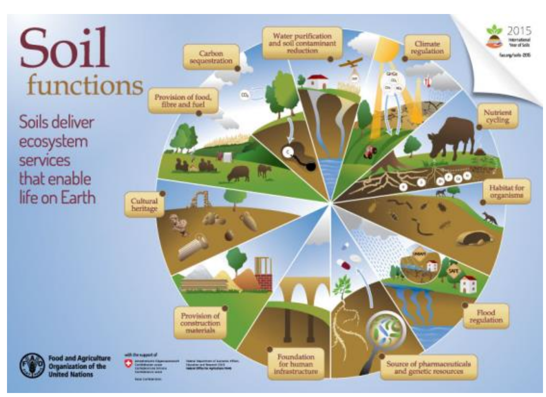
Soil degradation in the Czech Republic

Tomáš Chuman

Soil functions

- Soils are fundamental to life on earth providing number of ecosystem functions
  - carbon sequestration
  - climate regulation
  - nutrient cycling
  - flood regulation
  - food, biomass
  - structural material
  - water purification
  - the suppression of plant pests
  - provision of cultural value
  - etc.

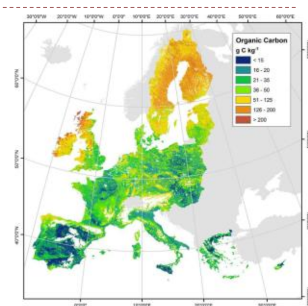


Soil degradation

- soil functions are threatened by a wide range of processes leading to a decline in the ability of soil to carry out its ecosystem services
- types of soil degradation:
  - organic matter content decline
  - soil erosion
  - soil compaction
  - soil sealing
  - soil acidification
  - salinization
  - desertification
  - soil contamination
  - soil biodiversity decline
- soil formation is an extremely slow process, soil can be considered a non-renewable resource, soils should thus be adequately protected and conserved to ensure that soil functions are not lost or diminished

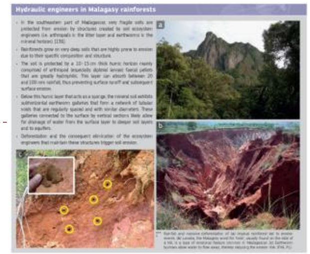
Soil organic matter decline

- SOM originates from residual plant and organisms remains transformed to humus (microbes, soil organisms)
  - influence on soil structure
  - stability of aggregates
  - water retention
  - soil biodiversity
  - source of plants nutrients
  - absorption of pollutants
- approx. 45% of mineral soils in Europe have low or very low SOC content (0-2%)
- 45% of soils in Europe have medium content of SOC (2-6%)
- agriculture soils in the Czech Republic have medium content of SOC (1,5 %)
- reasons
  - low input of plant residues
  - low input of organic fertilizers
  - unsuitable land management (intensification of agriculture, deforestation)
  - erosion
  - excess nitrogen – can cause an increase in the mineralization of organic matter
- impacts/results
  - loss of soil fertility
  - reduced water storage
  - negative impact on biodiversity
  - reduced absorption of pollutants

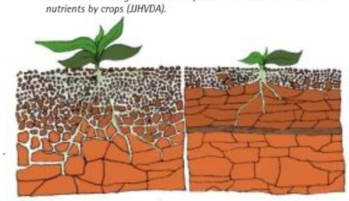


Soil compaction

- form of physical degradation
- reorganization of soil micro- and macro aggregates – these are deformed and destroyed under pressure
- cumulative threat
- impacts:
  - less permeable for roots, water and oxygen
  - infiltration rates
  - acceleration of run-off
  - decrease in water holding capacity
    - A cubic meter of „healthy" soil may contain up to 200 liters of water
  - alteration of soil aeration
    - The pores, or the voids between the solid mineral and organic particles, ensure that the soil is aerated, allowing roots and soil organisms to respire.
    - Besides air, the pores may contain water, held there by adhesion and capillary forces.
  - oxygen limitation can modify microbial activity
  - reduction of available habitats for soil organisms
  - reduction in biological activity
  - organisms contributing to the formation of macro-pores and tunnels have a direct effect on water, air and nutrient movement through soil profiles



A classic example of compacted topsoil. Note how the soil structure in the upper part of the profile has completely collapsed. This limits root growth and exploitation of soil water and nutrients by crops (JJHVDA).



