Mitigating forest fires in the Nordic region through forest management

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Climate change increase fire risk in the Nordic region

Forest fires are a natural disturbance agent in the boreal biome and important for the functioning of forest ecosystems. In the Nordic region, forest fires have been kept largely under control by effective fire suppression over the last 100–150 years, parallel to the expansion of industrial forestry. In comparison to other parts of the boreal biome, the area burned today is very small, although the number of fires is still high. To support fire-structured ecosystems, however, prescribed burning for nature conservation has been introduced.

Projections of future climate conditions point towards higher temperatures and more frequent extreme drought periods for the Fennoscandia. In 2018, the Nordic countries witnessed their largest forest fires in modern history. Emerging climate threats are expected to make Nordic forests, ecosystem services, and societies more sensitive to fires. This means that society's preparedness for forest fires within civil contingencies, community planning, and forest management needs to continue to develop.

Many Nordic countries have a long history of active forest management that has determined how forests look like today, and different management methods have been used to achieve different ecological, economic, and social goals.

Political discussions focus on mitigating the effects of climate change, and more practical recommendations and actions are needed. Current forest management plans in Nordic countries are rarely actively taking the risk of fire into account, even though many of the potential fire mitigation methods are already being used; albeit for other forest management purposes.

To create more fire resilient forests and societies in a changing climate, there is a need to actively identify fire risk in the Nordic forests and include fire mitigation as part of forest management plans, landscape and community planning, and wildfire preparedness analysis. Different mitigation methods can be applied, taking into account the local conditions and different forest management goals.

Surface fuels carry the fire

Wildfires require three main elements to ignite and spread – fuel, oxygen, and heat – the so-called ”fire-triangle”, whereas the ”fire environment” consists of weather, topography, and fuels, which control fire behaviour.

Climate, local soil, and site characteristics, together with tree species and management history all impact understorey vegetation and the canopy structure; i.e., forest fuels. Internal factors, such as the physical (e.g., thickness, surface area, perimeter) and chemical (e.g., lignin, moisture, mineral, and volatile content) properties of fuels drive fire via their effect on flammability. The moisture content of fuel is one of the most important factors affecting ignition risk and fire behaviour and it varies during the day and fire season, and between different forest and fuel types.

Surface fuels (including mosses, lichens, shrubs, grass, and litter) are the most important both for fire ignition and for rate of spread. Certain bottom layer cryptogams[1] (e.g., Hylocomium splendens, Pleurozium schreberi, Cladonia spp.) often constitute a large part of the surface fuel layer, and their moisture content corresponds with ambient weather conditions, being key to temporal variation in fire danger. In the field layer, e.g., heather (Calluna vulgaris) and crowberry (Empetrum nigrum) are more flammable than other common shrubs such as bilberry (Vaccinium myrtillus). In addition, grass is highly flammable as cured[2] litter in spring, but dampens fire when green in summer. The relative abundance of these species is largely controlled by soil and climate, but also by management measures such as tree species selection and thinning regimes.

Tree species composition, stand development stage, and forest structure all affect the risk of high intensity crown fire via impact on ladder and canopy fuels. Typically, young conifer forests, spruce forests with low branches, and forests with uneven canopy structures are at the highest risk of crown fires. On the other hand, a dense and complex forest structure slows fuel evaporation, decreasing the number of days when the ignition and spread of surface fire is possible.

At the landscape level, the potential for large fires is highest in unmanaged, homogeneous and remote forest areas and landscapes with less variation in soil wetness and long distances to roads. Thus, heterogeneity – via different tree species, age structures, and moisture conditions – creates variation in fire spread and intensity, therefore improving the overall fire resilience of the forest landscape.

As mentioned, the interplay of forest fuels, weather, and topography governs fire behaviour. Regional weather and long-term climate patterns play a key role in determining fire risk. Extended periods of low relative humidity combined with high wind speeds create favourable conditions for fire activity and spread. Topographic characteristics like slope, aspect, elevation, and other landscape features also have effects; for instance, southern slopes usually dry faster due to high solar radiation, and fire tends to spread faster uphill. In addition, topography affects the risk of post-fire erosion.

1 A plant or plant-like organism (such as a fern, moss, alga, or fungus) reproducing by spores and not producing flowers or seed.
2 Process of grass die-off, and the transition of live fuels into the dead fuel component of the fuel bed.

