially with the imminent threat of climate change. The depletion of forests in Syria during the war could increase the risk of desertification, soil erosion, loss of biodiversity—particularly among endemic and threatened species—and the loss of water security and carbon sequestration, along with changes in microclimates (IPCC: Summary for Policymakers, 2023). Deforestation also has socioeconomic and cultural impacts on the wellbeing of the Syrian rural communities by depriving them of forest products and diminishing their sense of place and cultural heritage (Christiawan, 2018; Hoelle, 2018). To address these issues, it is imperative for local governments and authorities to support forest communities in finding alternative clean energy resources for cooking and heating. They should also educate communities on sustainable forest management practices, create jobs, and improve services in rural areas to combat poverty and reduce the pressure on forests. International bodies should consider integrating strategies that address energy poverty into their humanitarian and post-conflict reconstruction plans. This could involve ensuring access to affordable energy sources, rebuilding energy infrastructure, and creating policies that prevent the over exploitation of energy resources during wars and crises. Addressing these issues can help stabilize communities, support economic recovery, and reduce long-term energy poverty in conflict-affected regions.

3.5. Conclusion:

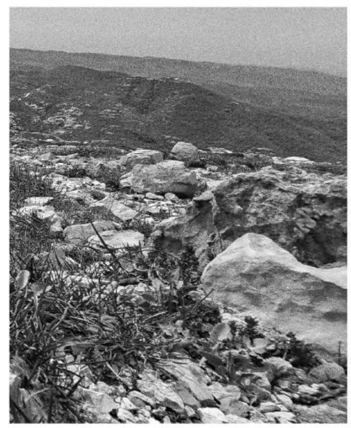
Our study underscores notable shifts in logging behavior during the Syrian war, driven more by economic hardship and energy shortages than by the direct impact of violence. During the conflict, logging activities increased significantly, with a marked rise in both the number of individuals involved and the frequency of logging days. This period also saw a narrowing of the gender gap in logging, as more men took part in wood harvesting compared to the pre-war period when women were more actively engaged in these activities.

Interestingly, the amount of wood harvested was not significantly related with the intensity of violence. Instead, gender and age were the primary factors influencing the amount of wood collected. Forests emerged as a vital resource for rural communities during the war, offering critical income that enabled households to meet their basic needs. Forests have become a crucial lifeline for rural communities in Syria amid the significant economic collapse caused by the war.

To ensure sustainable forest use in the post-war period, it is essential to implement effective forest management strategies. These strategies should focus on the conservation of the remaining forests, in particular, restoring and regenerating the degraded ones. Promoting sustainable logging practices that balance economic requirements with ecological recovery is also an important aspect to effective management strategies. Adopting these approaches will be vital for fostering both environmental sustainability and economic resilience in affected communities.

Chapter 04

New Insights Into the Ecology and Conservation of the Threatened Endemic *Iris Nusairiensis* in the Context of the Syrian War



Iris nusairiensis in Habitat © Angham Daiyoub

Daiyoub, A., Saura Mas, S., Shater, Z., & Salimeh, M. (in preparation). New insights into the ecology and conservation of the threatened endemic Iris nusairiensis in the context of the Syrian war [Manuscript in preparation for submission to Oryx].

New Insights into the Ecology and Conservation of the Threatened Endemic *Iris Nusairiensis* in the Context of the Syrian War

4.0. Abstract:

Iris nusairiensis is a narrowly endemic and critically endangered plant species restricted to high-elevation habitats in western Syria. This study presents the first comprehensive assessment of its life history, traits, distribution, ecology, population size, habitat, and conservation threats, with particular emphasis on the impacts of ongoing war. Through a combination of field surveys, habitat mapping, and ecological modeling using generalized linear and hurdle models, we assessed the abundance, distribution, and threat factors affecting *Iris nusairiensis*. Our findings revealed a single population located in the Syrian coastal mountains, encompassing two main localities—northern and southern—and five distinct subpopulations, four of which were newly identified by this study. The species' Extent of Occurrence (EOO) was estimated at 82 km^2, and its Area of Occupancy (AOO) calculated using a 2 × 2 km grid, spanned 32 km^2 across the Latakia and Hama governorates. In total, we recorded 13,651 individuals, of which 306 plants were mature, representing only (2.24%) of the total population. Trait analysis revealed significant differences between mature and non-mature individuals. Mature plants were significantly taller, with thicker stems, and produced more leaves, which were generally broader but shorter than those of non-mature individuals. Habitat analysis showed that 82% of individuals were found in *Juniperus oxycedrus* garrigue— of open, rocky mountain peaks and calcareous soils. Smaller portions of the population were located in mixed deciduous and coniferous woodlands (15%), including areas previously disturbed by forest fires and deforestation, and in evergreen *Quercus* matorral (3%), primarily in rocky clearings among shrubby oaks. The species is more abundant on rocky mountain peaks above 1300 meters in elevation, where full sun exposure and a favorable combination of temperature and rainfall likely create optimal conditions for its growth. Based on our field data and IUCN criteria, we classify *I. nusairiensis* as Critically Endangered. Its decline is driven primarily by anthropogenic pressures, especially intensive livestock grazing and war-related habitat destruction, including soil removal and disturbances caused by military activities. These findings underscore the urgency of updating the species' IUCN Red List status in light of newly identified threats and population data. Conservation recommendations include targeted habitat restoration, legal protection of key sites, and establishment of long-term monitoring programs. In regions affected by war, such as Syria, integrating ecological research with post-conflict recovery strategies is crucial for the survival

of endemic species. This study provides vital baseline information for future conservation efforts and highlights the immediate need to address both environmental and socio-political challenges threatening *I. nusairiensis*.

Keywords: Warfare, Conservation, The IUCN Red List, Endemic, Threatened Species.

4.1. Introduction:

Warfare is a significant anthropogenic driver of long-term ecological damage, often leading to irreversible habitat degradation and species population declines, ultimately contributing to biodiversity loss (Conteh et al., 2017; Lawrence et al., 2015; Rist et al., 2024) . While the environmental effects of war can be complex—ranging from beneficial to destructive, or mixed outcomes—the overall impact is overwhelmingly destructive, especially to ecosystem functioning (Hanson, 2018; Lawrence et al., 2015; Massó et al., 2019). Research indicates that nearly 80% of world´s wars that happened between 1950 and 2000 occurred within biodiversity hotspots, exacerbating threats to already vulnerable ecosystems (Hanson et al., 2009). For instance, the Iran-Iraq War led to an estimated 80% loss of Iran's wildlife species (Chefaoui et al., 2018; World Bank, 1995). Similarly, during the Vietnam War (1961–1971), the large-scale use of Agent Orange herbicide resulted in the destruction of approximately 3.1 million hectares of highly diverse tropical forests and a 50% decline in mangrove forests (Frey, 2013; Truong & Dinh, 2021) .

Wars exert both direct and indirect effects on ecosystems and biodiversity. Direct effects are often immediate, short-term, and geographically concentrated, whereas indirect effects can be long-lasting, widespread, and persist well beyond the conflict itself (Environmental Law Institute and UN Environment, 2019). One such impact is the deliberate targeting of wildlife by armed groups in remote areas or by displaced populations struggling with resource scarcity near refugee settlements.

For example, the armed conflict in the Democratic Republic of Congo (1995–2006) led to a nearly 50% decline in the population of the African elephant (*Loxodonta africana*) (Beyers et al., 2011), this species is classified as endangered on the IUCN Red List (Gobush et al., 2022). This decline was primarily driven by illegal poaching, exacerbated by the proliferation of weapons, as elephants were hunted for ivory and meat (Beyers et al., 2011; Draulans & Krunkelsven, 2002). Similarly, during the Rwandan Civil War (1990–1994), severe deforestation and habitat destruction occurred when refugees, displaced by the conflict, were forced to settle in forested areas alongside their livestock (Arakwiye et al., 2021; Biswas & Tortajada-Quiroz, 1996). This war also led to the local extinction of two antelope species—the roan antelope (*Hippotragus equinus*) and the eland (*Taurotragus oryx*) (Plumptre et al., 1997), and threatened the critical habitats of more than 100 species of orchids due to the fragmentation in the Nyungwe montane forest by land use change like agriculture expansion (Kanyamibwa, 1998).

The indirect effects of war, though often more chronic and far-reaching, are significantly underreported and receive far less attention than direct impacts. One critical yet overlooked consequence is the contribution of war-related emissions to climate change. Military activities—including the destruction of infrastructure, fossil fuel combustion, and deforestation—release large amounts of greenhouse gases. It was estimated that the total global greenhouse gas emissions with total military carbon footprint is approximately 5.5% of global carbon footprint (Parkinson & Cottrell, 2022), yet war-induced emissions remain largely neglected in international climate discourse and climate policy frameworks, such as negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) or COP summits (Parkinson & Cottrell, 2022).

Wars can also encourage the transportation of invasive species that can endanger native flora and fauna, examples can be drawn from the arial warfare in the small pacific islands during WW2 were the warplanes help transport invasive species of weeds and cultivated plant species too that were established and started competing with the endemic species driving their extinction (Lawrence et al., 2015).

The ongoing war in Syria, which began in 2011, has been one of the worst humanitarian catastrophes of the 21st century, causing the displacement of over 13 million people, widespread infrastructure destruction, and significant loss of life (UNHCR, 2024). Beyond its human toll, and while the full extent of environmental damage is yet to be assessed, the conflict has inflicted severe and widespread harm on Syria's ecosystems. The war has resulted in extensive deforestation (Daiyoub et al., 2023; PAX, 2023), soil degradation (Abdo, 2018), water pollution (Daher, 2022), and air contamination due to the destruction of industrial facilities, oil infrastructure, and agricultural lands (Gleick, 2014; Weir et al., 2019). The crisis of habitat destruction and species loss has been further exacerbated by the collapse of conservation efforts, leaving protected areas increasingly vulnerable. Syria's network of nature reserves has experienced significant damage, with eleven protected areas now facing heightened threats to the country's already fragile biodiversity (CBD, 2022). For instance, large-scale deforestation has occurred in reserves such as Balaas, Frunlok, Cedar and Fir, Dhomna, Al-Lajat, Lidhab, and Mount Abdulaziz. In Hama and Homs, thousands of Atlas pistachio, cypress, and pine trees have been cut down, and essential conservation facilities have been looted. Armed groups have contributed to wildlife declines through illegal poaching and smuggling of species like the Arabian Oryx and the Rhim Gazelle. In Idlib, 22 gazelles were stolen from Al-Basil Forest. Additionally, bird species such as the critically endangered Sociable Lapwing and the endangered Northern Bald Ibis have suffered due to the destruction of their habitats (BirdLife International, 2018, 2019; CBD, 2022). Marine ecosystems have also been affected, with unsustainable fishing and illegal shark hunting further threatening already vulnerable population (CBD, 2022).

Threats to species biodiversity in Syria existed long before the war began, but the conflict has significantly exacerbated them. Even prior to the war, conservation efforts in Syria were often ineffective. Despite the country signing and ratifying the Convention on Biological Diversity (CBD) in 1995 and joining the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2003, weak governance and law enforcement, inadequate biodiversity assessments, and insufficient funding resulted in poor environmental protection. The latest CBD report from Syria (2016) recorded a total of 31 protected areas , whereas the UNEP-WCMC (2025) Protected Area Profile for the Syrian, sourced from the World Database on Protected Areas (WDPA), lists only 19 protected areas, with just two having undergone management effectiveness evaluations. Anthony et al., (2012) noted that these evaluations consistently ranked in the 'Basic' management range, reflecting the absence of national monitoring strategies and action plans for systematic assessments of protected area effectiveness (Anthony et al., 2012). Additionally, there were significant gaps in the study of Syrian flora, including the lack of national lists for threatened species, habitats, and endemic plants, as well as the absence of a national threat categorization system (Almasri et al., 2010). The most comprehensive documentation of Syrian flora, compiled by Mouterde (1966–1983), remains outdated and has yet to be properly distinguished from Lebanon's flora (Almasri et al., 2010).

Despite these challenges, alternative sources of biodiversity data have emerged through non-governmental efforts. Notably, citizen science initiatives have gained traction, with nature enthusiasts utilizing platforms like iNaturalist to contribute valuable species observations. As of the year of 2025, about 24,394 observations have been recorded, covering 3,980 species, with contributions from 2,027 identifiers and 173 observers (iNaturalist, n.d.). Additionally, the development of the Syrian Flora Online platform has provided an expanding digital database for documenting Syria's plant diversity, offering researchers and conservationists an alternative resource in the absence of formal governmental data (Flora Syria On Line, n.d.).

The threats to Syria's biodiversity are particularly concerning given that Syria lies within the Mediterranean zone, a global biodiversity hotspot rich in endemic and threatened species, with ecosystems that are already vulnerable to disturbances. Syria's species richness can be attributed to its diverse climate and topography. The country's flora includes 3,077 species across 133 families and 919 genera (Mouterde, 1966), with the majority belonging to the Mediterranean or Irano-Turanian phytoregions. Additionally, Syria also hosts species from other phyto-geographical regions, such as Euro-Siberian and Saharo-Arabian. Notably, Syria exhibits a high level of endemism, with approximately 8% of its flora being endemic, including 243 species primarily from the genera *Iris*, *Astragalus*, *Centaurea*, and *Allium* (CBD, 2009, 2022).

Rarity and endemism are critical factors in establishing biodiversity conservation priorities, as species with limited distributions are often more susceptible to extinction (Burlakova et al., 2011). Endemic species, especially national endemics that are restricted to a single country should be central to the development of conservation management strategies. National endemics, especially narrow endemics with very limited ranges, play a disproportionate role in global extinction rates. Their loss represents not only a local decline in biodiversity but also a permanent loss at the global scale (Kraus et al., 2023).

Some foundational work has been conducted to identify Important Plant Areas (IPAs) in Syria, notably by Almasri et al. (2010) and Catullo et al. (2011), who proposed 33 IPAs based on their high concentrations of endemic and rare plant species. Among these, three regions were highlighted as top priorities for conservation due to their exceptional levels of endemism and ecological uniqueness.

One such area is Kurd Dagh, a botanical hotspot in the Northern Levant that serves as a significant center of endemism. It hosts a variety of species restricted to southern Türkiye and northern Syria, including *Vaccaria liniflora*, *Ranunculus millefolius*, and *Astragalus antabicus*. Another critical area is the Anti-Lebanon Mountains, considered the most important center of endemism in Syria. This is the only Syrian IPA that includes subalpine and alpine habitats, reaching elevations up to 2,616 meters. It supports a distinct assemblage of endemic species such as *Phagnalon linifolium*, *Helichrysum pygmaeum*, and *Thymus alfredae*. The third priority site is Jabal al-Druze, which ranks second after the Anti-Lebanon in terms of endemic richness.

It is particularly notable for its basaltic landscapes and supports a unique flora, including rare species like *Gagea procera*, *Allium drusorum*, and *Iris auranitica*.

The works of Almasri et al. (2010) and Catullo et al. (2011) identified anthropogenic pressures, particularly overgrazing as significant threats to the integrity of Syria's Important Plant Areas (IPAs). Overgrazing has long been recognized as a major challenge to species conservation in the region, with endemic and narrowly distributed species being especially vulnerable (Almasri et al., 2010; Catullo et al., 2011; Louhaichi et al., 2012).

Due to their limited ranges and specialized habitat requirements, these species often lack the resilience to withstand repeated disturbances caused by intensive grazing. Evidence from global studies supports this concern. For example, Baur et al. (2007) demonstrated that alpine slopes in the Southern Carpathian Mountains of Romania had significantly fewer endemic gastropod species in grazed sites compared to protected, ungrazed areas. Similarly, research by Moolman and Cowling (1994) in South Africa showed that goat grazing led to a marked decline in populations of endemic succulents.

This study focuses on *Iris nusairiensis*, a critically endangered and narrow endemic species from Syria, proposed as a flagship plant to evaluate the ecological impacts of the war on endemic native flora. It is classified as critically endangered by Shater et al. (2016), the species has been inferred to exhibit population decline and is suspected to be subject to indirect consequences of the Syrian war.

Iris nusairiensis has received limited research attention in its natural habitat since its first documentation in the Syrian flora in 1966. The existing IUCN Red List assessment offers only limited information on its status. While a review addressing its cultivation and ex situ conservation was published by Daiyoub et al. (2024), critical knowledge gaps persist concerning its ecology, reproductive biology, and population structure in the wild. The IUCN Red List has identified key research priorities necessary for developing effective conservation strategies, including assessments of population size, distribution and trends, life history and ecology, and threats (Shater, 2016).

Based on these identified research gaps, we outline the objectives of this study to address the critical knowledge needed for informed conservation planning: Concretely, our study present three objectives: 1) Collect and analyze life history traits, distribution, abundance and ecological data of the taxon to improve conservation planning and stablish a baseline data for long-term monitoring and future comparative studies; 2) Detect and analyze threats and impacts to reassess the species based on IUCN Red List criteria and provide essential data for developing conservation strategies; 3) Study the hypothesis that Syrian war has had direct and/or direct effects on the conservation of this endemic plant.

4.2. Methodology:

4.2.1. Study area and Species Information

Iris nusairiensis is a narrowly endemic species native to the coastal mountain range of northwestern Syria—historically referred to as the Nusayriyah Range or Jebel Nusairi. It is currently listed as Critically Endangered (CR) on the IUCN Red List of Threatened Species (Shater, 2016). The assessment was based on its limited extent of occurrence (EOO) of approximately 28 km^2, deteriorating habitat quality, and the number of mature individuals—although the latter was not explicitly quantified in the assessment (Shater, 2016). The evaluation inferred a continuing population decline due to pressures such as overgrazing and flower collection by local communities. It is important to note that this assessment was conducted in 2016, during the height of the Syrian conflict, and relied heavily on expert opinion in the absence of comprehensive field surveys or recent data collection.

The species *Iris nusairiensis* was first described by Paul Mouterde in Nouvelles Flore du Liban et de la Syrie (1966, Vol. 1, p. 311). In his account, Mouterde identified the locus typicus as the area surrounding Mount Slunfe, near Chatha in the Latakia Governorate (Mouterde, 1966). This location now falls partially within the boundaries of the Cedar and Fir Protected Area in the Syrian coastal mountains—historically known as the Nusayriyah Range. Based on Mouterde's description, we conducted a field survey at the original type locality to verify the presence of *Iris nusairiensis.*

In addition to the cedar and fir protected area, we expanded the survey to four additional sites along the coastal range to include the areas such as: Maqamat Bani Hashem, Jawbat Burghal North, Jawbat Burghal South, and Sheikh Hatem, guided by reports from local experts namely Zuheir Shater Ph.D. and Modar Salimah who had previously recorded a number of individuals of this species in these areas (Figure 4.1).

