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Notes on Reforestation in Tunisia

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Abstract

Global changes underway (climate change, urban heat islands, etc.) and biodiversity loss are probably the most pressing issues of the Anthropocene. Nature, through its ecosystem services, gives a lot to our society. Witnessing this alarming change in the global landscape, many have resorted to contributing to restoration. In many cases, initiatives are not science-based, and restoration efforts are not always environmentally, socially or economically beneficial. *Eucalyptus* plantations in Tunisia are now everywhere from the far south to the north and are those produced in great abundance in the nurseries of the General Directorate of Forests (DGF) along with other non-native species such as *Casuarina sp.* and *Acacias sp.* The unwarranted use of alien species in reforestation needs a second consideration. Biodiversity is a natural heritage that a country must protect. The introduction of a non-native tree like *Eucalyptus* can cause environmental disturbances and can lead to the loss of this unique biological heritage. Planting trees is already being used as a tool to mitigate climate change. It can be a large monoculture that affects biodiversity and can compromise food security. On the other hand, it can be used to restore ecosystems, which improves carbon sequestration and benefits biodiversity, which helps provide ecosystem services that improve the quality of human life. Tunisian stakeholders must work together to put in place a clear ecosystem restoration strategy and implement indices which serve as a tool to monitor the health of biodiversity and ecosystems.

Keywords: Reforestation, native species, invasive species, forest, Tunisia.

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Résumé

Les changements globaux en cours (changement climatique, îlots de chaleur urbains, etc.) et la perte de biodiversité sont probablement les problèmes les plus urgents de l'Anthropocène. La nature, à travers ses services écosystémiques, donne beaucoup à notre société. Témoins de ce changement alarmant dans le paysage mondial, plusieurs recourent à contribuer à la restauration. Dans de nombreux cas, les initiatives ne sont pas fondées sur la science et les efforts de restauration ne sont pas toujours bénéfiques sur le plan environnemental, social ou économique. Les plantations d'*eucalyptus* en Tunisie sont maintenant partout de l'extrême sud au nord et sont celles produites en grande abondance dans les pépinières de la Direction générale des forêts (DGF) avec d'autres espèces non indigènes comme *Casuarina sp.* et *Acacias sp.* L'utilisation injustifiée d'espèces exotiques dans le reboisement doit faire l'objet d'une seconde considération. La biodiversité est un patrimoine naturel qu'un pays doit protéger. L'introduction d'un arbre non indigène comme l'*Eucalyptus* peut provoquer des perturbations environnementales et peut entraîner la perte de ce patrimoine biologique unique. La plantation d'arbres est déjà utilisée comme un outil pour atténuer le changement climatique. Ça peut s'agir d'une grande monoculture qui affecte la biodiversité et peut compromettre la sécurité alimentaire. D'autre part, ça peut être utilisé pour restaurer les écosystèmes, ce qui améliore la séquestration du carbone et profite à la biodiversité, ce qui contribue à fournir des services écosystémiques qui améliorent la qualité de vie humaine. Les parties prenantes tunisiennes doivent travailler ensemble pour mettre en place une stratégie claire de restauration des écosystèmes et mettre en œuvre des indices qui servent d'outil de suivi de la santé de la biodiversité et des écosystèmes.

Mots clés : Reboisement, espèces indigènes, espèces invasives, forêt, Tunisie.

Introduction

Global change and biodiversity loss are probably the most pressing issues of the Anthropocene. Both are the consequences of our actions as a society. Our contribution to the aggravation of the situation is considerable. These 3 elements; Biodiversity loss, Climate change and Society are intertwined and share common drivers through human activities.

Nature, through its ecosystem services such as reducing carbon emissions in the atmosphere via carbon sequestration, is giving a lot to our society². Yet human activities are putting biodiversity at an unprecedented risk through ecosystem degradation. Despite conservation efforts, we still notice an aggravation in both climate change and biodiversity loss. Global actions to mitigate climate change sometimes have negative effect on biodiversity, hence the importance to understand the coherent interaction and between both and have them seen as undividable complex. Restoration projects such as reforestation and afforestation are already used worldwide to mitigate climate change, yet when implemented poorly a negative effect on biodiversity can be noticed. Notably, in Tunisia reforestation efforts are not evaluated which raise questions on its effectiveness on assessing biodiversity loss and climate change.