Mitigating forest fires through forest management

Forest management activities can be used to actively mitigate forest fires and increase the fire resilience of forest landscapes, and thereby positively impact local communities and support national and international strategies for climate adaption. Mitigation methods in forest management are based on the modification of the fuel conditions such as amount, structure, and moisture, and can be divided into short-term technical approaches and long-term strategies. Here this also includes building and maintenance of forest road networks and considering local topography. When selecting suitable management methods, local conditions related to fire risk should be evaluated together with multiple forest management goals. This should be done by connecting different spatial scales including stand, property, and landscape-level planning. To the right are listed the tentative management recommendations to decrease forest fire risk in the Nordic region, based on earlier scientific research.

Tentative management recommendations to decrease forest fire risk

Short-term

- Cleaning forest roads and removing harvesting residuals
- Prescribed burning and site preparation*
- Cleaning, tending, pruning, and thinning forests**
- Leaving the largest and healthiest trees in thinning (thinning from below)
- Timing forest operations (e.g., soil preparation, regeneration, pre-commercial thinning)

Long-term

- Selecting site-specific tree species and favouring deciduous trees and mixtures
- Selecting site-specific silvicultural systems (e.g., continuous cover***, even-aged**)
- Connecting management to local topography (e.g., fuel modification, erosion barriers)
- Building and maintaining forest road networks
- Rewetting and protecting naturally wet areas
- Creating landscape variation of different species and structures, including potential firebreaks

* Increased risk during the operation
** Decreasing risk of crown fires, but increasing risk of ignition and surface fires
*** Decreasing risk of ignition and surface fires, but increasing risk of crown fires

Short-term technical approaches such as mechanical removing of harvesting residuals or maintaining forest roads are minimising fire risk directly. Long-term conceptual approaches, such as selection of tree species or silvicultural system and landscape planning, should be in line with the general management goals of the region.

Site preparation, especially prescribed burnings, and cleaning of forest roads reduce fire risk since surface fuel is removed or altered. By stand cleaning, tending seedling stands, and pruning, thinning, and removing harvesting residuals, fire intensity and the risk of crown fires is decreased, with less available surface and ladder fuels and longer distances between tree crowns. Correct timing of forest operations can decrease fire risk: for example, by avoiding site preparation during the high-risk fire season, removing harvesting residuals or ladder fuels, and plantings trees as quickly as possible.

Tree species selection has a large impact on the risk of fire. Open and dry Pinus sylvestris-dominated forests are at higher risk of ignition and surface fires, whereas moist Picea abies, and especially deciduous forests, are at lower risk. On the other hand, old pines have the best survival rates in the case of surface fire. Among non-native species, Pinus contorta stands, with fluffy litter, planted especially in Sweden, create excellent conditions for rapid fire spread by generating a loose litter bed. Mixing deciduous and conifer trees in forests decreases fire risk. Young conifer forests, spruce forests, and mixed pine-spruce forests have the highest risk of crown fire.

Most mitigation methods reduce overall fire risk, but some may have complex effects, lowering one aspect of risk and increasing another. For example, mechanical removing of ladder fuels via cleaning, tending, pruning, and thinning forests, common in even-aged forestry; and increased distance between trees decrease the risk of crown fires, but will at same time increase the risk of ignition and surface fires, since more light and wind is let through the forest. Similarly, more structured and dense forests, typical in continuous cover forestry, likely decreases the risk of ignition and surface fire due to higher surface fuel moisture conditions but increases the risk of crown fire in high-danger fire weather due to an abundance of ladder fuels. More complex forest structure can also complicate fire suppression by placing fire fighters in greater danger. Large amounts of lying deadwood generally have good water storage capacity, but in dry conditions accumulations of large amounts of lying dead wood as well as standing dry deadwood can increase fire intensity and risk of spotting, correspondingly.

It is good to remember that management methods alone do not affect fire risk, but must be considered together with local fuel, terrain, and climate conditions. For example, surface fuel in dense spruce stands on former farmland is almost impossible to ignite. Likewise, the risk of crown fire is very low in forests on wetlands or deciduous forests regardless of forest structure. By connecting management methods to local topography, the risk of fire spread in steep slopes and post-fire erosion can be decreased; e.g., via fuel modification or erosion barriers, correspondingly. That is why site-specific fire mitigation strategies combined with other management goals should be applied. Even the best managed forests may burn under extreme weather conditions.

Varied forest landscapes with different tree species, stand structures, and moisture conditions (landscape mosaics) are more resilient to forest fire compared to large single-species homogeneous landscapes. This is because different fuel conditions increase the variation in ignition risk and fire behaviour in landscapes.