The Syrian coastal mountain range in which this species is distributed spans between 35°45′N and 37°00′N, bordering Türkiye in the North and Lebanon in the South. The highest point of the mountains is Nabi Yunis, reaching 1,562 meters above sea level. The mean annual temperature in the range varies between 12°C and 18°C, depending on altitude, while the mean annual precipitation ranges from 700 mm to over 1,200 mm, with the western slopes receiving significantly more rainfall due to the influence of Mediterranean winds. The natural vegetation consists of Mediterranean forests, woodlands, and scrubs depending on elevation and the bioclimatic zones. Higher elevations are characterized by mixed forests of Juniper (*Juniperus oxycedrus*), Turkish oak (*Quercus cerris*), Cedar (*Cedrus libani*) and Fir (*Abies cilicica*), while lower altitudes and eastern slopes support sparser vegetation adapted to semi-arid conditions, like shrubland and drought-resistant plants such as Brutia pine (*Pinus brutia*), Palestinian oak (*Quercus calliprinos*), and Carob (*Ceratonia siliqua*).

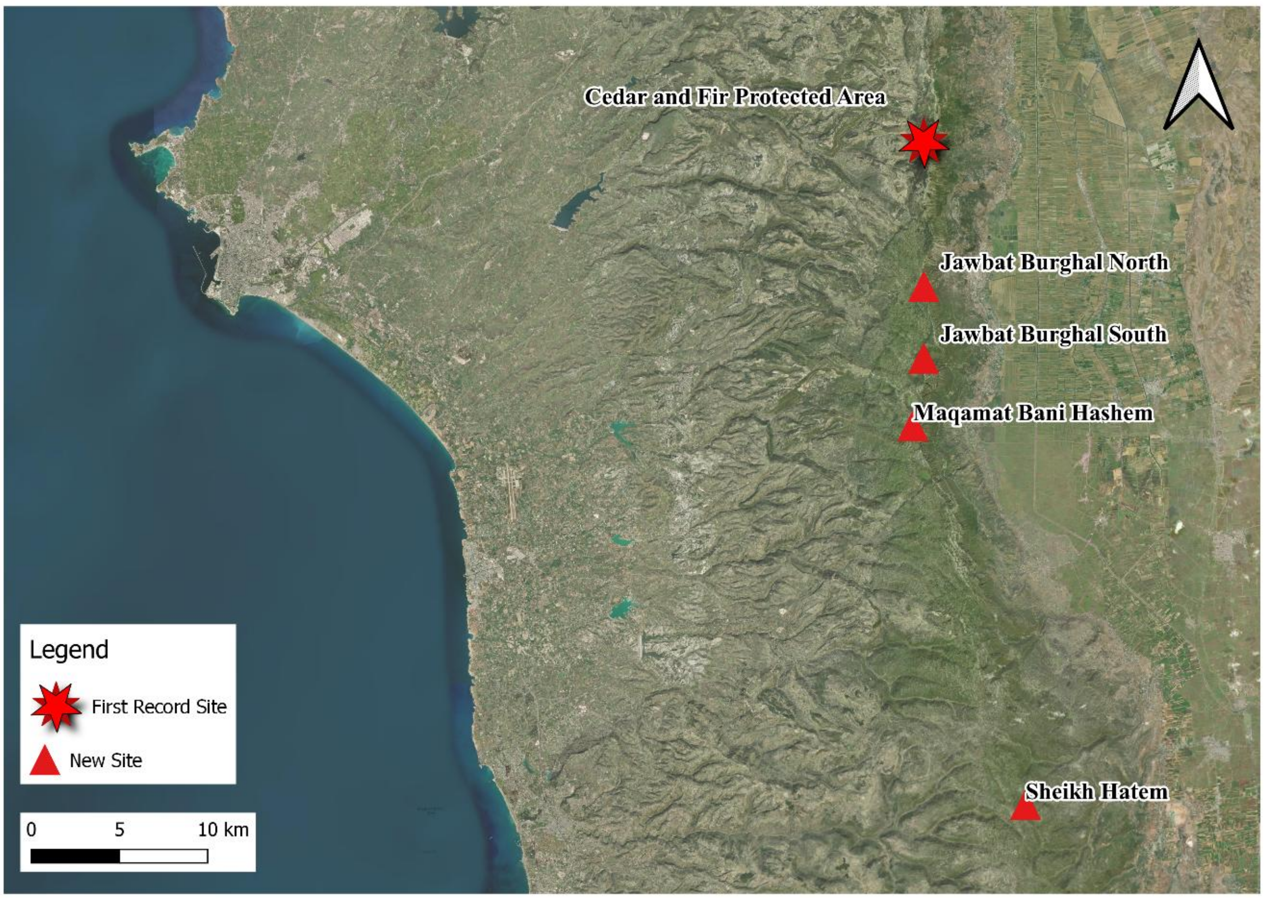


Figure 4.1 *The study area*

Iris nusairiensis belongs to the Juno irises group within the family *Iridaceae* and the genus *Iris L* (Figure 2). They have a unique distichous leaf arrangement, where leaves are positioned one above the other, even in seedlings stage (IKINCI et al., 2011). They also possess a distinct bulb structure, consisting of a true bulb and fleshy storage roots, which typically develop after a full growing season. These storage roots not only aid in nutrient storage but may also help fix the plants in their rocky habitat by pulling them deeper into the ground as they grow (Daiyoub et al., 2024; IKINCI et al., 2011; Mathew, 2000).

Information from cultivation and concretely observations from successful cultivation by Tony Hall and Thomas Freeth at the Kew Royal Botanical Gardens in London indicate that seeds are released in summer, with each fruit producing over 50 small seeds. After germinating in autumn with the seasonal rains, the plants take several years to reach maturity and the flowering season occurs in April according to the national flora (Daiyoub et al., 2024; Mouterde, 1966). In the wild, mature individuals were identified by the presence of flowers and seeds, which indicate reproductive capacity. This definition follows the Red List Categories and Criteria (Version 14, 2019), where mature individuals are those known, estimated, or inferred to be capable of reproduction (Standards and Petitions Working Group, 2019).

Figure 4.2 *Mature individual of Iris nusairiensis*

4.2.2. Population and Distribution

4.2.2.1. Population Census

The fieldwork involved recording all encountered plant individuals using a survey sheet. At the beginning, the population size and distribution of the species were largely unknown, aside from a single location cited in the national flora. Initial surveys relied heavily on input from local experts who had previously observed the species at multiple sites. A preliminary population count was conducted to document the total number of observed individuals. This included key population metrics such as the total number of individuals and the number of mature individuals which is an essential variable for assessing population size. According to IUCN Red List Categories and Criteria (Version 14, 2019), population size refers the total number of mature individuals across all locations and subpopulations (Standards and Petitions Working Group, 2019). Fieldwork was conducted from early March to late May 2022 to capture the full extent of the flowering season, as indicated by the national flora and confirmed by local botanical experts (Mouterde, 1966).

We also recorded signs of herbivory on the *Iris nusairiensis* individuals (e.g., leaf damage or stem browsing or animal traces like feces), and visible signs of insect infestations (e.g., boreholes or webbing) (See Figure 4.3).

In addition to the main population census, we took two other sub-samples to obtain more in-depth details about individual plants and their habitat:

Sub-sample 1 : Random GPS points were selected across the study sites, with the number of points per site varying depending on factors such as site accessibility and the presence of the target species. In some cases, fewer points were used in areas with restricted access, such as those near military zones. At each point, we recorded the number of individuals and collected ecological data. A total of 601 points were sampled, distributed as follows: Cedar and Fir (196 points), Maqamat Bani Hashem (27 points), Jawbat Burghal North and South (194 points), and Sheikh Hatem (184 points). At each point, key habitat parameters were recorded, including GPS coordinates, elevation, slope, soil type, canopy cover percentage, rock cover percentage. Indicators of plant health and herbivory, such as the presence of animal feces, insect presence, and insect infestations, were also documented (See Figure 4.3).

Sub-sample 2 : Plant morphology data were collected using the quadrant method (check the name of the method, plots). A total of 19 quadrats and 95 individual plants were measured across the four sites. Cedar and Fir, Maqamat Bani Hashem, and Jawbat Burghal each contributed six 5 x 5-meter quadrats, accounting for 30 individuals per locality. Sheikh Hatem included one quadrat with five individuals, as the area was heavily grazed at the time of the survey the survey, leaving very few individuals.

Morphological measurements included plant count, morphological phase (growth stage), plant height (measured from the base of the stem to the tallest point of the plant, including the flower if present), maximum stem diameter, number of leaves, and number of flowers. Leaf dimensions were taken by measuring the length from the base to the tip of the leaf and the width at the widest point. Health indicators such as visible signs of mammalian herbivory and insect infestation were also documented (See Figure 4.3).

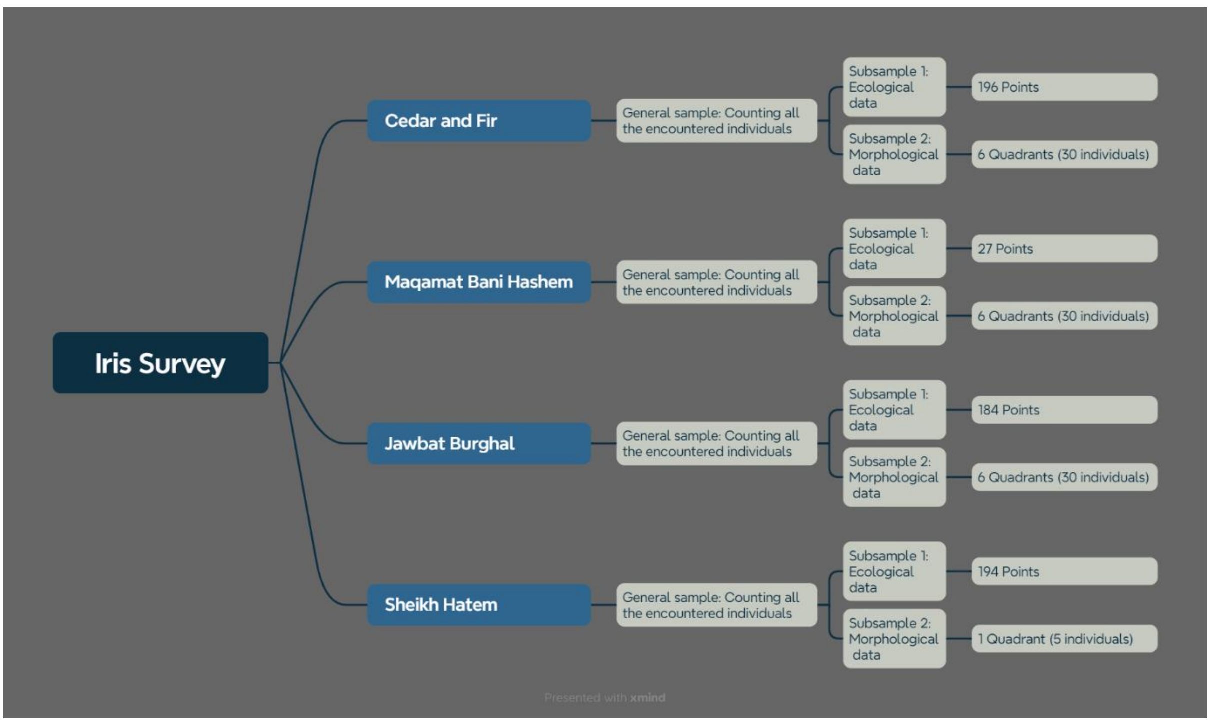


Figure 4.3 *A diagram summarizing the population census methodology.*

4.2.2.2. Defining Locality, Subpopulation and Population

We used the IUCN Red List Categories and Criteria (Version 14, 2019) to define populations, subpopulations, and localities for *Iris nusairiensis* (Standards and Petitions Working Group, 2019).

A subpopulation is defined as a geographically or otherwise distinct group within a population that experiences limited genetic exchange with other such groups (Standards and Petitions Working Group, 2019). The degree of isolation can vary depending on the species. For *Iris nusairiensis*, we defined subpopulations based on the maximum foraging ranges of its primary pollinators observed during fieldwork. These included *Andrena* solitary bees from the subgenus *Micrandrena*, with foraging ranges between 150 and 600 meters (Gathmann & Tscharntke, 2002), and *Tropinota* beetles, estimated to forage within 100 meters (El-Deeb et al., 2003). To account for potential gene flow facilitated by these pollinators, a 1-kilometer Subpopulation buffer was applied around plant occurrence points, representing the maximum likely extent of pollinator-mediated connectivity.

Location or locality is defined as an area affected by a specific threat. The size of a location depends on the extent of the threat and may cover multiple subpopulations. Additionally, the guidelines state that when multiple threats are present, the most significant threat should be used to determine the localities of the species population (Standards and Petitions Working Group, 2019). In this study, grazing was identified as one of the most frequently recorded threats across the studied sites, for that its impact was used to define locality size. Specifically, we relied on the maximum grazing range of animals away from a water source (goats, cattle, and sheep) as reported in the literature, which is approximately 5 kilometres (Cowley et al., 2015; Hart et al., 1993; Squires & Wilson, 1971; Wade et al., 2024). Consequently, we established a 5-kilometer locality buffer area around plant occurrence points to represent the extent of grazing-related impact.

The term population refers to the total number of individuals at all life stages, including all subpopulations within the species range. Following this definition, we considered all recorded plant individuals as part of a single population, which includes the aforementioned localities and subpopulations (Standards and Petitions Working Group, 2019). for that we chose a buffer of 15 km the measured includes all the localities and subpopulations.

Using QGIS, occurrence data from field surveys were processed to generate buffers around the data points, which were then dissolved to create contiguous zones representing the abovementioned population classes. Non-overlapping zones were considered distinct classes.

4.2.2.3. Extent of Occurrence (EOO) and Area of Occupancy (AOO) Calculations

To assess the distribution and conservation status of the *Iris nusairiensis*, we calculated the Extent of Occurrence (EOO) and Area of Occupancy (AOO) using the GeoCat Tool, an online platform designed for the standardized calculation of these metrics according to IUCN Red List Categories and Criteria (Version 14, 2019) (Bachman et al., 2011). We used species occurrence data collected from field surveys (601-point data). The occurrence points were compiled into a shapefile with precise geographic coordinates (latitude and longitude) and were uploaded into the GeoCat platform for analysis.

To calculate the EOO, we used the minimum convex polygon (MCP) method within the GeoCat Tool (Bachman et al., 2011). The EOO is reported as the area of the polygon, measured in square kilometers, which represents the overall distribution of the species across the landscape. For AOO, we applied a grid-based method using the GeoCat Tool. A 2x2 km grid was overlaid on the distribution of the occurrence points, and the tool calculated the number of grid cells containing species presence. The AOO is calculated as the total number of occupied grid cells, multiplied by the area of each grid cell. For the final distribution map, we downloaded the EOO and AOO shapefiles from the GeoCat platform, then overlaid them in QGIS using an elevation basemap derived from the DEM model.

4.2.3. Life History, Traits, and Habitats

4.2.3.1. Measured Morphological Traits

We analyzed plant traits to compare mature and non-mature plants, using mixed-effects models to account for the nested structure of the data (plants within quadrates, quadrates within sites). Using the lmer function from the lme4 package, we built separate models for Height and Diameter with Phase (mature or not) as a fixed effect and random effects for site and quadrate. For leaf traits (Leaf length, Leaf width, and Number of leaves), we added plant number as another nesting level to capture more detailed variability on the plant level. Comparative graphs were made using boxplots with the ggplot2 package to help visualize trait differences between phases.

We assessed pairwise associations among plant morphological traits (Height, Diameter, Leaf length, Leaf width, and Number of leaves) using Spearman's rank correlation coefficient (ρ) because several variables exhibited skewed distributions and non-constant variance.

4.2.3.2. Habitat Description and Types

Spatial data from field surveys was used to define the boundaries of each subpopulation and its surrounding habitat. Since no baseline habitat information exists for Syria, this study was carried out entirely from the scratch, relying only on field observations and measurements. Using the EUNIS 2021 Terrestrial Habitat Classification, we established the first baseline data on both the species' spatial distribution and its associated habitat types.

GPS coordinates were collected using an Android mobile application called *GPS Field Area Measure*. These GPS points were exported in KML format from the mobile app, imported into QGIS, and then converted into shapefiles for further spatial analysis. Due to security concerns—particularly the proximity to military zones and the ongoing conflict—traditional handheld GPS devices were not used. Local colleagues advised against their use to avoid drawing attention or causing potential sensitivities during fieldwork.

The spatial data derived from these field-based delineations served as the base layer for subsequent habitat mapping and analysis. Using QGIS and high-resolution imagery from Google Earth Pro, survey areas were digitized to identify and classify distinct habitat features. These habitat types were then cross-referenced with the EUNIS 2021 Terrestrial Habitat Classification (European Environment Agency, 2021) to ensure consistency with standardized ecological categories.

Final habitat maps were produced for each subpopulation, including digitized polygons representing different habitat types as defined through the classification process. Additionally, the maps included georeferenced occurrences of *Iris* individuals, based on GPS data collected during the field surveys.

4.2.4. Abundance and Ecology

4.2.4.1. Ecological Variables for Abundance Analysis

To study the effects of ecological variables on species abundance (plant count), we collected explanatory variables categorized into four main groups: climatic, topographic, microhabitat, and disturbance variables.

Climatic variables were obtained from the WorldClim database using bioclimatic variables (BIO1–BIO12), representing average annual temperature and annual precipitation. Topographic variables were extracted from a Digital Elevation Model (DEM) at plant occurrence locations. Using QGIS, we derived elevation, and slope steepness (degree). Microhabitat variables were collected through field surveys, including canopy cover percentage (Canopy cover was estimated visually by standing at each sampling location and estimating the percentage of the sky obstructed by vegetation overhead), rock cover percentage (Rock cover was visually estimated within a $1m^2$ by assessing the percentage of ground covered by rocks), vegetation composition (common associated species), and soil type. Disturbance variables included evidence of herbivory, recorded by noting signs of animal or insect damage on plant parts.

