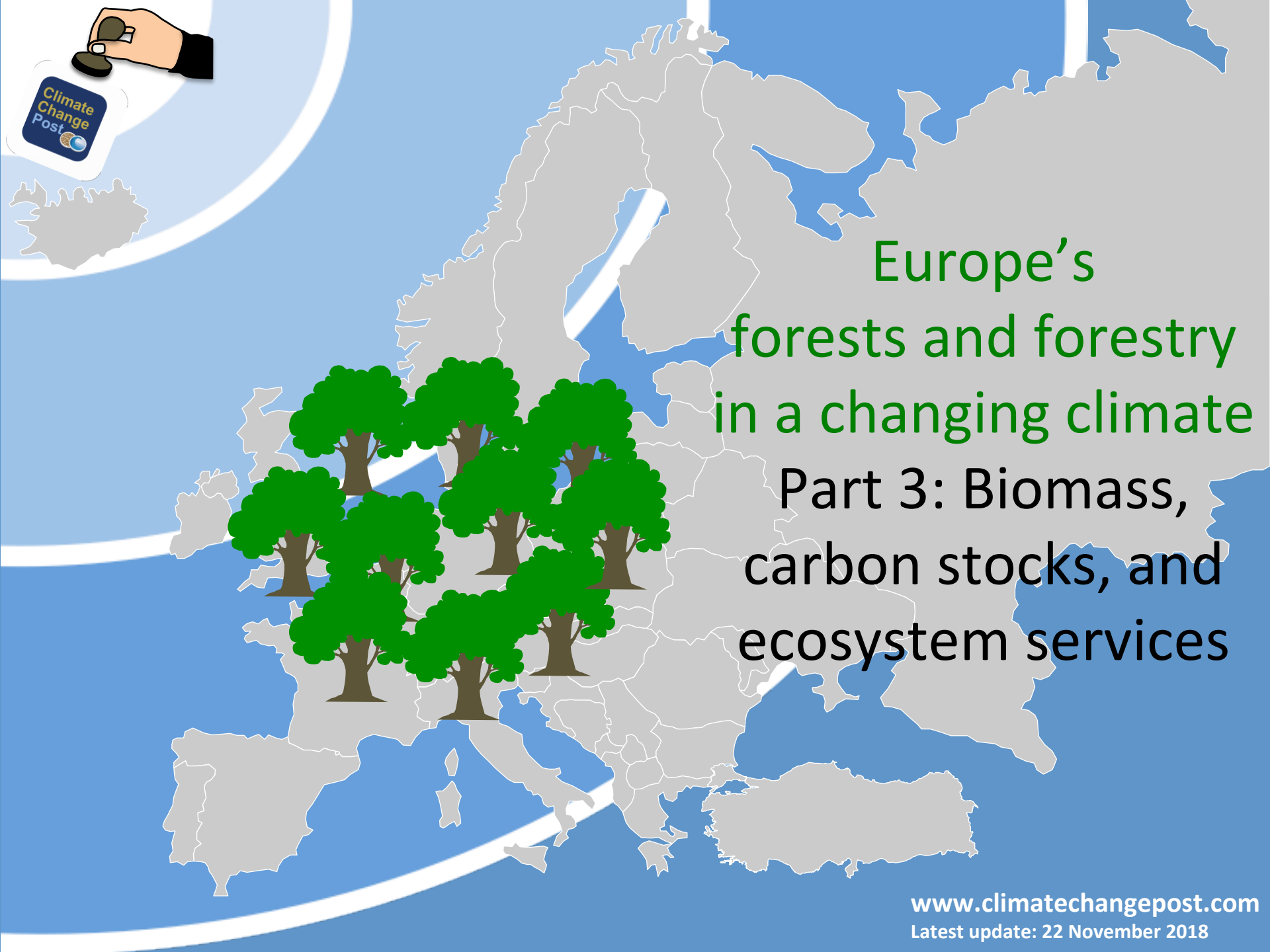

Europe's forests and forestry in a changing climate

Part 3: Biomass, carbon stocks, and ecosystem services

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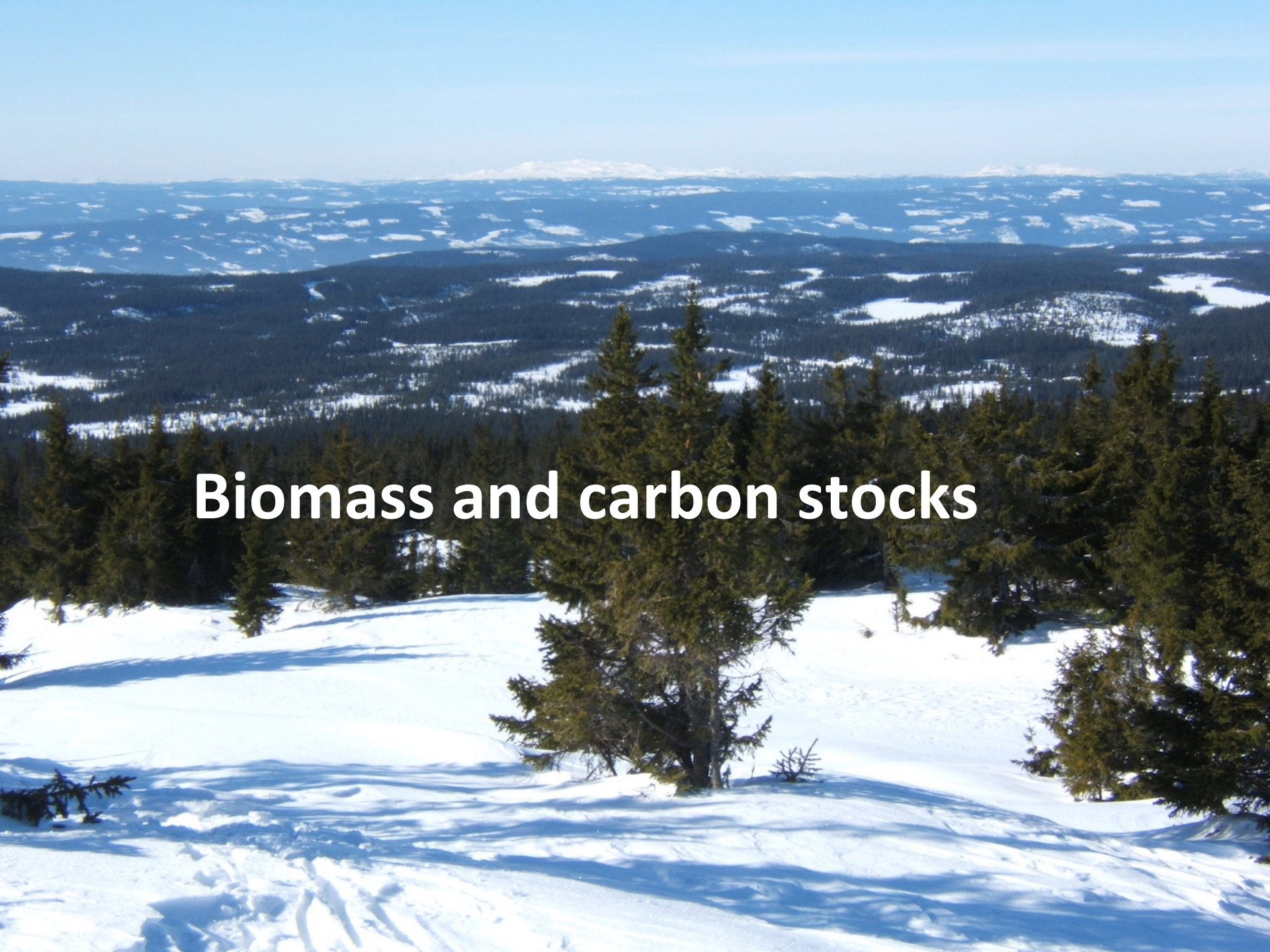
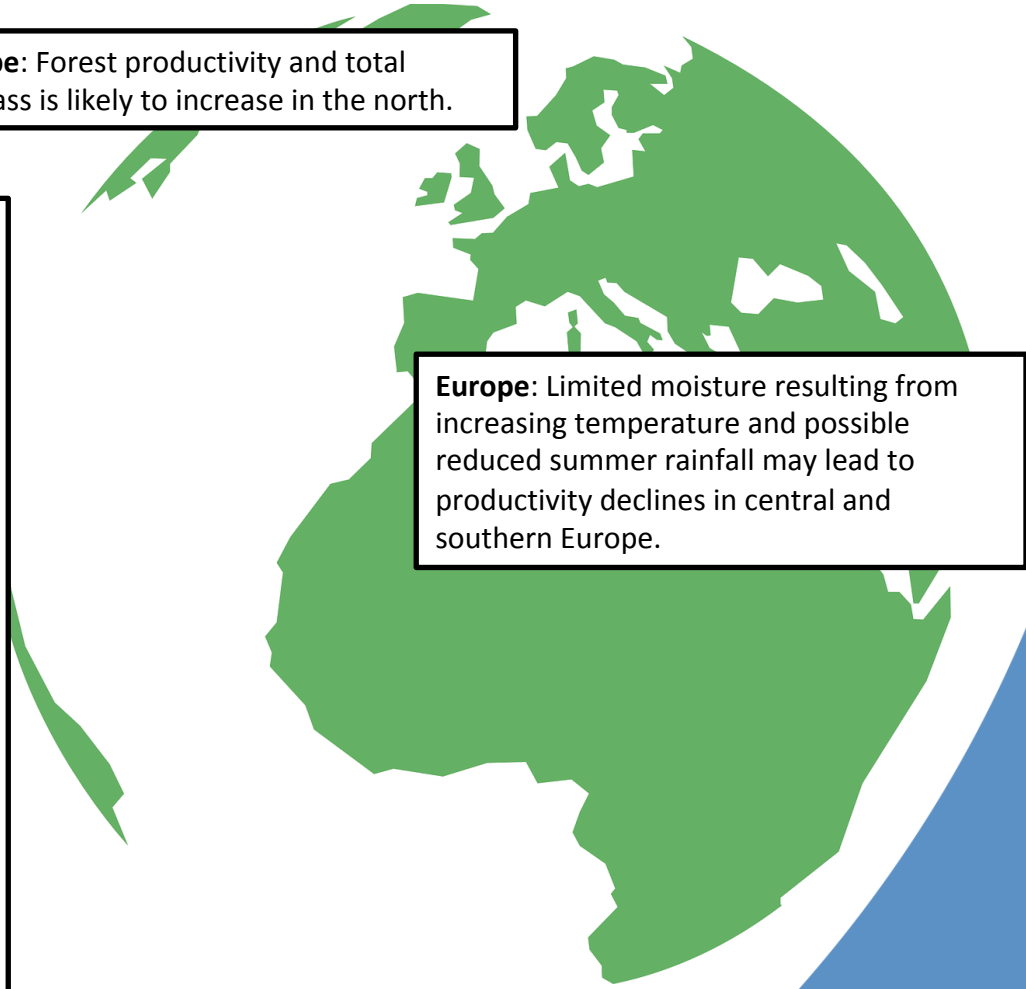

Biomass and carbon stocks

Global changes
Carbon sinks and sources

Europe: Forest productivity and total biomass is likely to increase in the north.



Europe: Limited moisture resulting from increasing temperature and possible reduced summer rainfall may lead to productivity declines in central and southern Europe.

