2.4 Forest damage

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> *The ongoing climate change is increasingly posing a challenge for the forest and forest management.*
> *Fewer unusual natural disturbances occurred between 2005 and 2012, apart from the floods in 2005. Most of them led to only moderate direct damage to the forest.*
> *Climate change increases the risk of forest fires, but with better prevention, the likelihood of severe damage can be reduced.*
> *Higher temperatures and drought amplify the risk of an infestation of forest insect pests, which can lead to the death of some stressed trees.*
> *Global trade has resulted in growing numbers of non-indigenous organisms being introduced. Usually they first appear in urban green spaces. This is why these areas should be monitored so as to have an early warning system for harmful organisms that may affect the forest.*
> *Ornamental plants and wood used as packing material, in particular, must be more strictly controlled, both internationally and nationally, to identify alien organisms.*

Climate change and abiotic natural disturbances

Temperatures worldwide will continue to rise further due to climate change – affecting Switzerland as well. As a consequence, extreme abiotic events are likely to become more frequent. The risk of forest disturbance can be reduced through various measures including: strengthening the resilience of existing forests, improving the adaptability of forest regeneration and introducing organisational measures like forest-fire prevention. The following estimates are based on linking the experiences from the extreme events during the period 2005 to 2012 with climate change scenarios for Switzerland.

Forest fires

In the period 2005 to 2012, 40 fires per year in Cantons Ticino (on the Southern slopes of the Alps), Valais and Grisons (Central Alps) were registered with an average burnt area size of 101 hectares per year (Fig. 2.4.1). Since 2008, 31 fires annually have occurred in the other cantons in Switzerland (North of the Alps) with, on average, an area of 6 hectares burnt. In recent years, fires North of the Alps have been reported more often, probably in connection with the introduction in 2008 of the forest-fire data-bank (WSL-FOEN) for the whole of Switzerland. The largest forest fires were those on 23 April 2007 in Ronco sopra Ascona (Canton Ticino), in which more than 200 hectares were burnt, and on 26 April 2011 in Visp (Canton Valais), when 130 hectares of forest were destroyed. In comparison with the period from 1980 to 2004, the number of forest fires annually in the Southern and Central Alps during the years 2005 to 2012 fell from 101 to less than half the number (40), and the average size of the area annually damaged from 477 hectares to 101 hectares.

One reason for this reduction is probably the increasing use of forest-fire protection strategies. These include regional and national evaluations of how dangerous the situation is on the basis of weather-data analyses, the internal organisation of fire brigades to improve fire-fighting and the building of infrastructure to ensure that there are water hydrants in priority areas. During the period from 2005 to 2012, the damage caused by forest fires was less than that caused by windthrow or beetle infestations.

In Switzerland the risk of forest fires will generally increase in the long term as more heat-waves and longer drought periods will occur due to climate change. To reduce this risk, the national and cantonal forest authorities are developing strategies for forest-fire protection involving silvicultural interventions, as well as an improved warning system for the public in case of danger. Since the Alarm Ordinance came into force on 1 January 2011, the federal government and the cantons have been obliged to inform the public about the danger of forest fires so that corresponding threat assessments can be systematically performed throughout the country.

Windthrow

Hurricane-force winds occur in Switzerland mostly during winter storms and cause large amounts of forest damage at irregular intervals – most often during the months of January and February. Switzerland was largely spared destructive storms from 2005 to 2012. The amounts of wind-damaged timber during this period were correspondingly small in comparison to the damage that the windstorm 'Kyrill' caused in neighbouring Germany, or the 13 million cubic metres of windtrow timber the windstorm 'Lothar' produced in 1999 in just Switzerland alone. In January 2007, the windstorm 'Kyrill' damaged timber on the Swiss Plateau amounting to around 100,000 cubic metres of timber, followed in March 2008 by 'Emma', which created 50,000 cubic metres on the Swiss Plateau and in the Pre-Alps, and 'Quinten' in February 2009 with around 200,000 cubic metres.

The winter storms that cause the most windthrow in forests in Central and Northern Europe are part of extratropical cyclone systems. According to the latest estimates of the Intergovernmental Panel on Climate Change IPCC, these are likely to move further towards the North Pole by 2050, so that the southern parts of Central Europe, and thus also Switzerland, should be less frequently affected by winter storms. This would mean that, in the long term, the risk of windthrow should fall, which goes against earlier assumptions and can be considered a new scenario. Nevertheless, in Zürich, which probably has the longest series of wind measurements worldwide, the total number of peak gusts per year has increased during recent decades (up to 2008; Usbeck et al. 2010).

