Europe's biodiversity in a changing climate

Part 4: Terrestrial biodiversity

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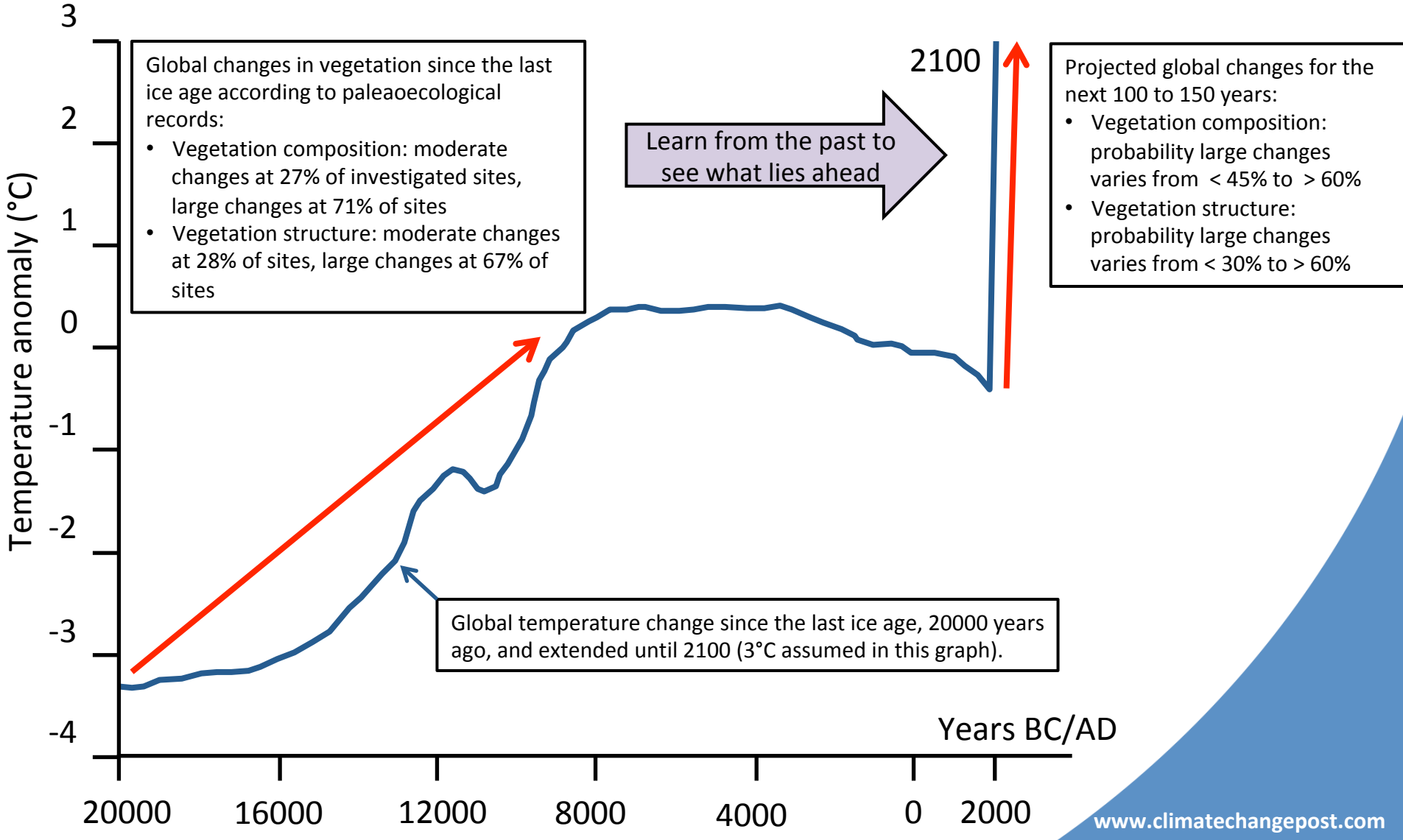
The main story

Source: Nolan et al. (2018)



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The main story

Extinction risk

Projections suggest that between one fifth and one third of European plant species could be at increased risk of extinction if global mean temperatures rise more than 2 to 3°C above pre-industrial levels. Effects will probably differ between species.

Impacts climate change

There are a number of further factors that impact biodiversity and nature conservation negatively at present and in future, namely land use changes, such as e.g. disturbance, fragmentation and destruction of habitats through development, transport, agriculture and forestry.

Additional pressures

Negative impacts on ecosystems and biological diversity will be the increased expansion of pests through milder winters, more frequent forest fires (due to increased temperatures and aridity in summer), extreme rainfall events, floods and droughts, and replacement of native species by invasive species.

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Shifts

- Spring advancement
- Northward shift
- Upward shift

Main impacts climate change

- Earlier leafing, flowering and fruiting
- Earlier arrival birds
- Species migration to the north and to higher altitudes

Vulnerable systems

- Peat bogs
- Forests
- Mountains
- Islands

Limited possibilities for migration

Vulnerable animals

- Birds
- Insects
- Reptiles and Amphibians
- Game

Trophic mismatch

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Spring advancement of life cycle events

Plant life cycle events are advancing

78% of all leafing, flowering and fruiting records of 542 plant species in 21 European countries advanced from 1971 to 2000. The average advance of spring/summer was 2.5 days/decade in Europe.

This advancement started at the end of the previous millennium

From a long-term dataset (1868-2010) it was concluded that until the beginning of the 1990s, there have been no significant changes in the timing of plant life cycle events in the Netherlands. During 2001-2010 the timing of flowering, leaf unfolding and fruit ripening has advanced on average by 13 days compared with 1940-1968. Some species have advanced up to over 35 days.

Norway
The growing season has increased up to 2-4 weeks in parts of Norway since the 1980s.

UK
Leafing, flowering and fruiting dates of terrestrial plants in the United Kingdom showed a rapid mean spring advancement of 0.58 days per year between 1976 and 2005.

This advancement correlates with temperature of the preceding months

Research in Germany has shown that events such as leaf unfolding and flowering of different species strongly correlate with temperature of the preceding months and their onsets have advanced by 2.5 to 6.7 days per °C warmer spring. Fruit ripening correlates well with summer temperature (shown for some species) and also advances by 6.5 and 3.8 days per °C (April–June). The length of the growing season is mainly increased by warmer springs and lengthened by 2.4 to 3.5 days/°C (February–April).