Globally:

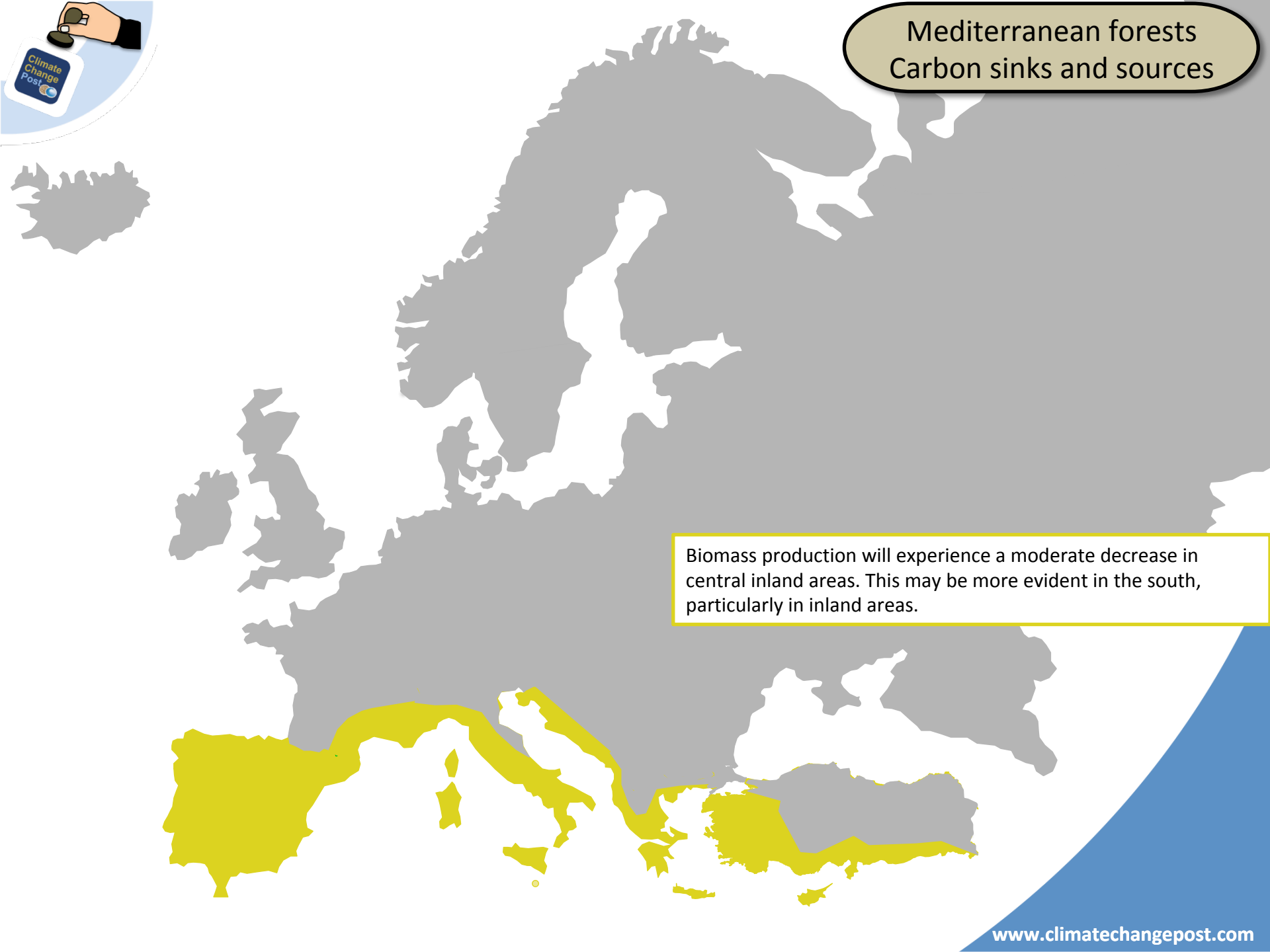
Globally, based on both satellite and ground-based data, climatic changes seemed to have a generally positive impact on forest productivity since the middle of the 20th century, when water was not limiting.

Climate change stimulates forest productivity on a global level. This is due to the fertilization effect of CO2. Increasing CO2 concentration can affect tree growth through increased photosynthetic rates and through improved water-use efficiency.

Global warming itself does not necessarily increase global forest carbon; it has a negative impact on global forest carbon, likely caused by more wildfires, and climatic effects like droughts.

Simulations indicate that total global live forest carbon stock will increase dramatically between now and 2100 by little over 50%. The vast majority of the total live forest carbon gain was simulated to occur in the southern hemisphere. For Europe only small increases were projected, while Russia was projected to see a significant decline, mainly due to forest contraction and more wildfires.