People, NGOs and governments around the world run to planting trees as a first solution to restore forests. Witnessing this alarming change in the global landscape, people, probably out of good faith, urge to contribute to restoration. Unfortunately, in many cases, these initiatives are not based on science or clear policies and strategies. Restoration efforts are not always beneficial environmentally, socially or even economically. Our aim through this article is to discuss reforestation in Tunisia focusing on planting *Eucalyptus* and other non-native species and

² Naidoo Robin, Andrew Balmford, and Others. *Global mapping of ecosystem services and conservation priorities*. Proceedings of the National Academy of Sciences, 105(28), 2008, pp.9495-9500.

Ian Thompson, Brendan Mackey Steven McNulty & Alex Mosseler. *Forest resilience, biodiversity, and climate change*. In Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43, 2009, pp. 1-67.

to emphasize on the importance of considering multiple factors and the importance of having a far-sight and a clear perspective prior starting reforestation campaigns.

I- Reforestation in Tunisia

1.Evolution of forest areas

All along the coast of the far north of Tunisia, coastal dunes occupy large areas. The strong winds coming from the North-West were able to feed the areas of accumulations located in the topographic corridors. At the turn of the century, more than 30,000 ha were covered with shifting coastal dunes in the north of the country³. The objective of reforestation of these dunes is to block the advance of sea sands progressing inland under the influence of the prevailing winds from the North-West and threatening to invade the land of crops, water points and neighboring towns. Several national programs have undertaken reforestation campaigns on private land intended for forestry, running the risk of erosion or presenting a danger of degradation of land, buildings and public facilities.

According to the first National Forest and Pastoral Inventory⁴, the forest area was estimated at 932,000 ha in 1993. From 1993 to 2000, the rate of forest reforestation was significant and exceeded 10,000 ha annually. The decade 2001-2010 was characterized by a slowdown in reforestation work with a total of 81,605 ha. From 2010 to 2015, a total of reforestation works were the lowest since the work was inventoried in 1995 with only 27,577 ha of forest reforestation.

The success of reforestation is not always guaranteed, especially if the protection of the planted area is not effective or if the erosion outweighs the natural recovery of vegetation. The forest gives way to scrub and grassy vegetation. This is not without posing various problems in management. The total land covered by forests in Tunisia is 15 536 000

³ Marc Motte, *Fixation et reboisement des dunes maritimes en Tunisie et plus spécialement dans la région de Bizerte*, Revue forestière française, n°5, 1963, pp.449-466. DOI : 10.4267/2042/24554

⁴ Direction Générale des Forêts. *Résultats du premier inventaire forestier national en Tunisie*. Ministère de l'Agriculture. 1995, 88 p

ha in 2020⁵ this includes natural or planting forests, garrigues and degraded lands classified under forest areas. 702 000 ha from the total land covered by forests are considered as true forests.

2.Planted species

The main tree species in terms of abundances are; *Pinus halepensis*, *Quercus suber*, *Eucalyptus sp.* and *Pinus pinea*. None of these forests are primary and only 75330 ha are forests, 11% of the total forests extent, where the management goals are dedicated to wildlife conservation and all are located inside protected areas. Monitoring for degraded forests is absent, while areas affected by fire reached 17709 ha in 2017⁶. Tunisian forests witnessed a decrease of 13% from 2001 to 2020 and this tree cover loss resulted in deforestation. Yet the annual reforestation is estimated to be 1400 ha/year for the period of 2015-2020. Historically, reforestation data collection started in 1992⁷. Prior that year, reforestation could've been occurred in Tunisia but data weren't collected. Most Tunisian forests are located in the north west of the country. The choice of species for reforestation has been the main objective of forestry research⁸. They took into account, to establish a of species, the lessons given by older introductions, as well as the bioclimatic homologies existing between Tunisia and other regions as in Australia and California. The trees planted were produced in the nursery after the seeds had been collected from the natural environment.