This advancement may damage plants

Acceleration of vegetation in the spring is accompanied by the danger of damage to plants by late frosts. Extremely high temperatures can increase the danger of occurrence of temperature stress. Climate change will enable the spreading of invasive non-indigenous species. Consequently even successful species will be forced to face so-far unknown competitors, natural enemies, parasites and organisms transmitting diseases.

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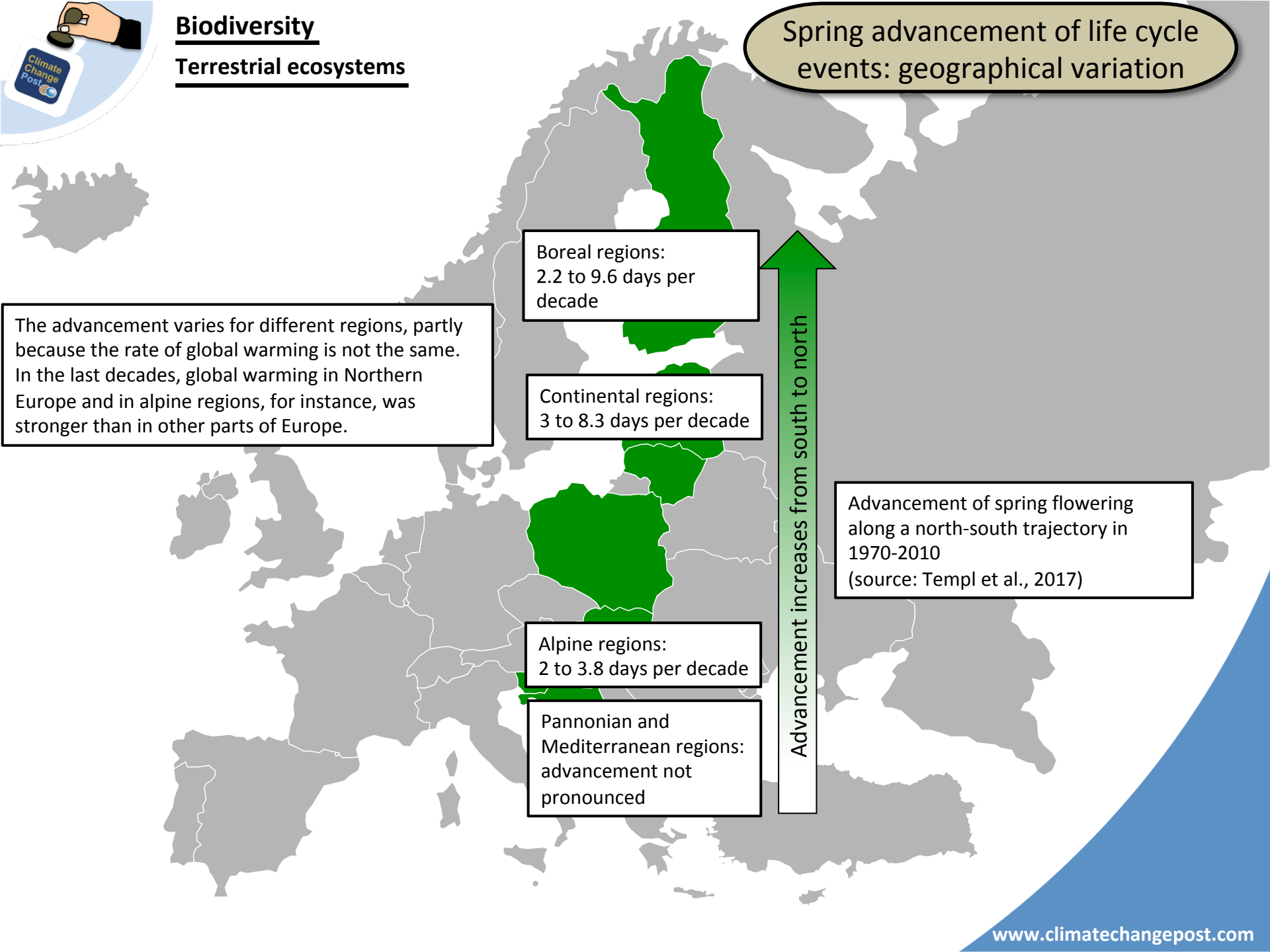
Spring advancement of life cycle events: geographical variation



The advancement varies for different regions, partly because the rate of global warming is not the same. In the last decades, global warming in Northern Europe and in alpine regions, for instance, was stronger than in other parts of Europe.

Advancement of spring flowering along a north-south trajectory in 1970-2010
(source: Templ et al., 2017)

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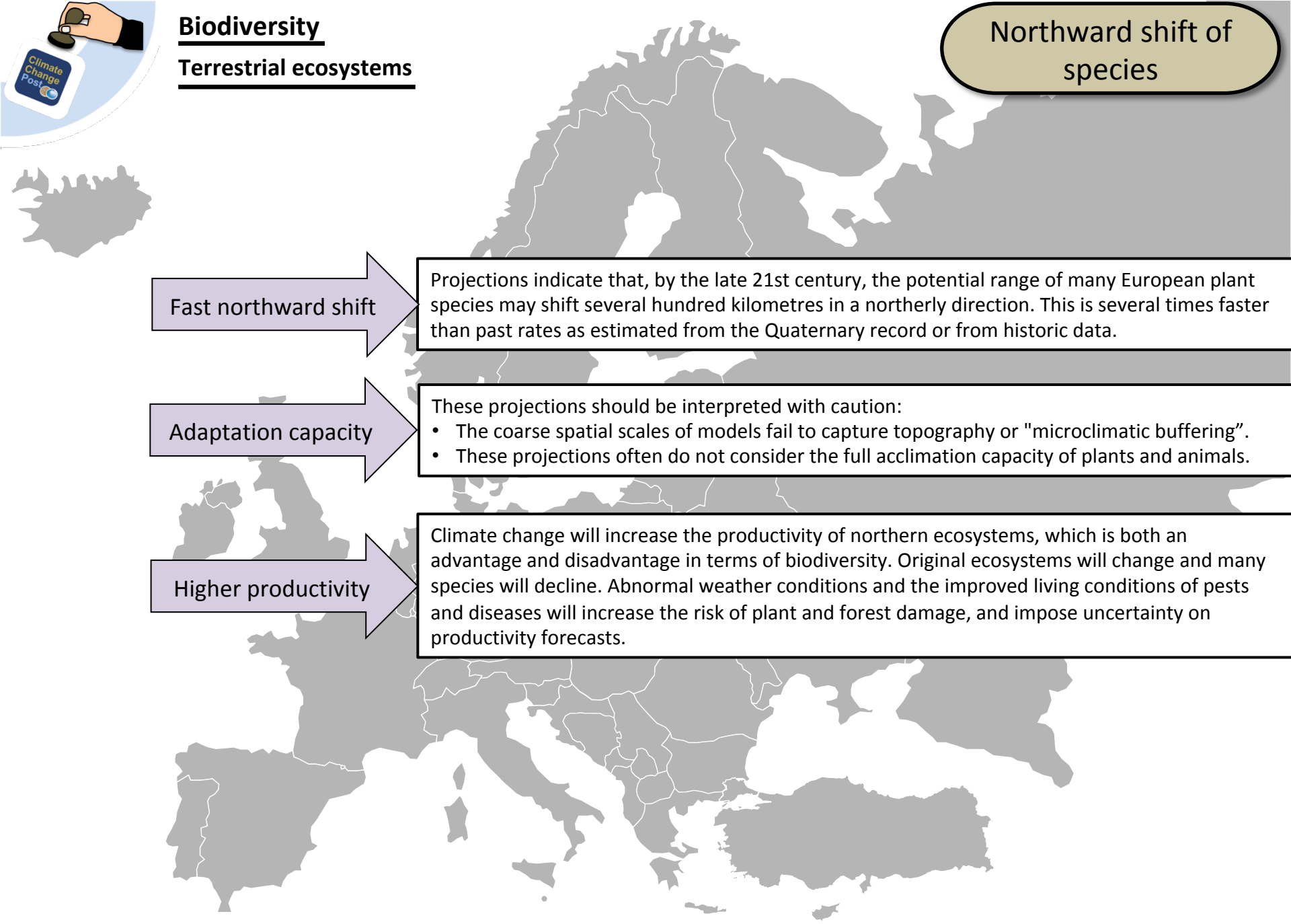
Northward shift of species