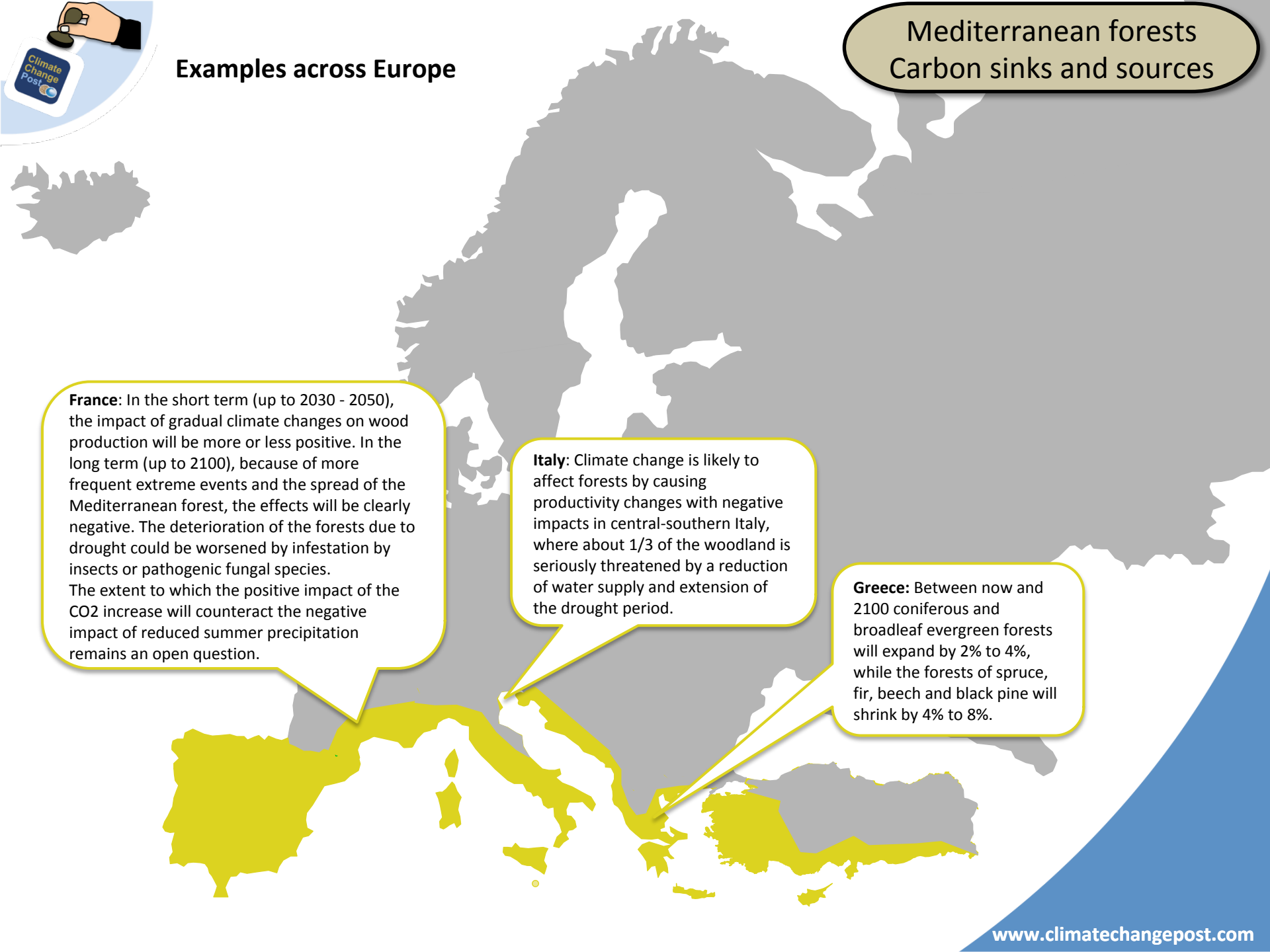
Mediterranean forests
Carbon sinks and sources



Biomass production will experience a moderate decrease in central inland areas. This may be more evident in the south, particularly in inland areas.

Mediterranean forests
Carbon sinks and sources

Examples across Europe



France: In the short term (up to 2030 - 2050), the impact of gradual climate changes on wood production will be more or less positive. In the long term (up to 2100), because of more frequent extreme events and the spread of the Mediterranean forest, the effects will be clearly negative. The deterioration of the forests due to drought could be worsened by infestation by insects or pathogenic fungal species.
The extent to which the positive impact of the CO2 increase will counteract the negative impact of reduced summer precipitation remains an open question.

Italy: Climate change is likely to affect forests by causing productivity changes with negative impacts in central-southern Italy, where about 1/3 of the woodland is seriously threatened by a reduction of water supply and extension of the drought period.

Greece: Between now and 2100 coniferous and broadleaf evergreen forests will expand by 2% to 4%, while the forests of spruce, fir, beech and black pine will shrink by 4% to 8%.

Temperate forests
Carbon sinks and sources

Present

Now robust carbon sinks
Temperate forest regions in the highly productive forests of western Europe are known to be robust carbon sinks.

… **with increasing biomass**
Forest productivity has been increasing in western Europe. This is thought to be from increasing CO2 in the atmosphere, anthropogenic nitrogen deposition, warming temperatures, and associated longer growing seasons.

… **but tree growth rates are declining**
Several studies find that tree growth rates in temperate forests passed their peak in the late 20thcentury and that the decline in tree growth rates can be attributed to climatic factors, especially drought or heat waves.

… and soil organic carbon stocks are decreasing
Global soil organic carbon stocks, particularly those in high-latitude or mountain ecosystems, are sensitive to climate change and are predicted to decrease in a warming climate, which may result in a positive feedback to climate change as well as in decreased productivity and ecosystem service accomplishment. The soil organic carbon losses induced by climate warming are likely to be due to accelerated microbial organic carbon decomposition with increasing soil temperature.
For instance, during the past three decades, soil organic carbon stocks in German Alps forest soils have decreased by about 14%. This is probably due to the temperature increase in recent decades.

Temperate forests
Carbon sinks and sources

2100

Productivity may decrease on the long term

Projections for the time near the end of the next century generally suggest decreasing growth and a reduction in primary productivity enhancement as temperatures warm, CO2 saturation is reached for photosynthetic enhancement, and reduced summer precipitation all interact to decrease temperate zone primary productivity. The projected increased occurrence of pests and pathogens, such as bark beetle outbreaks, particularly in drought-stressed regions, also contributes to decreased long-term primary productivity in some regions of temperate forests. Also, air pollutants such as ozone are known to diminish primary productivity.

… **in fact, sinks may become carbon sources**

The greatest climate change threat to temperate forest ecosystems is reduced summer precipitation, leading to increased frequency and severity of drought, making them also more susceptible to opportunistic pests and fire. Together, these related effects can potentially change large areas of temperate forest ecosystems from carbon sinks to sources.

