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GONE WITH THE WIND: MODELING FORESTRY RISK IN EUROPE

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EDITOR'S NOTE: AIR has developed a comprehensive framework to assess the winter storm risk associated with forestry insurance in Europe. Modeled countries are currently Norway and Sweden and will expand to include Finland later this year. .

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INTRODUCTION

Across Europe, forests cover approximately 160 million hectares, accounting for approximately 35% of total land area. The region currently outputs about a quarter of the world's industrial forestry products, and the forestry sector is vital to many economies, especially those of Nordic countries. In Sweden and Finland, for example, forests cover as much as 70% of the land area, and export of forestry products accounts for more than 10% of total exports and approximately 5% of gross domestic product.

Fierce extratropical cyclones can devastate vast areas of forest, felling millions of trees within hours and potentially causing insured losses well in excess of a billion Euros. Beyond the initial mechanical tree damage, felled trees are more susceptible to insect infestation and disease; sharp spikes in available timber that result from such mass felling can cause dramatic price drops that affect both the local economy and international trade; and forest damage can cause long-term distress to soil and water ecology, carbon sequestration, and biodiversity, among other economic and environmental impacts.

Figure 1. In 2005, winter storm Erwin (Gudrun) damaged 250 million trees in southern Sweden (Source: Swedish Ministry of Industry, Employment and Communications)

THE STATE OF THE INSURANCE MARKET

Forest ownership across Europe often reflects regional and national political history. In northern and western Europe, about two-thirds of forests are privately owned. Conversely, in parts of central and eastern Europe, state ownership can be as high as 90–100%. Financial risk management among forest owners varies widely in different countries, as does the availability and demand for private insurance. Even in many countries where insurance is available, fire coverage is typically the standard offering, while wind protection may require significantly higher additional premiums, or is not offered at all.

In a United Nations Environment Program survey of large reinsurers and insurers around the globe, less than half wrote forestry insurance, many citing the lack of reliable risk assessment capabilities (UNEP 2008). Many private forest owners decline insurance, even when available, because they do not rely on their forests as a main source of income, and because public assistance after a storm—to compensate for incurred losses or to assist with cleanup and replanting—is often available. For example, in Switzerland and Austria where government catastrophe funds are in place, forestry insurance is virtually non-existent. Germany's showing is a bit better, with 2% of forestland insured. Penetration in the United Kingdom is around 10% (EFI 2010) and in France around 7%. It is worth noting that these numbers may grow; after severe losses to France's maritime forests during winter storm Klaus in 2009, for example, the government passed a law in 2010 that limits state support for post-storm clean-up and reforestation to insured forestland, which goes into effect partially starting in 2011 and fully in 2017 (Government of France, 2010).

Forestry insurance in some Nordic countries, however, has been in existence for several decades and is much better embedded into the risk management practices of forest owners. Currently in Europe, only in Norway, Sweden, and Finland is storm insurance for forestry both readily available and commonly purchased, and hence this article will focus discussion on these three countries.

Norway's mutual forest insurance company Skogbrand—founded in 1912 and owned by its 40,000 policyholders—insures about half of privately owned forestland against wind (Skogbrand 2009). In Sweden, approximately 80% of forestland is owned by individuals and private companies (Swedish Forest Agency 2007), about half of which is protected against catastrophic wind damage. In Finland—where forestry policies cover the expected value of lost timber and, optionally, damage to future growth—about a third of family forests are insured (Finnish Forest Association 2009).

AT STAKE: LOSSES IN EXCESS OF A BILLION EUROS

Winter storms occur with considerable frequency in Europe, although typically only a few per year are strong enough to cause significant damage to forestry. In the past fifty years, two storms caused catastrophic forestry losses in the Nordic region, with effects most pronounced in Sweden. In late September of 1969, a winter storm traveled across southern Sweden with maximum wind speeds of 35 m/s, damaging more than 40 million cubic meters of forest. The forests were predominantly privately owned and contained mostly Norway spruce; estimated losses totaled 175 million Euros, based on 1969 currency (EFI 2010). Following the storm, Sweden experienced its worst recorded outbreak of spruce beetle, which damaged an additional 3 million cubic meters of forest.