Fast northward shift

Projections indicate that, by the late 21st century, the potential range of many European plant species may shift several hundred kilometres in a northerly direction. This is several times faster than past rates as estimated from the Quaternary record or from historic data.

Adaptation capacity

These projections should be interpreted with caution:

- The coarse spatial scales of models fail to capture topography or "microclimatic buffering".
- These projections often do not consider the full acclimation capacity of plants and animals.

Higher productivity

Climate change will increase the productivity of northern ecosystems, which is both an advantage and disadvantage in terms of biodiversity. Original ecosystems will change and many species will decline. Abnormal weather conditions and the improved living conditions of pests and diseases will increase the risk of plant and forest damage, and impose uncertainty on productivity forecasts.

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Northward shift of species: examples across Europe

The tree line rose around 100-150 m in the **Swedish** mountains in the 20th century, probably due to the changed climate.
The climate zones determining the range of the various biomes may move north by 50 to 80 kilometres a decade.

In the long run climate change could mean a slight increase in the overall species diversity in **Denmark**, provided that the sea level only rises slightly and that the species south of the border are actually able to spread northward. Some species could no longer be present and other species could arrive.

In **the Netherlands** the acreage of plant species that prefer warm conditions has increased while that of species that prefer cold conditions has decreased. It is estimated that the Netherlands will remain a suitable habitat for about 90% of the current plant species and will become suitable for about 5-15% new species. Newly arrived species will only be able to settle in the Netherlands if there are suitable locations of the necessary size and quality, and if barriers do not hinder their migration. A major concern is the threat posed by invasive species to indigenous species.

The northward progression of many animal and plant species from warm regions is noticeable in **Belgium**. Migration will not be possible for all species due to their low mobility or because landscapes and thus habitats are now highly fragmented. Species that will disappear probably will not do so because they can no longer stand the higher temperatures but because they are outcompeted by other species that are better adapted to higher temperatures.

Plants and animals from southern Europe gradually infiltrate **Slovakia**, including Mediterranean species of spiders and insects. Along with the migration of insects new pests are found in Slovakia.

A study of 99 species (birds, butterflies, Alpine plants) in **Germany** showed a shift in species distribution per decade of, on average, 6.1 km north or 6.1 m up in altitude respectively.

The treeline is predicted to shift upward by several hundred metres. There is evidence that this process has already begun in the **Alps**, and in Scandinavia and the Mediterranean.

Various ecosystems in the **Mediterranean** are close to the environmental limits, for example with respect to their ability to cope with drought stress. Under a high-end scenario of climate change, all of southern Spain turns into desert, deciduous forests invade most of the mountains, and Mediterranean vegetation replaces most of the deciduous forests in a large part of the Mediterranean basin