Natural forests are notably located in the dorsal area. Reforestation cover different lands under different jurisdictions even private lands (i.e. in some forests in Sajnene). Two types of reforestations are performed in Tunisia; reforestation for production purpose and reforestation for protection purpose. Forests exploitation is consisting of wood production, cork, rosemary, myrtle and other secondary products like fungi and

⁵ FAO, *Global Forest Resources Assessment 2020*, Main report 2020, 165p

⁶ Jesús San-Miguel-Ayanz, Tracy Durrant, and other, *Forest Fires in Europe, Middle East and North Africa 2017*. Joint Research Centre, 2018, 142p.

⁷ Département des forêts, Organisation des Nations Unies pour l'alimentation et l'agriculture. *Evaluation des ressources forestières mondiales*, 2010.

⁸ Mohamed Arbi Khouja. *Amélioration génétique : inventaire et bilan des recherches entreprises en Tunisie*. Annales de l'INRGREF, N° Spécial, 2001, p1-45

hunting products. 188 species with a total abundance of 15 361 240 trees are produced over 56 nurseries. Many among these species are exotic (i.e. 117 *Eucalyptus* species).

Table 1: Number and distribution of species planted in arboreta⁹

Genus	Number of species	Genus	Number of species	Genus	Number of species
<i>Eucalyptus</i>	117	<i>Populus</i>	2	<i>Ficus</i>	1
<i>Acacia</i>	26	<i>Abies</i>	2	<i>Fraxinus</i>	1
<i>Pinus</i>	18	<i>Acer</i>	1	<i>Fgourleya</i>	1
<i>Casuarina</i>	7	<i>Araucaria</i>	1	<i>Juniperus</i>	1
<i>Cupressus</i>	3	<i>Argania</i>	1	<i>Parkinsonia</i>	1
<i>Callitris</i>	3	<i>Castagnia</i>	1	<i>Pseudotsuga</i>	1
<i>Prosopis</i>	3	<i>Carrya</i>	1	<i>Melaleuca</i>	1
<i>Calligonum</i>	2	<i>Brachychiton</i>	1	<i>Tetraclinis</i>	1
<i>Cedrus</i>	2	<i>Ceratonia</i>	1		1
<i>Juglans</i>	2	<i>Celtis</i>	1		1
<i>Pistacia</i>	2	<i>Eleagnus</i>	1		
Total (genus): 32 / Total (species): 208					

Source: Khouja, 2001

While *Eucalyptus* has an important adaptation success were able to concur the world and have various benefits for human use, in a more ecocentric approach and less egocentric one, when planted out of their natural distribution they cause more harm than good for the ecosystem. The unexplained and unjustified use of exotic in reforestation need to have a second consideration. *Eucalyptus* trees are native to Australia and Indonesia. Since these species have been successful for human use (easy to grow), they have been widely planted around the globe¹⁰. The main motivation was for the benefits of the society¹¹ ignoring the impact of these introductions on ecosystems and biodiversity¹². This growing human interest in forest production and wood production is driving to multiple issues in many ecosystems around the globe.

⁹ Arboreta are sites designed to study the behavior of plant species exogenous to Tunisian bioclimates.

¹⁰ John Davidson. *Ecological aspects of Eucalyptus plantations. Proceedings of the regional expert consultation on Eucalyptus*. Vol. 1. RAPA/FAO, Bangkok, Thailand, 1993. [\[Online\]](#)

¹¹ C. H. Sellers. *Eucalyptus: its history, growth, and utilization*. AJ Johnston, 1910, 92p.

¹² Ping Liang & Xie Zong-Qiang. Effects of introducing *Eucalyptus* on indigenous biodiversity. Yingyong Shengtai Xuebao, 2009, pp. 1765-1774.

