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How to mitigate the impacts of wildfires in Portugal due to the forestry industry focusing on eucalyptus plantations?

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<u>Final report</u>

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1. Introduction

Eucalyptus plantations in the Iberian Peninsula considerably increased in the past years, allowing socio-economic benefits to Portugal, one of the pulp and paper industry world leaders. However, the substantial increase in the Portuguese forestry industry brings opportunities and challenges for Portugal. Wildfires are one of the main issues, especially when considering the unprecedented climate change in Europe.
This paper aims to understand the relationship between the increasing growth of eucalyptus plantations and wildfires to answer the research question: How to mitigate the impacts of wildfires in Portugal due to the forest industry with a focus on the effects of eucalyptus plantations.

This paper is structured in three main parts. First, the evolution of a literature review to better understand the Portuguese forestry industry, the opportunities and challenges of the eucalyptus industry, and the connection to wildfires as they become more and more prominent in Portugal. Then, the Scenario Planning Assessment methodology is used to answer the research question and have a clear understanding of what should be done to avoid wildfires from going out of control and minimize the potential impacts since it is challenging to predict what the future holds due to the climate change evolution. This part will briefly explain the concept of the Scenario Planning Assessment methodology, why it has been chosen for this research, and how it will be implemented through an outline before focusing on alternatives that will impact the surroundings or the Portuguese economy.

2. Literature review

2.1. The forestry industry in Portugal: evolution and impacts

Since ever, humans have considered forests as privileged places to answer their basic human needs. First, forests were the place to gather the necessary food and the basic needs for human survival in primitive areas (Nunes, Meireles, Gomes, and Ribeiro, 2019, p.1). Then, humans used forests for other purposes, such as agriculture, so the destruction of forests started. This close connection between humans and forests continues to increase, and forests evolved year after year in function of human needs, and this can explain why some species of trees are privileged over others (Nunes, Meireles, Gomes and Ribeiro, 2019, p.2). The illustration from Nunes et al (2019) down below with the graph perfectly shows the evolution of the forestry industry between 1980 and 2010.

Figure 1. Areas of occupation for different land uses in Portugal

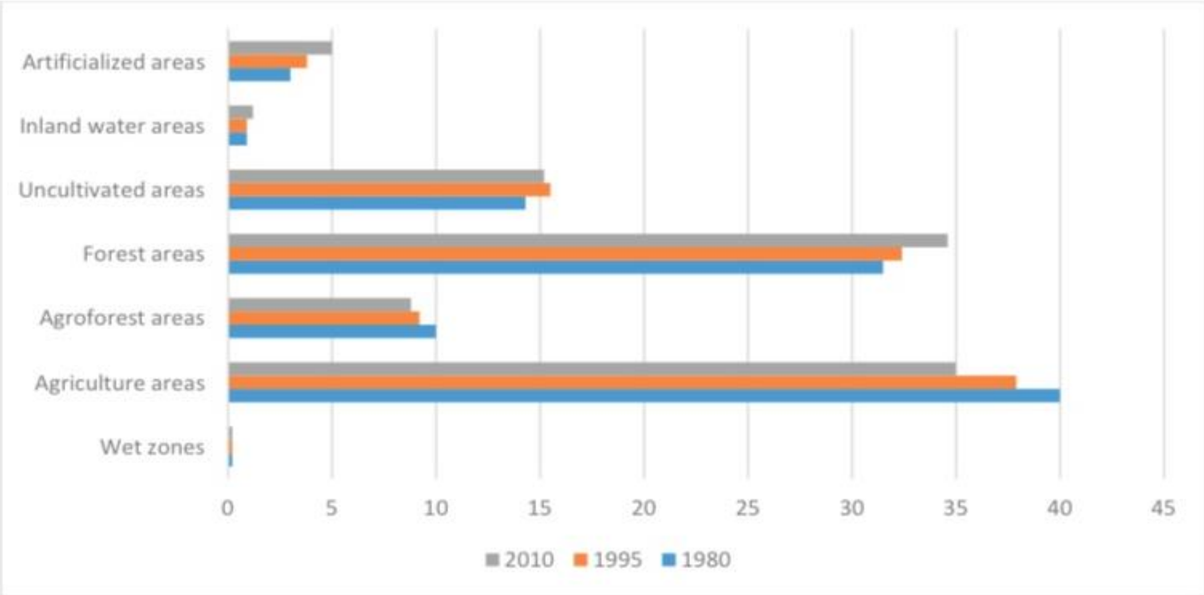


Figure 1. Areas of occupation for different land uses in Portugal (adapted from Reference [41]).

Source figure 1: (Nunes, L. J. R., Meireles, C. I. R., Pinto Gomes, C. J., & de Almeida Ribeiro, N. M. C. (2019).)

Portugal is considered one of the best examples to explain the evolution of forests in the last few years due to the fact that it can be clearly seen that human land occupation and use impacted how humans selected the species they planted in forests. Nunes, Meireles, Gomes, and Ribeiro (2019, p.2) explain that the changes Portuguese forests undertook characterized the history of Portugal, such as maritime pine that was cultivated for Portuguese naval expeditions.

The increasing need for wood provoked the development of rural parts of Portugal, and so Portugal became one of the world leaders in the resin industry. The maritime pine industry also helped the development of other types of industries, such as wood panels and biomass pellets. The evolution of the forest organization started with large-scaled planted eucalyptus aimed at the pulp and paper industry, which allowed Portugal to become one of the world leaders in bleached pulp production. Forests in Portugal continued to evolve year after year, with maritime pine, cork oak, and eucalyptus occupying three-quarters of the forest area.

Nevertheless, the primary forest culture in Portugal remains eucalyptus, with one-quarter of the forest area and an increase of ninety-five thousand hectares just before 2010 (Nunes, Meireles, Gomes, and Ribeiro, 2019, p.3). This increase in eucalyptus plantation is due to its "resprouting ability and wood properties" (Tomé, Almeida, Barreiro, Branco, Deus, Pinto, Silva, Soares, and Rodriguez-Soalleiro, 2021, p.489). This means that other tree species only represent twenty-eight percent of the forest space. Overall, forests represented thirty-six percent of the landscape in 2015 compared to seven percent in 1900. Portuguese silviculture represented more than 866 million euros (0,46% of the GDP) and more than thirteen thousand jobs (0.30% of total employment) (Cruz, Ramos, Barata, and Ferreira, 2021, p.151).

