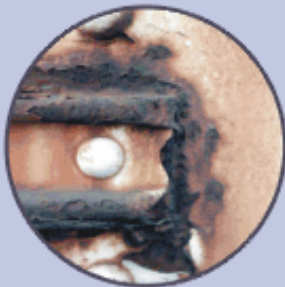




Potential Risk of Acidification in South Asia

**Kevin Hicks and Johan
Kuylenstierna SEI**

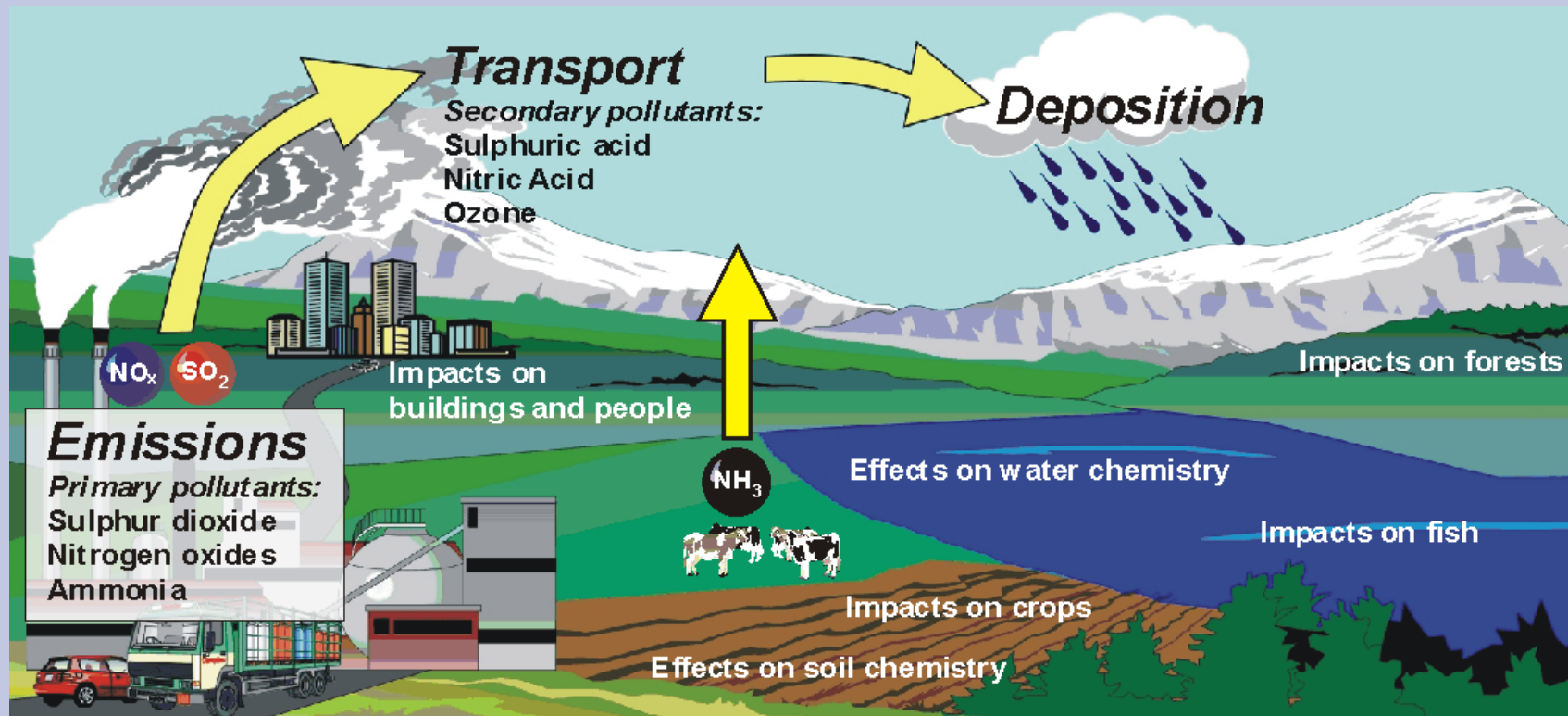
khicks@york.ac.uk



Aims

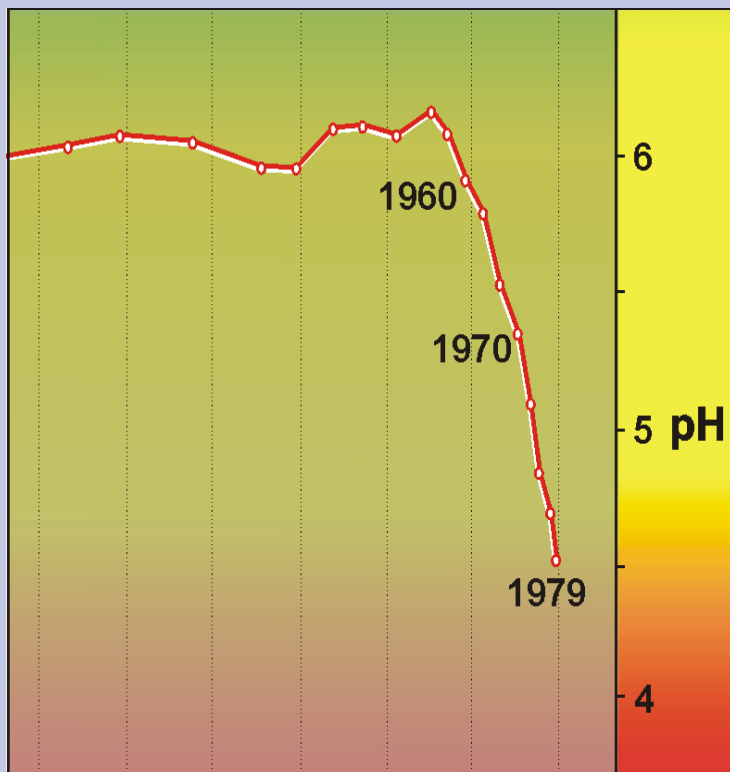
- Describe European experience of acidification
- Explain acidification processes and consequences
- Illustrate the dynamics of acidification over time
- Describe methodologies that could be used to promote national efforts to assess risk of acidification damage in the S. Asia