Soil compaction

- reasons:
  - passage of heavy machinery
  - wrong agricultural practices (inappropriate ploughing)
  - trampling of grazing animals
  - it depends on soil texture and structure, moisture and SOC content, climate and land use

Driving heavy tractors on the subsoil during ploughing and harvesting is a major cause of subsoil compaction. The picture clearly shows how the wheels on one side of the tractor are driven in the plough furrow and press directly on the subsoil (JJHVDA).

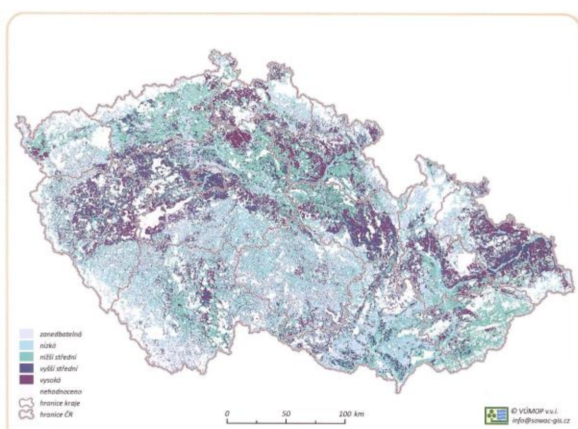
Areas degraded by soil compaction are increasing because wheel loads in agriculture are still increasing. Twenty years ago wheel loads of 50 kN (5000 kg) were considered very high. Nowadays wheel loads of up to 130 kN are used during the harvesting of sugar beet. Modern self-propelled slurry tankers with injection equipment with wheel loads of 90 – 120 kN are used in early spring on wet soils. Large tyres with an inflation pressure of about 200 kPa are needed to carry such high wheel loads. Even on moderate strong soil, compaction of up to 80 cm below the surface have been measured under such loads. The result is that the soil is increasingly compacted to ever-greater depth. The conclusion is that European soil is more threatened than ever (JJHVDA).

Soil compaction

- weight of tractors increased from 3t (1940‘) to 18t and more
- Hakansson (1985) weight >10t/axle cause soil compaction down to 50 cm
- heavy soils (containing more clay) are more susceptible to compaction than light soils (sandy)

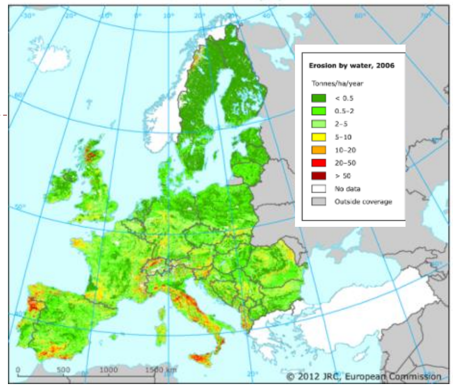
Soil compaction

- approx. 30 % of European soils are susceptible to compaction
- 25 mil. ha weakly compacted in Europe
- 36 mil. ha strongly compacted
- In the Czech Rep. 45% of agriculture land (1,9 mil ha) is threatened by compaction
- agri. land CR 4 219 867 ha
  - arable land 2 985 792 ha



Obr. 119: Mapa potenciální zranitelnost půd utužením

Erosion



- *Soil erosion* is a naturally occurring and slow process that refers to loss of soil by water and wind
- "Erosion" comes from *erodere*, a Latin verb meaning "to gnaw. " (Erosion gnaws away at the earth like a dog at a bone.)
- 112 mil. ha = 12% of Europe is threatened by water erosion
- 42 mil. ha is threatened by wind erosion
- in the CR
  - 50 % of agriculture land threatened by water erosion
  - 10,4 % is threatened by wind erosion
- annual loss of agriculture soil in the CR. 9 mil. t/year (Dostál et al. 2001).
- average loss of soil in the EU is 2,7 t/ha/y (European soil data centre)
- values exceeding 1 t/ha/y are considered negative
- 1t/ha/yr – irreversible within 50-100 years
- erosion rates varies according to climate, land use, soil texture, slope length, organic mater content, soil structure