Tall plants with low hydraulic conductance and high leaf area are most likely to die from future drought stress, implying that tall trees of old-growth forests are at the greatest risk of loss. Today's forests will be subject to continued increases in mortality rates that will result in substantial reorganization of their structure and carbon storage.

Temperate forests
Carbon sinks and sources

2100

A strong spruce decline under global warming may turn European forests into a carbon source and thus reinforce global warming.

The Carpathian forests as an example

The Carpathian forests are an example of forests where significant changes are expected in the composition of tree species, leading to a reduction of forest carbon sink capacity. These forests are the second largest mountain range in Europe predominantly covered with forests. They span seven countries (Czech Republic, Hungary, Poland, Romania, Serbia, Slovakia, and Ukraine).

A change in species composition may, in the long term, lead to a significant reduction of the amount of carbon that is stored in the trees above the ground, the so-called *'aboveground live carbon'*. Projected changes after 500 years show that this reduction may be between 2.1% and 14.0%. The additional impact of disturbances such as bark beetle infestations may lead to an additional reduction of 4.5% - 6.6% stored carbon.

This reduction is especially due to the contraction of spruce forests in favour of hornbeam- and maple-dominated forests, and an upward shift of beech- and fir-dominated forests. Soil water stress in response to increasing air temperatures is an important driver of these changes.

Temperate forests
Carbon sinks and sources

Examples across Europe

UK: Hotter, drier summers, milder wetter winters, rising CO2 levels in the atmosphere, and more frequent extreme weather events such as flooding and storms could result in changing forest productivity. These impacts are likely to be positive in the north and west and negative in the south and east. This may lead to changes in the identity, location and productivity of commercial forests affecting the timber processing industry.
For Scotland, the most serious risk to forestry from climate change appears to be the possibility of more extensive windstorms leading to more blow-down and limitation of tree height.

Denmark: Wood production in Denmark tends to increase further, additionally promoted by the increasing atmospheric CO2-concentration. Furthermore, the Danish forested area grows by approximately 1% on an annual basis due to afforestation efforts aiming at doubling the forest area within 80 to 100 years.

Germany: German forest will continue to be a sink of carbon in the next 100 years. However, this goes along with an aging of the forest stands, lower increments, and a higher susceptibility to weather extremes and calamities. Reasons for this trend are not so much climate changes, but the present trend in management of low wood extraction.

Ireland: It is envisaged that forest cover will double in Ireland within the next quarter of a century.

Alps: Indirect effects relate to losses caused by fire, insects and diseases. These negative effects can be of the same magnitude or even higher than the positive impacts of CO2 fertilizing and the lengthening of the growing season. Additional risk factors are the possibility of an increase of extreme events (e. g. storms).

Central Europe:

- European beech is one of the main tree species in Central Europe, covering one fifth of the forest area in Central Europe. A study showed that net primary productivity of beech in Germany decreases by 30% in 2071-2100 compared with the reference time span 1961-1990. This is caused by higher mortality rates, lower water availability and higher drought stress, though partly counterbalanced by longer growing seasons.
- Spruce and beech biomass is projected to decline this century at low elevations; of these species spruce is most sensitive to climate change.
- Oak production will either remain the same as now or will increase.

Boreal forests and tundra
Carbon sinks and sources

Forest type:

- Boreal forests
- Tundra

Annual tree growth may increase by over a third within a few decades, due to improved forestry, higher atmospheric CO_2 content, higher temperatures and longer growing seasons. Growth increase of several tens of percentages has been projected for northern Finland for the end of this century. Other studies present more modest growth rates: 10-15% in southern Finland and 25-35% in northern Finland.

By the end of this century, nearly half of Finland's forest resources could be located in northern Finland, whereas currently they are divided between southern and northern Finland at a ratio of about 70% and 30%, respectively.

For the forests in northern Europe, the combination of raised mean temperature and a higher frequency of extreme events will have negative effects that could ultimately be of greater importance than the positive outcomes of a warmer climate.

Damage resulting from storms, droughts and fire is expected to increase. Storms have been responsible for the greatest economic damage in forestry. Hurricane Gudrun in 2005 brought down or damaged around 75 million cubic metres standing volume, which is equivalent to almost a year's felling in Sweden.

Boreal forests and tundra
Carbon sinks and sources

Examples across Europe

Forest type:

- Boreal forests
- Tundra

Finland: Norway spruce represents, on average, approximately 40 % of the national forest resources. Higher temperatures and soil water stress reduce the primary production and net carbon sequestration of Norway spruce between now and 2100, especially in the southernmost region. The opposite occurs in northern Finland where the changing climate increases the primary production and net carbon sequestration this century.