Table 1. Macroeconomic indicators of silviculture and forestry and of the forestry products value chain

TABLE 1.
Macroeconomic indicators of *Silviculture and Forestry* and of the *forestry products value chain* (Portugal, 2016)

	Of the *Silviculture and Forestry*	Of the main industries producing the products of the *forestry value chain*
Weight of the main producer sectors on GDP	0.46%	2.42%
Weight of the main producer sectors on employment (*FTE*)	0.30%	2.73%
Weight of the main products on the output of the economy (at basic prices)	0.36%	3.60%
Weight of the main products on the exports	0.10%	10.09%
Trade balance *(€ million)*	-215	2,417

Source: Portuguese National Accounts (INE, 2019).

Sources table 1: (Cruz, L., Ramos, P., Barata, E., & Ferreira, J. P. (2021).)

Therefore, the economic benefits Portugal gains from the forestry industry are significant compared to other European countries and are illustrated by the continuous growth of forests in the twentieth century well slowed down in 2010 because of recurrent fires during the summer period.

Cruz, Ramos, Barata, and Ferreira (2021, p.151) insist on considering the "forestry products value chain" to understand the fundamental economic contribution of forests. So, they explain what composes this value chain with products "products produced directly or indirectly from wood and other forest products" such as "paper and cardboard articles." The eucalyptus forests are mainly owned by non-industrial private owners compared to other European countries, with approximately four hectares maximum for each property. The forestry industry generates a consequent income for non-industrial owners.

2.2. Opportunities and challenges of the eucalyptus industry

The evolution of the eucalyptus industry offers opportunities to Portugal but also challenges. As previously explained, eucalyptus significantly contributes to the Portuguese national economy. Developments have been made in this industry to increase productivity with dedicated forest management and special care for tree breeding. Tomé, Almeida, Barreiro, Branco, Deus, Pinto, Silva, Soares, and Rodriguez-Soalleiro (2021, p.495) consider three main challenges the eucalyptus industry faces in Europe and especially in Portugal. First, the environment impacts are mainly potential negative impacts on “water use, soil degradation, biodiversity loss and possible invasion of neighboring ecosystems. Then, the management of eucalyptus plantations is not always professional as most of them are owned by small non-industrial owners.

Furthermore, some of these plantations are abandoned. This non-professional management can have several consequences, such as wildfires. Finally, the eucalyptus plantations are vulnerable to pests and diseases, wildfires, and climate change, and everyone certainly remembered the deadly wildfires in the central part of Portugal in June 2017.

2.3. Wildfires: in Portugal: the importance of addressing this risk

Addressing the risk of wildfires in Portugal is essential as wildfires can generate significant consequences on the residents (injured or even dead citizens), the resources, the ecosystem, and the implemented industries of a burned area. The mega-fires have increased since the end of the nineties, and a Portuguese study reveals that among eight different tree species, the eucalyptus plantations are considered the species that have a high probability of fire damage, with a second-ranking position after maritime pines (Botequim, Garcia-Gonzalo, Marques, Ricardo, Borges, Tome and Oliveira (2013). However, it is interesting to note that next to its highly flammable propension, eucalyptus outstandingly recovers after a fire. Tomé, Almeida, Barreiro, Branco, Deus, Pinto, Silva, Soares, and Rodriguez-Soalleiro (2021, p.502) reviewed the literature to analyze the wildfires' phenomenon. They cite Fernandes, Guiomar, and Rossa (2019), who did not establish a relationship between the increase of eucalyptus plantations and the recurrent wildfires as eucalyptus replace other flammable species such as the maritime pine. Even if they did not establish a clear relationship, illustrating this data is relevant to determining whether there is a connection between eucalyptus forests and wildfires.

Figure 2. Study area- Forest cover in 1995 and 2015: (a) Maritime Pine, (b) Eucalypts

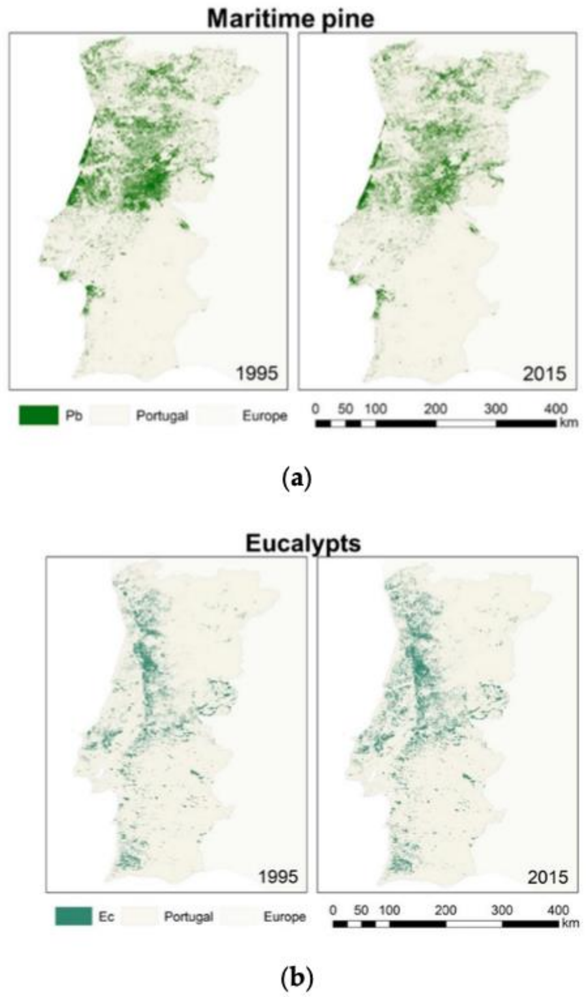


Figure 1. Study area—Forest cover in 1995 (COS1995) and 2015 (COS2015): (**a**) Maritime pine (Pb); (**b**) Eucalypts (Ec).

Source figure 2: (Alegria, C., Roque, N., Albuquerque, T., Gerassis, S., Fernandez, P., & Ribeiro, M. M. (2020).)

This first figure illustrates where eucalyptus forests are implemented. Eucalyptus remains the primary forest culture in Portugal, with one-quarter of the forest area mainly concentrated in the northwest of Portugal. The second figure below indicates the distribution of forest fires in Portugal between 1998-2007. Comparing both figures is exciting and allows us to note the connection between eucalyptus forests and recent forest fires.