Erosion

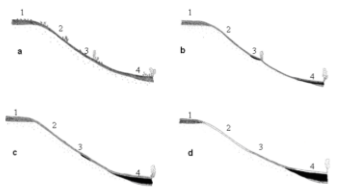
- reasons:
  - inappropriate land management
  - deforestation
  - overgrazing
  - forest fires
  - construction activities
  - landscape history – land nationalization and collectivisation, eradication of barns, field enlargements

- impacts:
  - loss of nutrients
  - transfer of nutrients to water causing eutrophication (algal blooms)
  - decline in productivity (loss of 5-15 cm of topsoil leads to decrease in yields by 15-30%)
  - influence on soil structure
  - stability of aggregates
  - water retention
  - soil biodiversity
  - absorption of pollutants
  - off-site effects (mudflows blocking roadways, building, inundation)

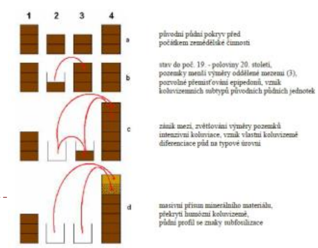
Erosion

- water erosion affects also forest land approx. 5-10% of forest land is threatened by water erosion

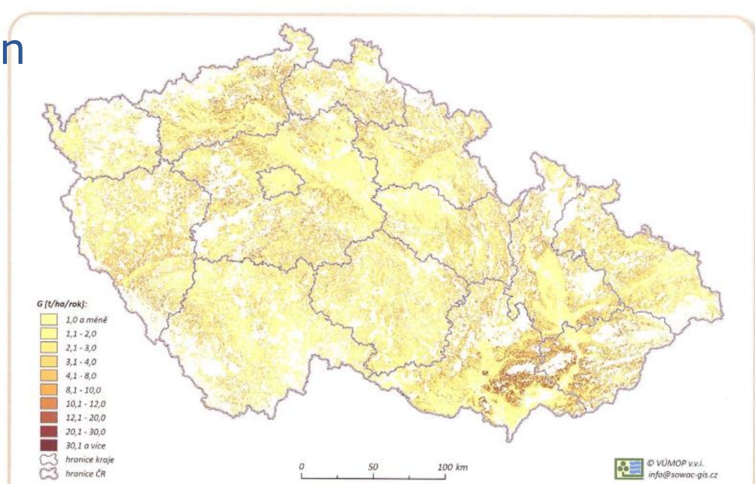
Erosion – situation in some regions of the Czech Republic



Obr. 5 Fáze koluviace ve vztahu k fázím zemědělské činnosti
1 – rozvodí; 2 – konvexní část svahu; 3 – část svahu za terénní překážkou; 4 – úpatí svahu
a – před počátkem obdělávání pozemku; b – extenzivní hospodaření; c – intenzivní hospodaření, velká výměra pozemků; d – současný vývoj bez aplikace protierozních opatření



Erosion



Obr. 122: Mapa ohrožení půdy vodní erozí

- in the Czech Rep. 18% of agriculture land is extremely threatened by water erosion – loss >7,5t/ha/yr

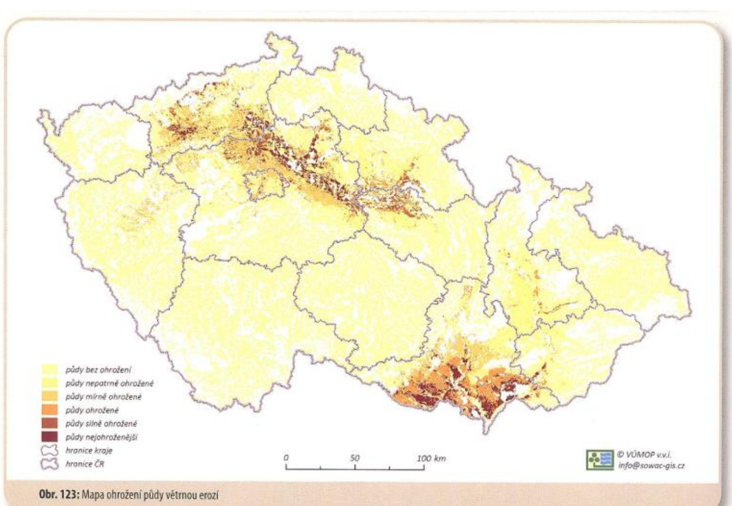
Wind erosion

- 10-42 mil. ha of Europe is threatened by wind erosion
- in the CR 10,4 % is threatened by wind erosion