It is not only the wind force that influences the extent of damage, but also the height of the stand. The taller the trees, the more damage is likely. Evaluations of the areas damaged by Lothar on the Swiss Plateau suggest that this interrelationship is more marked for conifers than for broadleaf trees (Dobbertin et al. 2002). Appropriate silvicultural measures can reduce the vulnerability of a stand to windthrow so that less damage occurs. They should aim to adapt the forest composition by, for example, reducing the growing stock or increasing the diversity of tree species, and structuring stands horizontally and vertically.

Heat, drought and interactions

The potential for damage to forests increases through interactions between various climatically extreme events. Two events during the past 15 years have shown this clearly. The first example is the enormous surge in populations of spruce bark beetles, which began on 'Lothar' windthrow areas. The following warm summers – especially the hot summer of 2003 – led to beetle-infested wood in quantities never encountered before. The second example is the effect of recurring droughts on tree growth: This has resulted in more infestations with harmful organisms and triggered the deaths of repeatedly stressed trees. This phenomenon has been detected in the lower regions of the Rhone valley in Valais, in the Rhine Valley near Chur and in Domleschg.

With further climate warming, larger numbers of trees, especially Scots pine, growing on dry subsoils in central alpine valleys can, in the medium term, be expected to die than after the dry period from 2003 to 2006. Climate scenarios suggest that the negative interactions between various climatically extreme events and harmful organisms on the Northern and Southern slopes of the Alps will become more significant (cf. *Invasive pests and pathogens* below).

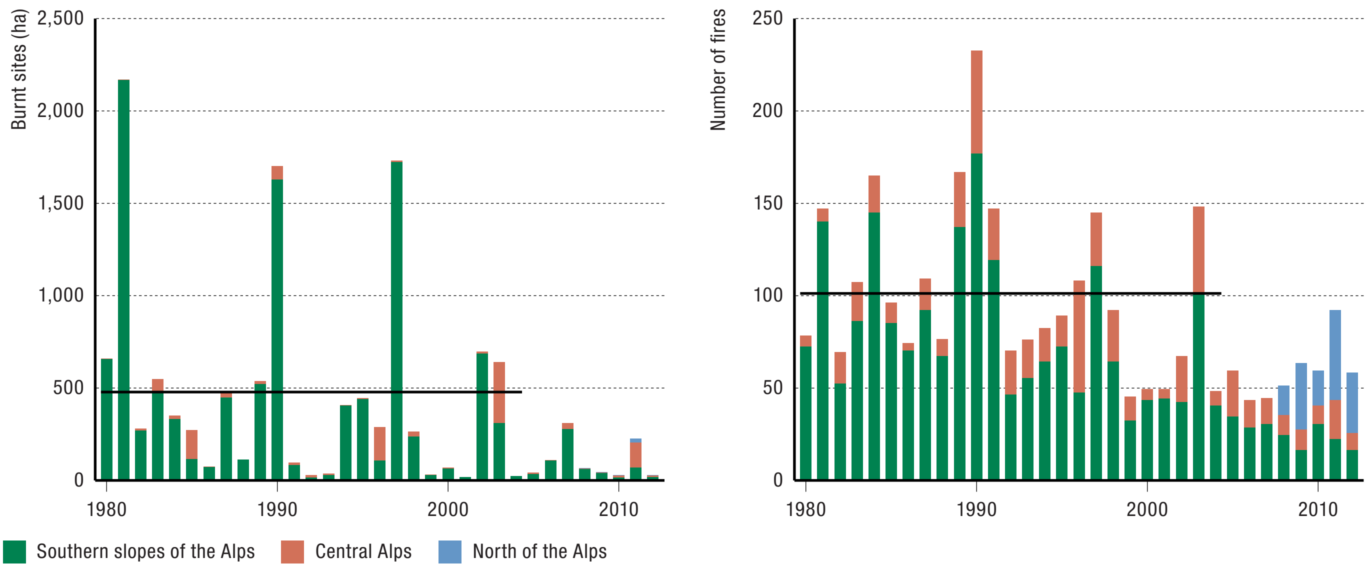

Fig. 2.4.1 *Burnt areas (left) and number of forest fires (right) in Switzerland from 1980 to 2012 in 3 regions. The horizontal lines show the mean values of the period considered for the Central Alps and Southern slopes of the Alps. Fire records North of the Alps have only been consistently kept since 2008 and are presented accordingly. Source: Forest fire data-bank*