4.2.4.2. Abundance Models

We examined the relationship between plant count (response variable) and the set of ecological predictors using generalized linear models (GLMs) with a Poisson distribution, suitable for count data. To ensure that multicollinearity did not distort model estimates, we first calculated variance inflation factors (VIFs) for each predictor using the vif() function. Variables with VIF values greater than 5 were considered for removal or interpretation with caution.

Multiple models were fit with different combinations of predictors, and the model with the lowest Akaike Information Criterion (AIC) value was selected as the best-performing model. The final model was then summarized and visualized using a forest plot. For each predictor, we extracted the coefficient estimate, standard error, p-value, and 95% confidence interval (CI). These results were plotted using the ggplot2 package, with point estimates shown as dots and 95% CIs represented by horizontal error bars. A vertical dashed line at zero indicated no effect. Predictors were color-coded by statistical significance (e.g., $p < 0.05$), and models were displayed in separate panels if multiple were compared.

4.2.5. Threats and Impacts

4.2.5.1. War Effects

4.2.5.1.1. Disturbed Areas Data

To map areas that had been disturbed within the species' habitat, we used a combination of fieldwork and satellite imagery analysis using Google Earth Pro to first determine when the disturbances occurred. By comparing images taken before and after the war began in 2011, we were able to include only the disturbances that happened after the war started. During our field surveys we did not observe any new military activities or signs of ongoing military presence, indicating that active operations had ceased at the time of our surveys in 2022.

First, we conducted field surveys where we used GPS points to record the locations of visible signs of disturbances such as tank tracks, tank platforms, military infrastructure, and places where soil had been removed (areas that been dug for example). These GPS points were then compared with high-resolution satellite images available in Google Earth Pro, which provides imagery with a resolution of about 0.5 to 1 meter. This allowed us to accurately match the disturbances seen on the ground with those visible from above.

Next, we used QGIS (version 3.34.13-Prizren) to delineate the disturbance using polygons. This was done manually by carefully tracing around the features seen in the satellite images, using the GPS points as a guide. Only those disturbances that could clearly be linked to war-related activities were included in the final dataset.

4.2.5.1.2. Effects of the War Data Analysis

To investigate the relationship between war-related disturbances and plant abundance, we divided the study area into a uniform grid of 50 × 50-meter cells, treating each grid cell as a discrete spatial unit. Disturbance features linked to war activities were digitized as polygons and overlaid with the grid. We calculated the total disturbed area and percentage of disturbed surface for each cell based on the intersection of disturbance polygons with the grid.

Plant occurrence data were represented by a layer of randomly sampled points across the study area. These points were spatially joined to the grid to determine the number of plant observations per cell, providing a measure of plant abundance. This spatial join allowed us to create a unified dataset containing, for each grid cell: the total plant count, the total disturbed area (m^2), and the percentage of the cell impacted by disturbance.

We analyzed the relationship between plant abundance and disturbance intensity by modeling plant count as a function of disturbance metrics, focusing on grid cells where war-related disturbances were present. Given the count nature of the response variable and the presence of both overdispersion and excess zeros in the data, a Negative Binomial Hurdle model was used. This model structure accounts for overdispersion through a dispersion parameter and handles excess zeros by modeling the zero and count processes separately.

All modeling was conducted in R using the hurdle function from the pscl package. Visualizations were generated with ggplot2 to illustrate the associations between plant density and disturbance. The analysis was performed in RStudio (version 2024.09.1+394 “Cranberry Hibiscus”) on a Windows platform. (See Figure 4.4)

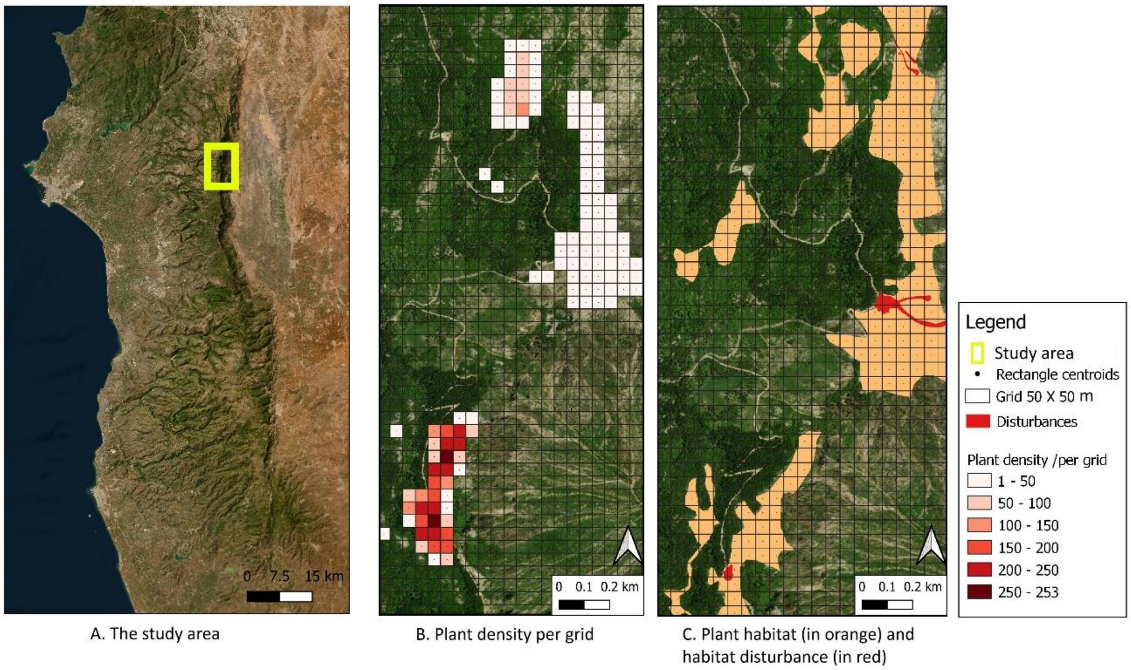


Figure 4.4 *Example of the spatial grid layers of war-related disturbances and plant density used to assess the effects of habitat disturbance on plant abundance in the study area.*

4.2.5.2. Herbivory

To assess the effect of herbivory on species abundance we first examined the relationship between insect presence (InsectPres) and plant count by fitting a Poisson GLM with a log-link function. This model assesses whether the presence or absence of insects has a significant impact on plant abundance. Next, we investigated how grazing affect plant count as a response variable by fitting a Poisson GLM that includes both grazing presence as a predictor.

4.2.6. Reassessment: Application of IUCN Red List Criteria

The reassessment of *Iris* nusairiensis on the IUCN Red List was conducted after completing the IUCN Red List Assessor online training course offered on the conservation training platform (https://www.conservationtraining.org/). The evaluation followed the Guidelines for Using the IUCN Red List Categories and Criteria (Version 14, 2019), available at www.iucnredlist.org/resources/redlistguidelines (Standards and Petitions Working Group, 2019). The assessment was based on data collected through fieldwork, along with the results of data analysis regarding the species' population, distribution, and the threats identified during field surveys.

4.3. Results:

4.3.1. Population and Distribution

4.3.1.1. Population and Subpopulation Units

Using the IUCN criteria to define population units, we analysed 601 field observations and identified one population that we name the population of *Iris nusairiensis* in the Syrian coastal mountains. This population includes two localities: the northern and southern localities. Within these localities, we identified five subpopulations that are arranged from North to South: Cedar and Fir (which also contains the area in which the species was first described in mount slenfe), Jawbal Burghal North, Jawbal Burghal South, Maqamat Bani Hashem, and Sheikh Hatem (See Figure 4.5).

It is important to note that during initial data collection, the areas of Jawbat Burghal North and South were treated as a single sampling site due to their geographic proximity and the absence of prior formal subdivision. Consequently, ecological and species occurrence data from both areas were aggregated and analyzed as one unit. However, following our latter classification of subpopulations—based on updated the IUCN criteria—Jawbat Burghal North and South were designated as two distinct subpopulations.

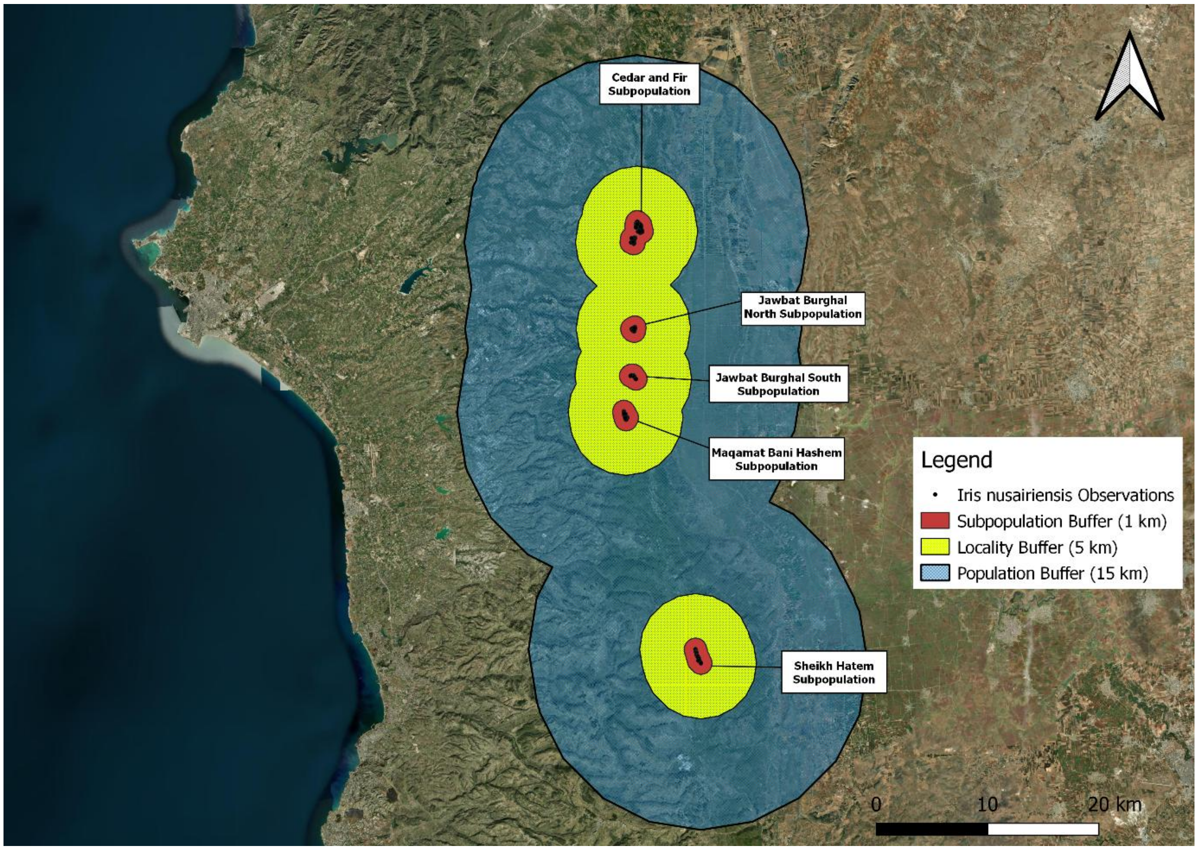


Figure 4.5 *Population units of the Iris nusairiensis on the Syrian coastal mountain range. The units are marked by colours: blue indicates the population, yellow indicates the locality and red indicates the subpopulation.*

4.3.1.2. Population size

The 2022 population census recorded a total of 13,651 *Iris nusairiensis* individuals across a surveyed area of 5.7 km^2. Among the individuals we surveyed, we found a relatively low number of mature individuals (306) forming only (2.24%) of the total population.

Among the subpopulations, Cedar and Fir had the highest number of recorded plants with 9,656 individuals, including 178 mature individuals, it is also the largest surveyed area with 3.3 km^2. The second largest subpopulation, Maqamat Bani Hashem, contained 2,708 individuals, of which 37 were mature, within a 0.6 km^2 survey area. The Jawbat Burghal North and South subpopulations together accounted for 1,052 individuals, with 86 mature plants, surveyed over 0.2 km^2 and 0.8 km^2, respectively. The last subpopulation, Sheikh Hatem, had the lowest number of plants with 235 individuals including and only 5 mature individuals, covering 0.9 km^2.

4.3.1.3. Distribution: Area of Occupancy (AOO) and Extent of occupancy (EOO)

The Extent of Occurrence (EOO) for the species is 82 km^2, representing the total area within which all known occurrences are distributed. The Area of Occupancy (AOO) was calculated using a 2×2 km grid and found to cover 32 km^2. The plant distribution extends over two governorates, the governorates of Latakia and Hama (Figure 4.6).

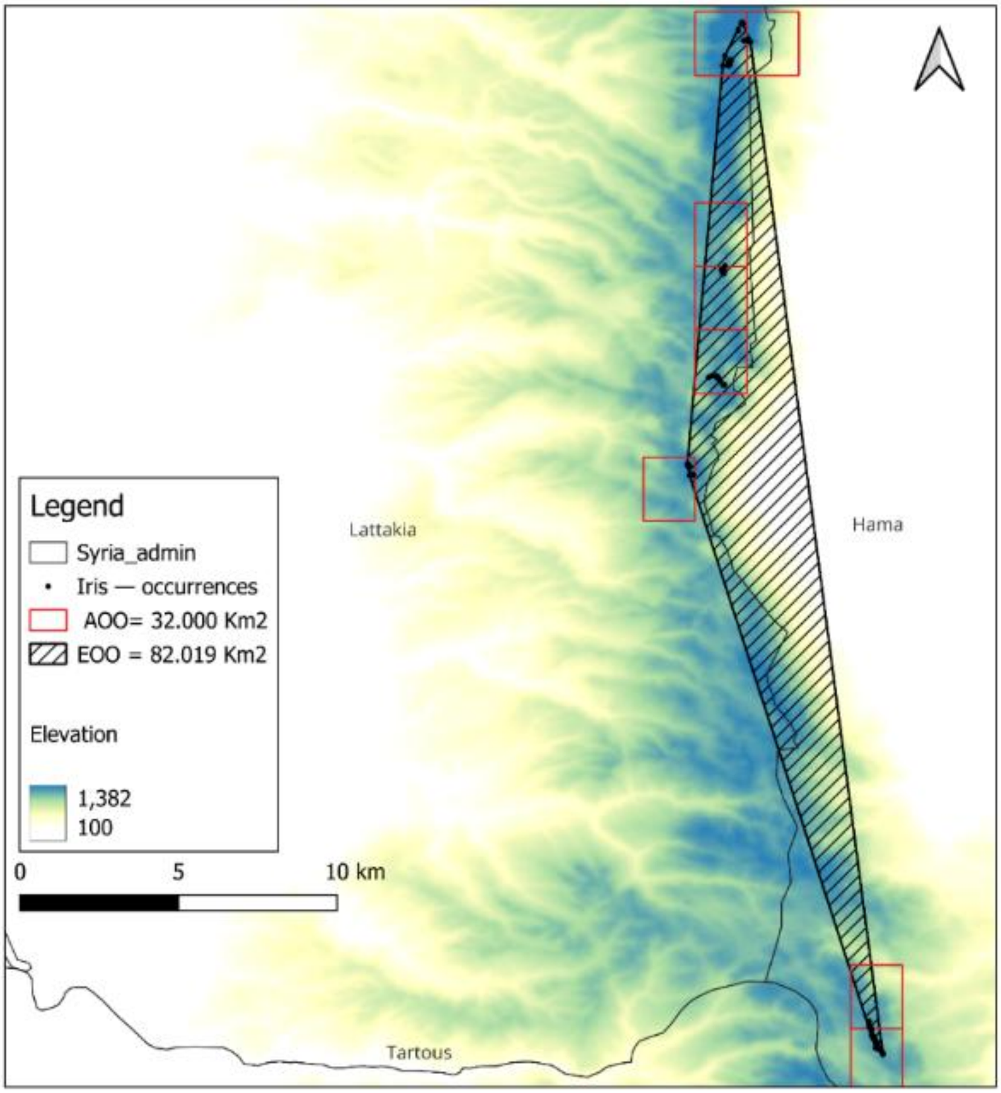


Figure 4.6 *Map of the Area of the Occupancy (AOO) and the extent of occurrence (EOO) based on the Iris nusairiensis occurrences collected from the population census in the study area on the coastal Syrian coastal range.*

4.3.2. Life History, Traits, and Habitats

4.3.2.1. Life History and Traits

The morphological traits of both mature and non-mature plants were measured, including plant height, diameter, leaf length, leaf width, number of leaves, and number of flowers. Summary statistics (minimum, maximum, and mean values) for these traits are shown in Table 4.1, with a comparative boxplot in Figure 4.7.

Plant height ranged from 6 to 20 cm in mature individuals, with a mean of 12.1 cm, while non-mature plants ranged from 1.5 to 14.1 cm, averaging 7.3 cm. The height difference between mature and non-mature individuals was highly significant. For stem diameter, mature plants ranged from 0.4 to 0.9 cm, with a mean of 0.63 cm, while non-mature plants ranged from 0.1 to 0.9 cm, with a mean of 0.4 cm. The difference in diameter was also highly significant.
Leaf length varied from 2.5 to 19 cm (mean = 9 cm) in mature individuals and from 2 to 20.8 cm (mean = 13.4 cm) in non-mature plants. Leaf width ranged from 0.5 to 4 cm (mean = 2 cm) in mature plants, compared to 0.1 to 8 cm (mean = 1 cm) in non-mature ones. Significant differences in both leaf length and width were found between the two groups. Mature plants had 4 to 8 leaves (mean = 6), while non-mature plants had 2 to 7 leaves (mean = 5), with this difference being statistically significant. Mature individuals produced 2 to 5 flowers, averaging 3 flowers per plant.

Table 4.4 *Summary statistics (minimum, maximum, and mean) for six morphological traits of Iris nusairiensis, comparing Mature (Mat) and Non-mature (Nmat) individuals. Traits measured include plant height, plant diameter, leaf length, leaf width, number of leaves, and number of flowers.*

	Plant Height (cm)		**Plant Diameter (cm)**		**Plant Leaf Length (cm)**		**Plant Leaf Width (cm)**		**Number of Leaves**		**Number of Flowers**
	Mat	*Nmat*	*Mat*	*Nmat*	*Mat*	*Nmat*	*Mat*	*Nmat*	*Mat*	*Nmat*	*Mat*
Min	6	1.5	0.4	0.1	2.5	2	0.5	0.1	4	2	2
Max	20	14.1	0.9	0.9	19	20.8	4	8	8	7	5
Mean	12.1	7.3	0.63	0.4	9	13.4	2	1	6	5	3

Number of mature individuals measured: (n = 36), Number of Non-mature individuals measured (n = 59).