The largest amount of recorded forestry damage in the Nordic region was in January 2005, when winter storm Erwin (named Gudrun by the Norwegian Meteorological Institute) damaged an astounding 250 million trees, or 160,000 hectares, in two days. The roughly 75 million cubic meters of damaged timber is nearly equal to the entire annual harvest of Sweden, and economic losses from forest damage were estimated at 1.9 billion Euros in 2005 currency (EFI 2010). Wind speeds in Sweden reached 42 m/s, although maximum winds in the inland forests where the damage occurred were lower at 35 m/s. Most of the affected area consisted of Norway Spruce (80%), followed by Scots Pine (18%), with deciduous trees such as Birch making up the remaining 2%. The storm resulted in an estimated 50,000 forestry insurance claims (Olson 2008), totaling approximately 275 million Euros in insured losses (out of about half a billion Euros of total insured losses in Sweden).

Other winter storms in recent years have caused lower levels of damage. 1999's Anatol caused 5 million cubic meters of damage in Sweden; windstorms Pyry and Janika in 2001 caused in excess of 7 million cubic meters of damage in central and southern Finland (Finnish Meteorological Institute 2009); and Hanno in 2007 damaged over 3 million cubic meters of timber in Sweden and Norway (EFI 2010).

Climate Change and Forestry Damage

While research surrounding the influence of a changing climate on extratropical cyclone (ETC) activity is not yet as mature as that of tropical cyclones, scientists are increasingly focusing on examining this very important peril that affects the mid-latitudes of the U.S., Europe, and other parts of the world. This includes a recent AIR study in collaboration with The Met Office to quantify how future climate scenarios may influence the frequency, severity and tracks of ETCs and associated insured losses in Great Britain.

Some recent studies have suggested that while the overall annual frequency of ETCs may actually decrease in a warming climate, the intensity of the most severe ETCs may be on the rise. Furthermore, the typical path of these storms over Europe may trend northward, which has important implications for the distribution of insured risk over Europe, including that associated with forestry.

A warming climate may also mean more precipitation and longer periods of unfrozen soil, which can make trees more susceptible to uprooting. For example, simulations have shown that a rise in temperature of 4°C can decrease the duration of soil frost in southern Finland from 4–5 months per year to 2–3 months, and this longer unfrozen period is expected to correspond to some of the windiest moths of the year (Peltola et al. 1999b). Combining these climate implications with a growing and aging forest stock, there is a clear potential for increased forestry losses in the future in Europe.

UNDERSTANDING THE MECHANICS OF TREE DAMAGE

During a windstorm, there are two main damage mechanisms that can cause tree failure—uprooting and stem breakage. The stability of the tree depends on the resistance of the root and stem to the applied wind and gravity forces, as depicted in Figure 2.

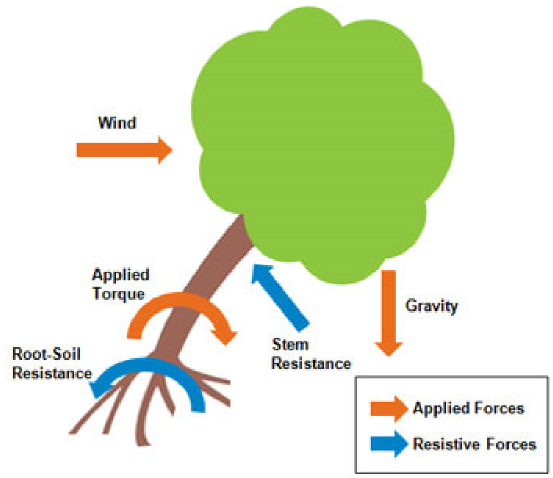

Figure 2. Factors and forces acting on a tree subject to high winds (Source: AIR)