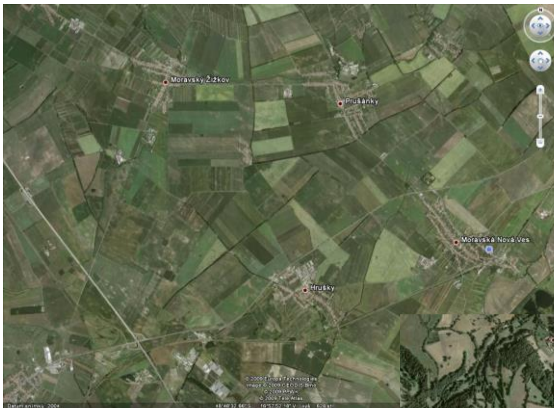
State of soil erosion by wind: Wind erosion is a serious problem in many parts of northern Germany, eastern Netherlands, eastern England and the Iberian Peninsula. Estimates of the extent of wind erosion range from 10 to 42 million ha of Europe's total land area, with around 1 million ha being categorised as severely affected (EEA, 2003; Lal, 1994). Recent work in eastern England reported mean wind erosion rates of 0.1–2.0 t ha1 yr1 (Chappell and Warren, 2003), though severe events are known to move much more than 10 tonnes of soil ha-1 yr-1 (Böhner et al., 2003). In a similar study, Goossens et al. (2001) found values of around 9.5 t ha-1 yr-1 for arable fields in Lower Saxony, Germany. Breshears et al. (2003) researched the relative importance of soil erosion by wind and by water in a Mediterranean ecosystem and found that wind erosion exceeded water erosion in shrubland (around 55 t ha-1 yr-1) and forest (0.62 t ha-1 yr-1) sites but not on grasslands (5.5 t ha-1 yr-1).

Obr. 5-4: Zavátí komunikace u Nového Přerova (foto: SPÚ Břeclav, jaro 2009)

Wind erosion

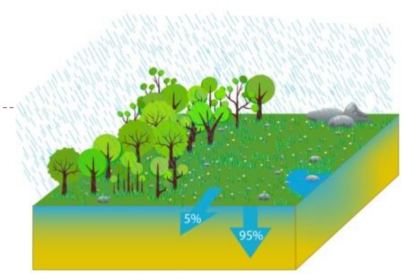


Obr. 123: Mapa ohrožení půdy větrnou erozí



Soil sealing

- destruction/covering of soil by buildings/artificial surfaces (asphalt, concrete)
- land take due to urban sprawl
- irreversible process
- the amount of land "sealed" by concrete and asphalt depends largely on economic growth
- built-up and other **artificial surfaces cover 4%** of the total area of **the EU countries**
- between 1990 and 2006, the sealed area in the EU countries **increased by 8.8%**