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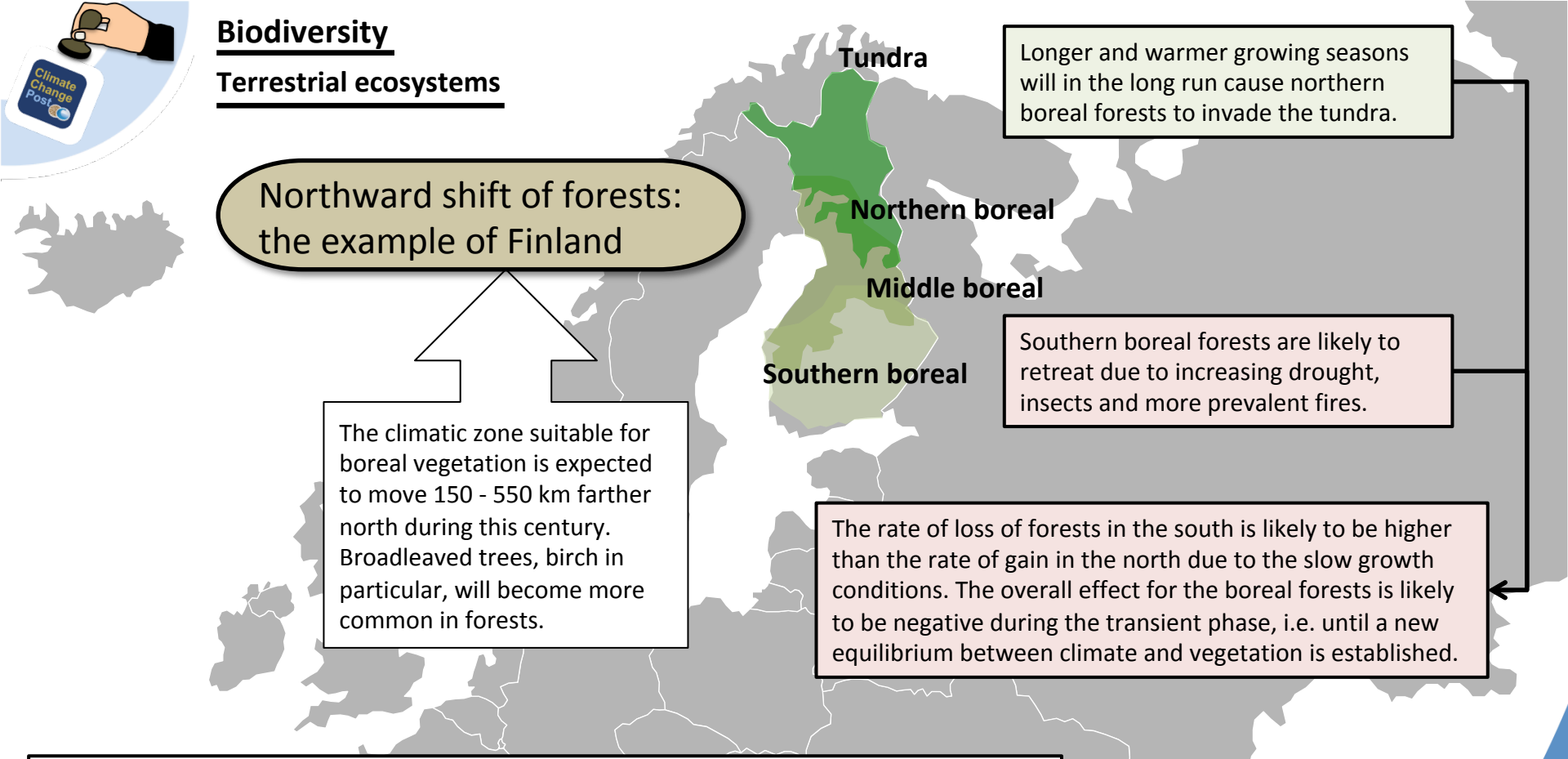
Northward shift of forests: the example of Finland



Longer and warmer growing seasons will in the long run cause northern boreal forests to invade the tundra.

Southern boreal forests are likely to retreat due to increasing drought, insects and more prevalent fires.

The climatic zone suitable for boreal vegetation is expected to move 150 - 550 km farther north during this century. Broadleaved trees, birch in particular, will become more common in forests.

The rate of loss of forests in the south is likely to be higher than the rate of gain in the north due to the slow growth conditions. The overall effect for the boreal forests is likely to be negative during the transient phase, i.e. until a new equilibrium between climate and vegetation is established.

- The overall number of flora and fauna species found in Finland is expected to increase. Species currently found in Southern Finland will migrate to Northern Finland, and new species will spread to Southern Finland from regions south of the country.
- However, some species characteristic to Finland, like relict cold water fish and other reminders of the ice age, may become extinct.
- Some 10% of the animal and plant species in Finland are endangered.
- For most of the endangered species, anticipated climate change is not the main threat; their habitats are undergoing harmful changes due to land use change and other direct anthropogenic factors.
- An increase in the total number of species is no compensation for the possible loss of northern species and species from northern biotopes, as these, due to the absence of large land masses to the north of Scandinavia, often have nowhere to go.

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Upward shift of species

Upward shift

Species have on average shifted their ranges 11 m up in altitude per decade.

Smaller habitats

Mountain tops are smaller than the bases. Therefore, the upward shift of vegetation zones results in the present belts at high elevations occupying smaller and smaller areas. Thus, the corresponding species would have smaller populations and might become more vulnerable to genetic and environmental pressure.

Model simulations indicate that by the end of this century high mountain plants will have lost 44-50% of their present alpine habitat ranges.

More competition

Additionally, species migrating from lower areas will increase the pressure. Such species may increase species diversity of Alpine regions in the short-term, but will lead to extinctions of endemic species in the long-term.

In fact, plant species richness of high alpine summit vegetation has increased during the last 100 years in the south-eastern Swiss Alps; this increase has accelerated since 1985, consistent with warmer summers. An acceleration of the trend in the upward shift of alpine plants has also been shown. Overall, the number of species in Switzerland is increasing steadily in spite of increasing loss of species, since immigrations are considerably more numerous than cases of extinction. However, in the overall evaluation, the losses have to be given more weight because many of these species are becoming entirely extinct, that is worldwide, while the immigrating species often have their main distribution area in the Mediterranean, sometimes even on other continents.

Vulnerability of birds: main message

Systematic monitoring schemes in Europe reveal that warm-adapted species have increased in abundance on average since the 1980s and cold-adapted species having declined.

A recent study of 122 terrestrial bird species shows that 92 species have declined their populations because of climate change, whereas 30 species have generally increased. A northward shift in bird community composition has been observed.

Many migratory species, including those that overwinter in sub-Saharan Africa, now arrive earlier at their spring breeding grounds in northern Europe.