Figure 4.7 *Comparative boxplot graphs showing the differences in plant traits (Height, Diameter, Leaf length, width, and number of leaves) between the mature and non-mature plants.*

The correlation analysis showed different patterns between plant traits (Figure 4.8). Height shows strong positive correlations with diameter (r = 0.66), leaf width (r = 0.63), number of leaves (r = 0.59), and number of flowers (r = 0.69). Diameter also correlates strongly with leaf width (r = 0.69), number of leaves (r = 0.71), and number of flowers (r = 0.66) with bigger stems support greater leaf and flower production. Number of leaves is positively associated with both leaf width (r = 0.49) and number of flowers (r = 0.41). Leaf width is positively linked to almost all other traits—including number of flowers (r = 0.71), number of leaves (r = 0.49), diameter (r = 0.69), and height (r = 0.63)—implying that broader leaves may contribute to or reflect greater overall plant performance. In contrast, leaf length exhibits negative correlations with several traits: it is negatively associated with height (r = -0.16), diameter (r = -0.16), leaf width (r = -0.25), and most notably, number of flowers (r = -0.54).

In conclusion, as plants grow, they tend to exhibit increased height, diameter, and number of leaves. Conversely, leaf length decreases while leaf width increases, and plants with larger diameters tend to produce more leaves and flowers.

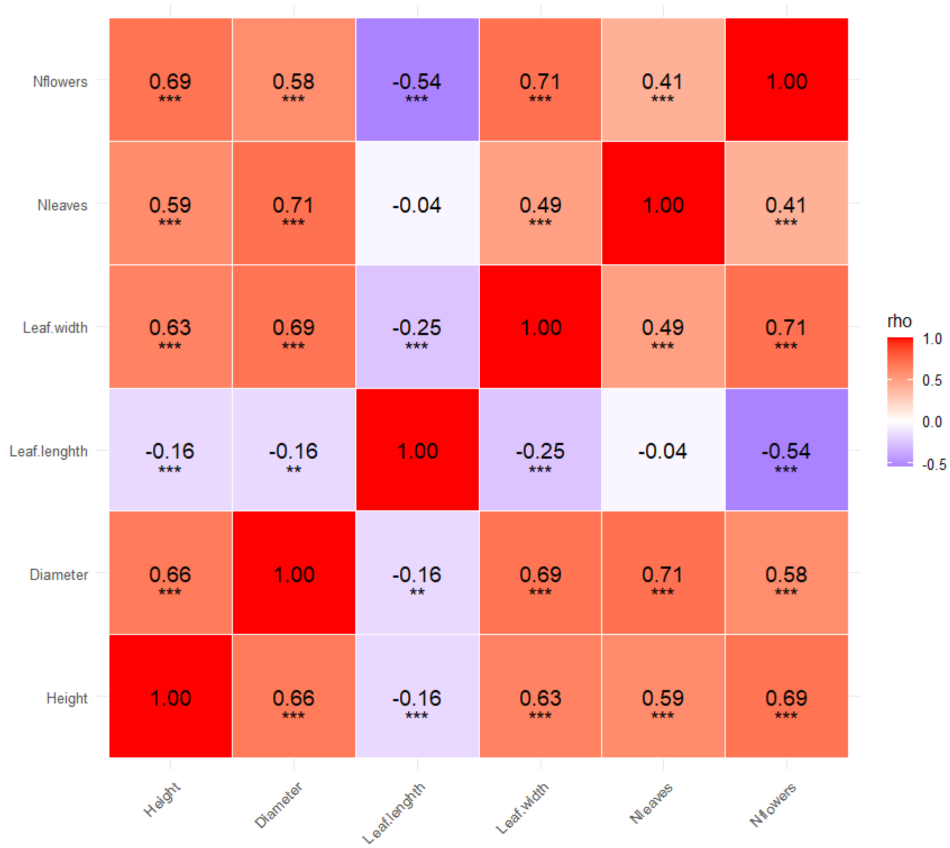


Figure 4.8 *Spearman correlation matrix showing relationships among plant morphological traits, including height, stem diameter, leaf length, leaf width, number of leaves, and number of flowers. Color intensity represents the strength and direction of the correlations (red = positive, purple = negative), with darker shades indicating stronger correlations. Asterisks denote statistical significance (***p < 0.001, **p < 0.01).*

Figure 4.9: *Iris nusairiensis in the non-mature phase.*

Figure 4.10*: Iris nusairiensis in the mature phase.*

4.3.2.2. Habitats

The habitat classification analysis, conducted using QGIS and following the European Habitat Classification Guidelines (EUNIS), identified five primary habitat types in the surveyed area (See Figure 4.11).

In Cedar and Fir subpopulation, the dominant habitat type, covering 70% of the study area, was the Mixed Deciduous and Coniferous Woodlands (EUNIS habitat code: G4). This habitat consists of conifer species such as Cilician fir (*Abies cilicica*), mixed with Turkish oak (*Quercus cerris*) on the western mountain slopes. Additionally, Lebanese cedar (*Cedrus libani*) is found alongside *Quercus infectoria* and *Quercus calliprinos* on the eastern slope. In Jawbat Burghal South, the Mixed Coniferous and Broadleaf Forest (G4) accounted for 27.5% of the total study area. However, this subpopulation was found severely degraded as it has undergone extensive logging, leaving only a few standing Lebanese cedar (*Cedrus libani)* trees mixed with Quercus cerris (Figure 4.12).

In the other four subpopulations, the dominant habitat was Evergreen Quercus Matorral (S511), consisting of dense, low, coppice-like evergreen oaks (*Quercus calliprinos*). This habitat covered 70% of the area surveyed in Sheikh Hatem, 55% in Maqamat Bani Hashem, 71% in Jawbat Burghal North, and 45.7% in Jawbat Burghal South.

The third most common habitat was *Juniperus oxycedrus* Garrigue (F6.25), characterized by low, shrubby *Juniperus oxycedrus*. This habitat accounted for 25.2% of the Cedar and Fir subpopulation, 26.8% of Jawbat Burghal North, 27.2% of Jawbat Burghal South, 43.7% of Maqamat Bani Hashem, and 28.6% of Sheikh Hatem. The remaining habitat types in the surveyed area occupied only a small percentage of the surveyed areas. These included Mediterranean Montane Grassland (E1.5), Arable Land (I1), and Low-Density Buildings (J2) (see Figure 12).

When crossing the plant occurrences with the habitat types in the surveyed areas we found that the plant was encountered in three distinct habitat types. The primary habitat, where 82% of the plants were found, was *Juniperus oxycedrus* garrigue (F6.25). This habitat is characterized by low-density shrubs in open areas on mountain peaks with a high percentage of rocks, with full sun exposure and no canopy cover and calcaric soils (See Figure 4.12).

The second habitat type, where 15% of the plant were found, consisted of mixed deciduous and coniferous woodlands (G4). The *Iris* was mainly observed in forest gaps between tree stands and near forest roads. We also recorded a number of individuals in productive and non-productive stages occurring in areas that have been exposed to disturbances like the 2020 forest fires at the Cedar and Fir subpopulation. In the Jawbat Burghal South subpopulation, it was also recorded in open areas within cedar forest that was exposed to extensive deforestation that resulted in increased light penetration to the forest floor (See Figure 4.12).
The third habitat type, including 3% of the encountered plants, was the Evergreen Quercus Matorral (S511). The plant was found in open, rocky areas between shrubby oaks.

Elevations where the plant was encountered varied, with the lowest recorded elevation at 1273 meters in the Jawbat Burghal subpopulation, and the highest at 1507 meters in the Cedar and Fir subpopulation. In general, the plant was typically found in open areas with full sunlight, in forest gaps, and in degraded, low-density forests, all associated with calcaric soils. Additionally, we recorded frequently co-occurring plant species, which are summarized in Table 4.2 below.

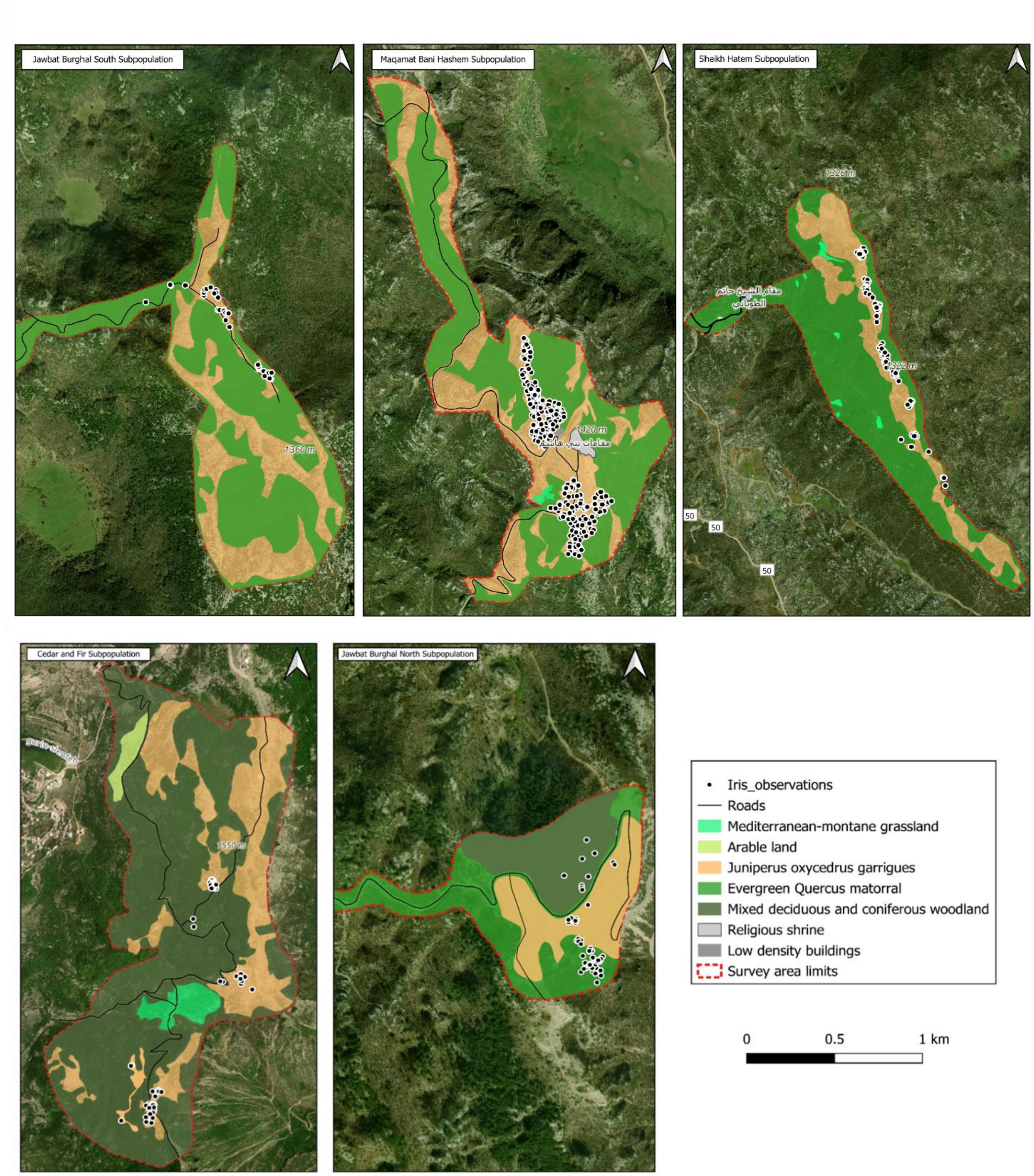


Figure 4.11 *Habitat maps of the five studied subpopulations, classified into seven habitat types based on EUNIS habitat specifications.*

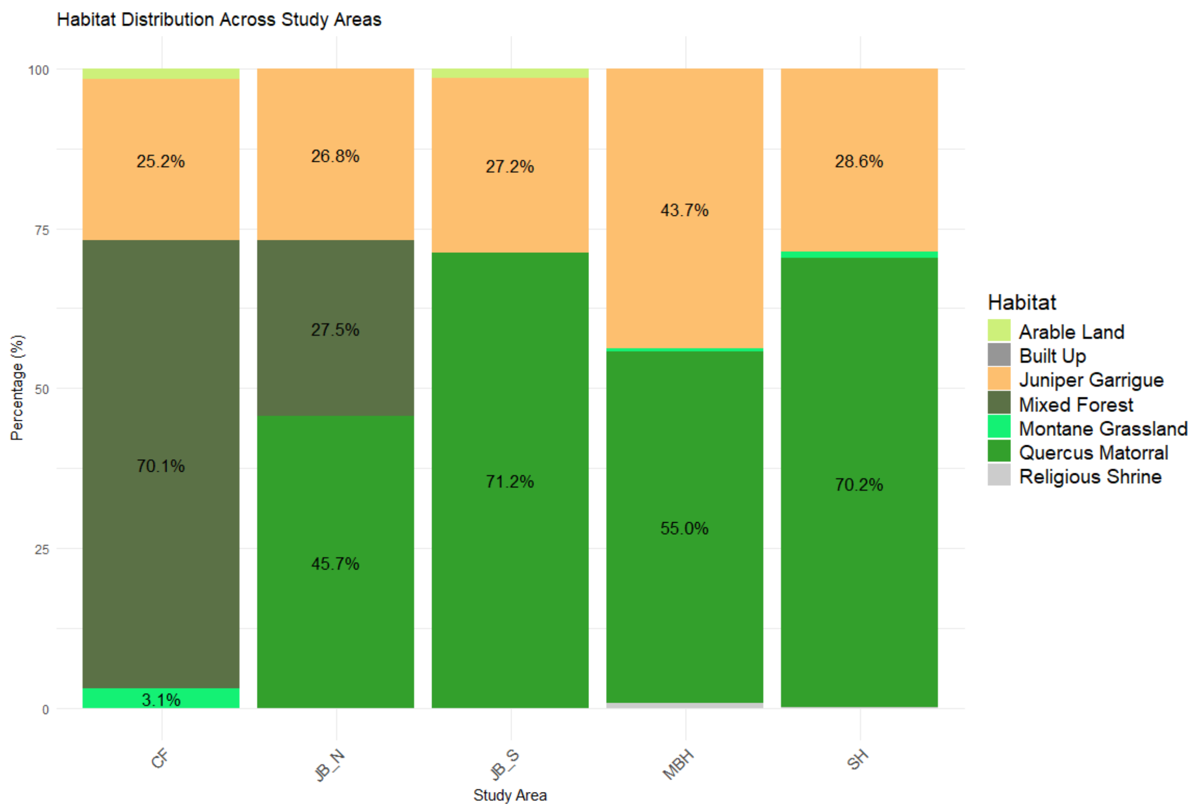


Figure 4.12 *Habitat composition across the five studied subpopulations (CF, JB_N, JB_S, MBH, and SH), expressed as the percentage of total area covered by each habitat type.*

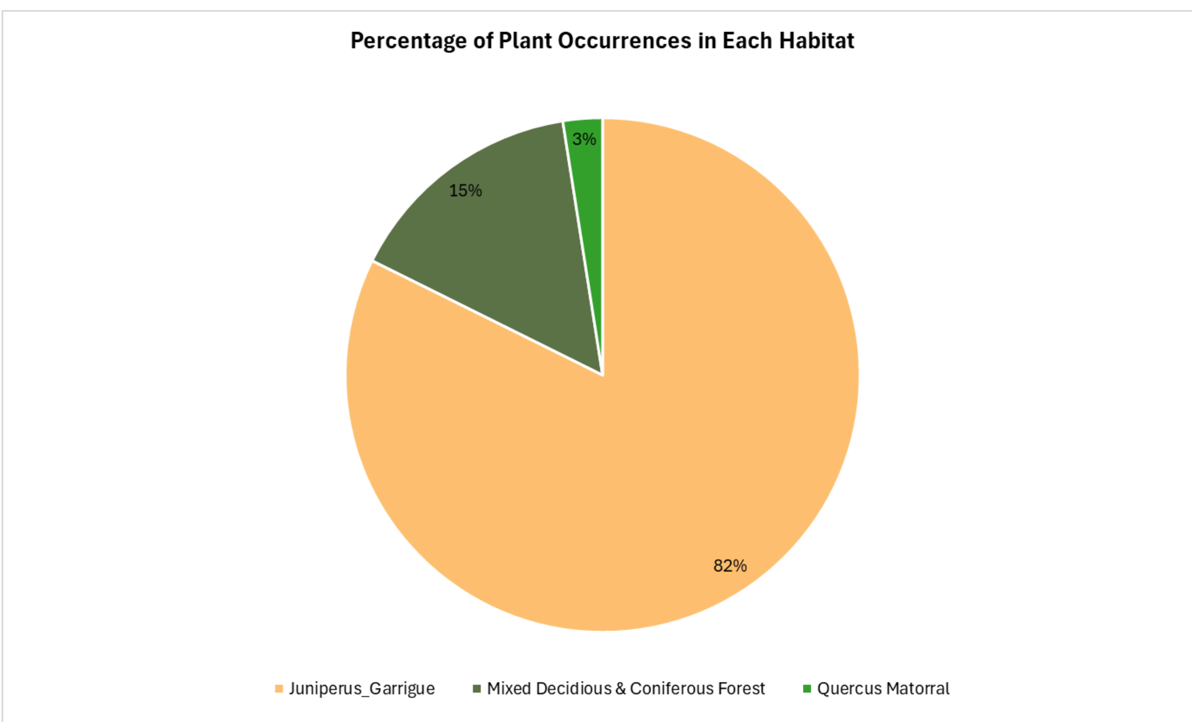


Figure 4.13 *Distribution of Iris nusairiensis occurrences across habitat types.*

Table 4.5 *List of the most common plant species associated with Iris nusairiensis in the habitat.*

Scientific Name	**Family**
Myopordon thiebautii (Genty) Wagenitz	Asteraceae
Bellevalia flexuosa Boiss	Asparagaceae
Gagea reticulata (Pall.) Schult. & Schult.f	Liliaceae
Viola modesta Fenzl	Violaceae
Sideritis syriaca subsp. nusairiensis (Post) Hub.-Mor	Lamiaceae
Myosotis alpestris F.W.Schmidt	Boraginaceae
Arabis aucheri Boiss.	Brassicaceae

Figure 4.14 *The Juniperus oxycedrus garrigue habitat in the cedar and fir subpopulation.*

4.3.3. Abundance and Ecological Variables

Before fitting the models, we evaluated potential multicollinearity among predictors using Variance Inflation Factors (VIFs). The VIF test revealed high multicollinearity between Mean Annual Temperature (MT) and Mean Precipitation (MP) as both exhibited VIF values above 10. Due to the strong overlap between MT and MP, we chose not to include both variables in the same model. Instead, we fit separate models to evaluate the individual effects of MT and MP on plant abundance.