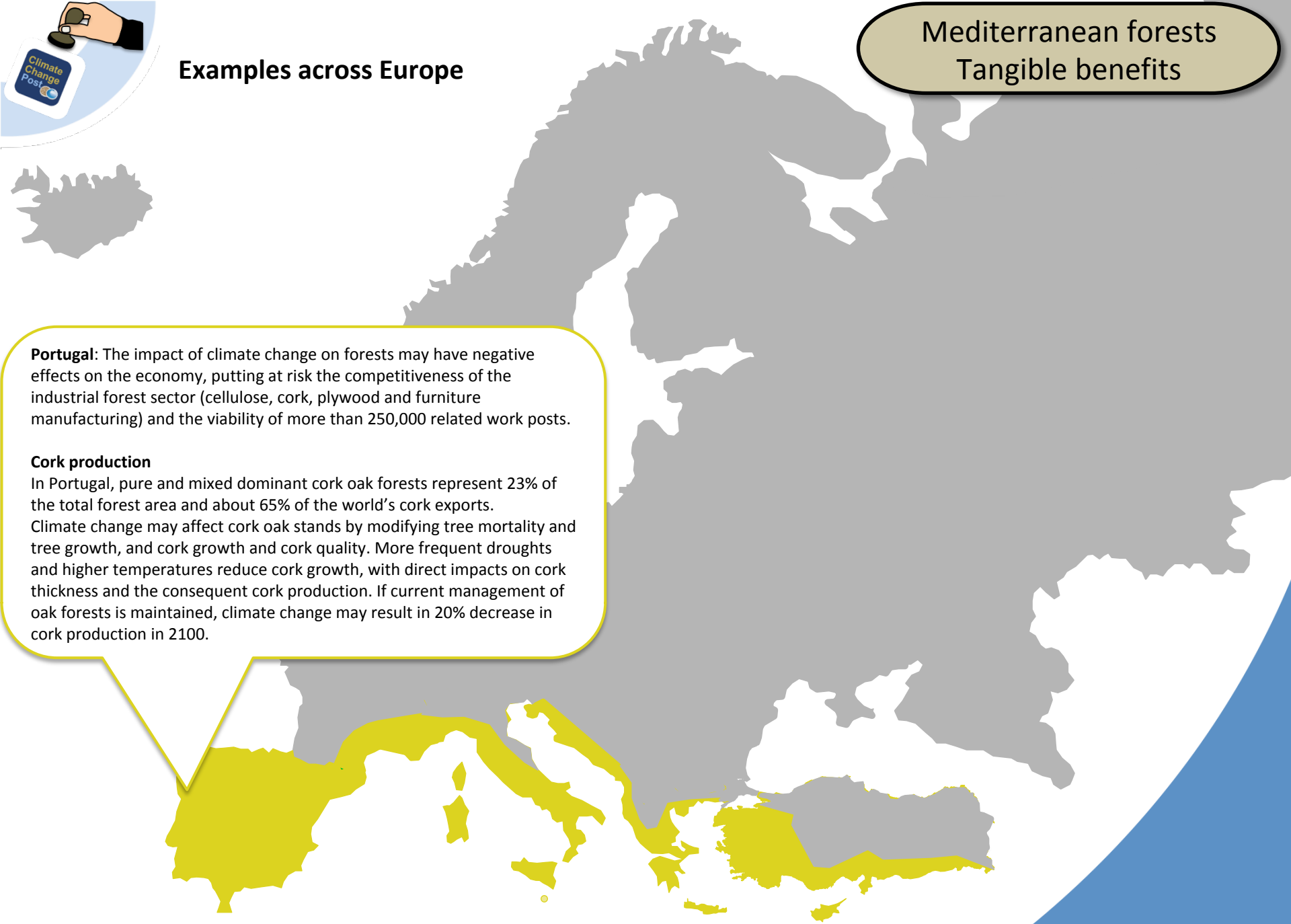
Russia: For the territory of Russia, global climate change in the next 30-40 years would not result in an abrupt deterioration of conditions required for normal growth and development of main forest forming species. In Russia the living conditions of the main forestry species will probably not deteriorate.

Ecosystem services

Photo credit: E. Dronkert, www.flickr.com

Mediterranean forests
Tangible benefits

Examples across Europe



Portugal: The impact of climate change on forests may have negative effects on the economy, putting at risk the competitiveness of the industrial forest sector (cellulose, cork, plywood and furniture manufacturing) and the viability of more than 250,000 related work posts.

Cork production

In Portugal, pure and mixed dominant cork oak forests represent 23% of the total forest area and about 65% of the world's cork exports.
Climate change may affect cork oak stands by modifying tree mortality and tree growth, and cork growth and cork quality. More frequent droughts and higher temperatures reduce cork growth, with direct impacts on cork thickness and the consequent cork production. If current management of oak forests is maintained, climate change may result in 20% decrease in cork production in 2100.

Temperate forests
Tangible benefits

From an economic view the most significant impact for central Europe would appear to be the reduction in areas under spruce and beech and the corresponding expansion of pine and oak. The heat-loving and drought-tolerant species can be expected to be economically less profitable than the species prevailing at present.

By 2100, 21 - 60% of European forest lands will be suitable only for a Mediterranean oak forest type with low economic returns for forest owners and the timber industry and reduced carbon sequestration.