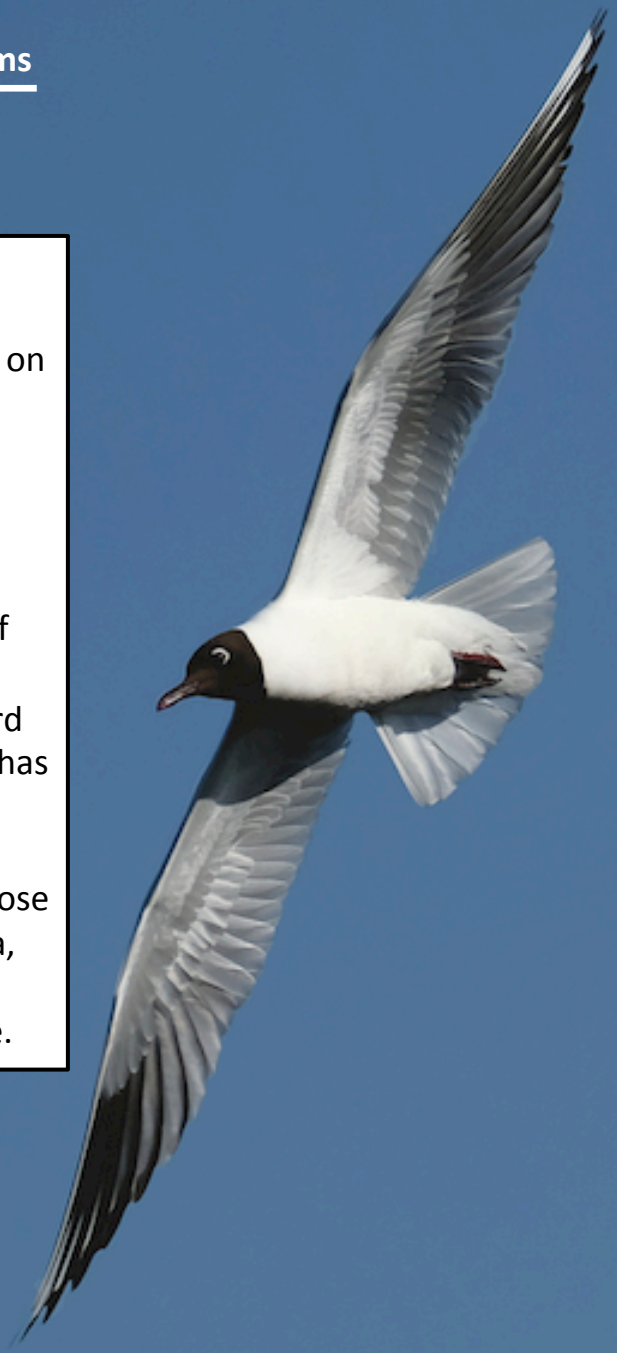

Photo credit: Patrice Puig, www.flickr.com

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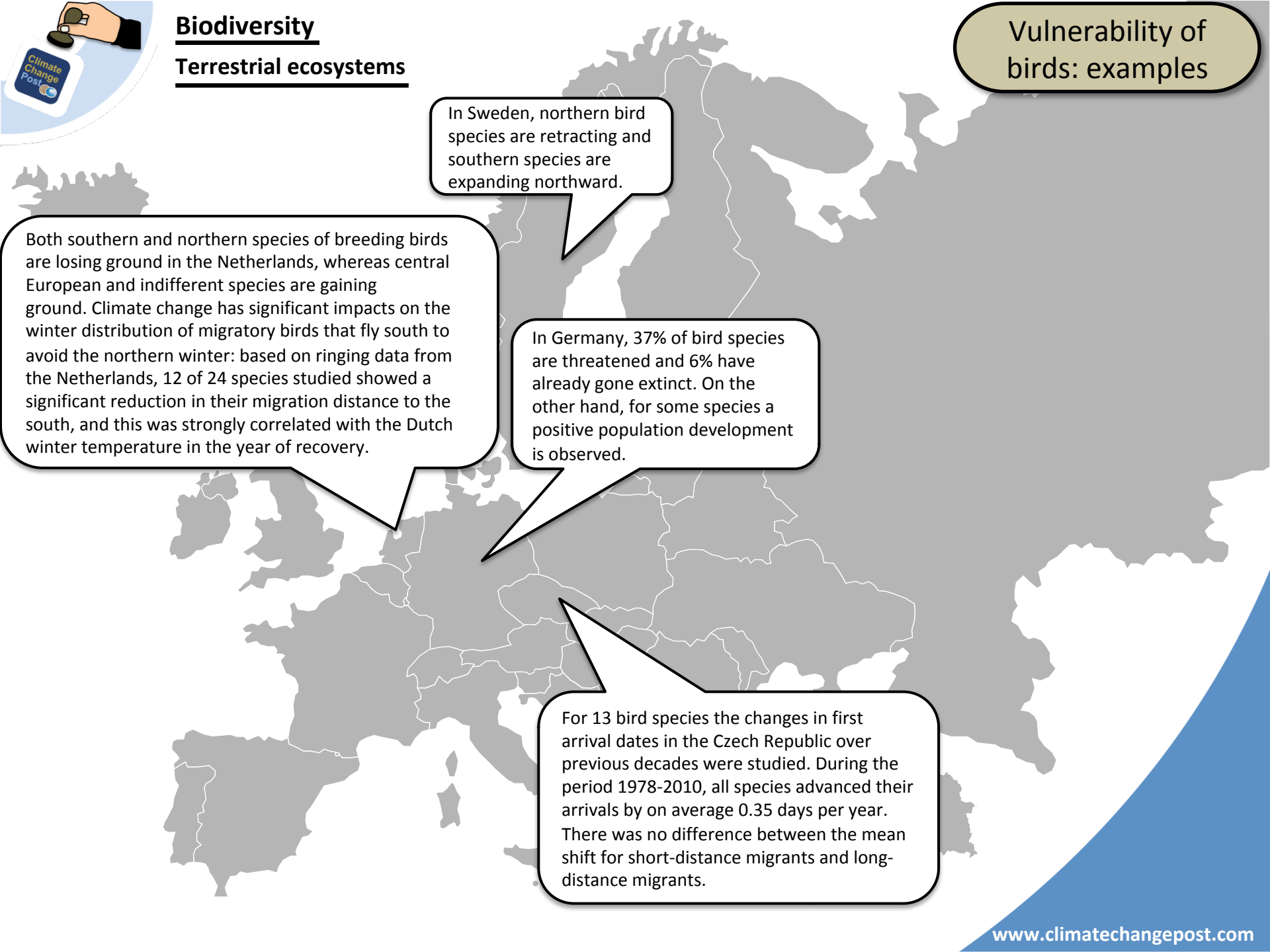
Vulnerability of birds: examples



In Sweden, northern bird species are retracting and southern species are expanding northward.

Both southern and northern species of breeding birds are losing ground in the Netherlands, whereas central European and indifferent species are gaining ground. Climate change has significant impacts on the winter distribution of migratory birds that fly south to avoid the northern winter: based on ringing data from the Netherlands, 12 of 24 species studied showed a significant reduction in their migration distance to the south, and this was strongly correlated with the Dutch winter temperature in the year of recovery.

In Germany, 37% of bird species are threatened and 6% have already gone extinct. On the other hand, for some species a positive population development is observed.

For 13 bird species the changes in first arrival dates in the Czech Republic over previous decades were studied. During the period 1978-2010, all species advanced their arrivals by on average 0.35 days per year. There was no difference between the mean shift for short-distance migrants and long-distance migrants.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Vulnerability of insects
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Vulnerability of insects

Loss of habitat

Bumblebee species seem to fail to move to the north of Europe and North America in response to global warming whereas they lose habitats at the southern range limits of these continents. Climate change appears to contribute distinctively, and consistently, to accumulating range compression among bumblebee species across continents.

Invasive alien species

According to recent research, about 100 invasive alien insect species are established in European forests. Mostly, these were introduced via global trade but their subsequent establishment in forests is often the result of higher temperatures.