Transboundary impacts of air pollution

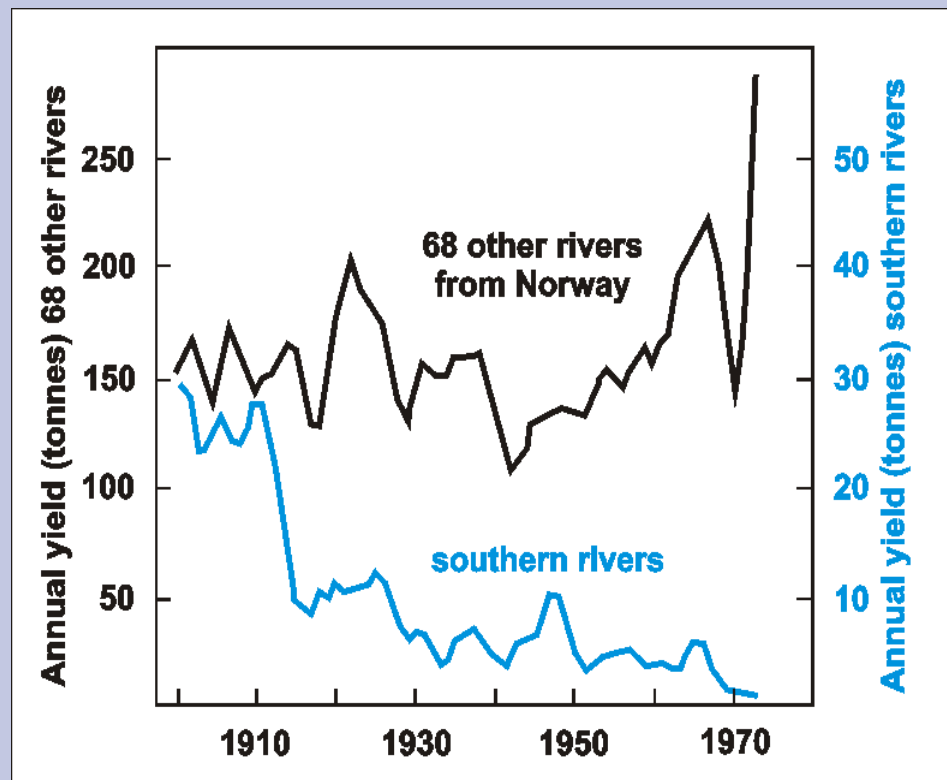




Effects of 'Acid Rain' in Europe

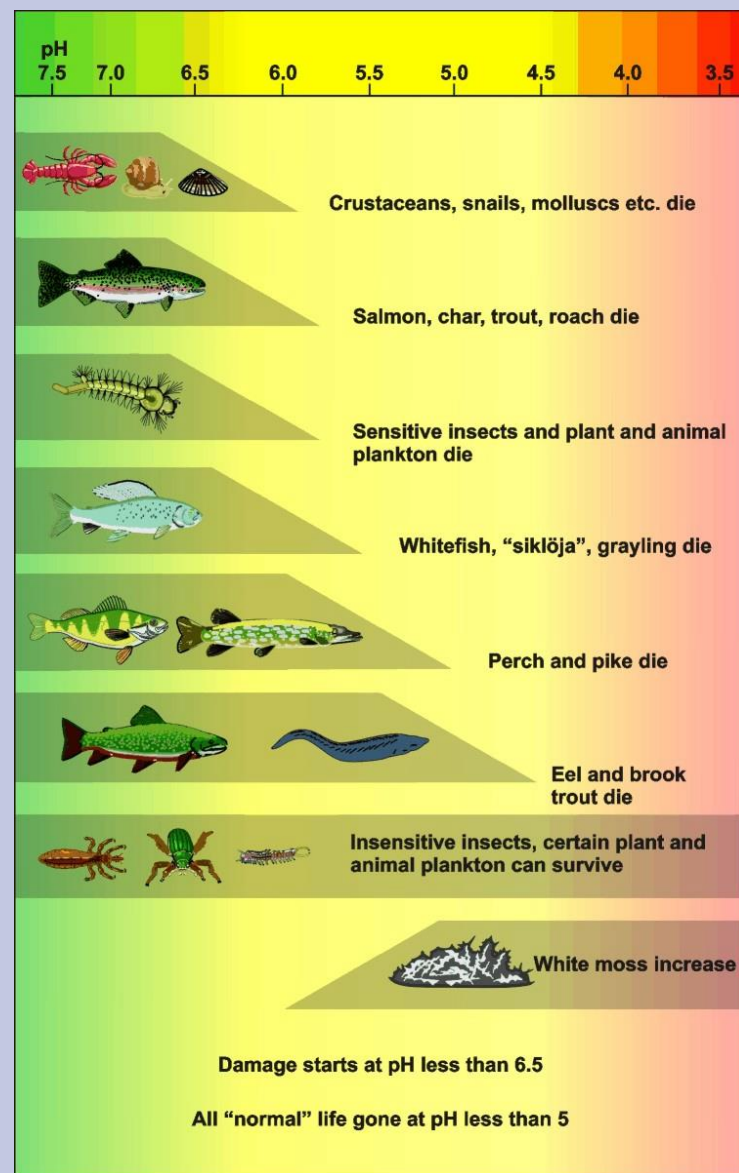


The pH of lake
Gårdsjön, SW Sweden



Salmon decline in the acidified
waters of southern Norway

The sensitivity of aquatic organisms to a lowered pH in freshwater



Lake and river acidification in Europe

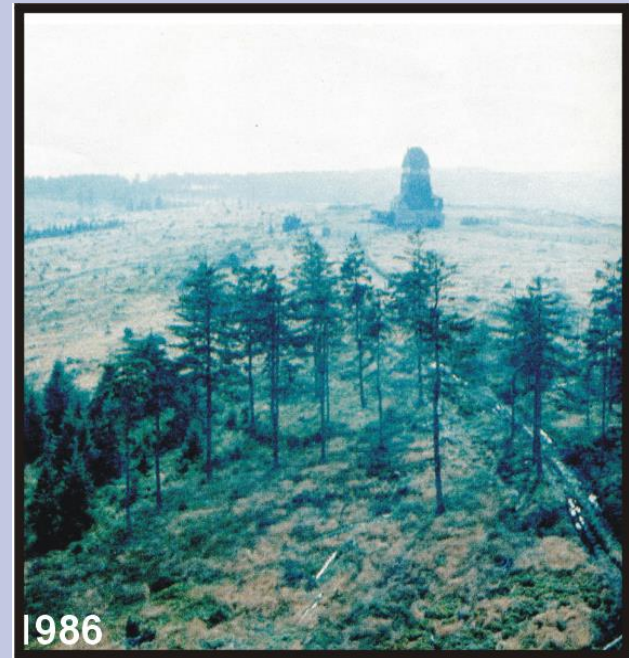
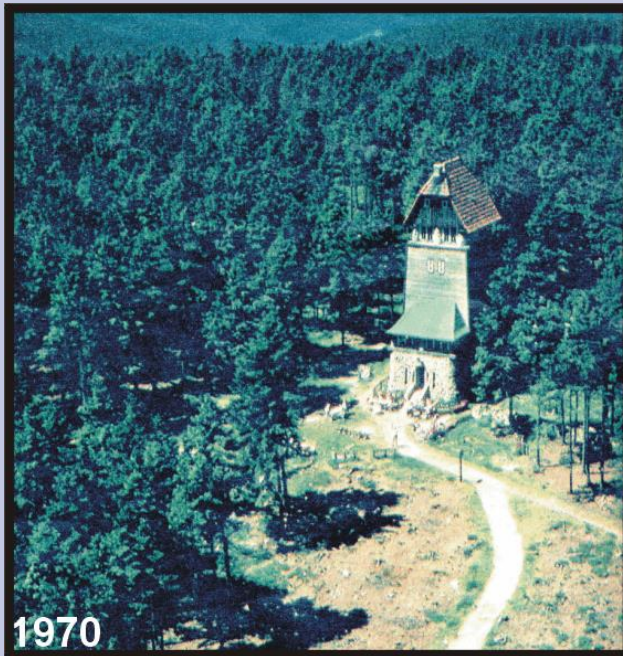