Regeneration on damaged sites

The hot summer of 2003 showed clearly the levels temperatures and droughts may, with more frequency in future, reach. In dry regions like the inner Alpine valleys, higher mortality rates due to forest fires or severe droughts are already being recorded today. This raises the question of whether natural tree regeneration is threatened in the future. WSL is currently carrying out several investigations to try to find answers. A study of the site of a forest fire in 2003 near Leuk, Canton Valais, found that natural regeneration on plots with shallow soils under 1,100 m a.s.l. develops much less quickly than at higher altitudes. Experiments on cleared areas in the Rhine Valley near Chur indicate that the success of the regeneration of, for example, spruce and Scots pine, depends mainly on the available precipitation, especially at sites that can quickly dry out.

Droughts during the vegetation period are likely to become more frequent due to climate change. Forest regeneration on sites that are already dry today may not be successful so frequently. Climate change has also led to milder winter months. The phenological conditions for tree sprouting are thus changing. Pioneer species and neophytes benefit most from this development because they require a less pronounced winter cold for their buds to open. They therefore have an advantage over climax tree species. Warmer temperatures generally are likely to promote neophytes that are less frost resistant (Wohlgemuth et al. 2014).

Biotic forest damage

Long dry spells during the vegetation period weaken trees, which is why they are more susceptible to various root and bark diseases. Thus widespread Scots pine mortality was observed in Canton Valais in 2010, caused by the bark fungus *Cenangium ferruginosum*. Affected pines developed crowns with an intensive red colour and showed signs of dying (Fig. 2.4.2). Since hardly any rain fell between August 2009 and May 2010, these dry periods had probably weakened the trees considerably, which is why the disease broke out. *Cenangium* fungal attacks on pine have been repeatedly detected in Switzerland. A severe infestation was observed in Valais in 1999, which extended from Sierre to Visp. The dieback usually lasts only a year, after which the infestation rapidly declines.

Insect pests

Hot and dry periods increase the supply of weakened trees for bark beetles to breed in, and thus the risk that beetle epidemics will break out. After the winter storms 'Vivian' and 'Lothar', mass propagation of the spruce bark beetle (*Ips typographus*) occurred for several years each time with hundreds of thousands of cubic metres of infested spruce (Fig. 2.4.3). The hot summer of 2003 was a further strong boost for the epidemic triggered by 'Lothar', leading to a record quantity of infected spruce wood amounting to more than 8 million cubic metres.

Hot and dry summers, like that of 2003, can also cause population explosions of other insect species, which may lead to forest damage 1 or 2 years later. One example is the spruce bud scale (*Physokermes piceae*), whose populations profilerated locally on the Swiss Plateau in 2005, especially in stands growing on soil with a low water-storage capacity. The infested spruce trees were subjected to further attack by the small spruce engraver beetle (*Pityogenes chalcographus*) and the spruce bark beetle. The occurrence of spruce stands infested with scales and beetles led to the clear-cutting of 10,000 cubic metres of wood.

Invasive pests and pathogens

The introduction rates of non-indigenous organisms (Neobiota) worldwide have risen considerably in recent decades. In Switzerland over 800 non-native animals, plants and fungi have been identified. Fungi and invertebrates in particular are transported as 'stowaways' with traded goods and packaging wood. Around one hundred years ago, 7 new insect species per year were introduced into Europe. Today, the number is almost 20 species annually. The two introduced tree diseases, Dutch elm disease (*Ophiostoma ulmi* or *Ophiostoma novoulmi*) and 'chestnut blight' (*Cryphonectria parasitica*), show clearly what fatal consequences the introduction of exotic pathogens can have for indigenous forest trees. As global trade flows increase, the introduction rate is likely to rise even further.

Fig. 2.4.2 *Scots pine in Valais with conspicuously reddened crowns due to infestation with the* Cenangium ferruginosum *fungus in May 2010. Photo: Waldschutz Schweiz*