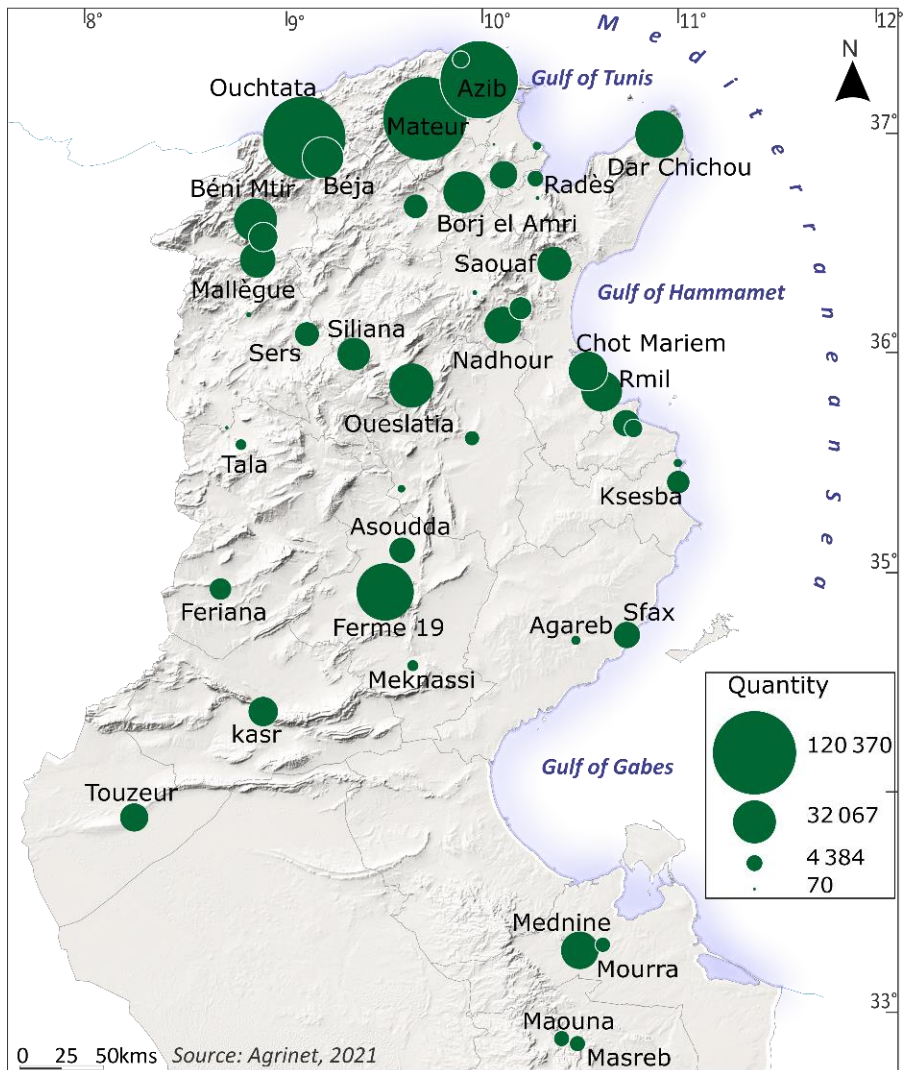


Fig. 1: Number of *Eucalyptus* plants in Tunisian nurseries

Eucalyptus was introduced to Tunisia & the North African region by the French coloniser but was already spread in Europe at that time¹³. It was used to shade roads, buildings and camping areas. Nevertheless, the plantation of *Eucalyptus* continued even after the colonization period (Fig.1). *Eucalyptus* forests are now everywhere from extreme south (desert oil field) to north and are the ones produced in high abundances in the General Directorate of Forests (DGF) nurseries along with other non-

¹³ Francisco Javier Silva Pando & Ramon Pino Perez. Introduction of *Eucalyptus* into Europe. *Australian Forestry* 79.4, 2016, pp.283-291.

native species like *Casuarina sp.* and *Acacias sp.*. Among the top 6 planted species in DGF nurseries, 3 are non native, with high abundances (reaching 2,446,489 plant) While, native species like Cork trees *Quercus suber* are occurring only in 2 or 3 nurseries nationwide with abundance of 47100 plants¹⁴

II- Reforestation: a solution, but what to plant?