By creating a heterogeneous forest landscape with small patches of homogenous fuels (stand size), by rewetting previously drained forests, and by protecting the natural wetland areas, the risk of fire can be decreased. In addition, by building forest roads to remote forest areas, and by maintaining the road network, the risk of large scale and high intensity forest fires can be reduced by giving rescue services easy access to the forest.

In the future, active identification and creation of firebreaks, like deciduous tree zones, in forest landscape and wildland urban interface (WUI) or targeted prescribed burnings and grazing, could be alternative mitigation methods in the Nordic region.

Locally adapted multi-objective forest management

Fire mitigation should be seen as part of a larger scheme of ecological, economic, and social forest management goals such as biodiversity, carbon-sequestration, monetary value, recreation, climate adaption or other risk management.

Many fire mitigation measures also support other forest management goals. For example, increasing the amount of deciduous trees and conducting nature conservation burnings have a positive effect both on biodiversity, fire risk, and other forest damage, e.g., damage occurring through droughts, storms, insects, or disease. Similarly, cleaning, tending, and thinning forests can both increase economic revenue and decrease the risk of crown fires. With continuous cover forestry, there might be positive effects on ecosystem functioning, the economy, recreation, and fire risk. Forest management goals including fire risk should be locally adapted.

Special fire mitigation methods should be applied to forests located close to human settlements, important infrastructure, and other social and cultural values. For example, in WUI (wildland urban interface), zones around protected areas can be created, where particular management like special tree species (often deciduous) or cleaning and thinning regimes are applied. Moreover, targeted management is needed in high-risk fire areas such as shooting ranges, old military areas, peat production fields, contaminated areas, nature reserves, and areas with steep unstable soil conditions.

Also, in rural areas, agricultural goals apart from forestry, can be combined with fire mitigation goals, e.g., via grazing schemes. Currently there is lack of knowledge on quantitative measures of fire mitigation methods and how to combine fire risk with different management goals in the Nordic region.

Filling the knowledge gaps

Forest fires are identified as an increasing problem in Europe, and Southern Europe has already experienced extreme megafires.

Forest fire research is an active discipline, especially in countries affected by large fires. In the Nordic countries, research on fire mitigation through forest management has so far been marginal.

There is a notable lack of quantitative analyses on how different management methods affect fire risk under Nordic conditions, which makes it difficult to formulate clear recommendations to practical managers.

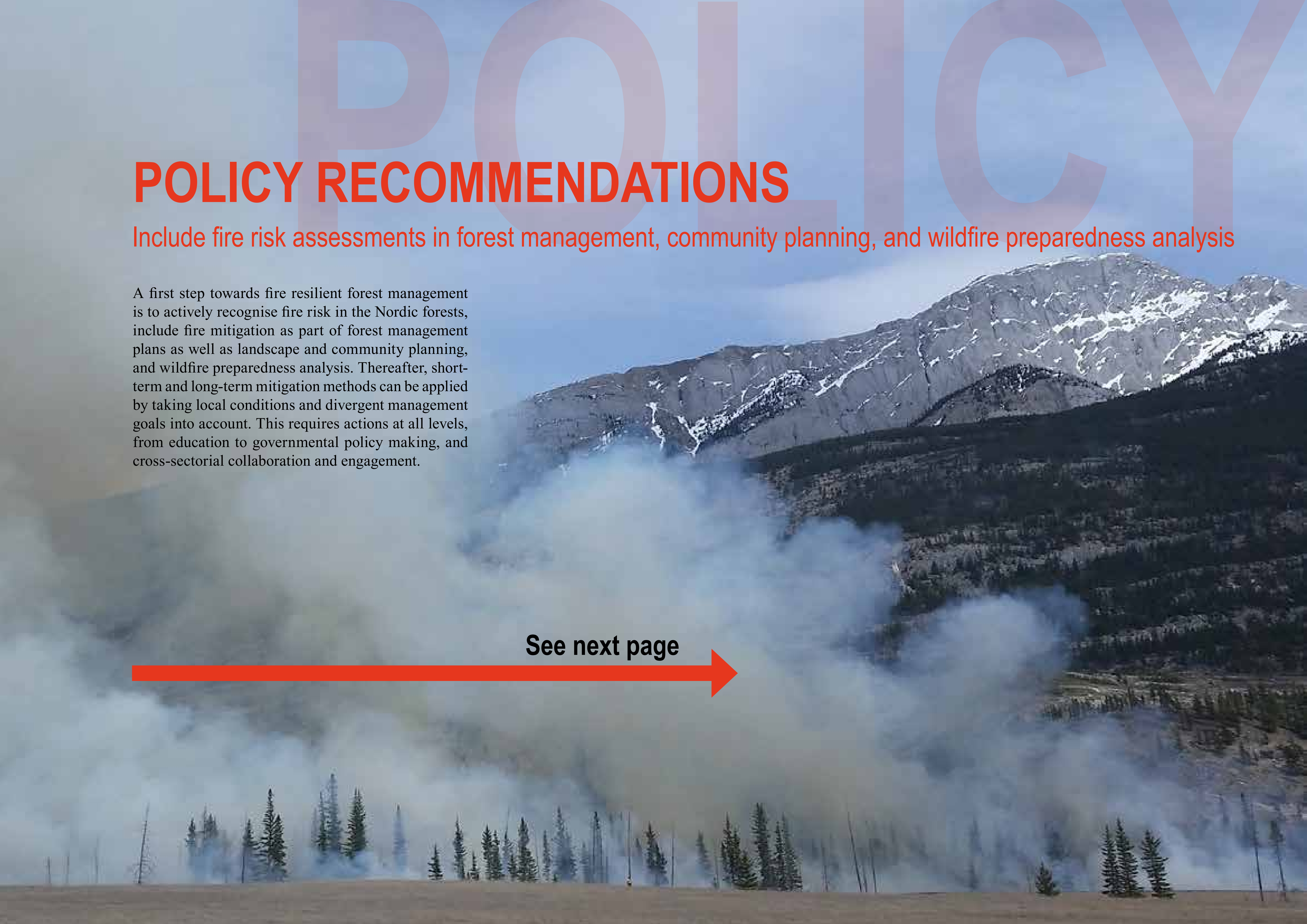
Sustainable forest management should also take into account different management goals for the forest; currently there are no studies in Fennoscandia where different fire mitigation methods are balanced against other forest management goals.