A generalized linear model (GLM) with a Poisson distribution was used to assess the effects of variables on plant abundance. The model included mean annual temperature (MT), canopy cover, slope degree, rock cover, elevation, and grazing. Mean annual temperature had a strong positive effect on plant count ($p < 0.001$), indicating that warmer conditions are associated with greater plant abundance. Elevation also showed a significant positive effect ($p < 0.001$), as did rock cover ($p < 0.01$). Canopy cover and slope were not significant predictors.
The model had an AIC of 2103 and reduced the residual deviance from 733.64 (null) to 631.78 with 572 degrees of freedom, suggesting an improved model fit compared to the null (Table 4.3 & Figure 4.16).

Table 4.6 *Summary of Poisson regression results from two generalized linear models (GLMs) examining the effects of ecological predictors on plant abundance. Estimates, standard errors (SE), z-values, and p-values are presented for each predictor in model MT.*

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Signif.
(Intercept)	-6.32059	1.024571	-6.169	6.87E-10	***
MT	0.221258	0.047335	4.674	2.95E-06	***
Canopy Cover	-0.00382	0.005323	-0.717	0.473309	
Slope	0.002173	0.006032	0.36	0.718682	
Rock Cover	0.00291	0.001127	2.581	0.009845	**
Elevation	0.002396	0.000689	3.479	0.000503	***
AIC	2103.5				

A second generalized linear model (GLM) with a Poisson distribution was fitted to assess plant abundance using mean annual precipitation (MP) in place of temperature, while retaining other variables. The model included MP, canopy cover, slope, rock cover, and elevation. Mean annual precipitation (MP) showed a strong negative effect on plant count (Estimate = $p < 0.001$), suggesting that higher precipitation levels were associated with lower plant. Elevation and rock cover again showed significant positive effects ($p < 0.001$ and $p = 0.0107$, respectively). Canopy cover, slope, and grazing were not significant predictors, consistent with the MT model. The model had an AIC of 2101, slightly lower than the MT model (AIC = 2103), and reduced the residual deviance from 733.64 to 629.78 on 572 degrees of freedom, indicating a modest improvement in fit (Table 4.4 & Figure 4.16).

Table 4.4 *Summary of Poisson regression results from two generalized linear models (GLMs) examining the effects of ecological predictors on plant abundance. Estimates, standard errors (SE), z-values, and p-values are presented for each predictor in model MP.*

Variable	Estimate	Std. Error	z value	Pr(>|z|)	Signif.
(Intercept)	-0.42216	1.132273	-0.373	0.7093	
MP	-0.00249	0.00051	-4.885	1.03E-06	***
Canopy Cover	-0.00375	0.005318	-0.705	0.4808	
Slope	0.002111	0.005987	0.353	0.7244	
Rock Cover	0.002873	0.001126	2.552	0.0107	*
Elevation	0.002427	0.000686	3.54	0.0004	***
AIC	2101				

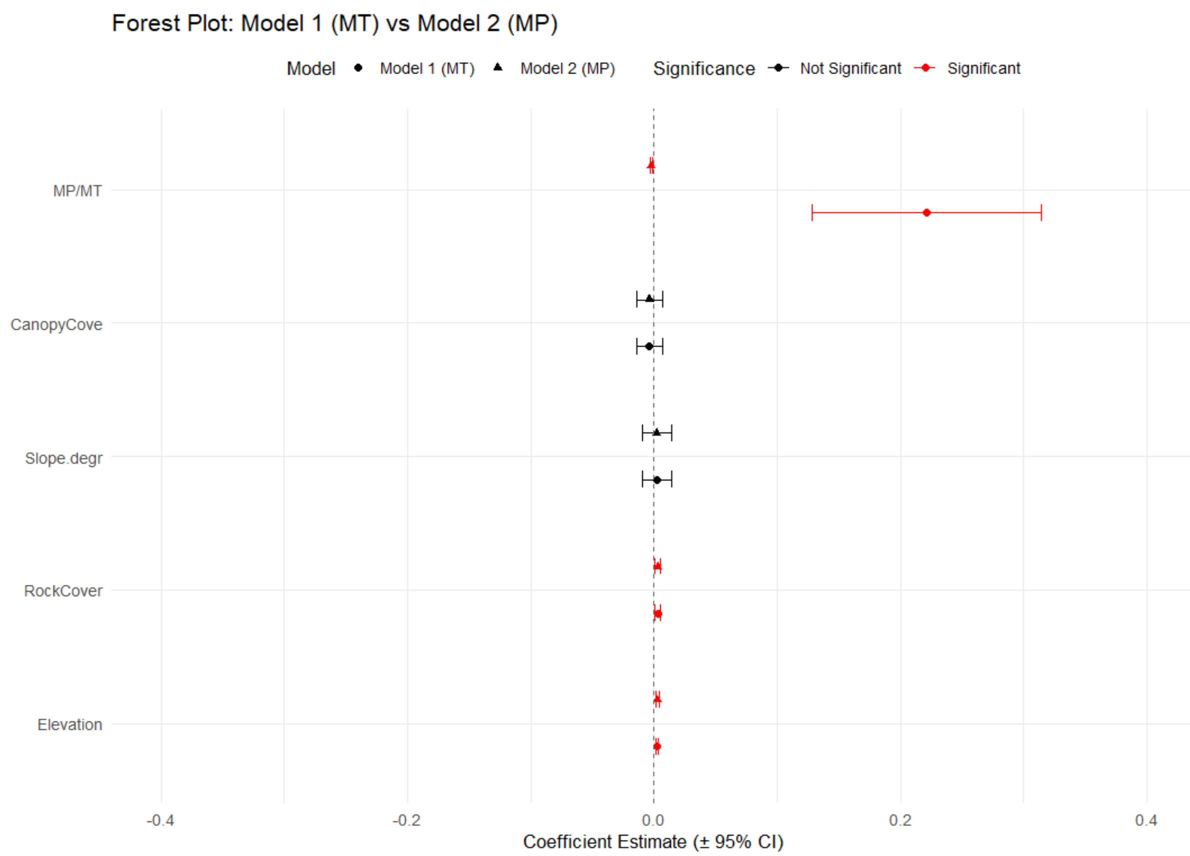


Figure 4.16 *Forest plot shows Poisson regression coefficients (log rate ratios) with 95% confidence intervals from two generalized linear models (GLMs). Predictors with statistically significant effects ($p < 0.05$) are highlighted in blue.*

4.3.4. Threats and Impacts

4.3.4.1. The Effects of War

Our results showed that three out of the five subpopulations are found to be affected by the war by causing disturbances of the species habitat by mainly soil removal, the subpopulations are: Cedar and Fir (CF), Maqamat Bani Hashem (MBH), and Jawbat Burghal (JB) North. We present here the results of the models that we fitted to study the relationship between the plant count (response variable) and the predictor (disturbed area %) in each of the subpopulations.

a) Cedar and Fir (CF) Subpopulation:

The results of the Negative Binomial Hurdle models describe how plant counts are influenced by disturbed area percent. In the Disturbed Area Percent Model. There was no significant effect of disturbed area percent on plant counts in these grids. However, the zero hurdle component showed that as the disturbed area percent increased, the likelihood of grids having no plants (structural zeros) significantly decreased (p=0.007). The model fits well, as indicated by an AIC of 2173.43 and a low overdispersion statistic of 0.9478, (Table 4.5 & Figure 4.17, 4.18, 4.19).

Table 4.5 *Summary of the results of hurdle models for the data taken from the Cedar and Fir (CF) Subpopulation.*

Model Component	Predictor	Estimate (β)	Std. Error	z-value	p-value
Disturbed Area model					
Count Model	Intercept	4.432	0.078	56.50	< 0.001 ***
	Disturbed Area Percent	-0.0055	0.0048	-1.15	0.250
	Log(θ\thetaθ)	0.323	0.109	2.96	0.003 **
Zero Hurdle Model	Intercept	0.893	0.166	5.38	< 0.001 ***
	Disturbed Area Percent	-0.0228	0.0085	-2.68	0.007 **
Model Fit	AIC	2173.43			
	Overdispersion Statistic	0.9478			

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

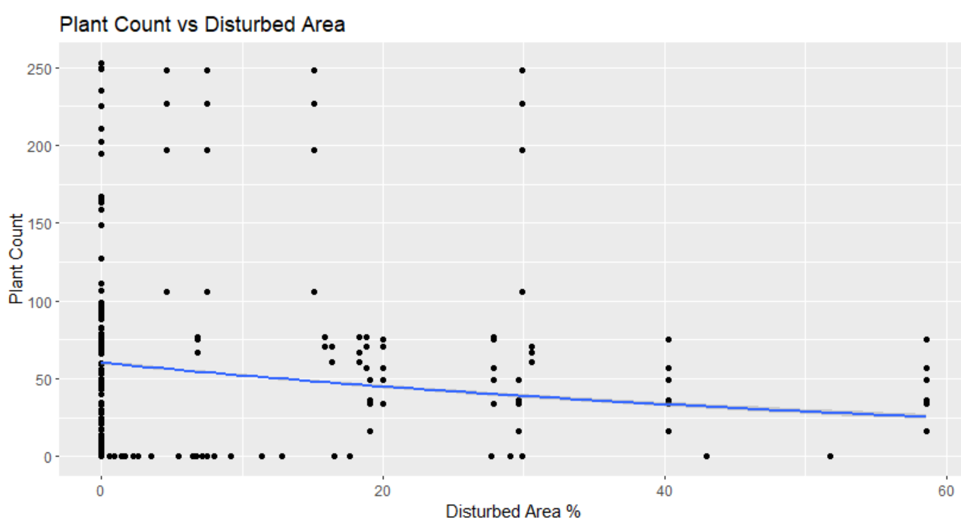


Figure 4.17 *Scatterplot showing the relationship between plant count and disturbed area percentage in the Cedar and Fir (CF) Subpopulation*

Figure 4.18 *Soil removed for a tank platform, arrows indicate Iris nusairiensis individuals in the removed soil around the platform.*

Figure 4.19 *Soil disturbance in the habitat of Iris nusairiensis*

b) Maqamat Bani Hashem (MBH) Subpopulation:

The Disturbed Area Model (MBH) showed no significant effect of disturbed area on plant counts in grids with plants. However, the zero hurdle model found that as the disturbed area increased, the likelihood of zero count grids (grids with no plants) significantly decreased. The model fit the data well, with an AIC of 485.07 and a low overdispersion statistic of 0.715, (Table 4.6 & Figure 4.20, 4.21).

Table 4.6 *Summary of the results of hurdle models for the data taken from the Maqamat Bani Hashem (MBH) Subpopulation.*

Model Component	**Predictor**	**Estimate (β)**	**Std. Error**	**z-value**	**p-value**
Disturbed Area Model					
Count Model	Intercept	4.240	0.166	25.61	< 0.001 ***
	Disturbed Area Percent	-0.0112	0.0188	-0.60	0.550
	Log(θ\thetaθ)	0.102	0.239	0.43	0.670
Zero Hurdle Model	Intercept	1.504	0.388	3.88	< 0.001 ***
	Disturbed Area Percent	-0.0819	0.0278	-2.94	0.003 **
Model Fit	AIC	485.07			
	Overdispersion Statistic	0.715			

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Figure 4.20 *Soil removal in the Maqamat bani Hashem in the Iris nusairiensis habitat.*

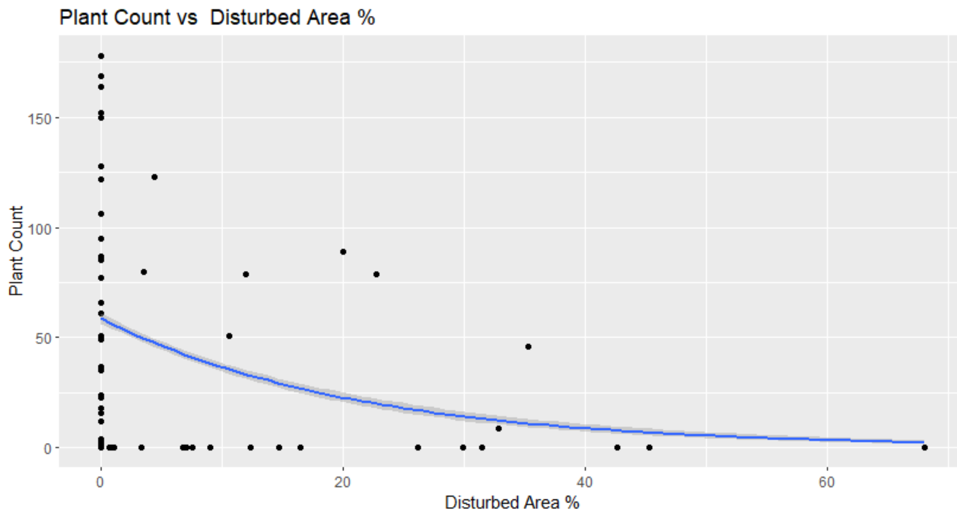


Figure 4.21 *Scatterplot showing the relationship between plant count and disturbed area percentage in the Maqamat Bani Hashem (MBH) Subpopulation.*

c) Jawbat burghal North (JB) Subpopulation:

The Disturbed Area Model revealed no significant relationship between disturbed area and plant counts in grids with plants. However, the zero hurdle component found a significant negative relationship between disturbed area and the likelihood of zero count grids (grids with no plants). The model demonstrated a good fit, with an AIC of 304.08 and a moderate overdispersion statistic of 0.7794, (Table 4.7 & Figure 4.22).

Table 4.7 *Summary of the results of hurdle models for the data taken from the Jawbat burghal North (JB) Subpopulation.*

Model Component	**Predictor**	**Estimate (β)**	**Std. Error**	**z-value**	**p-value**
Disturbed Area Model					
Count Model	Intercept	3.4721	0.1639	21.18	< 0.001 ***
	Disturbed Area Percent	-7.8892	67.0263	-0.12	0.906
	Log(θ\thetaθ)	0.2000	0.2890	0.69	0.489
Zero Hurdle Model	Intercept	4.4860	1.6020	2.80	0.0051 **
	Disturbed Area Percent	-3.7810	1.3740	-2.75	0.0059 **
Model Fit	AIC	304.08			
	Overdispersion Statistic	0.7794			

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

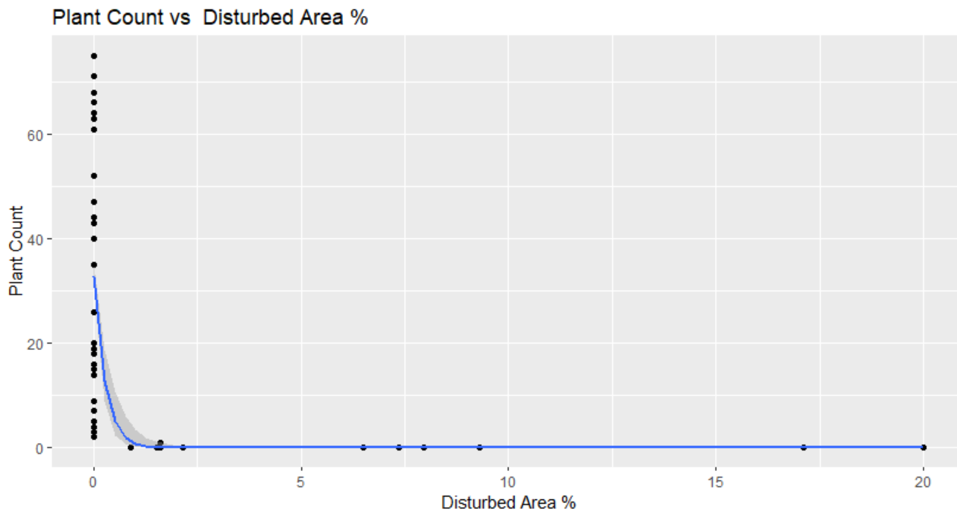


Figure 4.22 *Scatterplot showing the relationship between plant count and disturbed area percentage in the Jawbat burghal North (JB) Subpopulation.*

4.3.4.2. Other War-Related Effects

In addition to the direct habitat disturbances caused by war activities, our fieldwork revealed several secondary effects of the conflict that have impacted the Cedar and Fir subpopulation. One major consequence was the weakening of protection within this protected area. The reserve buildings were damaged and looted (Figure 4.23), and the absence of reserve guards or any enforcement measures further exacerbated the situation. Additionally, we observed signs of illegal tree removal by locals, specifically targeting Cilician fir (*Abies cilicica*) and Turkish oak (*Quercus cerris*). Other human activities included sheep grazing in the grasslands and fire pits. Furthermore, the reserve suffered from massive forest fires in 2021 (Figures 4.23, 4.24, 4.25, 4.26), adding to the degradation of the habitat. Collectively, these disturbances indicate a decline in the level of protection, rendering the protected area ineffective in maintaining the species.

Figure 4.23 *Signs of looting on the entrance of the Cedar and fir protected area.*

Figure 4.24 *Fir pit found in the Cedar and fir protected area.*

Figure 4.25 *Logged Cilicican fir (Abies cilicica).*

Figure 4.26 *Sheep grazing in the protected area.*

4.3.4.3. The Effects of Herbivory

We recorded several grazing animals foraging on the *Iris* plants, including cattle and sheep in the Cedar and Fir subpopulation, goats in the Sheikh Hatem subpopulation, and cattle in the Jawbat Burghal North subpopulation. Additionally, we observed evidence of herbivory on the plant's foliage and flowers by various insect species, including grasshoppers (*Orthoptera*), beetles (*Coleoptera*), and aphids (*Hemiptera*). See Figures (4.27,4.28).

The model results indicated that insect herbivory had no significant effect on the species' abundance. In contrast, grazing had a significant overall effect on plant abundance, with a p-value of 0.0118 (Table 4.8).