1. Effect of non-native trees on native biodiversity

Biodiversity is a natural heritage that a country must protect¹⁵. This natural heritage could be very specific and unique, englobing species that only exists in Tunisia and can't be found in any other place in the world. Species within a geographic range or area are adapted to the factors in that area. Hence, they have a long-lasting adaptation history to its surroundings, including adaptation to native plant covers. For that reason, introducing a non-native tree like *Eucalyptus* can cause several environmental disturbances and can cause the lost of this unique biological heritage. Some *Eucalyptus* species are officially classified as invasive in some countries around the globe (including the classification by the California Invasive Plant Council (CAL-IPC))¹⁶. Considering this fact, Tunisia is planting invasive, non-native trees instead of native species that could support the local biodiversity.

2. How Eucalyptus and non-native tree species can be bad for biodiversity?

Eucalyptus trees are Allelopathic species¹⁷. Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the germination, growth, survival, and reproduction of other organisms. Meaning it will prevent other plants from growing. And that's one of the negative consequences; reducing

¹⁴ www.agridata.tn/ar/

¹⁵ Volker Mauerhofer & Nyacuru Felister. *Biodiversity, migratory species, and natural heritage*. Routledge handbook of global environmental politics. Routledge Taylor and Francis Group, New York, 2014, pp. 481-493.

¹⁶ Carla C Bossard, John M Randall, Marc C Hoshovsky. *Invasive plants of California's wildlands*. Univ of California Press, 2000, 360p.

¹⁷ F. May & Jeremy D. Ash. *An assessment of the allelopathic potential of Eucalyptus*. Australian journal of botany 38.3, 1990, pp. 245-254.

plants' biodiversity. Native plant species won't be able to compete. Hence, the absence of understory in forests where *Eucalyptus* exists.

The reduction of plants species subsequently causes the reduction of habitat complexity in the ecosystem¹⁸. Insects adapted to live on those plant species or eat their leaves or hid on it will not find any microhabitats to survive in¹⁹; Lizards and reptiles who use the branches of those plants to hide, lay eggs and hunt will not find a habitat to survive in; the small mammals like weasels, rats, who use these bushes as an escape from predators, also will not survive; small birds who use it to nest will not have offsprings, and it goes on and on producing a butterfly effect that keeps propagating to reach predators and eventually touches the food chain in the ecosystem. In NW Spain, a study compared birds richness and abundance between native trees and *Eucalyptus* plantation, showed that birds diversity and species abundances in *Eucalyptus* is significantly lower and bird nesting was much higher in native forests²⁰. Many Countries introduced *Eucalyptus* reconsidered their decision, including Portugal²¹ who banned *Eucalyptus* plantation in some regions of the countries and is suctioning people who do so illegally. The fines could reach 44000 euros. This came as a consequence of many reforestation campaigns using *Eucalyptus* trees who turned out to be unsuitable for forests reorganization. Other than reducing biodiversity, *Eucalyptus* consumes a lot of water²² and can contribute to aggravate the water stress situation in Tunisia. Planting, *Eucalyptus* in the surrounding of dams, lakes and water-stream will reduce water availability. In the last few years, we started noticing the decrease of water level in many dams. It is not the result of a single factor, but an accumulation of many; bad management, global climate change, and other reasons, yet planting a

¹⁸ Adam Kimberley, Danny Hooftman and Others, *Functional rather than structural connectivity explains grassland plant diversity patterns following landscape scale habitat loss*. Landscape Ecology, 2021: 36(1), 265-280.

¹⁹ Jasmine I. St. Pierre & Katya E. Kovalenko. *Effect of habitat complexity attributes on species richness*. Ecosphere 5.2, 2014, pp. 1-10.

²⁰ Sandra Godeda, Johan Ekroos, Jesús Domínguez, and Others, *Effects of Eucalyptus plantations on avian and herb species richness and composition in North-West Spain*. Global Ecology and Conservation, 2019, pp. 1-13.

²¹ Lars Kardell, Steen Eliel & Antonio Fabiao. *Eucalyptus in Portugal*. Ambio 15.1, 1986, pp. 6-13.