There is also a need to study fire mitigation from the perspective of different forest owners and political aspects to find best methods before policies are applied.

Critical information on fire behaviour and fire risk need to be acquired through experimental fires, like through data collection on wildfires, which should be gathered into a comprehensive, long-term forest fire database.

Further recommendations for future research are:

- Quantify the effects of different management methods on fire risk (by burning experiments, modelling, simulations, case studies, etc.)
- Evaluate the effect of landscape and terrain structure on fire risk (fuel structure, firebreaks, erosion risk, wild land urban interface (WUI), etc.)
- Perform trade-off analysis of different fire mitigation methods in regard to other management goals
- Perceive spatial and temporal variations in fire danger more accurately
- Investigate the risk for extreme fires (megafires) as experienced in Southern Europe
- Identify future changes both in climate conditions and policy targets and analyse their effects on fire risk
- Evaluate the interest among different type of forest owners to minimise fire risk
- Analyse how to include forest fire mitigation into policy, legislation, and education
- Need for common infrastructure, such as comprehensive forest fire databases for Nordic countries, to support research and decision making



POLICY RECOMMENDATIONS

Include fire risk assessments in forest management, community planning, and wildfire preparedness analysis

A first step towards fire resilient forest management is to actively recognise fire risk in the Nordic forests, include fire mitigation as part of forest management plans as well as landscape and community planning, and wildfire preparedness analysis. Thereafter, short-term and long-term mitigation methods can be applied by taking local conditions and divergent management goals into account. This requires actions at all levels, from education to governmental policy making, and cross-sectorial collaboration and engagement.

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- Actively identify fire risk in Nordic forests, connected to climate change projections
- Include forest fire mitigation as an active part of forest management plans, landscape and community planning, and national risk management (e.g. wildfire preparedness analysis)
- Apply the recommended short-term technical and long term conceptual approaches listed in this policy brief
- Select mitigation methods and strategies based on local conditions (fuel, errain, climate) and take into account combined management goals
- Promote forest management that combines multiple objectives and landscape variability
- Increase the knowledge base and knowledge exchange on fire mitigation in the Nordic region via data collection, research, communication, and education
- Support collaboration, social and cross-sectorial engagement, and capacity building towards fire resilient forest management
- Acknowledge that more knowledge is needed on the trade-offs between fire mitigation and other forest management goals in the Nordic region to be able to offer well-founded recommendations and decision support
- Create a comprehensive forest fire database
- Accept that even the best-managed forests may burn in extreme weather conditions

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Further information
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Further reading

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