Table 4.8 *Summary of generalized linear model (GLM) results testing the effects of grazing, insect presence, and site on plant abundance. The table reports estimates, standard errors, z-values, and p-values for each model term. Asterisks denote statistical significance (p < 0.05 = *, p < 0.001 = ***).*

Model	Variable	Estimate	Std. Error	z value	Pr(>|z|)
Model Grazing					
Grazing Effect	(Intercept)	0.80442	0.02857	28.155	<2e-16 ***
Grazing Effect	Grazing	-0.2749	0.10921	-2.517	0.0118 *
Model Insect Effect					
Insect Effect	(Intercept)	0.78451	0.0287	27.334	<2e-16 ***
Insect Effect	InsectPres	-0.01954	0.10356	-0.189	0.85

Figure 4.27 *Signs of insect herbivory on the Iris flower.*

Figure 4.28 *Cow feces observed on the Iris individual.*

4.3.5. The IUCN Red List Reassessment

Based on the IUCN Red List criteria and the available species data collected during our census, we evaluated the conservation status of *Iris nusairiensis* using Criteria B and C, which are based on geographic range and population size, respectively.

1. Assessment Under Criterion B (Geographic Range)

Criterion B considers both the Area of Occupancy (AOO) and the Extent of Occurrence (EOO) to determine the level of threat to the taxon:

- The EOO is 86 km^2, meeting the threshold for Critically Endangered (CR) B1.

- The AOO of *Iris nusairiensis* is 32 km^2, which qualifies for the Endangered (EN) B2 category.

In addition, the species satisfies two of the sub-criteria required under Criterion B:

- (a) Number of Locations: The species is found in two localities, which classifies it as Endangered (EN).
- (b) Continuing Decline: There is a decline in the quality of habitat individuals due to ongoing threats such as habitat degradation, war, and grazing, fulfilling condition b (iii)

2. Assessment Under Criterion C (Small Population Size and Decline)

Criterion C evaluates the taxon based on population size and decline trends:

- The latest census data estimates fewer than 2,500 mature individuals, which meets the threshold for the Endangered (EN) category under Criterion C.
- C2: Subpopulation Structure
    - The number of mature individuals per subpopulation is ≤ 250, which meets the Endangered (EN) threshold under C2a(i).

5. Assessment Under Criterion D (very small or restricted population)

Number of mature individuals D1 <1000 which meets the Vulnerable (VU) threshold under D.

For the final assessment, we applied the highest level of extinction risk identified across the IUCN Red List criteria, as recommended by the IUCN guidelines outlined in the methodology section. Accordingly, the species is assessed as ***Critically Endangered (CR) under Criterion B1ab(iii)***.

4.4. Discussion:

4.4.1. Population and Distribution

The accurate delineation of a species' geographic range—particularly for narrow endemics—is fundamental for assessing extinction risk and informing conservation strategies (Farquhar et al., 2024; Mota-Vargas & Rojas-Soto, 2012). In this study, we calculated the Extent of Occurrence (EOO) of *Iris nusairiensis* for the first time, a metric that was missing from the initial IUCN Red List assessment. We also updated the Area of Occupancy (AOO), increasing it slightly from 28 km^2 to 32 km^2 (Shater, 2016). These updates will be submitted to the IUCN, as Red List assessments should be revised at least every ten years, and the last assessment was conducted in 2016 (Cazalis et al., 2024; Shater, 2016). In addition to range metrics, population data are essential for evaluating extinction risk, especially in small populations with few mature individuals and declining trends (O'Grady et al., 2004; Volis & Deng, 2020).

Our recent population census recorded a total of 13,651 individuals, including only 306 mature individuals representing just 2.24% of the total population. These were distributed across five subpopulations—four of which were newly discovered during this study, and one previously noted in the *Flora Mouterde* (Mouterde, 1966). This expanded our knowledge of the species' distribution considerably and highlights the importance of ongoing field surveys for rare and understudied taxa (Udyawer et al., 2020). Additionally, identifying new subpopulations helps clarify demographic structure and reproductive viability, which are crucial for prioritizing conservation actions (McDonald-Madden et al., 2008; Rivers et al., 2010).

However, the small number of mature individuals and the overall small, fragmented nature of the population raise significant conservation concerns. Such populations can be susceptible to genetic drift, reduced genetic variation, and demographic stochasticity, all of which can compromise adaptive capacity and increase the probability of extinction in the face of environmental fluctuations (Bijlsma & Loeschcke, 2012; Frankham, 2005; Lande, 1993).

While census data provides important baseline information, they are insufficient to capture the underlying genetic health of subpopulations. Accordingly, we recommend comprehensive genetic analyses to evaluate intra- and inter-population genetic diversity, population structure, and levels of gene flow. These data are essential for assessing the degree of isolation, identifying potential inbreeding or genetic bottlenecks, and informing conservation strategies aimed at maintaining or restoring genetic connectivity, especially in narrowly endemic plant species (Ellstrand & Elam, 1993; Frankham et al., 2010).

4.4.2. Life History, Traits, and Habitats

4.4.2.1. Life history and Traits

The results demonstrate significant morphological differentiation between mature and non-mature individuals, with mature ones generally exhibiting greater height, stem diameter, and number of leaves. These traits likely reflect the increased structural and energetic demands associated with flowering and reproductive development. The significantly greater plant height and diameter in mature individuals may offer an advantage in floral display and pollinator attraction, which has been observed in other herbaceous species undergoing growth transition

(Hernández-Villa et al., 2020).

Juno irises are known to have unique distichous leaf arrangement and unifacial leaves even at the seedling stages (Mathew, 2000). As they mature, the lower leaves become wider than the upper ones which is a pattern observed among the species of the *iris* group, In fact (Mathew, 2000) points that the arrangement of the leaves on the flowering stem is a helpful indicator of Juno irises. The shift in leaf morphology during the transition to maturity may reflect a strategic reallocation of resources. According to (Koelewijn, 2004) plants often undergo changes in growth patterns upon entering the mature phase, reallocating resources from vegetative growth to reproductive structures. The broader leaves in mature plants could enhance photosynthetic efficiency to meet the increased energy demands of reproduction.

Morphological characterization of Iris' traits could be a potential indicator of the growing stage of the species, especially when detecting this growing stage is highly challenges when the reproductive parts are not observed. Additionally, the morphological characters that provided by this study could give insights into the correct identification of the species as suggested by (Celep et al., 2022). Further investigation of this plant's morphological traits is necessary to develop a comprehensive understanding of its life history, growth dynamics, pollination ecology, maturing age, and the influence of biotic and abiotic factors on its development and reproduction.

4.4.2.2. Habitats

The majority of *Iris nusairiensis* individuals were found in the *Juniperus oxycedrus* garrigue habitat, this habitat is characterized by calcaric and rocky soils and low, open shrubland dominated by *J. oxycedrus*. It offers the sunlight availability necessary for the growth and successful reproduction of the species. Moreover, *Juniperus* shrubs may play a facilitative or "nurse plant" role, providing microhabitat conditions that protect emerging seedlings from herbivory and environmental stress—an interaction commonly observed in Mediterranean ecosystems (Padilla & Pugnaire, 2006). In addition to these primary habitats, several *Iris nusairiensis* individuals were also found in degraded habitats, particularly within mixed forests of coniferous and deciduous species that had experienced disturbance events such as forest logging or fire. These disturbances are likely to reduce canopy cover and forest density, creating more open conditions favorable to the ecological requirements of *I. nusairiensis*. Such dynamics have also been reported for other Mediterranean *iris* species. For instance, a study by Arenas-Castro et al, (2019) on the rare and endemic *Iris boissieri* in Portugal suggested that fire disturbances can facilitate plant colonization by promoting light availability and reducing interspecific competition.

Currently, Syria lacks detailed and standardized habitat maps, which presents a major barrier to effective conservation planning and species management. It is therefore critical to classify and document the habitat preferences of threatened and endemic species such as *Iris nusairiensis*, and to evaluate the ecological consequences of habitat modification, particularly those caused by forest fires and land-use change, on their population dynamics and long-term viability.

Establishing a high-resolution, open-access habitat map within international frameworks such as EUNIS or CORINE would enable consistent biodiversity monitoring, support conservation prioritization, and guide the development of targeted habitat restoration strategies. Furthermore, it would facilitate the integration of national biodiversity data into broader regional efforts, enhancing the protection of narrow endemics and other vulnerable taxa.

4.4.3. Abundance and Ecology

According to our findings, the abundance of *Iris nusairiensis* is significantly influenced by ecological variables such as elevation, mean annual temperature (MT), mean annual precipitation (MP), and rock cover.
Higher elevations were associated with greater plant abundance, higher elevations provide isolation, unique microhabitats, and reduced competition, supporting evolutionary processes that foster endemism and localized abundance (Di Musciano et al., 2021).

Precipitation (MP), in contrast, showed a negative correlation with abundance and this could be explained by plant preference to well-drained soil, Juno irises bulbs are well adapted to drought conditions and equipped have evolved with deeply set, tunic-covered bulbs and fleshy storage roots that grant drought tolerance, enabling survival through hot, dry summers after a short, moisture-reliant spring, this could also could support our results on the preference of this species to slightly higher mean annual temperature (MT). For that we stress the importance of the interplay between water and temperature is a critical determinant of *I. nusairiensis* success. Warmer spring temperatures accelerate flowering and growth, while limited but well-timed moisture from snowmelt or early rains supports rapid early development. If moisture levels are excessive or mistimed, bulbs may face anoxic stress or pathogen attacks; conversely, insufficient spring moisture can delay emergence and reduce flowering success (Boltenkov, 2016). Given the species' narrow ecological window and dependence on precise environmental cues, controlled experiments under greenhouse conditions could provide valuable insights into its physiological thresholds. Simulating varying temperature and moisture regimes would help disentangle the relative influence of each factor and identify tolerance limits. Such data could inform both in-situ and ex-situ conservation strategies, especially under scenarios of climate change and habitat disturbance. Rock cover also emerged as a positive predictor of abundance.

Rocky habitats improve drainage, increase aeration, and reduce competition from dense vegetation. Comparable ecological patterns are seen in other Juno irises like *Iris albomarginata, and Iris willmottiana among others. Iris albomarginata* found on stony slopes at 2300–3000 m*; and Iris willmottiana,* occurring on foothill and middle mountain slopes between 900 and 2500 m in Kazakhstan and Kyrgyzstan) (Sennikov et al., 2023).

Although *Iris nusairiensis* has not been previously studied in its natural habitat, evidence from long-term cultivation supports our findings regarding its ecological preferences. At the Royal Botanic Gardens, Kew, the species is successfully grown in alpine houses or raised beds with full sun exposure and sharply draining substrates composed of loam, sand, and grit, with overhead protection from rain. During dormancy, bulbs are kept dry to mimic the hot, arid summer conditions of its native range. In cultivation, mortality is often associated with freezing temperatures and excessive soil moisture around the bulbs. These horticultural practices highlight the plant's dependence on distinct seasonal cues—cool, moist winters that support early growth, followed by warm, dry summers that signal dormancy (Daiyoub et al., 2024).

Ecological variables are not the sole factors influencing the abundance, anthropogenic pressures such as herbivory and war also influence *Iris nusairiensis* abundance. These threats are addressed in detail in the following threats section.

4.4.4. Threats and Impacts

4.4.4.1. War

Soil disturbance due to warfare is a well-documented phenomenon that is observed throughout history and across the world. The excavation of trenches and the removal of soil for military fortifications significantly alter soil properties, compromising its structure and ability to sustain life (Certini et al., 2013). In Syria, this pattern has been particularly evident on mountain peaks, which have been strategically utilized during military operations for their elevated points over surrounding terrain. The preference for high ground in warfare is a long-standing tactical principle, as emphasized in both historical and modern military doctrine. Sun Tzu famously stated that "all armies prefer high grounds to low" (Tzu et al., 1994), while (Banderet & Burse, 1978) noted that high elevations provide advantages in observation, fire control, and defense.

Since the disturbed areas directly overlap with the natural habitats of *Iris nusairiensis*, our analysis revealed a significant negative correlation between the extent of disturbance and plant abundance across three subpopulations—Cedar and Fir, Maqamat Bani Hashem, and Jawbat Burghal North. Specifically, subpopulations with a higher proportion of disturbed habitat had notably fewer individuals. This pattern strongly suggests a direct effect of habitat destruction—caused by military activity—on the species' population size. As the percentage of disturbed land increased, the number of *Iris nusairiensis* individuals declined, indicating that war-related habitat alteration is having an immediate and measurable impact on the species' survival.The statistical significance of these findings was detected only in the zero-hurdle models, while no significant effect was observed in the count model. This distinction underscores the importance of using hurdle models to accurately assess the impact of habitat disturbance on plant populations, as they account for both species presence and absence separately especially when detecting overdispersion and excess of zeros in the dataset (Montilla Velásquez et al., 2023; Smith et al., 2019).

These findings are consistent with evidence from other regions, which show that endemic and threatened plant species are particularly vulnerable to habitat modification. For example, Robinson & Hermanutz (2015) found that human-induced soil disturbance significantly reduced the abundance of the narrow endemic *Salix jejuna*, highlighting how even small-scale modifications to soil structure can negatively impact the regeneration and persistence of rare species. Similarly, the soil removal and physical alteration observed in *I. nusairiensis* habitats likely disrupt the conditions necessary for seed germination and plant growth.

Our findings also showed that war has had indirect effects on the conservation of *Iris nusairiensis*. Field observations showed a complete breakdown in the management of the Cedar and Fir Protected Area, with clear signs of neglect and harm, including vandalized infrastructure and the absence of any active protection measures. We also recorded illegal deforestation of threatened cilicican fir (*Abies cilicica*) and Lebanese cedar trees (*Cedrus libani*) (Gardner, 2013; Gardner & Knees, 2013), widespread grazing by livestock, and evidence of firepits—all activities that would typically be restricted in a functioning protected area.

The conflict has severely weakened enforcement and oversight, creating conditions that enable damaging human activities. These pressures not only affect the *Iris nusairiensis* but also pose serious threats to other endemic and endangered species that this protected area is known to harbour. Without immediate restoration of protection measures, the ecological integrity of the area may continue to deteriorate.

Several examples illustrate the indirect effects of war on biodiversity conservation across different regions in the world. In New Caledonia—one of the world's most critical biodiversity hotspots and home to approximately 2% of the planet's threatened animal, plant, and fungal species—conflict and violence resulted in weakened conservation institutions, reducing their ability to enforce environmental protections. As a result, unsustainable fishing, poaching, and other destructive activities have escalated, placing additional pressure on fragile ecosystems (Oedin et al., 2024, 2025). Similarly, the ongoing war in Ukraine has raised serious environmental concerns, with researchers warning of a potential ecocide if urgent measures are not taken to protect the country's ecosystems (Sousa et al., 2022). The conflict has rendered four major protected areas ineffective in safeguarding threatened species, further exacerbating biodiversity loss (Filho et al., 2024).

4.4.4.2. Grazing

Overgrazing is a well-documented driver of habitat degradation and biodiversity loss, particularly in arid and semi-arid environments such as the Mediterranean Basin and the Middle East. Its effects are especially pronounced on rare, narrow endemic plant species with limited distribution and low reproductive resilience (Bounejmate et al., 2004; Louhaichi & Tastad, 2010; Papanastasis et al., 2002). Several studies have shown that overgrazing pressure, particularly from unmanaged livestock, can directly threaten species persistence by reducing adult population sizes and preventing seedling recruitment (Eldridge & Delgado-Baquerizo, 2017; Franca et al., 2016). In our study, grazing was shown to significantly affect the abundance of *Iris nusairiensis*. Field observations revealed a disproportionately low number of mature individuals relative to seedlings. This suggests that young plants are often grazed before reaching reproductive maturity, thereby interrupting generational turnover. Moreover, the reduced presence of adult individuals may further hinder seedling survival due to the lack of seed input and vegetative structure, which are critical for microhabitat stabilization.

Our results are consistent with studies by (Gedeon & Khalilieh, 2024) which focused on three narrow endemic and threatened *Iris* species in the West Bank, Palestine (*Iris haynei* and *Iris atrofusca* listed as vulnerable, *Iris lortetii* as endangered), and identified overgrazing—along with habitat loss due to urban expansion—as a primary factor pushing these taxa toward extinction. Similarly, (Othman et al., 2023) reported that *Iris bismarckiana*, an endemic species of northern Jordan and Palestine, is under severe threat from overgrazing. Their study emphasized that unless grazing is managed and conservation strategies implemented, the species could face local extinction.

4.4.5. The IUCN Red list Reassessment and Recommendations for Conservation

Our updated assessment of *Iris nusairiensis* maintains its classification as Critically Endangered, consistent with the 2016 IUCN evaluation. However, we have revised the list of threats to include significant emerging factor—warfare-related disturbances to its habitat—which was not documented in the previous assessment. Ongoing threats also include intensive livestock grazing, which continues to reduce the number of individuals and likely hinders seedling survival. Initial observations have also revealed damage within the protected cedar and fir areas. This highlights the need for further investigation into the effectiveness of these protected areas, particularly their role in preventing habitat degradation and biodiversity loss. Such assessments are especially critical for conserving narrowly endemic and threatened species like *Iris nusairiensis*.

To ensure the long-term conservation of *Iris nusairiensis*, a comprehensive and adaptive strategy is required, integrating in situ and ex situ conservation measures. Priority actions include expanding field surveys to identify more sites, restoring war-damaged areas through erosion control and habitat reconnection, and strengthening enforcement within protected areas like the Cedar and Fir Reserve by managing grazing and mitigating human pressures.

Conservation planning must also incorporate currently unprotected but ecologically viable subpopulations. Establishing long-term ecological monitoring will enable adaptive management (Lindenmayer & Likens, 2010), while seed banking and cultivation in botanical gardens will safeguard the species' genetic diversity for future reintroduction. With Syria highly vulnerable to climate change (Mathbout et al., 2023), predictive modelling of habitat shifts is critical for proactive conservation planning (Hamann & Aitken, 2013). Equally vital is the engagement of local communities—particularly pastoralists and local residents—through participatory approaches such as community-based grazing management and habitat monitoring, ensuring conservation efforts are socially feasible and sustainable in post-conflict landscapes (Berkes, 2004).

Limitations and challenges of the study:

Many of the limitations of this study were due to the challenging conditions imposed by the ongoing war. At the time of fieldwork, the country was facing a severe energy crisis, with gas prices surging. This significantly affected both the cost and availability of reliable transportation to our remote mountain study sites. As a result, we had to limit the timing and frequency of our field surveys to adapt to these constraints.