Figure 3. Distribution of forest fires occurred in Portugal during the period 1998-2007

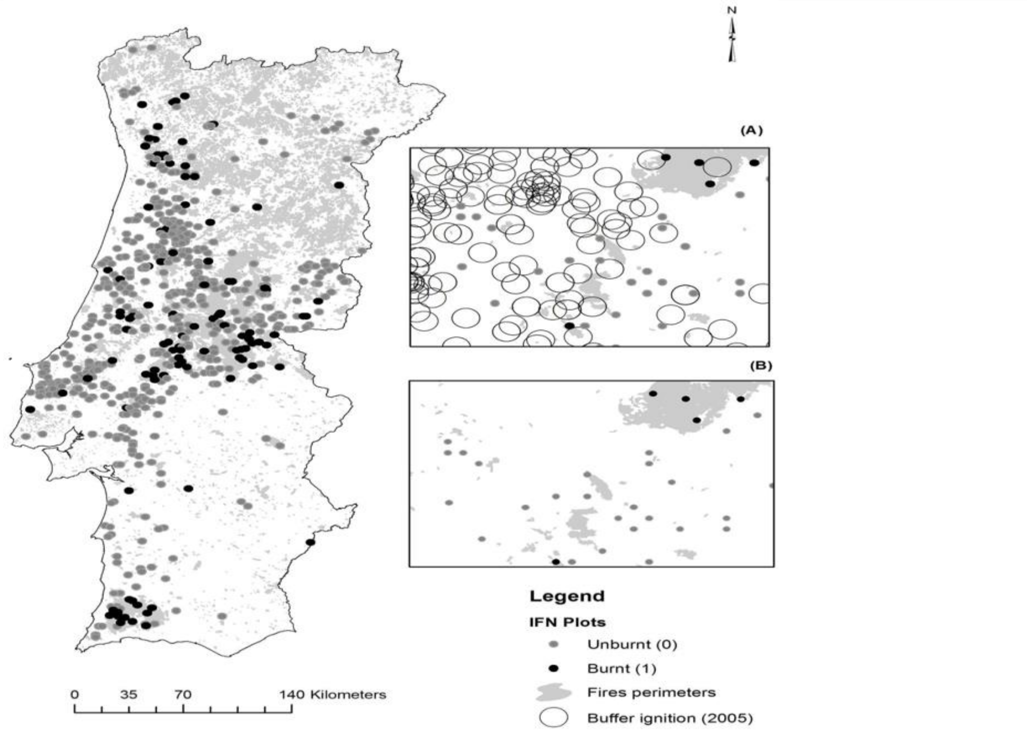


Fig. 1 - Distribution of forest fires occurred in Portugal during the period 1998-2007, over- laid with the pure/even-aged eucalyptus plots. Boxes on the right represent: (A) selection of unburned plots (example for the year 2005) based on their distance from ignition points; (B) a part of the National Forest Inventory plots used in the study.

Source figure 3: (Botequim, B., Garcia-Gonzalo, J., Marques, S., Ricardo, A., Borges, J. G., Tome, M., & Oliveira, M. M. (2013).)

Furthermore, Fernandes, Guiomar, and Rossa (2019) state that wildfires of eucalyptus plantations could increase in the coming future because of an abandonment of plantations, as previously explained. Next, intense spotting at the fire front is also a significant difficulty for firefighters. Tomé, Almeida, Barreiro, Branco, Deus, Pinto, Silva, Soares, and Rodriguez-Soalleiro (2021, p.502) also cite Mirra et al. (2017), that considers that control on fuel should occur each three to five years in most ignition plots as eucalyptus plantations are highly flammable. It is part of the management of plantations. A dedicated law was even proposed to constraint forest owners to maintain their plantations with a "low load of brush biomass" and at a "safe distance from villages" (p.502). As for many issues with socio and economic interests, the regulation has not been implemented consistently. However, the evolution of science can bring some positive enhancements. Jiménez et al. (2012) explain that young eucalyptus trees can be "treated with prescribed burning without crown scorching and any apparent decrease in diameter growth" (p.502).

Fernandes, Guiomar, and Rossa (2019, p.86) demonstrate in their study that the expansion of the eucalyptus industry does not affect the total burned areas in Portugal.

Instead, more eucalyptus species in burned regions are a more logical development of the regional scope and the evolution of the forest. However, they do not exclude future impacts and propose future research on the topic, which seems of scientific relevance considering the climate change evolution in Europe. In conclusion, there seems to be a lot of confusion around what to do when it comes to the eucalyptus plantations.

3. Assessment: Scenario planning

3.1.1. Choice of assessment method: Scenario planning

Biodiversity in Portugal is a factor that the government praises since the forestry industry has for a long time kept its reputation and has always been significant, suitable for 10,9% of the exporter. This industry employs around 2.73% of the Portuguese people. (Cruz, Ramos, Barata, and Ferreira, 2021, p.151). But what is the need to assess this industry? It is important to remember that wildfires have become more and more prominent in Portugal, and this is not bound to change anytime soon if nothing is done to prevent it. The Scenario Planning assessment was chosen to assess this issue as precisely as possible since it is challenging to predict the future due to this unprecedented climate change. What is Scenario planning, how does one use it, and why use it for this research?

3.1.2 Scenario Planning

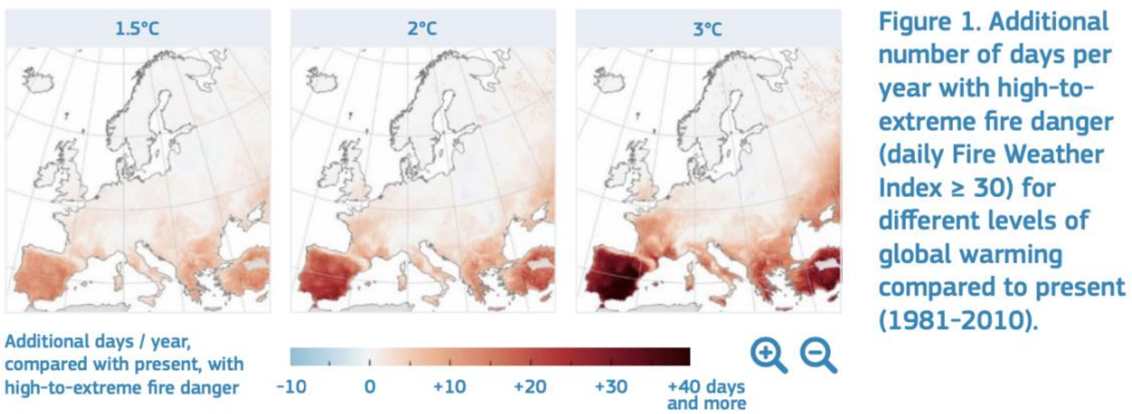
One of the founding members of this concept, Herman Kahn, defined scenario planning as the following: "a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points" (Kahn et al.. 1967). A few decades have passed; today, the main idea of the concept has not changed but is a lot more widely used, and with that, certain principles have become more apparent. These principles were set out by Erika et al.. (2014) are the following: the fact that it is most appropriate to use in cases of high uncertainty and low controllability, it explores plausible but not always probable futures, it is underpinned by strategic thinking on how today's decision limit future options, it is not a one size fits all and many others. When it comes to the validity of the usage of this assessment method, it is essential to acknowledge that uncertainty is one of the main drivers of this subject since climate change is in full swing. In addition to this, it is necessary to note that there is also uncertainty regarding the relationship between eucalyptus trees and the connection to wildfires. Research has shown that it is inconclusive and that more research is needed (citation needed). However, while it may be inconclusive, this also brings uncertainty to many different stakeholders, such as the government and its policy-making to reduce wildfires.