85% of all acidified lakes and watercourses in Europe and North America are in six countries: Sweden, Norway, Canada, U.S.A., Scotland and Finland.

In Europe, about 50 000 – 100 000 lakes have been affected by acidification

This occurred in acid-sensitive regions where the soils have a low ability to neutralize continuous inputs of strong acids

Widespread forest decline in C Europe



Forest damage in Germany

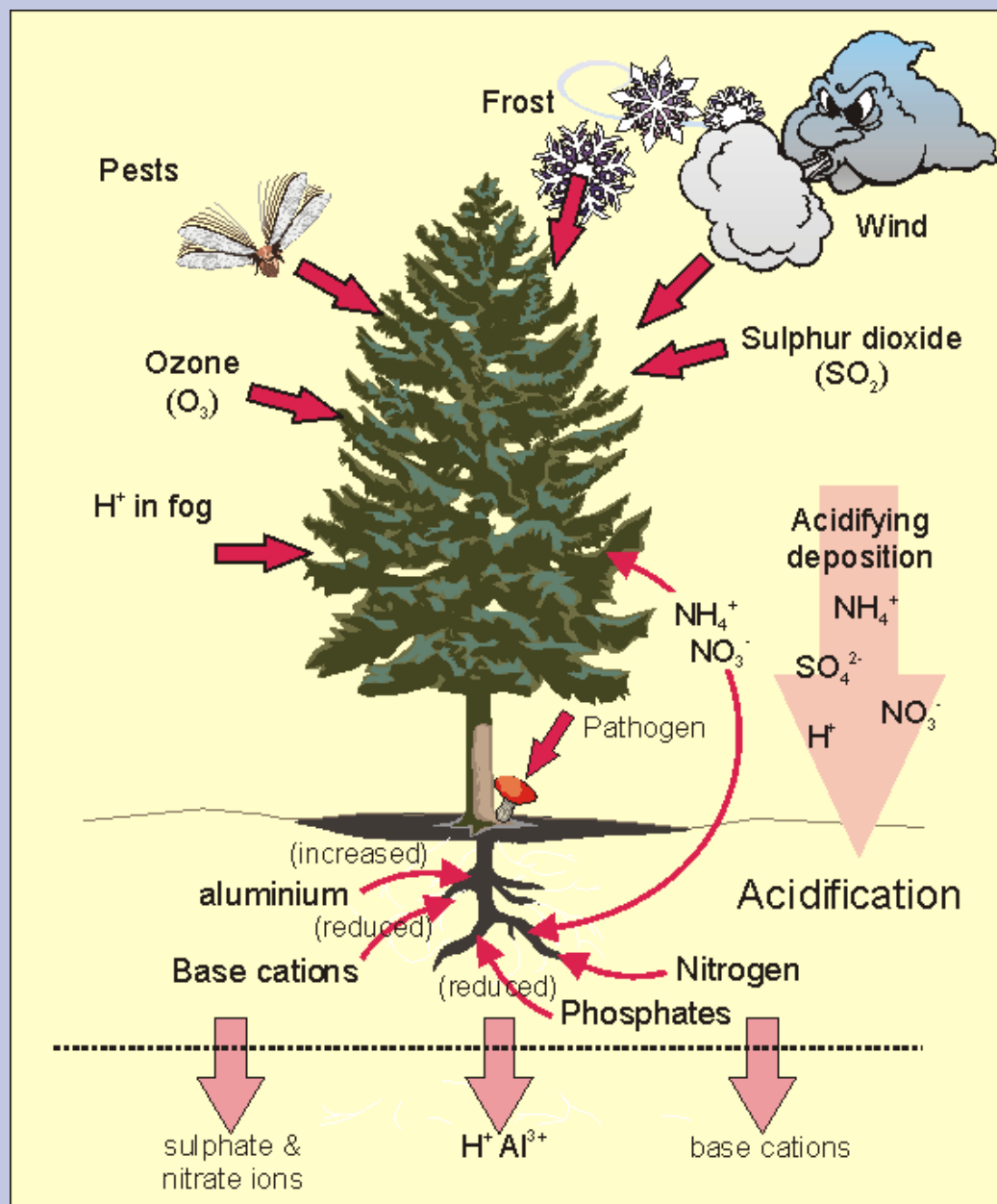
Forest Decline

Forest decline experienced in many countries of central Europe and in eastern United States in the late 1970s and early 1980s

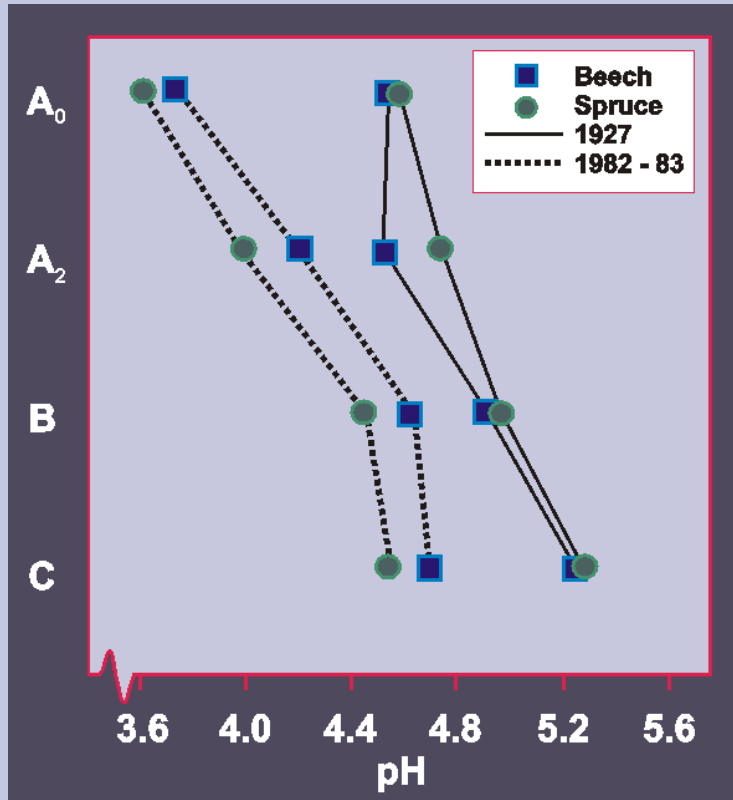
The main air pollution hypotheses were:

- direct effects of gaseous pollutants and acidic rain, alone or in combination
- indirect effects via soil acidification (e.g. reduced availability of certain plant nutrients (Ca, Mg etc) and/or toxic effects of aluminium)
- excess availability of nitrogen (+ve and –ve effects)

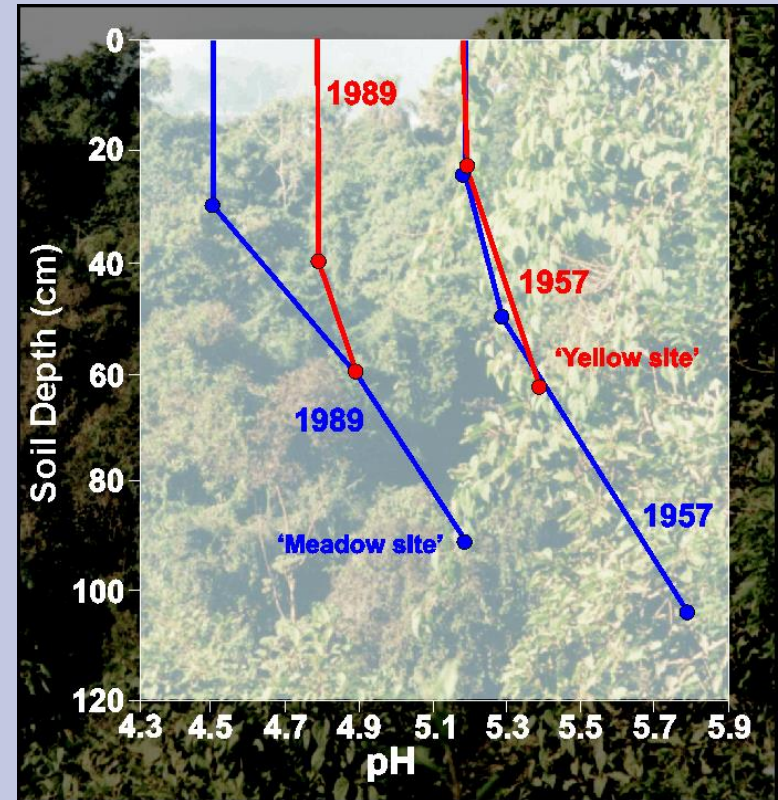
Various factors contributing to forest decline



Evidence of Soil Acidification in Europe and southern China



The decrease in soil pH between 1927 to 1982-83 in a beech and spruce forest in southern Sweden (Hallbäcken and Tamm, 1985).



Soil acidification at Mt. Lu in southern China (Zhao, 1996)

Evidence of soil acidification in South Asia?

- Few studies on acidification
- Evidence of potential acidification of waters surrounding industry in India
- Studies of water catchments in Nepal – no strong acidification seen
- Critical Load approach applied to soils in India, showing no 'exceedance'
- There is a need to collate all available studies and data on acidification in South Asia

Some definitions of terms commonly used in soil acidification work

Acidity is defined as:

$$\text{pH: } -\log [\text{H}^+] \quad \text{or} \quad [\text{H}^+] = 10^{-\text{pH}}$$

pH 7 neutral $[\text{H}^+] = [\text{OH}^-]$

>pH 7 alkaline

<pH 7 acidic

Acid precipitation < pH 5.6 (which is the value for pure water in equilibrium with atmospheric CO_2)