Advancement

Two studies on Swedish butterfly species showed that the average advancement of the mean flight date was 3.6 days per decade since the 1990s. Of the 66 investigated butterfly species, 57 showed an advancement of the mean flight date, which was significant for 45 species.

Trophic mismatch

Different organisms do not respond to climate change at the same pace, which has led to an ecological mismatch between some consumers and their prey.

An example: Dutch pied flycatchers, which overwinter in sub-Saharan Africa, do not arrive earlier at breeding grounds, but the populations of their insect food peak earlier as a result of warmer spring temperatures. This mismatch between breeding and food availability has caused a decline of up to 90% in Dutch pied flycatcher population sizes.

Vulnerability of reptiles and amphibians

Photo credit: Roger Wasley, www.flickr.com

The limited dispersal ability of many reptile and amphibians, coupled with the fragmentation of ecological networks, is very likely to reduce the ranges of many species, particularly those in the Iberian Peninsula and parts of Italy.

Populations may crash if the emergence of vulnerable young is not in synchrony with their food source or if shorter hibernation times lead to declines in body condition — as evidenced in the lower survival rates of some amphibians.

Projections for Germany indicate an increase in species richness until 2050 by approximately 10%, followed by a decline to previous levels by 2080. The reason for this is that under a moderate increase in temperature current and new species from the south could co-exist. If temperature rises further, conditions for current species deteriorate rapidly.

Vulnerability of peat bogs

Bogs, mires and fens are considered to be the most vulnerable habitat types, with up to 75% potentially negatively affected in the near future.

This is particularly worrying because bogs and mires are important carbon stores and their degradation releases greenhouse gases into the atmosphere.

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Vulnerability of peat bogs

Melting of palsa mires in recent years has been observed in **Norway**. The degeneration of the most marginal palsa peat land areas is expected in the course of a few decades.

Highland permafrost string bogs in **Iceland** (palsamires) are already under threat from the recent climate warming. The string bogs and their discontinuous permafrost areas might even disappear with further warming. The permafrost string bogs hold much soil organic matter that currently is unavailable to decomposition. The thawing of these soils could therefore result in more emissions of greenhouse gasses.

Species that are dependent on the now rapidly retiring areas of palsa bog (permafrost) in **Sweden** will disappear.

Peat lands make up 22.3% of **Estonia**'s territory. Climate warming trends will increase the deterioration of Estonia's bog landscapes.

Peat bogs in **Belgium** (the Hautes Fagnes) have been deteriorating for a long time due to drying out, pollution and tourism. If this deterioration continues and climate change increases, the last peat bogs that are still almost intact will probably disappear within the next 20 to 50 years.

Peat lands in **Ireland** are expected to suffer considerably from summer drying. An increase in decomposition, a reduction in peat formation, more erosion, changes in species composition, loss of carbon storage and an increase in acid runoff may occur in this already fragile resource.

In **Switzerland**, except for the southern part, a decrease in the number of species is particularly expected in low moors. This will become even stronger if precipitation decreases and the extension of these habitats decreases due to water shortage. The higher temperatures and the longer dry periods endanger the moss cover and enable species uncommon in upland moors to invade these habitats.

In the Guadiana catchment in **Spain**, the drying out of peatland through excessive groundwater abstraction and rainfall scarcity has at times already resulted in its spontaneous combustion and almost all of the peat is now burnt.

Vulnerability of forest ecosystems

Photo credit: Patrice Puig, www.flickr.com

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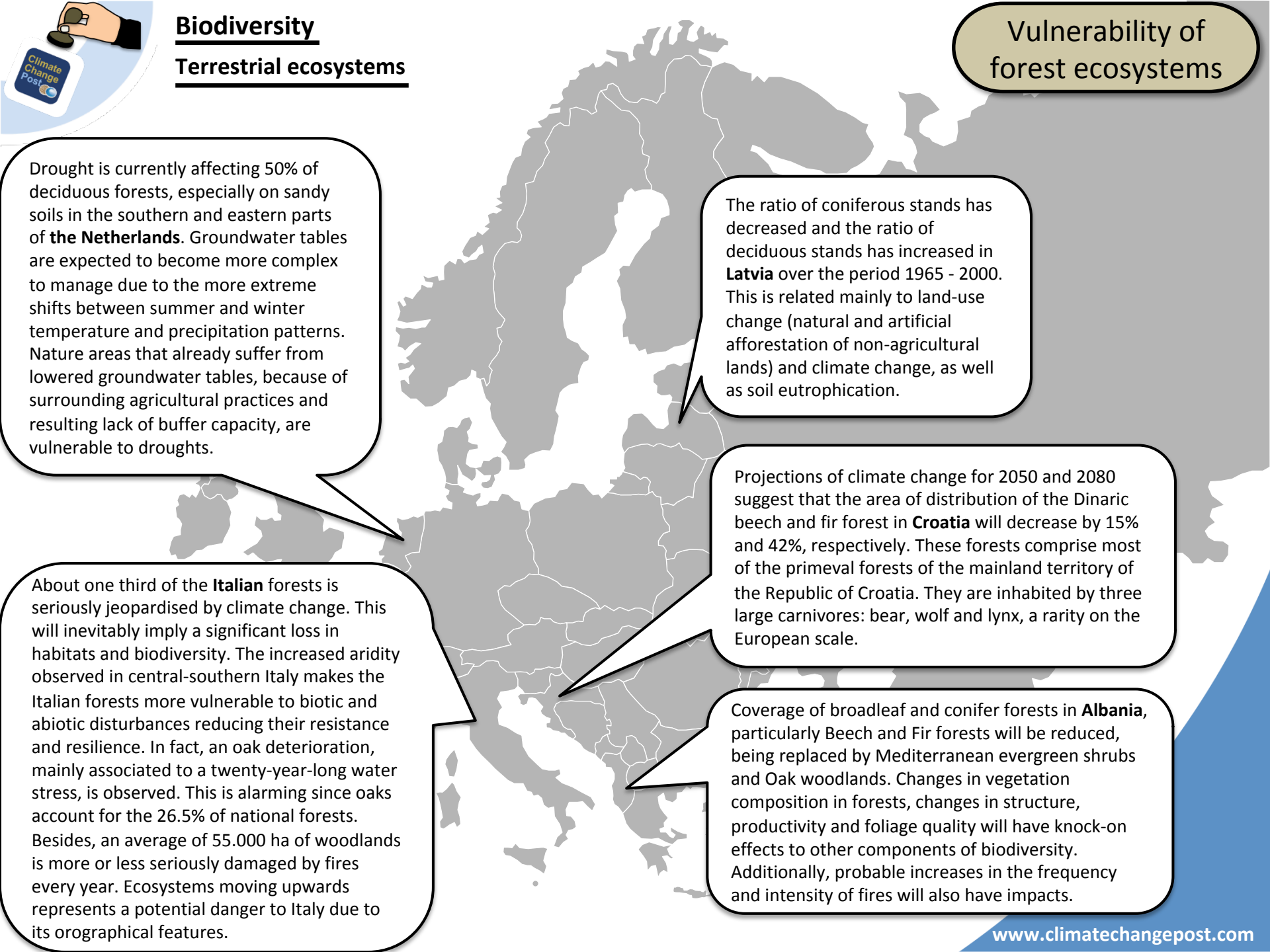
Vulnerability of forest ecosystems