The government is yet to make new decisions on new policies on limiting wildfires. In addition to this, the challenges faced by Portugal's government, such as the environmental impact, the lousy management of eucalyptus trees, the abandonment of eucalyptus plantations and many other species and climate change are all, to some degree, uncertain and uncontrollable factors.

3.1.3 Overview of Scenario planning of Portugal’s wildfire problem

As stated earlier, scenario planning suits this area of research like a glove since there is a lot of uncertainty related to Portugal's wildfires and climate change. However, according to Costa et al. (2020), a report from the European Union, climate change is becoming more and more noticeable every year. Moreover, some other studies from the European Commission have also shaped up different figures showcasing the impact of climate change on the additional number of days per year of wildfires. In the case at hand, the figure below from the European commission demonstrates different possible scenarios showcasing a correlation between the increase in temperature and wildfires.

Figure 4. Additional number of days per year with high to extreme fire danger



Source figure 4: (Costa, H., De Rigo, D., Libertà, G., Houston Durrant, T., & San-Miguel-Ayanz, J. (2020).)

Furthermore, the research from Allen, M.R et al. (2018) from the IPCC global warming report supports these claims by stating that both 1.5º Celsius and 2º Celsius are likely to happen with high confidence levels. However, with this in mind, it is essential to acknowledge that there is still a level of uncertainty on how the temperature will rise and with that what the impact will be on Portugal's forestry industry, more specifically, the eucalyptus paper industry. For this reason, using the scenario planning assessment method is essential to fully grasp the scale of the issue and then plan different potential scenarios to prevent new disasters.

3.2 Structure of scenario planning

The figure below from Rowland et al. (2014) shows that scenario planning is divided into three main phases, each containing many steps.

Phase one is about defining the scenario and finding the necessary resources needed to make the preparation as smooth as possible. There are a few essential factors to determine in this first phase: 1. identify the key questions, 2. Finding key people to get involved in the process, 3. understanding what information is needed and available. Phase two is about building and refining the different scenarios; the phase is critical to determining the uncertainties used to create the different scenarios. Once the scenarios have been developed within phase two, it is essential to explain the related assumptions, showcase the scenarios quantitatively or visually, and peer-review the different scenarios when necessary. Phase three is about using the scenario where the focus is to see the potential impacts of these scenarios on resources and management. Additionally, it is also essential to assess the available options and then take the necessary actions according to the available information. Once all these different steps are taken carefully, the last step is to carefully create monitoring indicator points to assess the different scenarios while using them.

Figure 5: Three phases in the scenario planning process

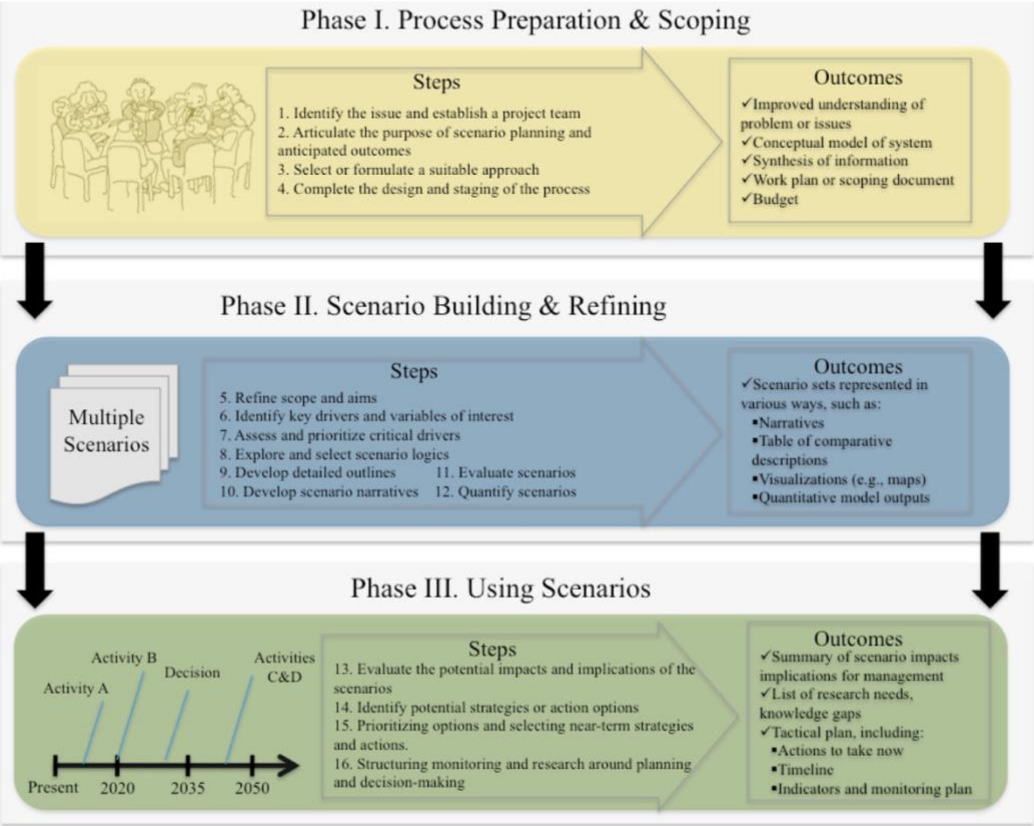


Figure 1.1. Three phases in the scenario planning process (modified from Wiseman et al. 2011 and others). More detail about the phases, the steps within each phase, and outputs for each phase can be found in Section 2.