Examples

pH of acid rain in Europe has been < pH 4

pH of rain in S Asia = 5.3 - 7.2

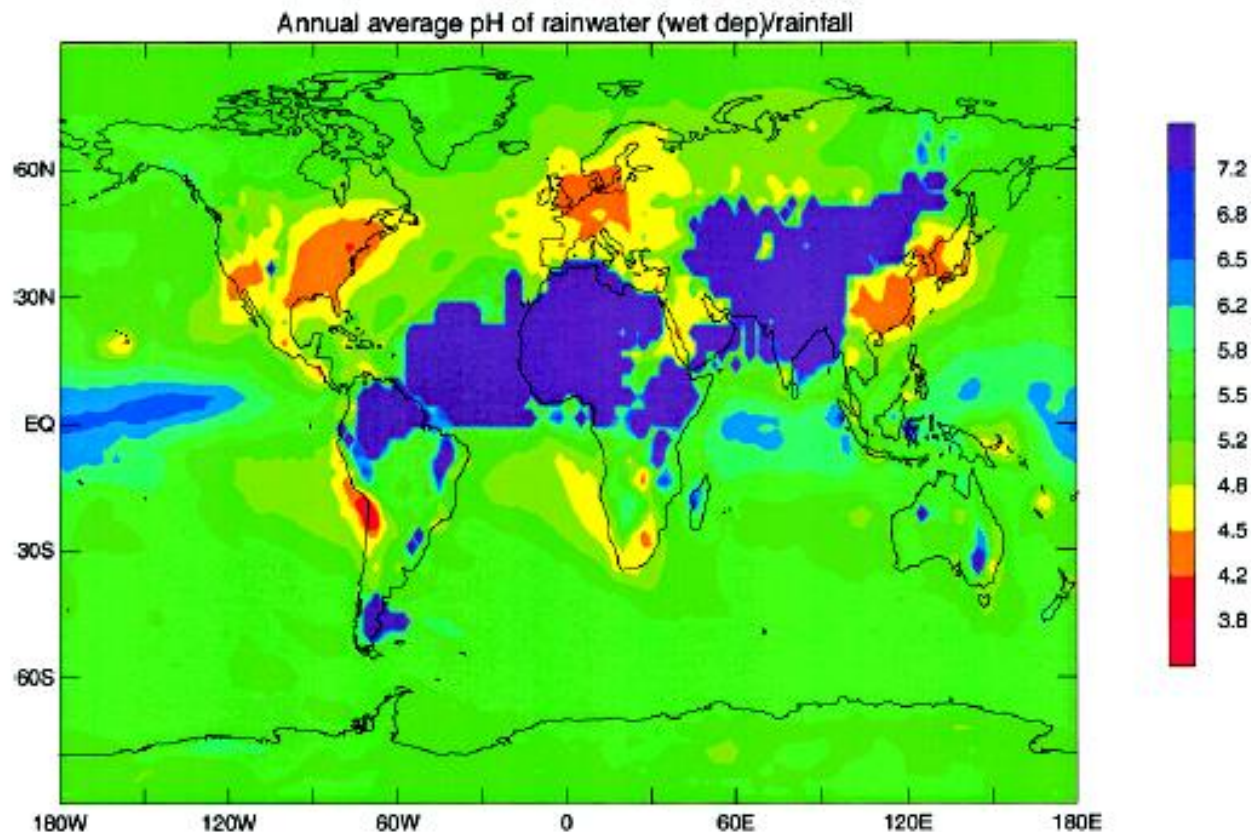


FIGURE 2. Annual average pH of precipitation calculated from volume weighted averages of H^+ according to eq 1. The most acidified regions occur in eastern North America, Europe, and China. The maximum in South America is associated with emissions from a smelter in northern Chile coupled to low amounts of rainfall in that region.

Some definitions of terms commonly used in soil acidification work

Weathering rate (WR) - rate of buffering of acidity by the chemical weathering of soil minerals

Cations – positively charged ions

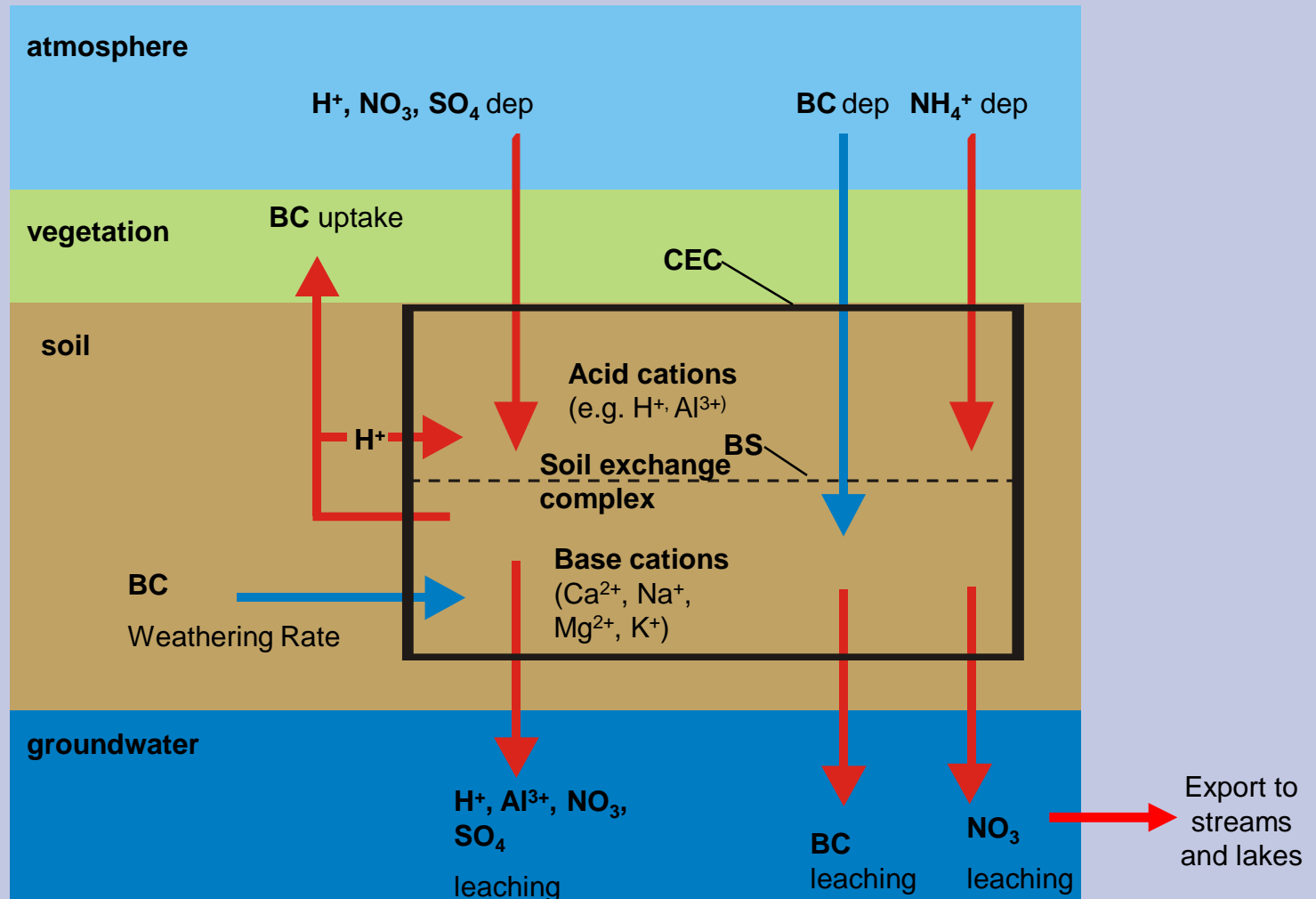
Base cations = Ca^{2+} , Mg^{2+} , Na^{+} , K^{+}