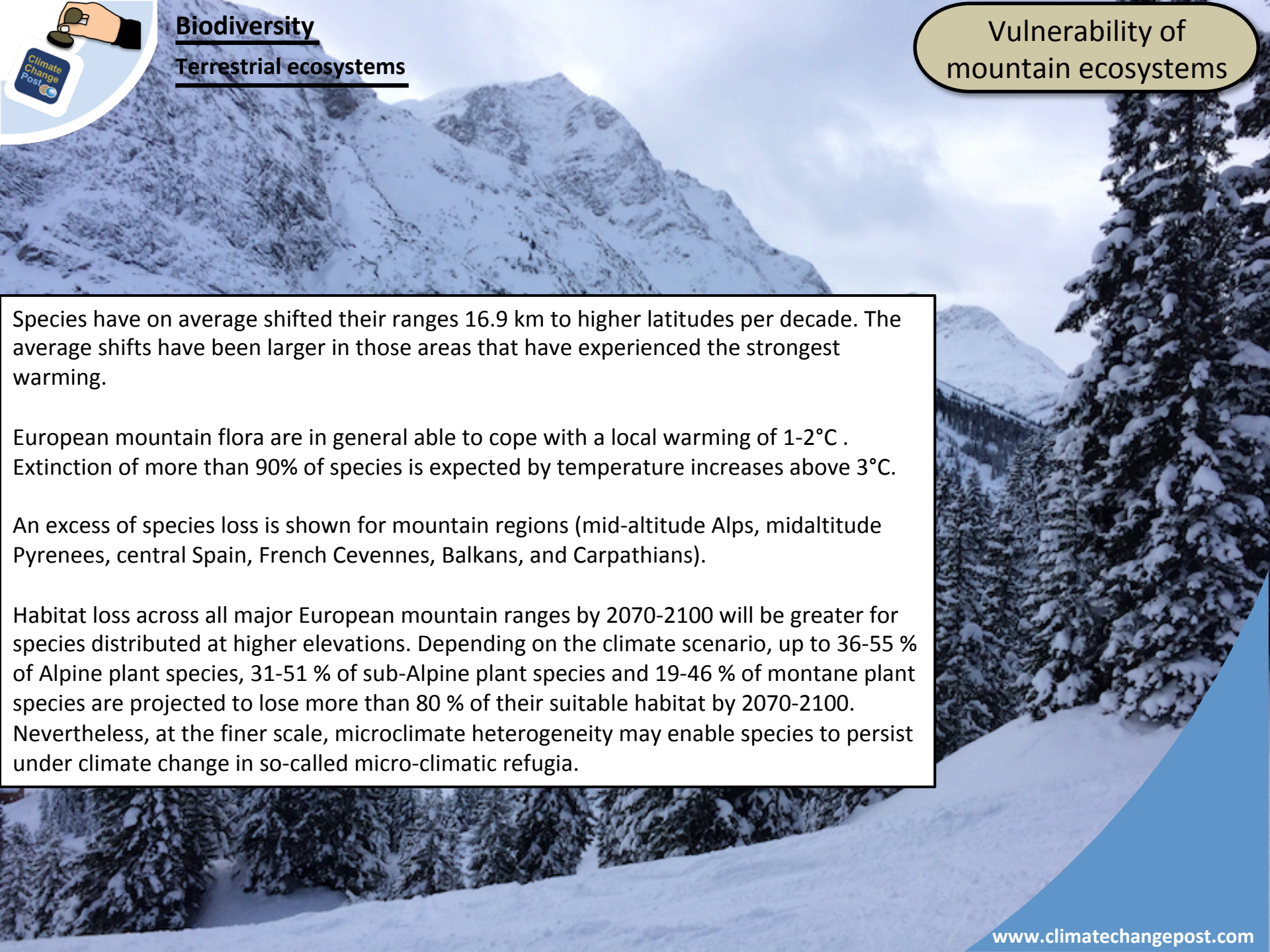
Drought is currently affecting 50% of deciduous forests, especially on sandy soils in the southern and eastern parts of **the Netherlands**. Groundwater tables are expected to become more complex to manage due to the more extreme shifts between summer and winter temperature and precipitation patterns. Nature areas that already suffer from lowered groundwater tables, because of surrounding agricultural practices and resulting lack of buffer capacity, are vulnerable to droughts.

The ratio of coniferous stands has decreased and the ratio of deciduous stands has increased in **Latvia** over the period 1965 - 2000. This is related mainly to land-use change (natural and artificial afforestation of non-agricultural lands) and climate change, as well as soil eutrophication.

Projections of climate change for 2050 and 2080 suggest that the area of distribution of the Dinaric beech and fir forest in **Croatia** will decrease by 15% and 42%, respectively. These forests comprise most of the primeval forests of the mainland territory of the Republic of Croatia. They are inhabited by three large carnivores: bear, wolf and lynx, a rarity on the European scale.

About one third of the **Italian** forests is seriously jeopardised by climate change. This will inevitably imply a significant loss in habitats and biodiversity. The increased aridity observed in central-southern Italy makes the Italian forests more vulnerable to biotic and abiotic disturbances reducing their resistance and resilience. In fact, an oak deterioration, mainly associated to a twenty-year-long water stress, is observed. This is alarming since oaks account for the 26.5% of national forests. Besides, an average of 55.000 ha of woodlands is more or less seriously damaged by fires every year. Ecosystems moving upwards represents a potential danger to Italy due to its orographical features.