Source figure 5: (Rowland, E. R., Cross, M. S., & Hartmann, H. (2014).)

3.3 Phase I. Preparation & Scoping

Phase I. Preparation & Scoping (also called "Scenario Definition" in Mahmoud et al. 2009): This phase, which is split into four steps, focuses on spending time at the outset to identify what questions the exercise will help address, how these are related to the decision and/or planning needs, and what the group is hoping to get out of the exercise (e.g., products and outcomes). It is also essential to understand what information is available, who will need to be involved in the process, and whether the process will be managed in-house or by others, such as outside consultants. The first step identifies the issue, which is the risk of wildfires due to eucalyptus plantations and, more specifically, the risk of wildfires going out of control. A project will be established to mitigate this issue and reduce the impacts of these wildfires. The primary stakeholder will be part of this project team, such as forest managers, landowners, forest industry, government representatives, firefighters, environmental and climate experts. The second step articulates the purpose of this method and the anticipated outcomes. Drawing the different strategies allows a better prediction for choosing the best option. Three main strategies can be considered to mitigate the studied issue: (i) a more qualitative forest management plan, (ii) respect for intervention standards in forestry areas and (iii) strict respect for the quota of areas occupied by eucalyptus trees. The third step in this first phase aims to select or formulate a suitable approach. A more qualitative forest management plan is undoubtedly part of the desired approach. As soon as a suitable approach is selected or formulated, the final step of this first phase can start by completing the design and the staging of the process.

3.4 Phase two: Scenario building and Refining

3.4.1 Step 5: Refine scope and aims with key participants:

Before developing the critical scenarios, it is essential to make sure that the scope of the research is on point. According to Rowland et al. (2014), in this step, it is worthwhile to refine the questions so that the scope is not too narrow or too broad because otherwise, if narrow, information will be lost and if broad, unnecessary information will be added. In the case at hand, the critical question is the research question on the topic “How to mitigate the impacts of wildfires in Portugal due to the forest industry with a focus on the effects of eucalyptus plantations". Other questions such as the potential impacts of climate change on the eucalyptus plantations and the paper industry? Which stakeholders are affected by these wildfires? What are the current policies put in place to prevent eucalyptus led wildfires? What other industries may be affected by the eucalyptus led wildfires? And lastly, what are the potential economic costs related to the current wildfires in Portugal's forests? Now that the scope is more precise, key participants such as economists, risk assessors, government officials, forest managers, affected industries and affected residential areas should all develop these scenarios to get the best scenarios. In the case of this research, the resources were limited, and only key research documents were used to develop the scope of research.

3.4.2 Step 6: Identify key drivers and variables of interest related to the focus question

This step is significant since here; the facts are being assessed, synthesised and structured to have the most precise and helpful information possible. According to Rowland et al. (2014), there are many different approaches to structuring the information. For the sake of simplicity and due to the limited number of resources, the approach taken is the STEEP analysis approach which will overview the societal, technological, Economic, Environmental and Political factors. The following in table 2, down below strictly covers the essential information to develop the different scenarios as close to reality as possible.

Table 2. STEEP analysis of the eucalyptus pulp and paper industry and wildfires.

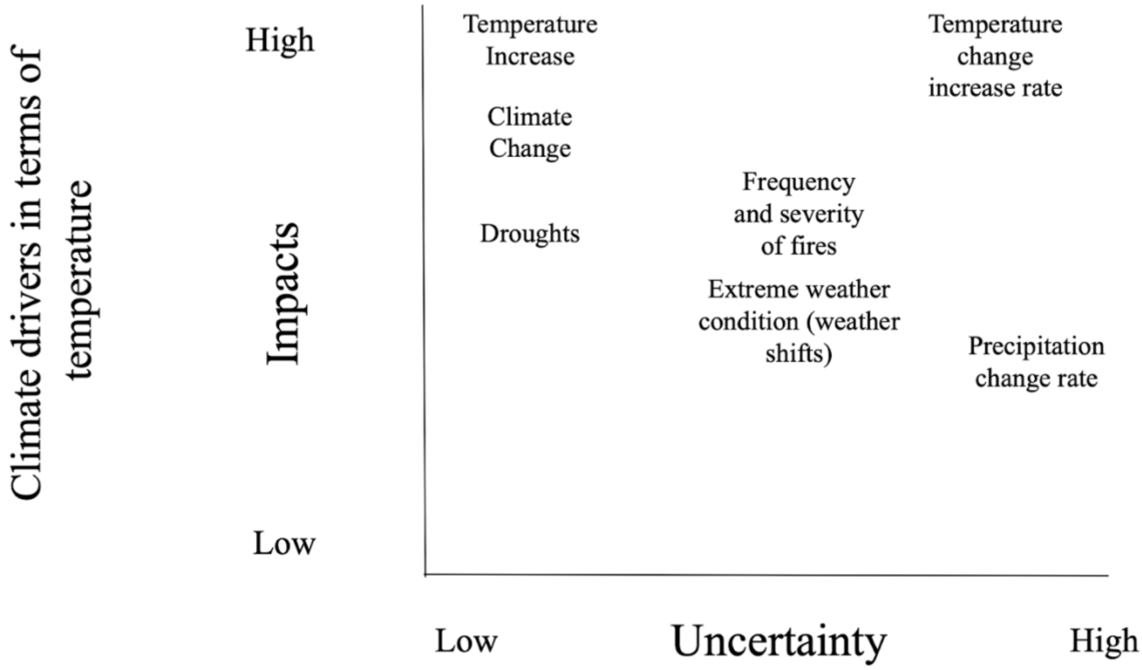
Societal	It is essential to acknowledge that 98.4% (5.2% of that is industry-owned) of all the forest is privately owned, according to Nunes et al. (2019). In addition to this, the research from Nunes explains that the pulp and paper industry employs around 4000 workers, which makes it quite an extensive practice. Lastly, issues such as negligence of management of the eucalyptus tree land and the abandonment of eucalyptus plantations are also to consider.
Technological	Since the topic of interest is the eucalyptus forests and the pulp and paper industry are at play, there are not too many technological factors to consider here. Furthermore, when it comes to fire prevention, while fire towers are used, according to Beighley and Hyde (2018), this should be revised since they are not optimized to today's needs. Other technologies such as citizen calling or cameras are also not enough since they do not cover all parts of the forests.
Environmental	Here, the environmental factors to consider are climate change, rising temperatures, and the increased number of wildfires in Portugal forests (Beighley & Hyde, 2018). Other issues are also directly related to the increased number of eucalyptus monocultures, negatively impacting the land's biodiversity and making it more susceptible to wildfires. In addition to this, issues such as the vulnerability of eucalyptus trees to