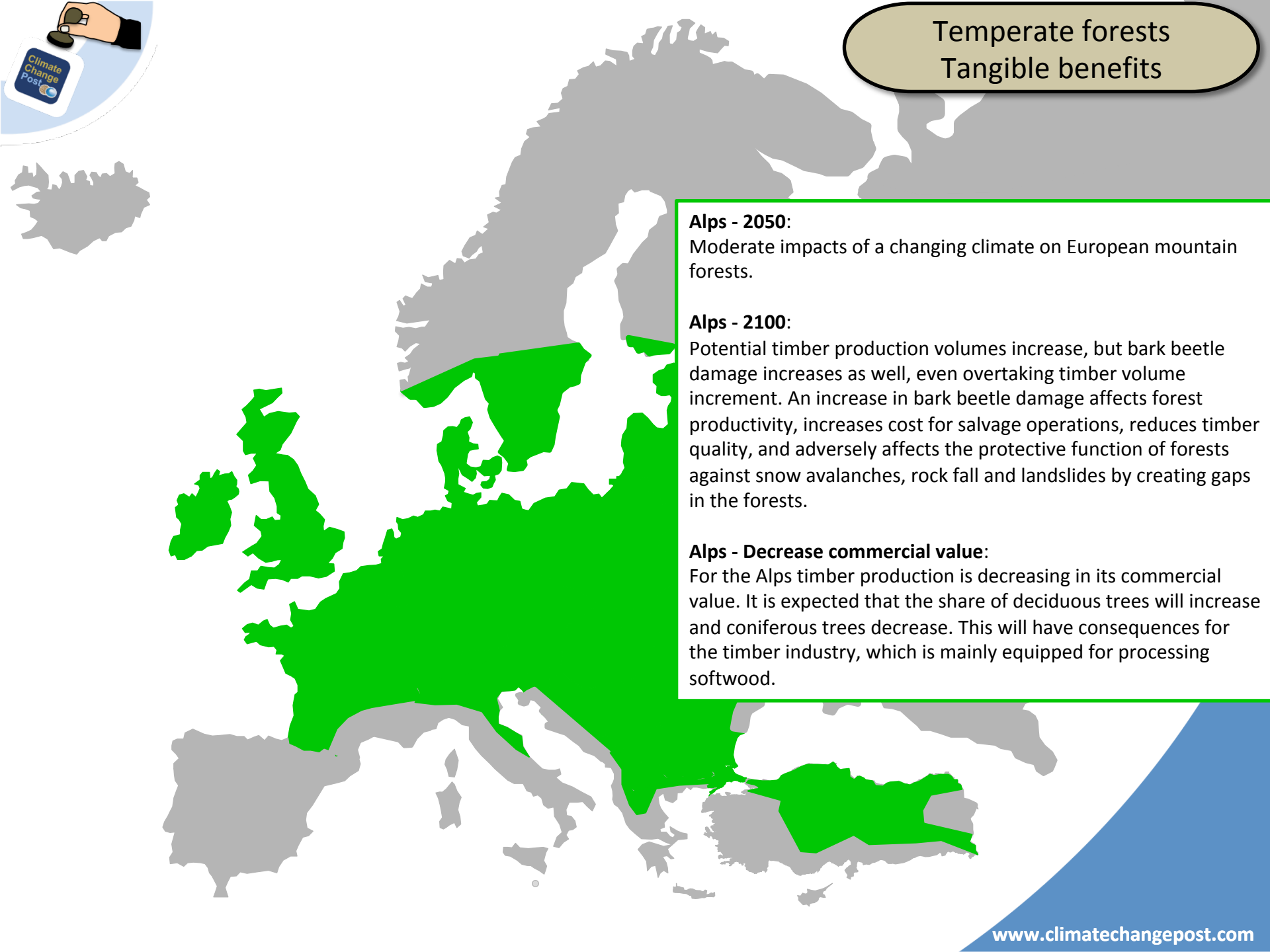
Economic value of European forest land:
The value of European forest land is expected to decrease owing to the decline of economically valuable species (such as Norway spruce, one of the major commercial tree species in Europe) in the absence of effective countermeasures.

By 2100, this loss varies between 14 and 50% of the present value of forest land in Europe, excluding Russia, and may total several hundred billion Euros.

Increased wind damages, especially in northern and western Europe, may more frequently result in an imbalance in orderly harvesting procedures with increased costs and disturb timber markets with an imbalance between the supply and demand of timber.

Reduced availability of timber due to the inaccessibility of forest resources on wet soils outside the frost period will pose a threat to the forest industry.

Temperate forests
Tangible benefits



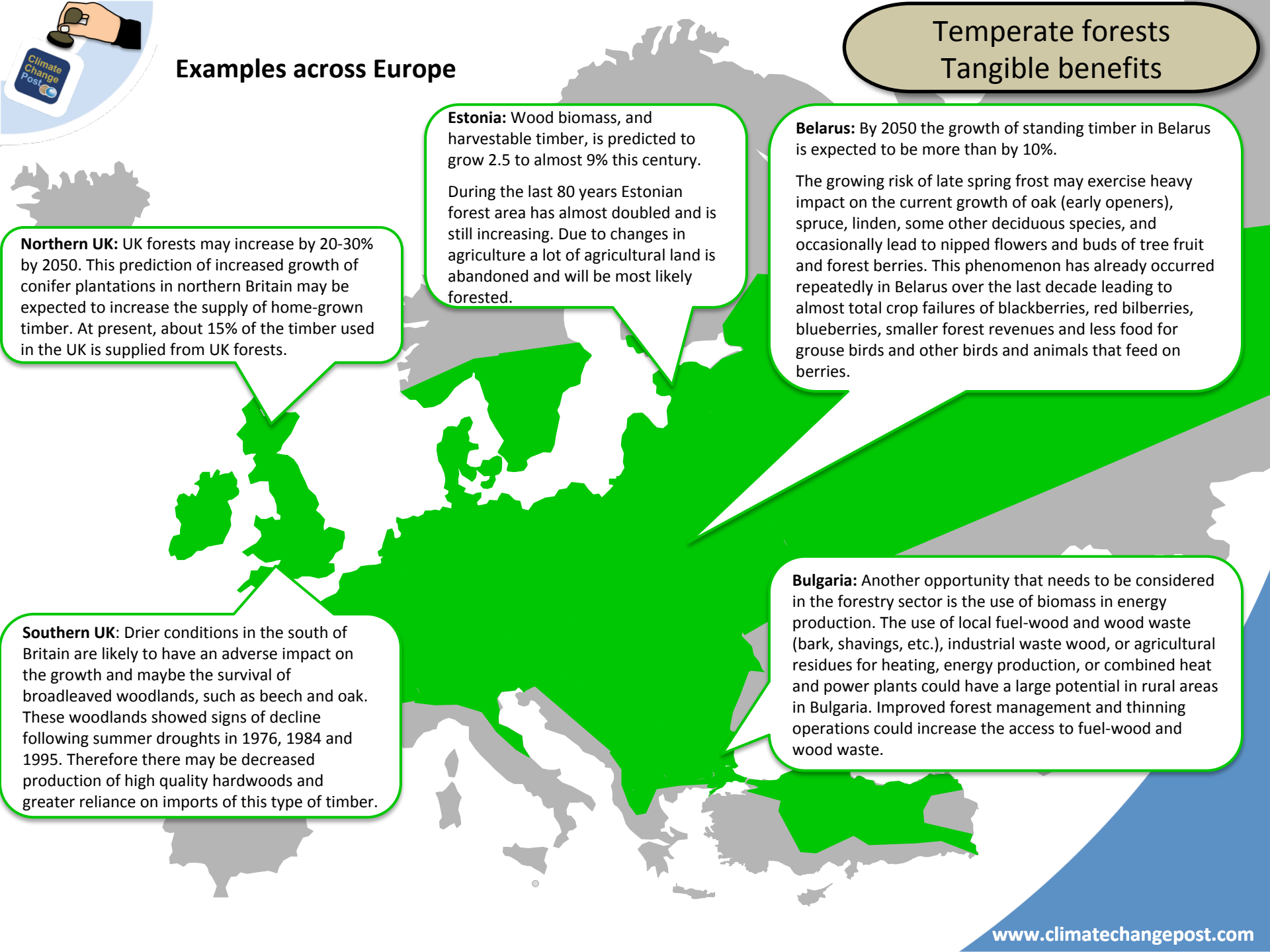
Alps - 2050:
Moderate impacts of a changing climate on European mountain forests.