Security concerns also played a major role. Some of the study areas were in remote regions that had experienced incidents of kidnapping and robbery, further restricting our access. In addition, reaching some mountainous areas proved to be physically difficult due to poor infrastructure or lack of accessible routes in some areas. For these reasons, we prioritized study sites with better accessibility and lower security risks. However, this may have led to the exclusion of other important areas that could also harbor significant populations worthy of study.

These logistical and security challenges forced us to adapt our methodology during the project. Changes in political and safety conditions required frequent adjustments to our field plans, which in turn affected the amount of data we were able to collect and introduced some inconsistencies in our survey methods.

4.5. Conclusions

This study establishes critical baseline data on the traits, habitats, ecology, distribution, population and threats of *Iris nusairiensis*, enabling a reassessment of its conservation status. While the discovery of new subpopulations and updated habitat information enhances our understanding, the very low number of mature individuals could indicate high vulnerability. Notably, our findings reveal that war-related disturbances—such as habitat disturbance and soil removal and weakened protection measures—have had direct negative impacts on the species' abundance and habitat integrity. Combined with grazing pressure, these threats underscore the urgent need for targeted conservation actions, habitat restoration, and stronger protection frameworks and Ex-situ conservation. Long-term monitoring, research and community engagement will also be essential for ensuring the survival of this endemic species in a post-conflict landscape.

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Chapter 05

General Discussion and Conclusions

Hope, Community, and Trees © Green Bridges

5.1. General Discussion

The impacts of warfare on ecosystems and the human communities dependent upon them are deeply interconnected, complex, and multifaceted (Francis & Krishnamurthy, 2014). This thesis addresses the impacts of the Syrian war through an interdisciplinary lens, integrating perspectives from political ecology, socio-ecological frameworks, and biodiversity conservation. Initially, adopting a political ecology perspective, I examined the root causes of environmental degradation in Syria. This analysis considers not only the direct impacts of violence but also the underlying structural inequalities that contribute to environmental degradation. Furthermore, this approach allowed for an exploration of community responses, including environmental activism that emerged amid ongoing political instability. Subsequently, I investigated the socio-ecological dynamics resulting from prolonged conflict, highlighting significant shifts in human-nature interactions. Finally, a detailed case study on *Iris nusairiensis*—a critically endangered endemic plant—demonstrated how war severely disrupts conservation efforts, particularly in ecologically vulnerable and inadequately protected habitats.

5.1.1. Biodiversity Conservation in the Context of the War in Syria

This thesis demonstrates how the war in Syria has had severe direct and indirect impacts on the country's natural ecosystems and biodiversity. In **Chapter 2**, I show how the war directly triggered large-scale deforestation that was carried out by armed groups, resulting in entire protected and public forest areas being systematically logged and sold in local markets. Similar patterns of deforestation by armed groups occur on larger scales in other forest-rich conflict zones, such as the Democratic Republic of Congo, where timber revenues were systematically exploited to finance military operations (Kranz et al., 2018). This rapid deforestation causes dramatic changes to forest landscapes and has serious implications for biodiversity—especially considering that Syria lost approximately 20% of its forest cover between 2010 and 2019—and that could have serios implications and threats to the country's ecological sustainability (Daiyoub et al., 2023).

Chapter 3 moves beyond direct military impacts to examine how the war-induced energy crisis and widespread poverty severely limited civilians' access to fuel and electricity. Consequently, many turned to forests as their primary source of energy and income. This increased pressure further degraded Syria's forest ecosystems. Several studies identify logging for firewood as a leading cause of forest loss in Syria and other conflict-affected regions (CEOBS, 2021; Mohamed, 2021; PAX, 2023). This is particularly concerning because Syrian forests are part of the Mediterranean biome—an internationally recognized for its biodiversity—and also hosts a rich diversity of trees, shrubs, aromatic plants, fungi, and wildlife. Their loss could lead to serious threats to species, habitat fragmentation, and disruption of ecological processes essential for sustaining rural livelihoods (FAO, 2018).

Another indirect way by which the war has damaged Syrian ecosystems is the collapse of governance and compromised state control over critical infrastructure—sewage networks, power-plant oil tanks, factory air-filter systems, water treatment facilities, solid-waste collection, and more. **In Chapter 2**, our case studies illustrate how the influx of internally displaced persons and the population increase in the coastal cities of Tartus and Latakia and the capital Damascus overwhelmed already strained waste-management services, leading to widespread pollution of vital ecosystems. This pattern of indirect ecological harm is far more prevalent than direct military damage—in fact, non-combat impacts are estimated to account for nearly twice as many environmental consequences as battlefield activities (Hsiao et al., 2023). In such contexts, war redirects public funding away from development and infrastructure maintenance toward defense and security, creating a new "war economy" that prioritizes militarization over environmental protection and public services (CEOBS, 2020).

In **Chapter 4**, I demonstrate how the militarization of protected areas further accelerates biodiversity loss. Some of the habitats of *Iris nusairiensis* were converted into strategic military zones, with its critical narrow habitats occupied by armed forces, affecting its population. This militarization not only disrupted local ecosystems but also brought any ongoing conservation activities to a halt. Prior to the war, although protective measures were limited, forest guards and local infrastructure provided some degree of monitoring and habitat management. However, once military control replaced conservation oversight, these habitats became highly disturbed and effectively unprotected. The militarization of protected areas can have serious implications on species conservation as they disrupt conservation actions and planning, divert funding and also can cause direct harm to species population and their habitats (Gaynor et al., 2016; Hsiao et al., 2023).

A major challenge for conservation in Syria is the lack of comprehensive species data, which is particularly concerning given the country's rich flora and high number of endemic species sensitive to disturbance—especially within the *Iris* genus. Despite this richness, fewer than 11% of Syrian endemic plant species have been assessed under the IUCN Red List (Daiyoub, 2020).

Other endemic and Critically endangered plant species such as *Iris damascena* (Damascus iris) and *Iris antilebanotica* (Anti-Lebanon iris) remain severely understudied, with even fundamental ecological information missing from their IUCN assessments (Lansdown, 2016; Sapir, 2016). This data gap hampers effective conservation planning and increases the risk that these vulnerable species will be overlooked amidst ongoing habitat loss and conflict-related pressures.

The war in Syria has imposed severe challenges on conservation efforts beyond habitat destruction. As shown in **Chapter 2**, conflict has accelerated illegal poaching and trade of threatened species, undermining decades of recovery work. For example, the reem gazelle—a species once extinct in Syria but successfully reintroduced through conservation programs—has been pushed back toward local extinction due to rampant war-related poaching. Armed groups have deliberately hunted and captured these animals for sale, exploiting the collapse of government control and law enforcement and power vacuum that war created in Syria as well as in other war torn areas around the world (Aidek & Eid, 2025; Nowrot, 2020).

The widespread availability of firearms, initially used for warfare, has also facilitated illegal hunting, turning weapons into tools for wildlife exploitation (Nowrot, 2020). Similarly, the saker falcon (*Falco cherrug*), a globally threatened species and a national symbol of Syria, has become a frequent target of illegal trapping and trade. Valued for falconry, the species is trafficked both domestically and internationally, often in violation of international agreements like CITES. Despite its cultural importance, the saker falcon lacks explicit protection under Syrian law, and enforcement mechanisms are effectively absent amid ongoing instability. This combination of legal gaps and weakened governance has left emblematic species highly vulnerable to exploitation during the war.

In light of these findings, it is critical that Syria, with the support of international partners, develops and enforces robust conservation legislation. Laws must specifically address the protection of threatened and endemic species and be coupled with institutional capacity-building for enforcement and monitoring. Conservation must also be integrated into broader post-conflict reconstruction and development agendas. This includes restoring damaged ecosystems, protecting surviving habitats, rebuilding infrastructure for conservation management, and reviving environmental education and research. Experiences from other post-conflict countries show that integrating biodiversity into peacebuilding frameworks can yield long-term benefits for both people and nature.

5.1.2. Socioecological Aspects of the War in Syria:

The interplay between war, poverty, and the environment in Syria demands a holistic, nuanced discussion—one that situates the struggle over resources within broader debates on environmental justice, gender perspective, and the right to a peace and security. At the heart of this debate lies a fundamental question: when wars strip away state services and cause widespread poverty, do natural systems become safety nets for the vulnerable, or do they turn into arenas of intensified exploitation that ultimately erode ecological integrity and people's relation to nature?

Historically, Syrian forests have provided poor rural communities with vital resources such as firewood, medicinal plants, wild fruits, and grazing lands that together formed an important buffer against energy shortages and poverty (Nahal & Zahoueh, 2005). In one of the case studies I presented in **Chapter 3** we see that when the war erupted and state energy infrastructure supplies collapsed, households rapidly lost access to reliable electricity and subsidized fuel. With few alternatives, families transformed occasional wood-gathering into systematic logging: more people spent more days per week felling trees, not only for warmth and cooking but also to sell firewood as a desperately needed source of cash (90 % of the population lives in extreme poverty; OCHA, 2021). **Chapter 3** also shows how this transformation reshaped people's relationship with the forest, turning it from a safety net into a critical long-term lifeline. Similar patterns have been documented elsewhere in wartime settings—whether among displaced populations around Mount Nyiragongo in the Democratic Republic of the Congo or in refugee camps across South Sudan, Ethiopia, and Rwanda—where conflict intensifies dependence on forest resources both for domestic energy and for income generation (Andrews et al., 2024b; Draulans & Krunkelsven, 2002; Negash et al., 2023; Ordway, 2015).

Gender dynamics adds another layer to this debate. Firewood collection has long been coded as women's work across much of the global South—an unpaid labor that entangles domestic household work with ecological stewardship (Njenga et al., 2021). I also show in **Chapter 3** that when war erupts, the gendered division of labor becomes unstable. Men, traditionally engaged in paid or more visible forms of manual labor, now join wood harvesting excursions, blurring the lines between "man" and "woman" environmental tasks. This shift is actually seen in Syria not only with men participating in logging but also with women taking on roles that were previously deemed the domain of men such as running small businesses, trading goods, and, in many cases, becoming their household's primary breadwinner during the war. This wartime fluidity reveals both the fragility and adaptability of gendered labor norms under wartime (Buecher & Aniyamuzaala, 2016).

Chapter 3 also shows that, despite men and women spending a similar number of days per week harvesting wood during the war, women still collect less firewood overall. I theorize this gap arises because rural women remain primarily responsible for unpaid domestic duties—cooking, cleaning, and childcare—which significantly reduces their available daily time in the forest. Comparable studies across developing contexts confirm this dual burden: women shoulder both household labor and fuelwood collection, limiting their harvest compared to men (Nagbrahmam & Sambrani, 1983; Njenga et al., 2021).

Even as men join wood harvesting to meet survival needs, women's expanded workload—inside and outside the home—goes entirely uncompensated. This mirrors Maria Mies's concept of "housewifisation," whereby women's subsistence and care work is rendered invisible even though it sustains families and local economies (Mies, 2014). From an ecofeminist standpoint, post-conflict reconstruction must confront these intertwined injustices by valuing and remunerating all forms of care work, embedding women's ecological knowledge in forest governance, and dismantling the patriarchal structures that treat both nature and unpaid domestic labor as limitless resources (Shiva & Mies, 2014).

The impoverished Syrian population's dependence on natural resources has deepened during the war, extending beyond forests to include freshwater, fertile soils, coastal and other ecosystems. War transformed these ecosystems into vital lifelines for health, livelihoods, and well-being. It is globally recognized that in low-income settings, natural resources often considered as "the wealth of the poor," supplying daily essentials when formal services fail (United Nations Development Programme, 2005). In **Chapter 2**, I trace how the war gave rise to a form of wartime environmentalism: ten case studies reveal grassroots, often informal movements whose primary aim was defending access to clean water, soil, sea, air —not to protect nature in the abstract, but to secure the means of survival. This mirrors Guha and Martínez-Alier's (1997) concept of the "environmentalism of the poor," whereby marginalized communities mobilize around ecological struggles as part of broader fights for social and economic justice.

People's relationship with nature is not merely materialistic—it is also deeply spiritual, cultural, and communal (Chan et al., 2012; Cooper et al., 2016) . One of the most overlooked consequences of Syria's conflict is the erosion of this multisensory bond: Chapter 2 shows how the pollution of the Barada River—once the lifeblood of Damascus—has left residents feeling like strangers in their own city, as neither clean water nor memory flows as it once did.

Equally profound is the decline of species such as the reem gazelle and the saker falcon, whose beauty and symbolic presence once underpinned folk knowledge, poetry, and ritual. Beyond wildlife decline, the wholesale removal of forests and the occupation of sacred groves by foreign fighters have stripped away the very landscapes where communities gathered for Nowruz and other ancestral festivals. In each of these cases, war has done far more than degrade ecosystems—it has severed the cultural anchors that once wove people, nature, and history into a shared sense of home.

This sentiment resonates in a traditional Syrian folk song by Sabah Fakhri (Fakhri, 2022):

Arabic original:
يَا غَزَالَ الرَّمْلِ وَآهِ وَجَدى عَلَيْكِ
كَادَ سِرِّي فيكِ أَنْ يَنْهَتَكِ
هَذِهِ الصَّهْبَاءُ وَالْكَأْسُ لَدَيْكِ
وَغَرامِي في هَواكِ اشْتَبَكَ

English translation:
"O gazelle of the desert, my longing burns for you;
My hidden passion for you nearly overwhelmed me.
This tawny beauty and the goblet belong to you,
And in your love my heart is utterly entwined."

Ultimately, rebuilding Syria's landscapes must go hand-in-hand with rebuilding community resilience and cultural continuity. Restoring ecosystems like forests as true safety nets requires more than planting trees—it demands the revival of reliable clean energy systems, the affirmation of communal land rights, and the elevation of local voices in decision-making. Integrating reforestation with distributed microgrids, mapping and co-managing shared woodlands, and empowering women's cooperatives in sustainably harvesting fuelwood can knit ecological recovery together with social justice (Njuki et al., 2022). Embedding environmental justice into post-conflict laws and policies will ensure that, when the next shock—be it economic upheaval or renewed violence—hits, the most vulnerable communities can draw on both their forests and their traditional knowledge, rather than being cast aside at the margins of a fragile peace.

5.1.3. Challenges of Working Under War Constraints, Complicated Funding Situation and Immigration Status and Their Implicated Limitations on This Research:

This research was shaped by a number of significant limitations and practical challenges, beginning from the earliest stages of the PhD journey. I was awarded a scholarship that covered only one year of study, which led to ongoing financial instability and a continual search for additional funding. A considerable amount of time and energy was devoted to writing grant applications instead of focusing exclusively on the research. Furthermore, my legal status as a student in Spain prohibited me from working to support my research independently. This limitation was compounded by a lengthy and stressful bureaucratic process involving residency applications, legal appointments, and periods of uncertainty and anxiety.

Fieldwork in Syria presented even greater difficulties. Despite repeated efforts, it was not possible to establish formal coordination or obtain permits through institutional collaboration between my home university (UAB) and Syrian universities. Nonetheless, I travelled to Syria for two consecutive years to conduct fieldwork, including interviews and ecological surveys. These visits were carried out under considerable personal risk. Any activity perceived to be affiliated with Western organizations was regarded by the Assad regime as a potential national security threat—posing the danger of surveillance, arrest, or worse.

Due to these constraints, I relied on informal and trusted social networks to identify interviewees and conduct research in a safer, more discreet manner. I also collaborated with local scientists who played a crucial role in helping me access remote areas and navigate the terrain more securely.

While safety was the most pressing concern, logistical challenges also heavily impacted the fieldwork. The ongoing fuel crisis in Syria made transportation extremely difficult. Cars, drivers, and fuel were often unavailable, forcing me to use public transport or adapt to whatever means were accessible at the time. These limitations required significant adjustments to the original research design, including reducing the number of study sites and shortening the time spent at each location.

Despite these obstacles, every effort was made to ensure the research remained rigorous, ethical, and as comprehensive as possible under the circumstances.

5.1.4. Final Reflections: Toward Environmental Peacebuilding

This thesis identified violence as a primary driver of environmental degradation in Syria through both direct and as structural violence. These forms of violence, both emergent during the war and deeply embedded in Syria's pre-war political and environmental history, have converged to accelerate ecological collapse. Therefore, I argue that any attempt at environmental reconstruction must be grounded in the pursuit of what Johan Galtung defines as positive peace—a condition not merely characterized by the absence of violence (negative peace), but by the presence of justice, equity, and sustainable institutions (Galtung & Fischer, 2013).

From this standpoint, environmental sustainability cannot be disentangled from political stability. Meaningful ecological recovery depends on a post-war peace process that is inclusive, transparent, and grounded in environmental justice. Peacebuilding must go beyond ceasefires and political negotiations to address the root causes of conflict and the structural conditions that enable environmental harm. As Galtung & Fischer (2013) emphasize, a ceasefire represents only one-sixth of the peacebuilding process; the remaining components involve transforming the societal relationships, institutions, and conditions that reproduce violence—both human and ecological.

Ultimately, this thesis carries a message of peace for Syria, emphasizing that human well-being is deeply interconnected with the health of our ecosystems and the species we share this planet with. It is my hope that the experience of the Syrian war will serve as a profound lesson—for Syrians and for humanity at large—that violence is never a sustainable solution to our problems. There is no alternative to coexistence, cooperation, and the protection of both people and nature.

Angham

5.2. General Conclusions:

Chapter 2:

- **War-driven environmental collapse has intensified across Syria**: The war in Syria has significantly accelerated environmental degradation, introducing new forms of ecological harm such as the widespread pollution of ecosystems, rampant deforestation, and accelerated biodiversity loss. Conflict has also severely disrupted access to critical natural resources, with water being weaponized to create deliberate scarcity and deepen humanitarian crises. These impacts have been further exacerbated by foreign military interventions, territorial fragmentation, and the near-total collapse of environmental governance structures.

- **In the absence of formal governance, communities have adapted through grassroots strategies**: In response, a form of 'wartime environmentalism' has emerged—rooted in both survival and resistance. Syrians, particularly those from marginalized and vulnerable communities, have developed grassroots, often informal and nonconfrontational strategies to cope with and protest ecological harm. These practices not only aim to meet immediate environmental, and subsistence needs but also serve as subtle expressions of dissent and assertions of environmental rights in the face of systemic neglect, repression, and institutional breakdown.

- **State's environmental responses have largely lacked effectiveness and legitimacy**: The Assad regime's environmental initiatives have largely been symbolic and performative, designed to reinforce the power and interests of the regime elite rather than to confront Syria's deep-rooted ecological crises. Systemic corruption, entrenched patronage networks, and institutional fragility have severely undermined the capacity for genuine environmental reform or sustainable resource management.