In general, a forest's susceptibility to storm damage is affected by a complex relationship between wind climate, individual tree and stand characteristics, soil and site conditions, and damage mitigation and forest management practices (Figure 3)

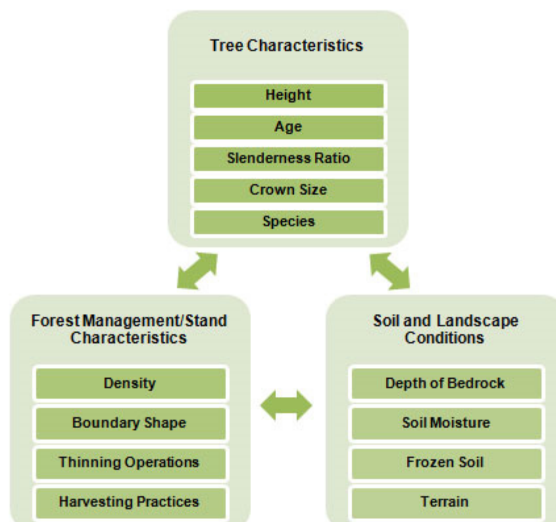

Figure 3. Tree vulnerability is dependent on a complex interplay between tree, stand, and site characteristics. (Source: AIR)

Tree characteristics that affect their ability to resist wind loads include height (taller trees are generally more vulnerable), age (older trees are generally more vulnerable), slenderness ratio (broader trees are less vulnerable), and species (as a result of different rupture resistances of their trunks, root anchorage systems and crown characteristics.) However, variation in vulnerability can also be attributed to the site and soil characteristics and to growing practices, rather than to inherent differences in characteristics of the individual trees of different species.

Shallow bedrock and wet soil can prevent deep root growth, while frozen soil reduces vulnerability because it can prevent trees from uprooting. For example, the very high tree damage from winter storm Erwin can be partly attributed to the unfrozen soil during the warm winter in 2005. The density of trees, the thinning process, the shape of the perimeter, and gaps in the stands also affect potential damage from storms. In addition, the terrain also plays a factor because wind speed is affected by slope, elevation, and nearby barriers or ridges.

Further complicating the assessment of tree vulnerability is that many of these factors are interdependent. For example, trees have been shown to adapt to the wind climate, so forests in regions that frequently experience more severe windstorms are better able to withstand damage, especially at the forest edges. A denser forest shelters many of the inner trees from wind and the trees tend to have a smaller height-to-diameter ratio, which decreases their risk of being toppled when exposed to strong winds. However, they are also more likely to be struck by neighboring trees.

In recent years, a significant amount of research has aimed to isolate the impact of these individual parameters on forest damageability and to develop corresponding forest management strategies to reduce the adverse effects of winter storms. Using fundamental principles of physics that govern wind and gravity forces, empirical experiments (including tree swaying, tree pulling, and wind tunnel tests) and mechanistic models, it is possible to determine the critical wind speed required to damage a tree within a stand for a given species and location.

The most commonly used mechanistic models—and those used to inform the AIR Extratropical Cyclone Model for Europe—are HWIND (Peltola et al. 1999), GALES (Gardiner et al. 2000) and FOREOLE (Ancelin et al. 2004), which are similar in their basic structure. Figure 4 shows the critical wind speeds from the HWIND model that cause uprooting and stem breakage for each the most commonly harvested species of trees in the Nordic region: Norway Spruce, Scots Pine, and birch.