Acid cations = H^{+} Al^{3+}

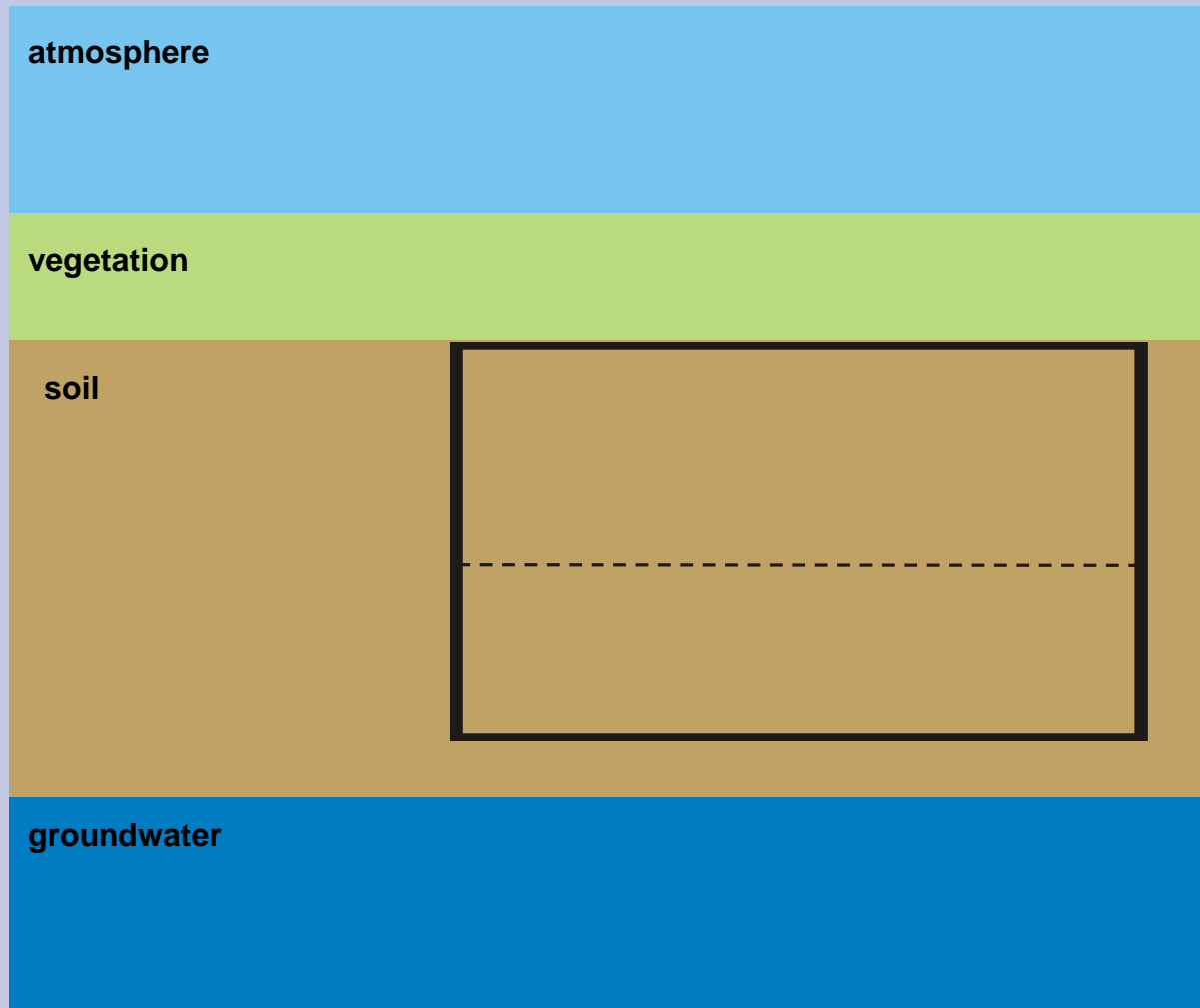
Cation exchange capacity (CEC) – measure of the capacity of the soil to bind cations to soil particles