- **Environmental degradation has become entangled with broader socio-political dynamics**: Environmental degradation in Syria is deeply political, intricately bound up with struggles over justice, sovereignty, and national identity.

The destruction of ecosystems, inequitable access to natural resources, and the weaponization of the environment reflect and reinforce broader patterns of repression and marginalization. As a result, ecological recovery is not merely a technical challenge but a profoundly political one—inseparable from questions of rights, representation, and reconciliation.

- **Future recovery efforts must prioritize justice-centered environmental governance**: Meaningful post-conflict recovery requires inclusive and transparent environmental governance that is rooted in justice and accountability. Without broad-based participation from local communities, particularly those historically excluded or displaced, and without sustained international cooperation that prioritizes environmental equity, ecological harm will persist. Failure to address these issues will deepen social divisions, perpetuate environmental injustice, and undermine prospects for a durable and just peace.

Chapter 3:

- **Participation in forest logging increased during the war.** Before the war, 53.8 % of respondents (n = 80) engaged in logging, while 46.2 % did not harvest wood. Once the war broke out, many of these non-logging people began wood harvesting, increasing the overall number of people participating in forest exploitation. Women were already the majority of loggers at both sites before the war: they constituted 54.5 % of loggers in Blouta and 57.1 % in Nehel al-Annaze, indicating that women were the primary participants in logging across both locations.

- **Logging frequency increased significantly**: Average logging days significantly increased from 1.5 days/week before the war to 4 days/week during the war. The increase of forest use was manly a result of war induced poverty and lack of energy resources for cooking and heating rather than the violence itself.

- **Gender and site effects on logging during different periods**: Generalized-linear modelling showed significant effects for gender, period (before and during war). Pre-war, women logged significantly more than men in Blouta; this difference disappeared during the war, with both genders logging equally in both villages. The war narrowed traditional gender roles, as economic hardship compelled both men and women to participate in household provisioning through wood collection.

- **Volume of wood related to gender and age**: Women harvested on average 0.47 tons less wood per month than men. Harvest volume also decreased with age: the 30–44-year age group collected about 0.7 tons more than the 45–59 group. Other factors—income, household size, education—were not significant.

- **Economic reliance on wood income**: During the war, income from wood harvesting became a vital source of livelihood. On average, participants earned about $150.60 per month from wood, compared to $31.80 from other sources. In Blouta, wood income helped close the income gap by nearly 85 %, and in Nehel al Annaze by about 47 %. For 20 % of respondents, wood was their only income source, with some working full-time as loggers. These results demonstrate the role of forests as economic safety nets during conflict-induced collapse, echoing patterns seen in other war-affected regions.

Chapter 4:

- **The first comprehensive data on the population size and distribution of the species:** The study identified a single population of *Iris nusairiensis* confined to high-altitude habitats in western Syria, with five distinct subpopulations across two localities (northern and southern). Four of these subpopulations were documented for the first time. The species' estimated Extent of Occurrence (EOO) is 82 km^2, and its Area of Occupancy (AOO) spans 32 km^2 across the Latakia and Hama governorates. A total of 13,651 individuals were recorded, but only 306 (2.24 %) were mature plants.

- **Morphological differences among life stages**: Significant trait differences were observed between mature and non-mature individuals. Mature plants were taller, had thicker stems, and produced more leaves. These leaves were broader but shorter compared to those of non-mature individuals, suggesting distinct developmental thresholds linked to reproductive capacity.

- **Habitat preferences**: Approximately 82 % of individuals were found in *Juniperus oxycedrus* garrigue habitats—sun-exposed, rocky mountain peaks with calcareous soils above 1300 m elevation. Additional individuals were found in disturbed mixed woodlands (15 %) and evergreen *Quercus* matorral (3 %). These results highlight the species' strong affinity for open, high-elevation rocky environments with full sunlight and specific temperature–moisture conditions.

- **The abundance of *Iris nusairiensis***: is strongly influenced by elevation, temperature, precipitation, and rock cover. Higher elevations and rocky, well-drained soils support greater plant density, reflecting the species' adaptation to dry, high-altitude conditions. In contrast, excessive or mistimed precipitation negatively impacts abundance. These findings highlight the species' narrow ecological requirements and vulnerability to environmental change.

- **War-related habitat disturbance reduces species abundance:** In the Cedar and Fir, Maqamat Bani Hashem, and Jawbat Burghal North subpopulations, areas with higher levels of disturbance had significantly lower individuals of *Iris nusairiensis*. This negative relationship was statistically significant in the zero-hurdle model, highlighting the direct impact of war-driven habitat destruction on population decline.

- **Grazing reduces adult plant abundance and disrupts regeneration**: Grazing was found to significantly reduce the plant abundance. I also found a low number of mature individuals compared to seedlings. This suggests that young *I. nusairiensis* plants are heavily grazed before reaching maturity, preventing reproductive turnover and population stability.

- **Conservation implications and recommendations**: *I. nusairiensis* qualifies as Critically Endangered under IUCN criteria. This study provides the first baseline data to support updating its Red List assessment. Recommended actions include habitat restoration, legal protection of key subpopulations, and the establishment of long-term monitoring. In the context of ongoing armed conflict, conservation efforts must be integrated into broader post-conflict ecological recovery and governance strategies.

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Appendixes:

Chapter 2

Table A.2. *Data on the anonymous interviewees who participated in the study*.

Interviewee Number	Gender	Occupation	Age
1	Female	Researcher in ecology and agriculture	35
2	Female	Student in Forestry	31
3	Male	Student in environmental sciences	25
4	Male	Environmental activist	30
5	Male	Wildlife researcher and activist	50
6	Male	Factory worker	45
7	Female	Agricultural engineer	30
8	Male	Wildlife activist	33
9	Female	Journalist	25
10	Male	Wildlife activist and agricultural engineer	32
11	Female	Journalist and human rights activist	34
12	Male	Civil engineer	20
13	Male	University professor in ecology and botany	55
14	Male	Head of an environmental NGO	40
15	Male	YouTuber	30

Chapter 3

Table A.3.1. *Showing the fitted generalized linear models (GLMs) with a Poisson family for predicting the number of logging days per week among sites and gender.*

model_simple <- glm(Days_logging ~ Period, data = days, family = poisson)
model_SS <- glm(Days_logging ~ Period + SS, data = days, family = poisson)
model_GR <- glm(Days_logging ~ Period + GR, data = days, family = poisson)
model_comb <- glm(Days_logging ~ Period + SS + GR, data = days, family = poisson)
model_interaction1 <- glm(Days_logging ~ Period + GR + SS + GR*SS, data = days, family = poisson)
model_interaction2 <- glm(Days_logging ~ Period + SS + GR + GR*SS*Period , data = days, family = poisson)

Table A.3.2. *AICc test results for model comparison. The table includes the number of parameters (K), corrected Akaike Information Criterion (AICc), delta AICc, AICc weight (AICcWt), cumulative weight (Cum.Wt), and log-likelihood.*

Model	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
interaction.mod2	8	686.71	0	0.54	0.54	-334.88
GR.mod	3	689	2.29	0.17	0.71	-341.42
combination.mod	4	689.02	2.31	0.17	0.88	-340.38
interaction.mod1	5	689.98	3.26	0.11	0.99	-339.79
sitestatus.mod	3	695.27	8.56	0.01	0.99	-344.56
days.period.mod	2	695.27	8.56	0.01	1	-345.6

Table A.3.3 *Table of post hoc contrasts from the emmeans pairwise comparison analysis for interactions between variables in the chosen model (interaction.mod2). where: Gender (GR1 = Man, GR2 = Woman), period (DLB = days of logging before war, DLD = Days of logging during), and site status (SS1 = Blouta, SS2 = Nehel al Annaze). The table includes contrast estimates, standard errors (SE), degrees of freedom (df), z-ratio, and p-value for each comparison.*

Contrast	Estimate	SE	df	z.ratio	p.value
DLB SS1 GR1 - DLD SS1 GR1	-1.2528	0.231	Inf	-5.413	<.0001
DLB SS1 GR1 - DLB SS2 GR1	-0.3483	0.267	Inf	-1.307	0.8967
DLB SS1 GR1 - DLD SS2 GR1	-1.0986	0.236	Inf	-4.661	0.0001
DLB SS1 GR1 - DLB SS1 GR2	-0.9491	0.24	Inf	-3.948	0.002
DLB SS1 GR1 - DLD SS1 GR2	-1.3437	0.229	Inf	-5.863	<.0001
DLB SS1 GR1 - DLB SS2 GR2	-0.5831	0.255	Inf	-2.289	0.2996
DLB SS1 GR1 - DLD SS2 GR2	-1.2164	0.232	Inf	-5.234	<.0001
DLD SS1 GR1 - DLB SS2 GR1	0.9045	0.203	Inf	4.45	0.0002
DLD SS1 GR1 - DLD SS2 GR1	0.1542	0.161	Inf	0.96	0.9799
DLD SS1 GR1 - DLB SS1 GR2	0.3037	0.167	Inf	1.814	0.6106
DLD SS1 GR1 - DLD SS1 GR2	-0.091	0.151	Inf	-0.603	0.9989
DLD SS1 GR1 - DLB SS2 GR2	0.6696	0.188	Inf	3.571	0.0085
DLD SS1 GR1 - DLD SS2 GR2	0.0364	0.156	Inf	0.234	1
DLB SS1 GR2 - DLD SS1 GR2	-0.3947	0.164	Inf	-2.402	0.2402
DLB SS2 GR1 - DLB SS1 GR2	-0.6008	0.213	Inf	-2.815	0.0912
DLB SS2 GR1 - DLD SS1 GR2	-0.9954	0.201	Inf	-4.96	<.0001
DLB SS2 GR1 - DLB SS2 GR2	-0.2348	0.229	Inf	-1.023	0.9711
DLB SS2 GR1 - DLD SS2 GR2	-0.8681	0.204	Inf	-4.248	0.0006
DLD SS2 GR1 - DLB SS1 GR2	0.1495	0.173	Inf	0.863	0.9892
DLD SS2 GR1 - DLD SS1 GR2	-0.2451	0.157	Inf	-1.558	0.7755
DLD SS2 GR1 - DLB SS2 GR2	0.5155	0.193	Inf	2.675	0.1303
DLD SS2 GR1 - DLD SS2 GR2	-0.1178	0.162	Inf	-0.727	0.9962
DLB SS1 GR2 - DLD SS1 GR2	-0.3947	0.164	Inf	-2.402	0.2402
DLB SS1 GR2 - DLB SS2 GR2	0.3659	0.198	Inf	1.844	0.5898

DLB SS1 GR2 - DLD SS2 GR2	-0.2673	0.169	Inf	-1.584	0.7601
DLD SS1 GR2 - DLB SS2 GR2	0.7606	0.185	Inf	4.117	0.001
DLD SS1 GR2 - DLD SS2 GR2	0.1273	0.152	Inf	0.836	0.9911
DLB SS2 GR2 - DLD SS2 GR2	-0.6332	0.189	Inf	-3.356	0.018

Table A.3.4. *Overview of models fitted to explore the relationship between the amount of harvested wood (LAT) and socioeconomic factors. The table lists model numbers, names, formulas, variables included, significance of results, degrees of freedom (DF), and Akaike Information Criterion (AIC) values.*

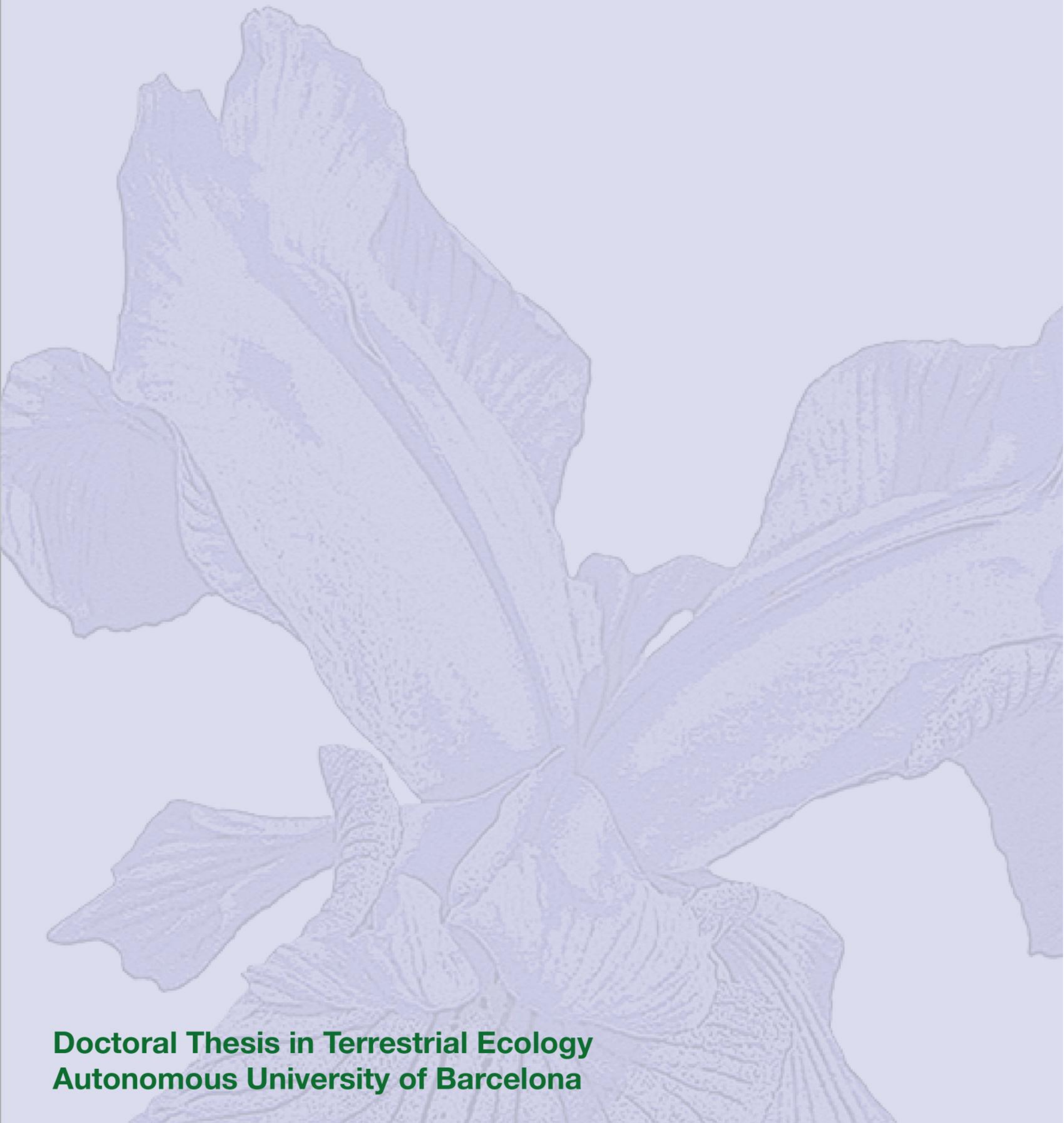
Model Number	Model Name	Formula	Variables	Significant Results?	DF	AIC
1	Model 1	LAT ~ GR	GR	0.0379 *	3	230.2081
2	Model 2	LAT ~ SS	SS	No	3	234.6285
3	Model 3	LAT ~ SS + GR	SS, GR	No	4	232.1804
4	Model 4	LAT ~ SS + GR + SS * GR	SS, GR, SS*GR	No	5	234.1615
5	Model 5	LAT ~ EL	EL	No	3	233.9766
6	Model 6	LAT ~ EL + GR	EL, GR	No	4	232.2061
7	Model 7	LAT ~ EL + GR + SS	EL, GR, SS	No	5	234.1786
8	Model 8	LAT ~ EL + GR + EL * GR	EL, GR, EL*GR	No	5	233.1069
9	Model 9	LAT ~ EL + GR + SS + EL * GR * SS	EL, GR, SS, EL*GR*SS	No	9	239.8504
10	Model 10	LAT ~ MI	MI	No	3	234.6513
11	Model 11	LAT ~ MI + GR	MI, GR	No	4	231.6917
12	Model 12	LAT ~ MI + GR + SS	MI, GR, SS	No	5	233.6742
13	Model 13	LAT ~ MI + GR + MI * GR	MI, GR, MI*GR	No	5	230.5626
14	Model 14	LAT ~ MI + GR + SS + MI * GR * SS	MI, GR, SS, MI*GR*SS	No	9	233.5262
15	Model 15	LAT ~ AG	AG	0.0142 *	3	228.4418
16	Model 16	LAT ~ AG + GR	AG, GR	No	4	228.8641
17	Model 17	LAT ~ AG + GR + SS	AG, GR, SS	No	5	230.7977
18	Model 18	LAT ~ AG + GR + AG * GR	AG, GR, AG*GR	No	5	230.5412
19	Model 19	LAT ~ AG + GR + SS + AG * GR * SS	AG, GR, SS, AG*GR*SS	No	9	237.4447
20	Model 20	LAT ~ NM	NM	No	3	230.1927
21	Model 21	LAT ~ NM + GR	NM, GR	No	4	228.5037
22	Model 22	LAT ~ NM + GR + SS	NM, GR, SS	No	5	230.4071
23	Model 23	LAT ~ NM + GR + NM * GR	NM, GR, NM*GR	No	5	229.9199
24	Model 24	LAT ~ NM + GR + SS + NM * GR * SS	NM, GR, SS, NM*GR*SS	No	9	236.8426
25	Model Inter 1	LAT ~ GR + AG + EL + MI + NM	GR, AG, EL, MI, NM	No	7	228.688
26	Model Inter 2	LAT ~ GR + AG + EL + MI + NM + GR * AG * EL * MI * NM	GR, AG, EL, MI, NM, GR*AG*EL*MI*NM	No	33	256.93
27	Model Inter 3	LAT ~ GR + AG + EL + MI + GR * AG * EL * MI	GR, AG, EL, MI, GR*AG*EL*MI	No	17	237.2512
28	Model Inter 4	LAT ~ GR + AG + EL + NM + GR * AG * EL * NM	GR, AG, EL, NM, GR*AG*EL*NM	No	17	242.3758

Chapter 4

Figure A.4.1. *The diversity of floral color shades on Iris nusairiensis.*

Figure A.4.2. *Signs of insect herbivory on the plant's foliage and flowers.*

Figure A.4.3. *Habitats of Iris nusairiensis.*



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