	pests and diseases. Lastly, 26% of the forest occupied is by eucalyptus trees (Nunes et al., 2019).
Economic	According to Nunes et al. (2019), the eucalyptus pulp and paper industry corresponds to 5% of national exports and employs 4000 people. In addition to this, it is essential to understand the economic cost of wildfires since it affects many different economic practices such as the natural resources loss (eucalyptus trees and others), the resources used to stop the fires, the residential areas lost due to the fires and inevitable human deaths (Costa et al., 2020).
Political	According to Beighley and Hyde (2018), the national priorities of dealing with the wildfires may not be the most optimal since it first wants to protect human life, then buildings and infrastructure, then national parks and conservation areas lastly, general forests and shrublands. While it is appropriate to prioritize human life and infrastructure, the government seems to neglect the distinction between general forests between privately owned and state owned forests. They also seem to neglect the distinction between managed and unmanaged forest lands. Nevertheless, the government has published a document stating that they are working towards 2030, 2050 and 2100 sustainable goals to reduce their carbon footprint and reduce wildfires (ICNF Instituto conservaçäo de Natureza e das Florestas, 2021).

3.4.3 Step 7: Assess and prioritise critical drivers

This is the step just before creating the scenarios. Here it is essential to document the high impact and low probability forces. According to Rowland et al. (2014), the prioritisation and selection of these key drivers will strongly influence which scenarios will be built. To do this as clearly as possible, it will be illustrated through a graphical approach. The first figure will illustrate the climate drivers in terms of temperature, with the temperature change increase rate being the most uncertain and impactful. The second figure illustrates the eucalyptus wildfire prevention drivers through policies/ regulations with the Eucalyptus tree reduction policy being the most impactful and most uncertain. Finally, the third figure illustrates the economic cost of eucalyptus forest wildfire drivers in terms of damages.

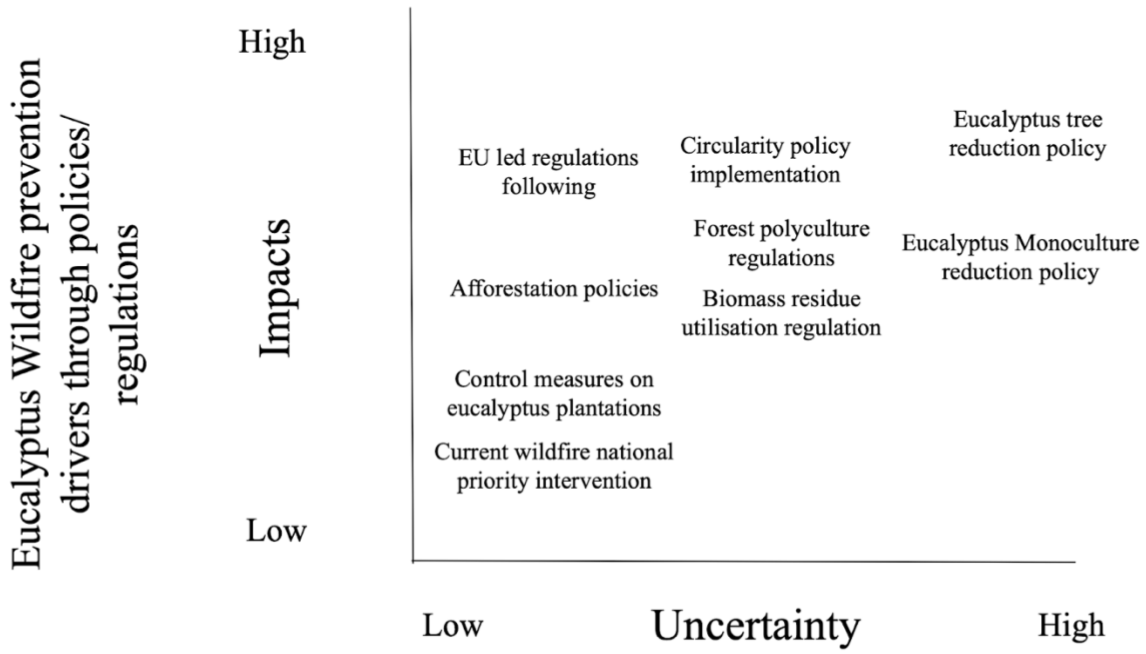
Figure 6: Climate drivers in terms of temperature



Source figure 6: (Tremlett, C. Made for the research)

The reason behind choosing the temperature change increase rate as the high impact, high uncertainty is because current research suggests that the increase in temperature is heavily dependent on what different countries decide to do to reduce carbon emissions (Costa et al., 2020). In addition, the research from Costa et al. (2020) also explains that weather conditions will most likely become less predictable, which means extreme temperatures.

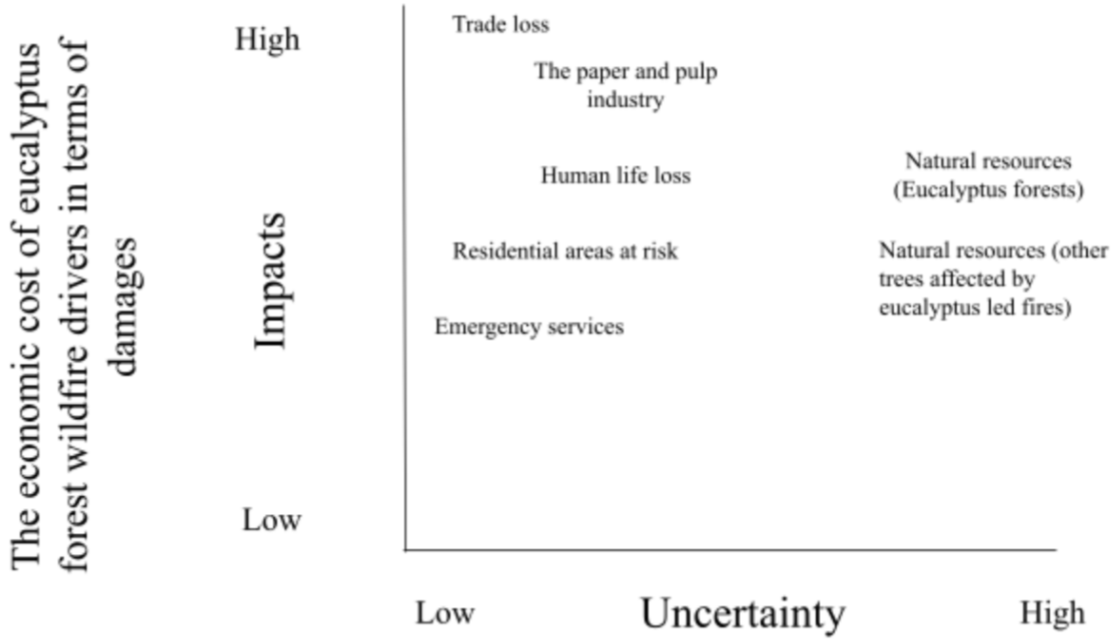
Figure 7: Eucalyptus wildfire prevention drivers through policies/ regulations