Coverage of broadleaf and conifer forests in **Albania**, particularly Beech and Fir forests will be reduced, being replaced by Mediterranean evergreen shrubs and Oak woodlands. Changes in vegetation composition in forests, changes in structure, productivity and foliage quality will have knock-on effects to other components of biodiversity. Additionally, probable increases in the frequency and intensity of fires will also have impacts.



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Vulnerability of mountain ecosystems

Species have on average shifted their ranges 16.9 km to higher latitudes per decade. The average shifts have been larger in those areas that have experienced the strongest warming.

European mountain flora are in general able to cope with a local warming of 1-2°C . Extinction of more than 90% of species is expected by temperature increases above 3°C.

An excess of species loss is shown for mountain regions (mid-altitude Alps, midaltitude Pyrenees, central Spain, French Cevennes, Balkans, and Carpathians).

Habitat loss across all major European mountain ranges by 2070-2100 will be greater for species distributed at higher elevations. Depending on the climate scenario, up to 36-55 % of Alpine plant species, 31-51 % of sub-Alpine plant species and 19-46 % of montane plant species are projected to lose more than 80 % of their suitable habitat by 2070-2100. Nevertheless, at the finer scale, microclimate heterogeneity may enable species to persist under climate change in so-called micro-climatic refugia.

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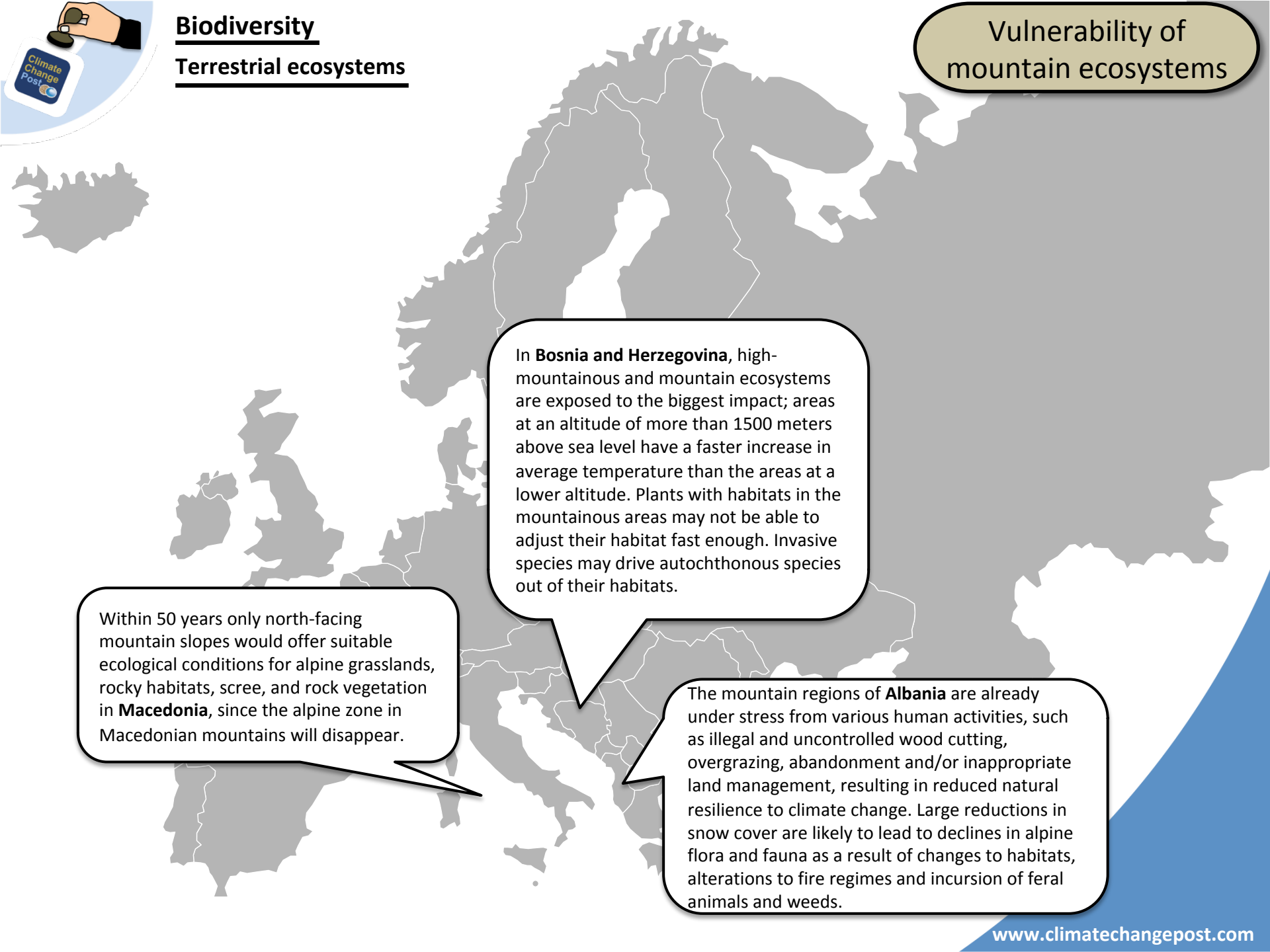
Vulnerability of mountain ecosystems



In **Bosnia and Herzegovina**, high-mountainous and mountain ecosystems are exposed to the biggest impact; areas at an altitude of more than 1500 meters above sea level have a faster increase in average temperature than the areas at a lower altitude. Plants with habitats in the mountainous areas may not be able to adjust their habitat fast enough. Invasive species may drive autochthonous species out of their habitats.

Within 50 years only north-facing mountain slopes would offer suitable ecological conditions for alpine grasslands, rocky habitats, scree, and rock vegetation in **Macedonia**, since the alpine zone in Macedonian mountains will disappear.

The mountain regions of **Albania** are already under stress from various human activities, such as illegal and uncontrolled wood cutting, overgrazing, abandonment and/or inappropriate land management, resulting in reduced natural resilience to climate change. Large reductions in snow cover are likely to lead to declines in alpine flora and fauna as a result of changes to habitats, alterations to fire regimes and incursion of feral animals and weeds.

Vulnerability of island ecosystems

With about 10,000 islands and islets, the Mediterranean Sea represents one of the regions of the world with the most islands and archipelagos. Most islands belong to the Greek archipelago.

The possibilities of endemic flora and fauna to migrate are limited.

So far, there is little evidence for direct depletion or extinction of populations due to climate change on these islands, however. Species appear to be able to cope with drastic climate change thanks to differences in small-scale habitats.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