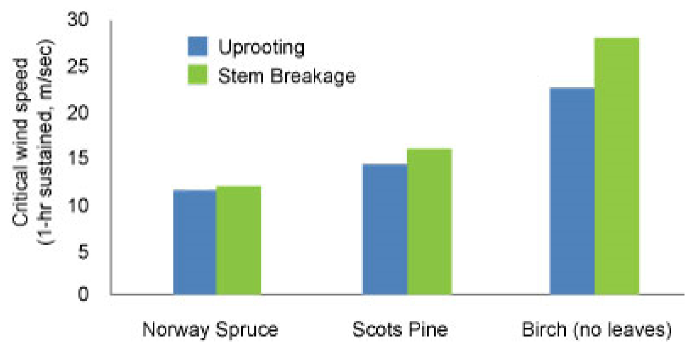

Figure 4. Critical wind speeds for Norway Spruce, Scots Pine, and Birch trees (Adapted from Peltola et al., 1999)

TRANSLATING WIND SPEEDS INTO INSURED LOSSES

Using numerical weather prediction analysis, AIR's Extratropical Cyclone Model reflects the complete range of potential windstorm experience across Europe, including their frequency, severity and track. The model captures the complex surface-level wind fields associated with these storms at a very detailed resolution, incorporating information on elevation and surface roughness that can cause highly localized wind gusts.

To translate these wind speeds into forestry damage, AIR has developed damage functions that estimate the susceptibility of tree stands based on the mechanistic damage models mentioned in the previous section, and validated using high-quality insurance claims data available from winter storms Anatol (1999), Erwin (2005) and Hanno (2007), in Sweden.

Company data provided to AIR and collaboration with market experts revealed that insurance companies generally only have information on area insured and sums insured by unit area, without detailed data on tree characteristics. Accordingly, AIR engineers developed damage functions for the "unknown" tree type, representing a tree whose characteristics are representative of regional tree stands.

Additionally, the AIR model provides a default replacement value per unit area in cases where it is unavailable. This default value takes into account the fact that damaged trees do not constitute a total loss and can often be salvaged, for pulp, for example. As a result, the replacement value for wind damage is lower than for fire, as burnt timber usually has little or no salvage value.

AIR has also created high-resolution industry exposure databases (IEDs) for Norway, Sweden, and Finland (Figure 5) using data from various forestry institutes and remote sensing agencies. Through disaggregation capabilities available in AIR's CLASIC/2™ software, these IEDs provide considerable value to companies who lack detailed exposure data. The model is also available in CATRADER® for Sweden and Norway, and Finland will be added in the next release of the AIR Extratropical Cyclone Model for Europe.

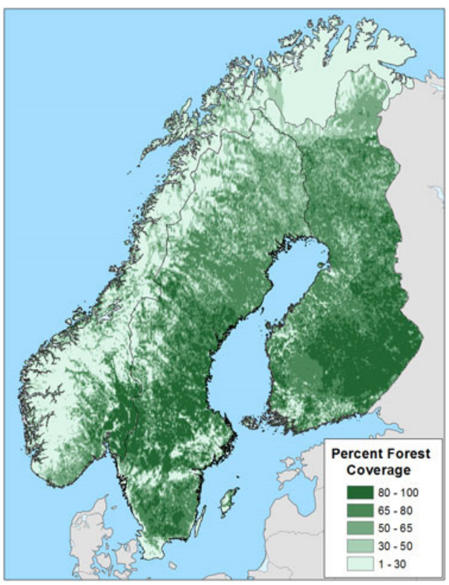

Figure 5. Tree coverage in Norway, Sweden, and Finland. Protected forests, which are geographically interspersed with harvestable tree stands, are not included. (Source: AIR)

CONCLUSION

Looking forward, a number of studies have concluded that the expansion of private insurance is of prime importance to sustainable forest management, both to prevent deforestation and the release of carbon dioxide into the atmosphere, and to protect forest owners and governments against increasing storm losses. Numerous initiatives—both private and public—are underway around the world. An example is France's recently passed law limiting state subsidies for post-storm clean-up and reforestation. In the private sector, a few respondents in the 2008 UNEP insurance survey reported that they are developing new forestry products and tailoring existing ones, and some are exploring alternative risk transfer solutions.

Addressing these growing needs, AIR's comprehensive framework for modeling forestry damage leverages state-of-the-art numerical weather prediction analysis to determine the frequency and severity of potential windstorm events, and sophisticated tree damage functions that take into account the complex and interdependent factors that affect tree vulnerability.

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