Source figure 7: (Tremlett, C. Made for the research)

The eucalyptus tree reduction policy was chosen as a high impact and high uncertainty force because the newly set legislations by the government against eucalyptus forest plantations are only to manage and limit new plantations (ICNF Instituto conservaçäo de Natureza e das Florestas, 2021). Furthermore, when it comes to reducing the carbon footprint, the government encourages afforestation and reforestation of new areas. They also state that the economic interest stays at the forefront of any action against limiting wildfires (ICNF Instituto conservaçäo de Natureza e das Florestas, 2021). Nevertheless, since the government keeps its economic interest, it will make more sense to use the eucalyptus monoculture reduction policy, which is merely changing current and future forests into polycultures ones.

Figure 8: The economic cost of eucalyptus forest drivers in terms of damages



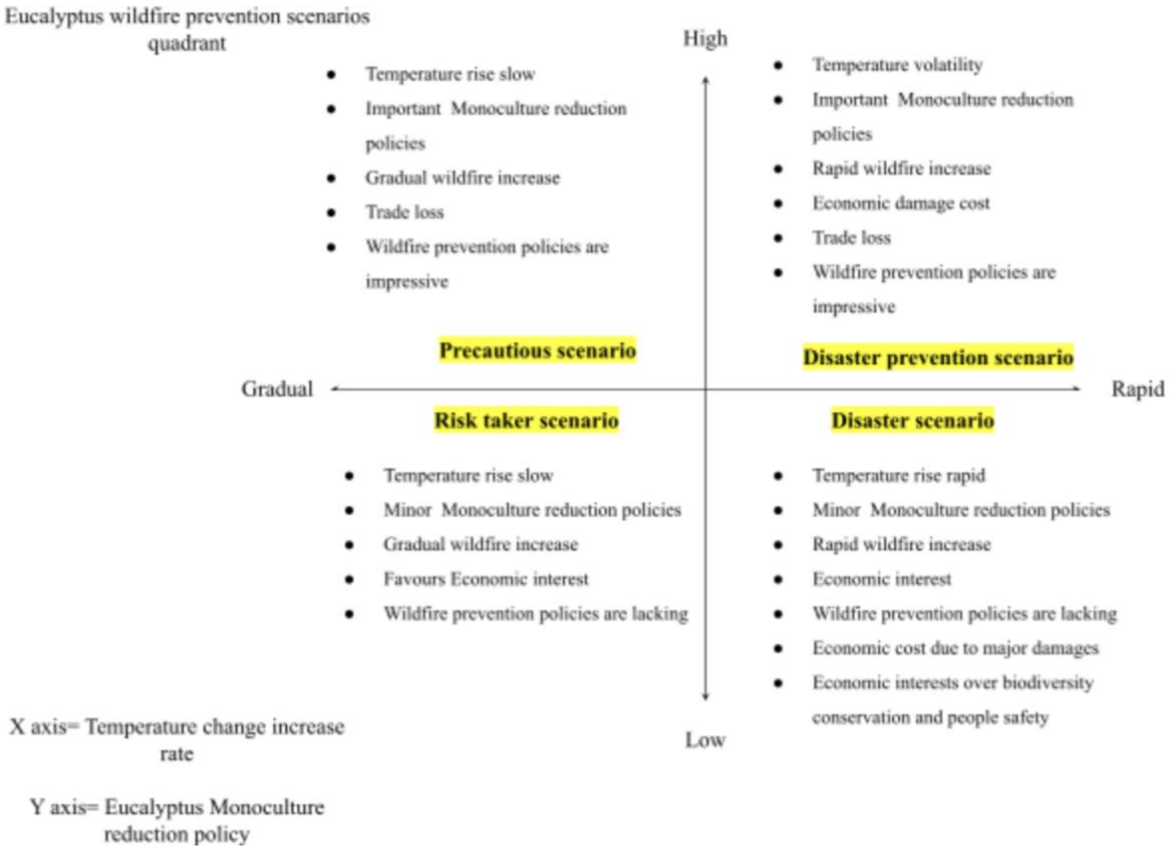
Source figure 9: (Tremlett, C. Made for the research)

Natural resources (Eucalyptus forests) were chosen as high impact and high uncertainty because the government has a great interest in the pulp and paper industry. Furthermore, the level of uncertainty is so high because climate change and the increasing temperatures are difficult to predict. With that in mind, the increase in wildfires damages the eucalyptus tree plantations and thus the economy with it.

3.4.4 Step 8: Explore and select scenario logic

In this step, the basic structure of the scenarios is created. However, before developing the scenarios is possible, choosing a specific method for which the scenarios become divergent is essential. For the sake of simplicity, this study chooses the Basic Quadrant, which targets two key uncertain drivers and generates four different scenarios. Furthermore, this method will allow the natural process of having divergent scenarios. The figure below showcases the different scenarios at play according to the two drivers used (temperature change and eucalyptus monoculture reduction policy).