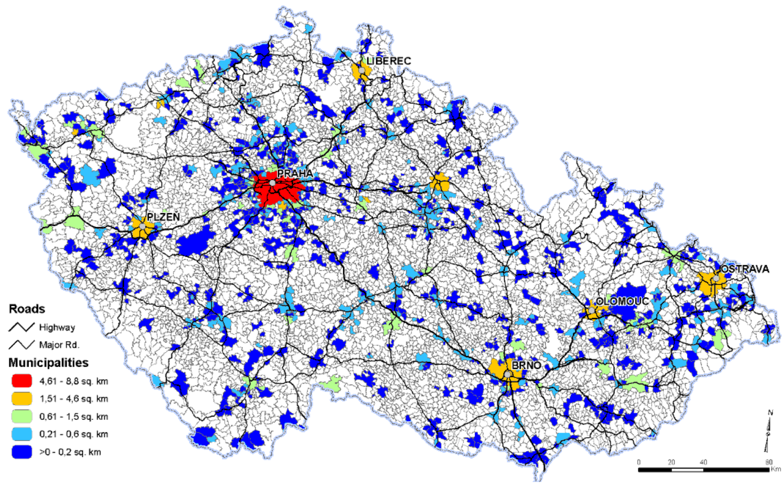


Before

After

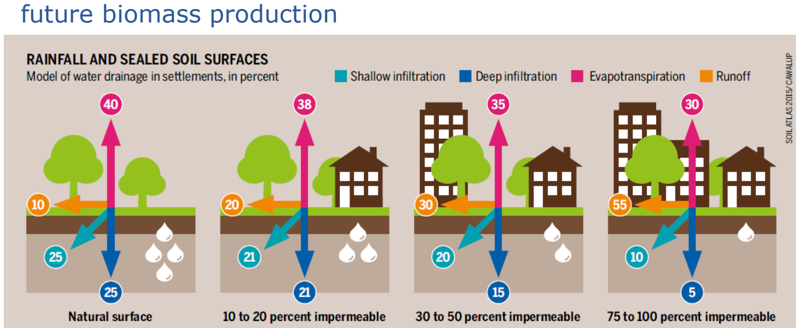
Soil sealing

- since 1990 urban land has been increasing 15 km^2/yr.)



Soil sealing

- impact:
  - water infiltration
    - rapid flow of rainwater from sealed surfaces to river channels
  - biodiversity
  - nutrient cycling
  - water purification
  - sealing of high-productivity soils on the outskirts of towns – future biomass production



Salinization

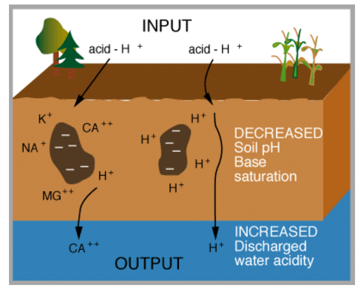
- accumulation of salt in soil due to inappropriate irrigation practices
- not a serious threat in the Czech Republic

Soil contamination

- main causes of contamination are past and present industrial or commercial activities
- the most common contaminants are heavy metals (Co, Cu, Cd, As, Be, Zn) and mineral oil
- over-application of agrochemicals (pesticides and mineral fertilizers)
- nutrient inputs from human activities
  - nitrogen (N) inputs to ecosystems are 30 - 50 % greater now than they were 100 years ago
  - phosphorus (P) inputs via fertilizer
- the soil cannot retain all of the added N and P
- nutrient overloading has perhaps the strongest effects on aquatic ecosystems
- the excess nutrients end up in surface and groundwater leading to „eutrophication" (excessive growth of algae)

Soil acidification

- loss of base cations (calcium, magnesium, potassium, sodium) through leaching
- the main reason
  - is the deposition of acidifying compounds S, N, emitted to the atmosphere as anthropogenic emissions (fossil fuel combustion in power plants, engines)
  - intensive agriculture (ammonia emissions)
- very acidic soil can reduce crop productivity by up to 50% through loss of organic material, nutrient deficits, aluminium toxicity, increased solubility of metallic trace elements (aluminum, copper, mercury, arsenic)
- increasing soil acidity affects microorganisms (e.g. bacteria and fungi
- reduction of species diversity



Emissions of sulphur dioxide (SO2) and nitrogen oxides (NOX) to the atmosphere increase the natural acidity of rainwater, snow or hail. This is due to the formation of sulphuric and nitric acid (H2SO4, HNO3), both being strong acids. Ammonia contributes to the formation of particulate matter in the air, including ammonium (NH4 +). After deposition to ecosystems, the conversion of NH4+ to either amino acids or nitrate (NO3-) is an acidification process.