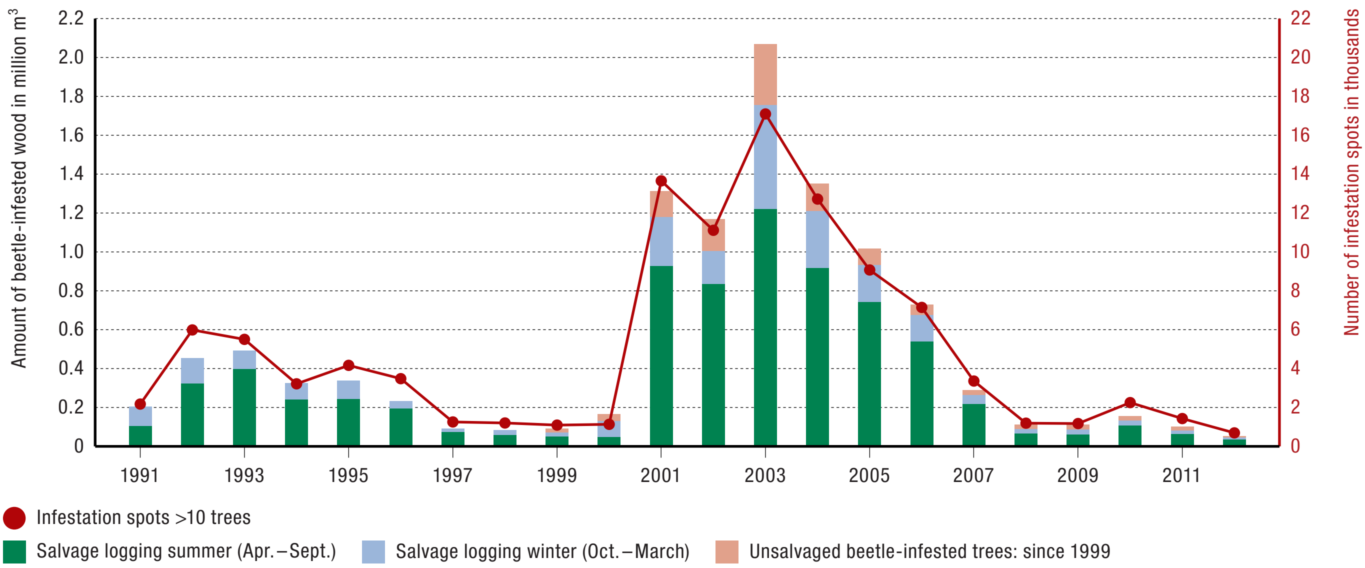

Fig. 2.4.3 *Bark beetle (*Ips typographus*): Amount of beetle-infested wood and number of infestation spots in Switzerland from 1991–2012. Source: Waldschutz Schweiz*

The most important introduction pathway for non-indigenous harmful organisms for woody plants is the trade with living plants. They are transported great distances from the countries where they are produced. Any harmful organisms that might by chance be transported with them find host plants in the import countries that have not adapted to them and can then cause much damage. Such invasive species often occur first in urban green spaces, where they become established and may well proliferate. As a result, some may become a threat for forest trees. Of the arthropods introduced into Europe so far, 15 per cent are also spreading in the forest. Climate change promotes the increase in neobiota insofar as the milder winters are favourable for their survival and the increasing dry spells in summer may reduce host plants' resistance (Wermelinger 2014). Warmer conditions have also led to insect and fungi species spreading northwards and/or to higher altitudes because of climate.

Of the fungi and insects that have recently been observed for the first time on woody plants in Switzerland and that have become established in urban green spaces or in the forest, several species are considered invasive. A few, like the Asian longhorned beetle (*Anoplophora glabripennis*), could endanger forest stands and are therefore classified as 'especially dangerous harmful organisms'. Their occurrence must be reported to the authorities and eradication measures are mandatory.

Invasive insects

The two Asian longhorned beetles introduced into Europe attack broadleaf trees of almost all species and sizes. Up until now they have preferred maple species. Only 4 cases of the citrus longhorned beetle (CLB; *Anoplophora chinensis*) in Switzerland are known, involving imported ornamental maple. The Asian longhorned beetle (ALB), however, attacked hundreds of indigenous trees in 2011 in Brünisried (Canton Fribourg), 2012 in Winterthur (Canton Zürich) and 2014 in Marly (Canton Fribourg) (Fig. 2.4.4). While the CLB attacks roots and the lower parts of the stem, and is mainly imported via living plants, the ALB attacks the whole length of the stem and branches of the crown. It enters Switzerland mostly in packaging wood, for example, in slatted crates for Chinese granite. Both beetle species must be officially reported. In Switzerland, no infestation of forest stands has occurred so far. Several infestations of copses and broadleaf stands are known from abroad. Eradication measures are being strictly implemented worldwide at the introduction sites with some success.

The Asian chestnut gall wasp (*Dryocosmus kuriphilus*) was first discovered in Ticino in 2009 (Fig. 2.4.5). It creates galls on leaves and flowers (causing a deformation). As a result, some shoots die and the production of leaves and fruit declines, sometimes drastically. Since then practically all chestnut-producing regions on the Southern slopes of the Alps have been affected. Infestation sites have also been identified in Chablais in the Rhone Valley (Canton Valais), as well as North of the Alps (Fig. 2.4.6). These can usually be traced back to imports of infested young plants.