Figure 9 Eucalyptus wildfire prevention scenarios quadrant



Source figure 9: (Tremlett, C. Made for the research)

3.4.5 Step 9 Develop detailed outlines of the time evolution scenarios

Step nine is all about developing a timeline of the different scenarios; according to Rowland et al. (2014), this step is essential since it can help scenarios consider time-sensitive decision-making and help identify the actions that may need to occur. In the case of the precautious scenario, as the name gives it away, the government, in this case, would implement policies limiting and reducing eucalyptus plantation monocultures to reduce the fire. Portugal would be well prepared to face the rising temperatures since it was early in its preventive measures. For the Risk-taker scenario, here, while the temperatures are rising slowly and the wildfires are gradually increasing, the government prioritises its economy and will do so until the wildfire is more consecutive. In other words, the government will favour the economy and will not implement or will implement only minor regulations to eucalyptus monocultures until the fire becomes more of a threat. For the disaster prevention scenario here, like the precautious one, implementing eucalyptus monocultures reduction policies is a top priority since wildfire is increasing rapidly, and the government would want to avoid significant damages. In other words, the government will be fast in implementing regulations. The last scenario is the disaster scenario, where the government prioritises the economy even though the temperatures and wildfires are becoming more frequent and scarier. Furthermore, the loss of natural resources may seem manageable; however, the longer the government waits to implement consecutive regulations against eucalyptus monocultures, more and more factors will be at risk.

3.4.6 Step 10: Develop scenario narratives

This step is all about developing compelling stories for each scenario and showcasing all the factors that are into play for the different scenarios. The first scenario is the precautious one, which is the safest by far here; the focus is on protecting and increasing biodiversity while reducing eucalyptus forest wildfires. In this scenario, the government is aware that the temperatures are rising slowly, so they have a lot of control over the situation if they start implementing regulations against the eucalyptus monocultures as soon as possible. However, this approach does mean that there will be a loss of trade since reducing eucalyptus monocultures means that the paper and pulp industry will suffer and, in turn, the national exports too. When we look at the Risk-taker scenario, the government decides to wait before putting heavy legislation and favours the economy. By doing so, the government is risking more since the wildfires can also destroy other woods used by other industries, residential areas could be at risk in the long term, and a loss of natural resources is more than likely. Since the rise in temperature and wildfire are gradual, the government still has room to change things for the better. The third scenario is the Disaster prevention scenario; it is called that way because, in this scenario, temperature and wildfire are both rising very rapidly. The government will need to have stringent measures concerning the eucalyptus monoculture reduction policies to prevent this. Since, in this scenario, the government is already losing natural resources, to prevent the damage costs from reaching other areas such as the residential areas, the government would prefer to lose money through export trade. In other words, the economic costs are heavy; however, they could be more significant if the policies are not implemented. The last scenario is the disaster scenario. It is called that way because the temperatures and wildfires are increasing rapidly, and the government is not implementing many measures. The reason why this scenario would be disastrous is that if the wildfires became uncontrollable, there would be hefty natural costs (eucalyptus and other trees), loss of biodiversity, residential area, human life, the paper and pulp industry and other forests industries would be affected (trade loss). This, in turn, would have astronomical economic damage costs.

3.4.7 Steps 11 and 12: Evaluation of scenarios, quantifying and simulating scenario narratives

While common when developing a scenario planning assessment method, in the case at hand, due to the limited resources of the study, the evaluation by others with the appropriate expertise is not possible. This goes the same when talking about quantifying and simulating scenario narratives.

3.5 Phase III. Using scenarios

3.5.1 Step 13, 14, 15 and 16 Using scenarios

Step 13 is about evaluating the potential impacts and implications of the scenarios; for the sake of not having repetition, the potential impacts are listed in step 10 when developing the scenario narratives. Finally, step 14 & step 15 is about identifying potential strategies or action options and then prioritizing them in terms of importance, urgency, co-benefit, feasibility, robustness and costs. While all four scenarios are possible directions in which Portugal's government may go, it is most likely to engage with the eucalyptus monoculture reduction policies. Furthermore, it is in Portugal's best interest to keep the disaster economic costs as low as possible. For these reasons, the precautious scenario is the ideal choice. With this taken into account, the strategies and action points that will need to be implemented to have Portugal make the best choice are the following: 1. Educate them about the economic cost of each scenario and the severity of the issue, 2. Raise awareness of the lack of research on the connection between eucalyptus trees and wildfires, 3. Educate all stakeholders about the impact of climate change and the relation to eucalyptus led wildfires. 4. Make the private land forests regulations stricter. 5. Implement more strict policies in terms of the eucalyptus monoculture plantations. Step 16 is the last step of scenario planning; it is about structuring, monitoring, and researching any future information. In the case at hand, the best way to monitor how the governments and the other stakeholders will implement the different scenarios is to have them complete surveys to know if they have or have not diverted from the current scenarios. Also, this monitoring process will enable the Eucalyptus fire prevention scenarios to be adapted if feedback or new conclusive research were to come (Rowland et al., 2014).

4. Conclusion

In conclusion, Portugal's forest has been changing for the last few centuries and is inherently part of its day-to-day basis; it has been a very lucrative business through the pulp and paper industry for Portugal's different stakeholders. However, some shortcomings need to be assessed, such as the environmental impact, the lack of management of the eucalyptus trees, the abandonment of eucalyptus plantations, and the vulnerable eucalyptus trees to pests and diseases. These shortcomings all come up with one major issue: the increased number of wildfires, as stated in the paper. Furthermore, with climate change hitting its full swing, more people and stakeholders are at risk of economic and health welfare. Although scenario planning was decided to be used, it is essential to understand the deep-rooted issues that stem from these different forestry industries. The first phase of Scenario planning aims to improve understanding of the issue, synthesise the information, and prepare a work plan.
The second phase aims to develop the different eucalyptus wildfire prevention scenarios, resulting in a precautious, risk-taker, disaster prevention and disaster scenario, each having quite different narrative paths. Finally, the third phase uses the scenario: by evaluating the different scenarios, creating strategies to put them in place and then monitoring the process once it is used.

Nevertheless, now that the assessment of scenario planning has been developed, it is important to first turn towards the recommendations for Portugal when it comes to implementing one of the scenarios, followed by the limitations of this study.
To have Portugal fight wildfire as efficiently as possible, it is recommended that it implements fire breaks, reduces monocultures by replacing them with polycultures, creates vegetation walls, define strict planting zones. Other recommendations are, for example, to implement strict regulations to reduce eucalyptus monoculture plantations, implement stricter eucalyptus shedding pickup regulations and educate local populations about wildfire risk.
However, when it comes to the limitations and challenges of this study, there are a few factors to consider. The first is the fact that more research is needed in the field of eucalyptus provoked wildfires. The second is that while the different scenarios were based on academic research and government reports, it is impossible to give a probable estimation without more resources and time. The third limitation is that without a BCA assessment, it is difficult to

estimate the approximate overall damage costs of these wildfires. To conclude, while developing these scenarios is a good step in the right direction, further research, monitoring, resources, and hours are needed before government officials can use them.

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