S,N emissions and deposition in the CR

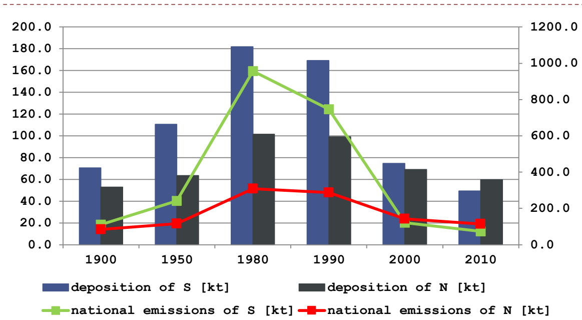
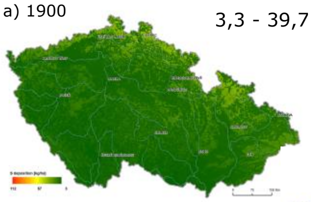


Table 8.1. Total sums of S and N emissions and deposition for the Czech Republic

YEAR	1900	1950	1980	1990	2000	2010
national emissions of S [kt/yr]	111.3	242.0	956.3	746.0	120.6	74.0
national deposition of S [kt/yr]	70.5	110.7	182.0	169.1	74.6	49.3
deposition/emission of S ratio [%]	63.3	45.8	19.0	22.7	61.9	66.6
absolute difference of S emissions - S deposition [kt/yr]	40.9	131.3	774.3	576.9	46.0	24.7
national emissions of N [kt/yr]	83.6	116.2	308.3	286.7	142.2	113.6
national deposition of N [kt/yr]	53.0	63.6	101.6	99.2	69.1	59.6
deposition/emission of N ratio [%]	63.4	54.8	33.0	34.6	48.6	52.4
absolute difference of N emissions - N deposition [kt/yr]	30.7	52.6	206.6	187.4	73.0	54.1

S deposition

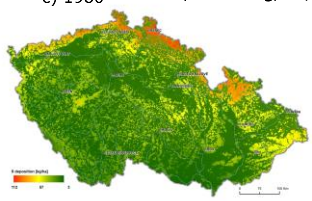
a) 1900



3,3 - 39,7 kg/ha/yr.

c) 1980

1980 5,7-112 kg/ha/yr.

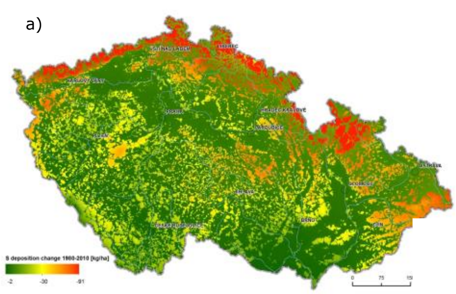


2010 2,7-29 kg/ha/yr.

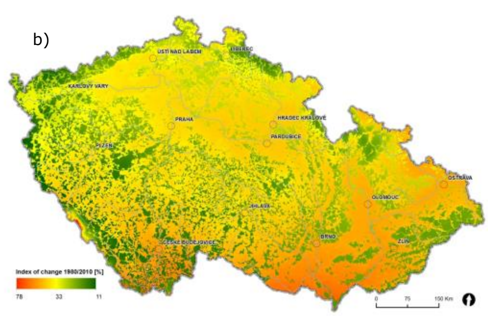
f) 2010

S deposition change

a)



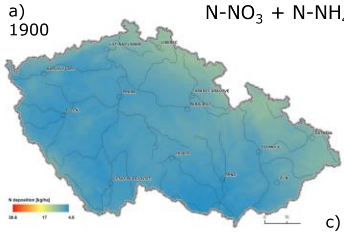
b)



N deposition

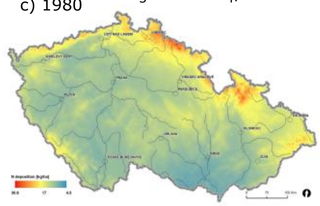
a) 1900

N-NO_3 + N-NH_4, bulk 4.5 - 11.3 kg/ha/yr

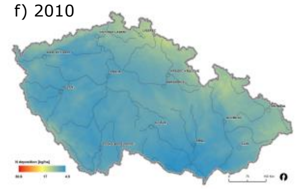


c) 1980

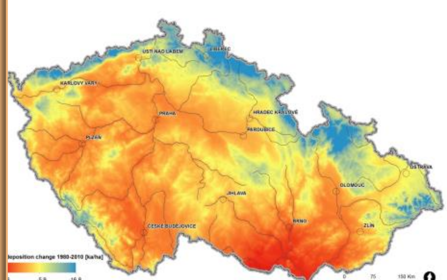
N-NO_3 + N-NH_4, bulk 7.5 – 30.6 kg/ha/yr