Alps - 2100:
Potential timber production volumes increase, but bark beetle damage increases as well, even overtaking timber volume increment. An increase in bark beetle damage affects forest productivity, increases cost for salvage operations, reduces timber quality, and adversely affects the protective function of forests against snow avalanches, rock fall and landslides by creating gaps in the forests.

Alps - Decrease commercial value:
For the Alps timber production is decreasing in its commercial value. It is expected that the share of deciduous trees will increase and coniferous trees decrease. This will have consequences for the timber industry, which is mainly equipped for processing softwood.

Temperate forests
Tangible benefits

Examples across Europe



Estonia: Wood biomass, and harvestable timber, is predicted to grow 2.5 to almost 9% this century.

During the last 80 years Estonian forest area has almost doubled and is still increasing. Due to changes in agriculture a lot of agricultural land is abandoned and will be most likely forested.

Belarus: By 2050 the growth of standing timber in Belarus is expected to be more than by 10%.

The growing risk of late spring frost may exercise heavy impact on the current growth of oak (early openers), spruce, linden, some other deciduous species, and occasionally lead to nipped flowers and buds of tree fruit and forest berries. This phenomenon has already occurred repeatedly in Belarus over the last decade leading to almost total crop failures of blackberries, red bilberries, blueberries, smaller forest revenues and less food for grouse birds and other birds and animals that feed on berries.

Northern UK: UK forests may increase by 20-30% by 2050. This prediction of increased growth of conifer plantations in northern Britain may be expected to increase the supply of home-grown timber. At present, about 15% of the timber used in the UK is supplied from UK forests.

Bulgaria: Another opportunity that needs to be considered in the forestry sector is the use of biomass in energy production. The use of local fuel-wood and wood waste (bark, shavings, etc.), industrial waste wood, or agricultural residues for heating, energy production, or combined heat and power plants could have a large potential in rural areas in Bulgaria. Improved forest management and thinning operations could increase the access to fuel-wood and wood waste.

Southern UK: Drier conditions in the south of Britain are likely to have an adverse impact on the growth and maybe the survival of broadleaved woodlands, such as beech and oak. These woodlands showed signs of decline following summer droughts in 1976, 1984 and 1995. Therefore there may be decreased production of high quality hardwoods and greater reliance on imports of this type of timber.

Boreal forests and tundra
Tangible benefits

Forest type:

- Boreal forests
- Tundra

Climate change will probably increase timber production and reduce prices for wood products in Europe:

- For 2000 - 2050 a change of timber production in Europe is expected of -4 to +5%.
- For 2050 - 2100 an increase is expected of +2 to +13%.

In general, management has a greater influence on wood production in Europe than climate or land-use change. Forest management is influenced more strongly by actions outside the forest sector, such as trade and policies, than from within.

The increase in forest growth in the northern boreal region implies an increase in the potential timber harvest and carbon sequestration. At the same time, however:

- these forests may be severely affected by summer dry spells and droughts, making trees more susceptible to frost damage, wind throw, storms and attacks by pests and diseases
- the duration and depth of soil frost will reduce substantially, which makes the winter-time timber harvest more difficult and reduces the overall profitability of timber harvest

For the forests in northern Europe, the combination of raised mean temperature and a higher frequency of extreme events will have negative effects that could ultimately be of greater importance than the positive outcomes of a warmer climate.

Boreal forests and tundra
Tangible benefits

Examples across Europe

Forest type:

- Boreal forests
- Tundra

Norway: The perspectives for increased timber production in the next 60 years are fairly good. The overall effects on forestry in Norway are likely to be positive in the end. When the forests have reached their dynamic stability, both forest productive area, genetical selection, species selection, timber production and ecosystem diversity will most likely be improved.

Sweden:

- Pine and spruce are the most important tree species in Swedish forestry and the forest industry. A warmer climate provides the potential to cultivate new tree species for timber production. Among the valuable broadleaved trees, it is considered that oak and beech could expand northwards.
- The consequences for Sweden's forests and forestry will be significant. Increased growth will result in greater timber production, although increased frequency and extent of damage primarily from insects, fungi and storms, as well as wetter forest land, can entail considerable costs.
- In recent decades, biofuels from the forest have once again become important, along with timber for wooden goods, paper and packaging.

Finland: In Finland, snow damage accounts for about 7% of the total indemnities paid by insurance companies to forest owners. Most damage to Finnish forests is due to windstorms though: windstorms account for about 77% of forest damage in Finland compensated for by private insurance companies. Heavy snow loads may damage forests. Trees may break or bend, and they may be uprooted when the soil is unfrozen. When winters get warmer in the coldest parts of Europe snow-induced forest damage may actually increase when the characteristics of the snow load changes. The risk for snow-induced forest damage is likely to increase in the future in the eastern and northern parts of Finland, partly due to the increase in wet snow hazards but also due to more favourable conditions for rime accumulation in a future climate that is more humid but still cold enough.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