²² Karl White & Masakazu Kashio. *Proceedings of the Regional Expert Consultation on Eucalyptus*. Regional Expert Consultation on Eucalyptus (1993: Bangkok, Thailand). FAO, 1995. [\[Online\]](#)

water's over-consuming species is not going to help. Moreover, *Eucalyptus* are fire-intensive plants. Their shedding bark, leaves and twigs are fuel to fire. In the last few years, fire occurrence in the country is getting higher, and it is only wise to consider *Eucalyptus* plantation as a contributor to the scene. Fires cause habitat fragmentation and, in some cases, where reforestation is done with non-native species, the global landscape of the region will change, causing heterogeneity in the ecosystem. For many species with big home range, this creates the edge effect hence, moving around would be an arduous task for them. As an example, we can mention the Barbary stag who once was roaming forests in North Tunisia and is now confined to few places in the northwest of Tunisia.

III- Aspects to take in consideration prior reforestation / afforestation campaigns

1. Don't underestimate species introduction

Species introduction is seen as the necessary evil in conservation field. Among any initiative to introduce a species, there is usually a lot of planning and studies that can tell us whether it is worth it to introduce species²³. Overall, many initiatives ended up by disturbing natural ecosystem or transformed to invasive species. And this is don't concern only trees. There are many examples where introductions went wrong. Maybe one of the most famous examples is the cane toad. In the 1930's Australia had an issue with cane beetles who destroyed sugar cane fields. The Australian authorities decided to use a natural pesticide. Instead of looking in their environment for a natural predator of these beetles, they had the idea to bring 102 toads from Puerto Rico. In no time, their numbers boomed to reach 200 millions and instead of being pests control, they became the pest²⁴. Another example from Tunisia, is when authorities decided to bring palms tree to be used for ornamentation in cities' streets. The red weevil used the palms as Trojan horses and in no

²³ Justin G.D. Byrne, & Jonathan W. Pitchford. *Species reintroduction and community-level consequences in dynamically simulated ecosystems*. Bioscience Horizons : The International Journal of Student Research, 2016.

²⁴ Benjamin L. Phillips, Gregory P. Brown, Matthew Greenlees, Jonathan K. Webb, Richard Shine. *Rapid expansion of the cane toad (*Bufo marinus*) invasion front in tropical Australia*. Austral Ecology, 2007. 32(2), pp.169-176.

time, they invaded most palm trees in major cities of Tunis and surroundings²⁵.

2. Initiatives must be based on science

With all the overwhelming news about climate change and biodiversity loss, there is an urgent responsibility and need to do something about it. And that's understandable and usually there is a good faith behind it. Yet planting trees is not a miracle solution to save the earth. and reforestation is overrated. Driven by their love for the environment people, NGOs and governments. will start acting on planting trees without recurring to experts in forestry or wildlife management or without having a clear restoration strategy. In 2014, 51 countries pledged to plant 3.5 million square km of forest by 2030 – so far most planted forests are vast extent of monocultures of invasive species. If fundamental notions of ecology were considered, we wouldn't end-up doing similar practices. One example on how lack of strategy can affect biodiversity is the example of Chili who encouraged reforestation since 1974 without any implemented strategy. The outcome was loss of biodiversity and poor carbon sequestration rate²⁶. “The idea that you can go out and plant a tree and help reverse global warming is an appealing, feel-good thing,” as Ken Caldeira, an ecologist from Carnegie Institution of Washington in Stanford, said. In fact, a better solution to restore forests and ecosystem is to let natural resilience do it²⁷. Forests have the capacity to regenerate in a natural way to have a better resilience. Thus, a better practice is to protect lost areas of forests from overgrazing and anthropic activities to regenerate naturally. When DGF nurseries only provide non native invasive species for NGOs' led initiatives, it's better not plant if we can't assess the impact of the plantation. Those initiatives may appear helping the environment, yet when the planted species is invasive, it has as a long-lasting effect on the loss of biodiversity. Initiatives, needs to consult with

²⁵ Hamda Chebbi. *First record of Rhynchophorus ferrugineus on Phoenix canariensis in Tunisia*. Tunisian Journal of Plant Protection, 2011 : 6.2, pp.1-5.