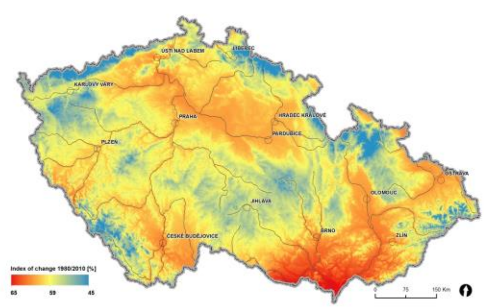


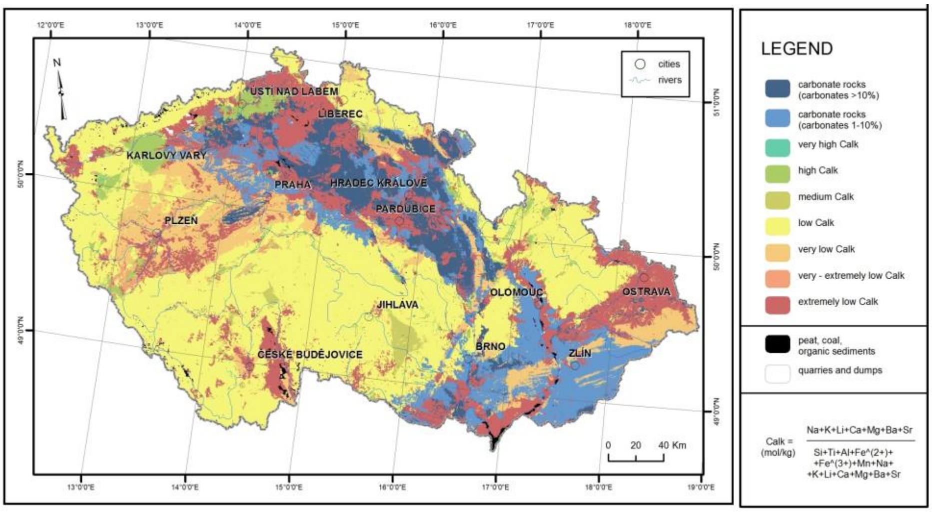
f) 2010



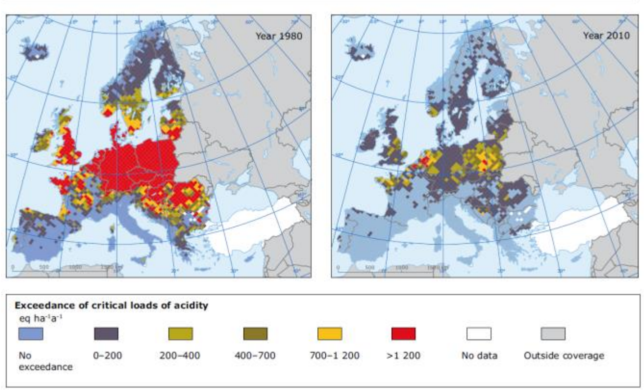
N deposition change







Map 2.7 **Exceedance of critital loads of acidity**



Note: Maps showing changes in the extent to which European ecosystems are exposed to acid deposition (i.e. where the critical load limits for acidification are exceeded. In 1980, areas with exceedances of critical loads of acidity (i.e. higher than 1 200 equivalent ha^{-1} year^{-1}, shaded red) cover large parts of Europe. By 2010, the areas where critical loads are being exceeded have shrunk significantly compared to 1980. These improvements are expected to continue to 2020, although at a reduced rate.

Source: Deposition data collected by European Monitoring and Evaluation Programme (EMAP); Maps drawn by Coordination Centre for Effects (CCE); EEA 2010.

END