The box-tree moth (*Cydalima perspectalis*) has been found in Switzerland since 2007, and has, until now, mainly attacked box trees in residential areas. It has spread within a few years throughout the whole of Switzerland through the sale of infested box trees. In the Basel area, natural box-tree

Fig. 2.4.4 *The introduced Asian longhorned beetle (ALB;* Anoplophora glabripennis*) attacks healthy trees of almost all broadleaf species. Photo: Doris Hölling*

Fig. 2.4.5 *Galls of the chestnut gall wasp (*Dryocosmus kuriphilus*). Photo: Beat Forster*

stands in the forest have also been affected. In 2010 they were completely defoliated and have not really recovered since then (Meier et al. 2013).

Invasive fungi

The pathogen causing ash dieback (*Hymenoscyphus pseudo-albidus*) was first identified in Switzerland in 2008, after which it spread rapidly. In the 1990s, the fungus, which originally comes from Asia, was transported unwittingly to Poland – most likely with infected young ash trees. Since then the pathogen has spread throughout Europe as its speed of propagation is between 30 to 40 kilometres per year. In 2015, 5 years after it was first observed in Switzerland, virtually all ash stands were found to be affected by this fungal disease. In young ash stands, losses of up to 90 per cent have been observed, and more infected old ash trees are also showing signs of dying (Fig. 2.4.7).

The red-band needle blight (*Dothistroma septosporum*) has spread from urban green spaces to the forest. This dangerous disease attacks the needles of pines and was first detected in Switzerland in 1989. Since then it has spread and is sometimes found today in residential areas in the northern part of Switzerland on mountain pine. In Canton Grisons and Canton Obwalden the disease was first spotted on Scots pine in forests in 2013.

Appropriate measures must be taken to protect the forest against damage from newly introduced harmful organisms. The number of new introductions must first be reduced, which means having stricter international and national regulations and border controls. In Switzerland the monitoring activities of the Plant Protection Service should be coordinated and extended in cooperation with the city park services. It is especially important to establish a form of monitoring in urban green areas, where new organisms first appear, as an early warning system for harmful organisms relevant to the forest. The earlier infestation sites are discovered, the more successful and less expensive it is to eradicate them. Once the neobiota have, however, already spread to the forest, it is virtually impossible to control them.

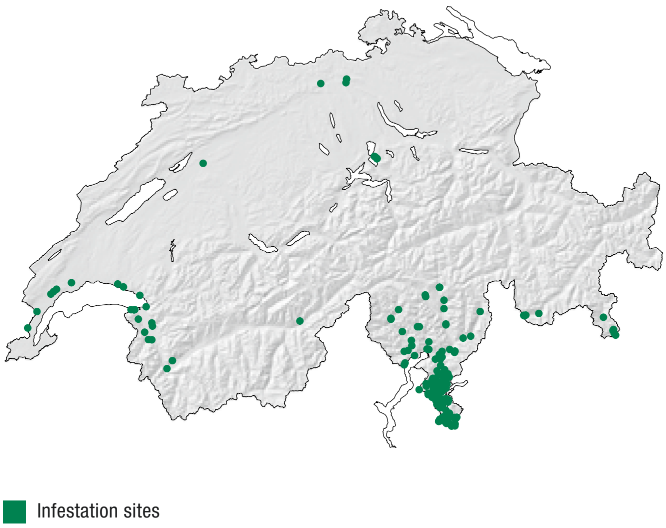

Fig. 2.4.6 *Infestation sites of the chestnut gall wasp (*Dryocosmus kuriphilus*) recorded by the end of 2013. Source: Waldschutz Schweiz*

Synthesis

Many of the factors that damage the forest are likely to become more important with the ongoing climate change, including storms and forest fires, as well as heat and droughts. Insects and fungi can multiply dramatically under the changed conditions and cause a great deal of damage, while invasive species find favourable conditions for dissemination. It is against this background that FOEN and WSL 2009 started a broadly based research programme 'Forest and Climate Change', in which the effects of various climate scenarios are identified and appropriate silvicultural strategies developed. To implement them, the Forest Act has been supplemented to allow various measures to, ultimately, support forest owners in keeping their forests vital and healthy in the long term, even under climatically changed conditions.

Fig. 2.4.7 *Ash infected with ash dieback. Photo: Roland Engesser*