²⁶ Laura Nahuelhual, Alejandra Carmona, Antonio Lara, Cristian Echeverría & Mauro E. González. *Land-cover change to forest plantations: Proximate causes and implications for the landscape in south-central Chile*, Landscape and Urban Planning, Volume 107, Issue 1, July 2012, pp. 12-20.

²⁷ Lourens Poorter et al., *Multidimensional tropical forest recovery*. Science, 374(6573), 2021, pp.1370-1376.

experts and reforestation needs to be planned in a way to take into consideration all factors that could negatively affect not only people but biodiversity as well.

3. Planting accordingly to the natural distribution of species

One of the aspects that makes Tunisia a beautiful country is the diversity of its landscapes and habitats. Following a gradient going from north to south, we can see a multiple types of ecosystems and landscapes from oak forests in the northwest to sand dunes in the south; from wetlands to savannah in Bouhedma National Park. This ecosystemic diversity is also unique and needs to be preserved. There is a constant envy to plant trees in desert or arid areas, assuming that these ecosystems are not viable habitats and that's a general misconception that we need to avoid. Desert and ecosystems that probably don't look as pleasant or green as forests are also important for biodiversity and hold species that are adapted to live only in that kind of ecosystems²⁸. It's important to follow the natural distribution of species when planning for reforestation. And in Case of afforestation, it needs to be done in damaged lands and not in habitats that are not naturally forests²⁹ like Garrigue and Macquis shrubland which are unique in the Mediterranean region.

4. Restoration Effectiveness / Reforestation Effectiveness

Finally, we need to understand that conservation efforts can go wrong. And this is why it's very important to monitor restoration efforts. It's time for Tunisia, as a country, to think about putting in place a monitoring system to have a long-lasting better assessment of the evolution of the environmental situation overtime. This monitoring system can help modify the strategies to concentrate efforts on what is working and to try to solve what didn't work. Constant surveys in reforested area are needed, either through direct observation or using tools

²⁸ Norbert Ju. *Floristic biodiversity and history of African arid regions*. Biodiversity & Conservation, 1997. 6.3 , pp.495-514.

²⁹ Guanglei Gao, Guodong Ding, Haiyan Wang, Yintong Zang, & Wenjun Liang. *China needs forest management rather than reforestation for carbon sequestration*, 2011.

such as bioacoustics to compare diversity over time and space³⁰. It's important to communicate about reforestation campaigns in details as well as clear documentations accessible to the public that illustrate the geographic extent and supported by numbers and statistics³¹.

Conclusion

Actions intended to mitigate climate change effect can be either beneficial or harmful depending on the implementation and the policies. Biodiversity and climate change should be considered simultaneously as a single complex. Ignoring one over the other can lead to non-efficient solutions to both crises. Tree-planting is already used as a tool to mitigate climate change. It can be large monoculture that affects biodiversity and may compromise food security. On the other hand, it can be used to restore ecosystems leading to enhance carbon sequestration and benefits biodiversity which contribute on providing ecosystem services that enhance human quality of life. Tunisian Stakeholders should work together to set up a clear strategy for ecosystem restoration. This strategy needs to be based on multidisciplinary studies. The use of new technologies in studying & monitoring ecosystems needs to be fostered. Tools like artificial intelligence, machine learning, bioacoustics, remote sensing and mathematical modeling will not only give us the possibility to understand historical trends and build a wider overview on our ecosystems but will allow us to predict and model future biodiversity trends leading to a better understanding and eventually advising on better planning / management decisions. Biodiversity assessing indices should be based on these tools. These indices need to serve as a tool to monitor biodiversity & ecosystems' health and should be persistent in time - long-term monitoring and space - can be used nationwide.

³⁰ Zuzana Burivalova, Michael Towsey, Tim Boucher, Anthony Truskinger, Cosmas Apelis, Paul Roe & Edward T. Game. Using soundscapes to detect variable degrees of human influence on tropical forests in Papua New Guinea. *Conservation Biology*, 32(1), 2018, pp. 205-215.

³¹ John Kanowski, Carla P. Catterall & Debra A. Harrison. Harrison, *Monitoring the outcomes of reforestation for biodiversity conservation.* "Living in a dynamic tropical forest landscape, 2008, pp. 526-36.