Base saturation (%BS) = sum of base cations/CEC

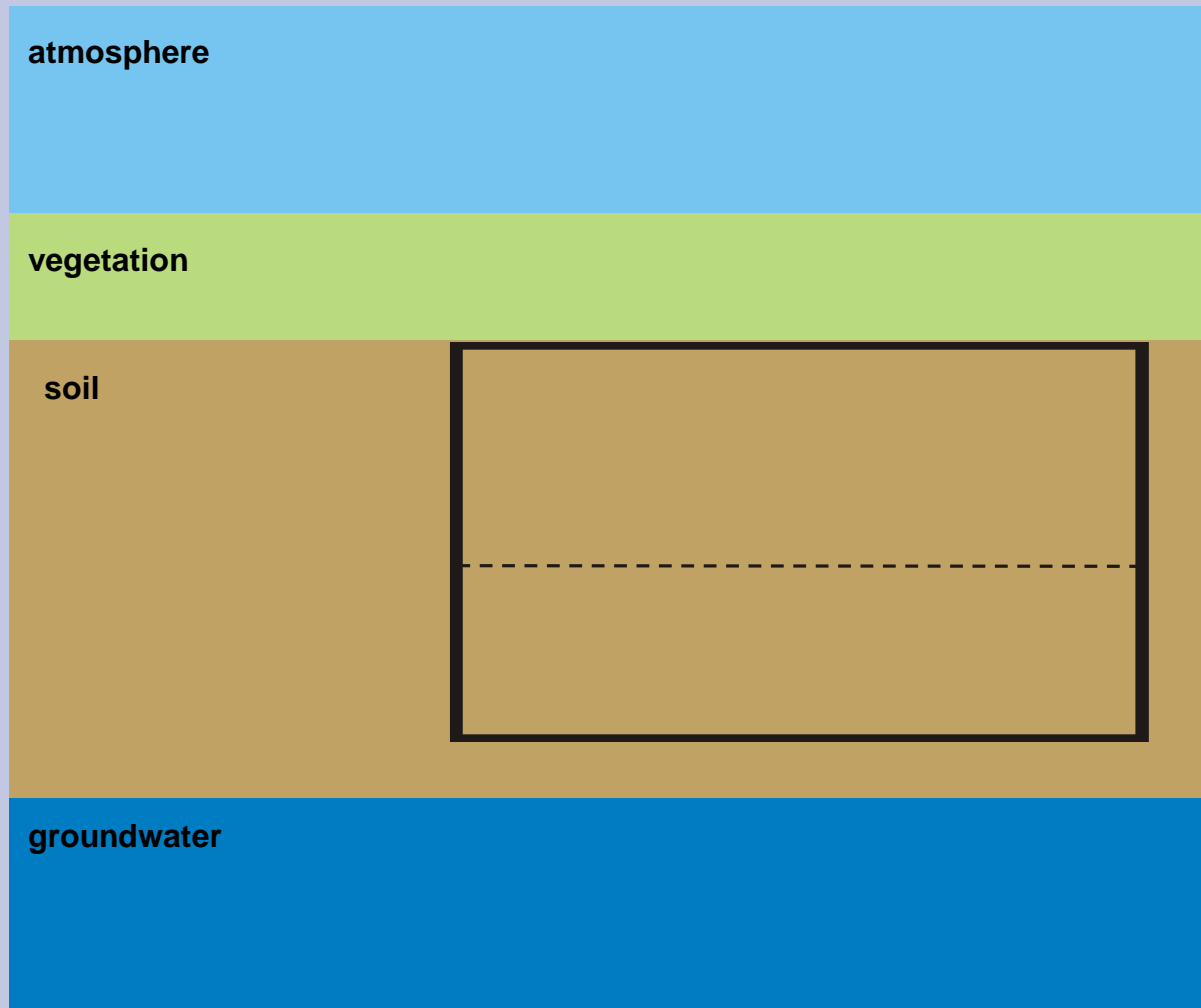
The soil acidification process



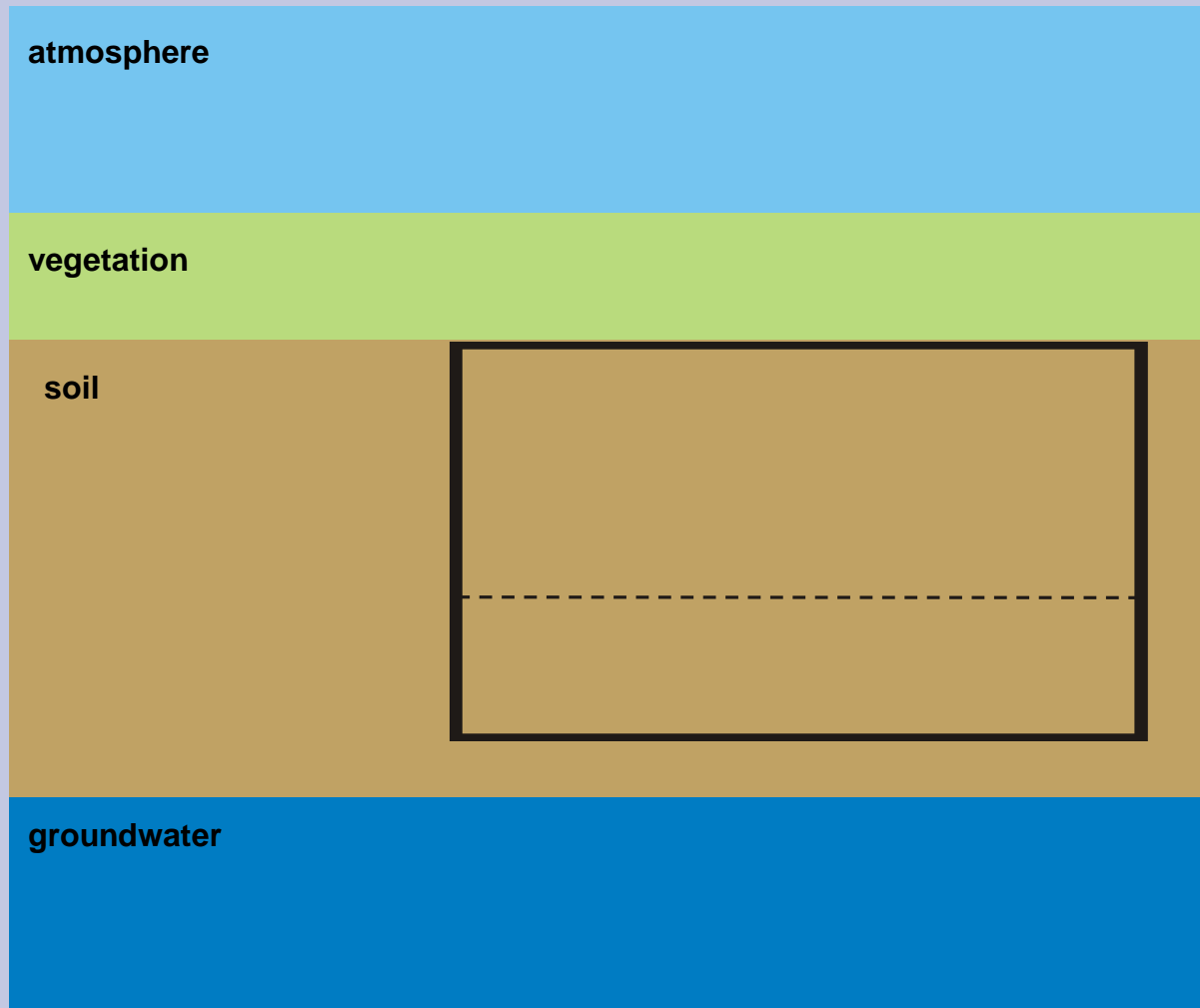
The soil acidification process



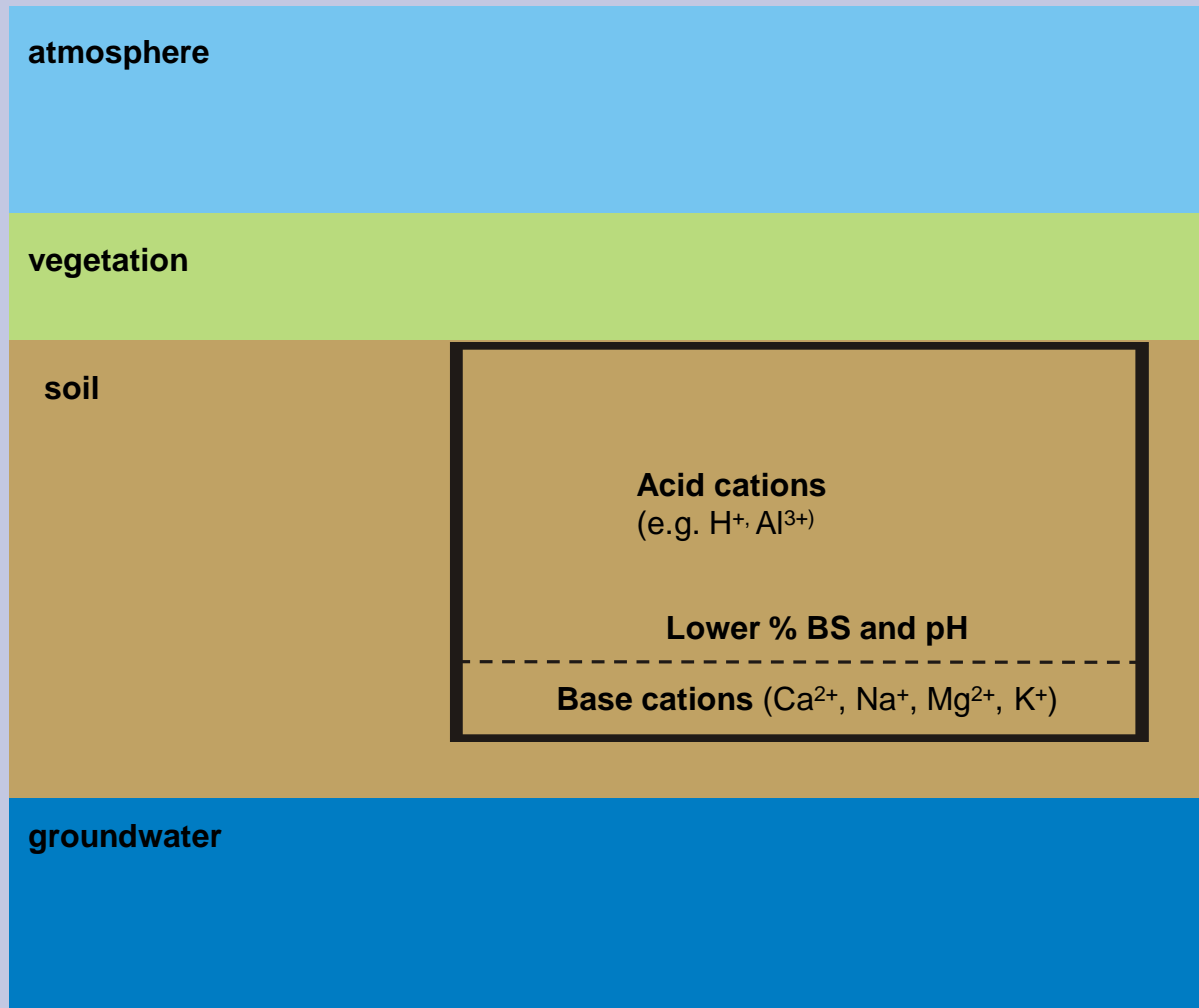
The soil acidification process



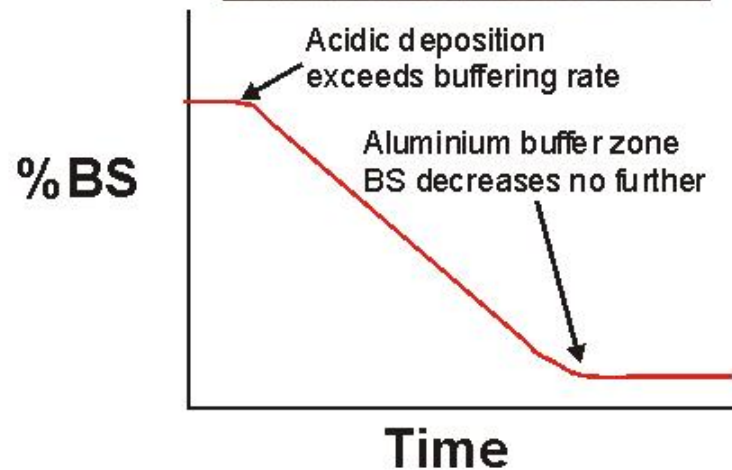
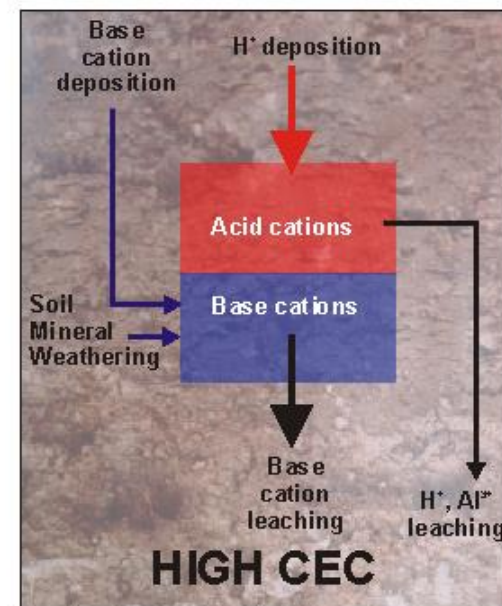
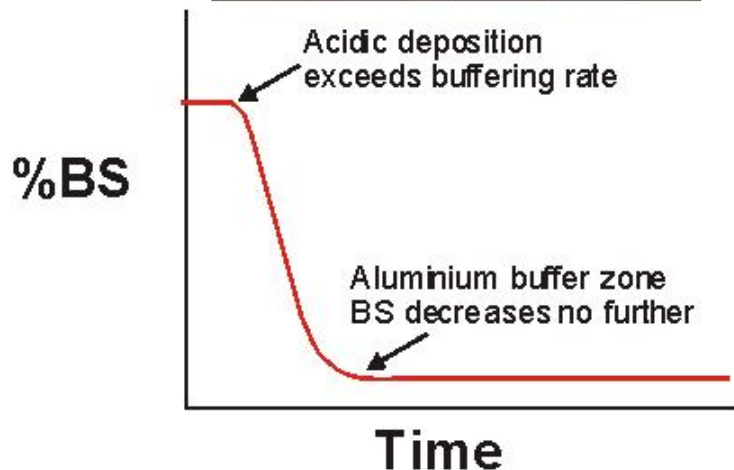
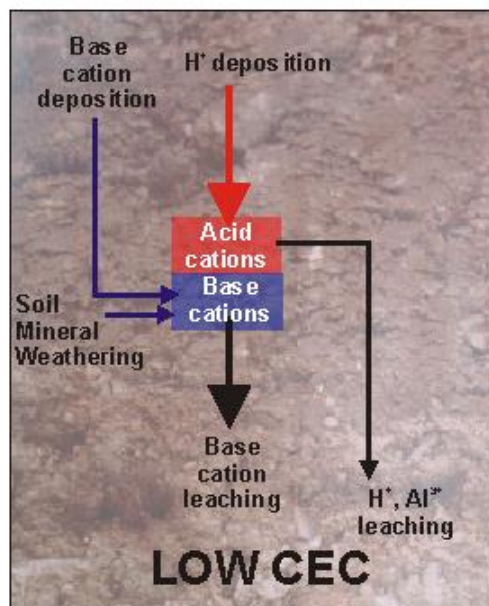
The soil acidification process



The soil acidification process



The Role of CEC and Aluminium in Soil Acidification



The soil acidification process summary

- Acid deposition (S, NO_x and NH_x) can increase acidity and reduce buffering capacity of soils
- pH drops and toxic aluminium ions can be released into the soil (toxic to plants) and can be leached to streams and lakes (toxic to fish)
- Acidity of rain water, measured by pH, is one measure of acid rain inputs but not the whole story
- The 'potential' acidity is released if ammonium is transformed to nitrate in the soil and leached

What is the risk of soil acidification?

Crucial Questions:

What is the acidic input to the soil from atmosphere and vegetation growth?

How much of the potential acidity in deposition is released?

How well can the soil buffer the acidic inputs?

Acidity and 'potential' acidity of rain

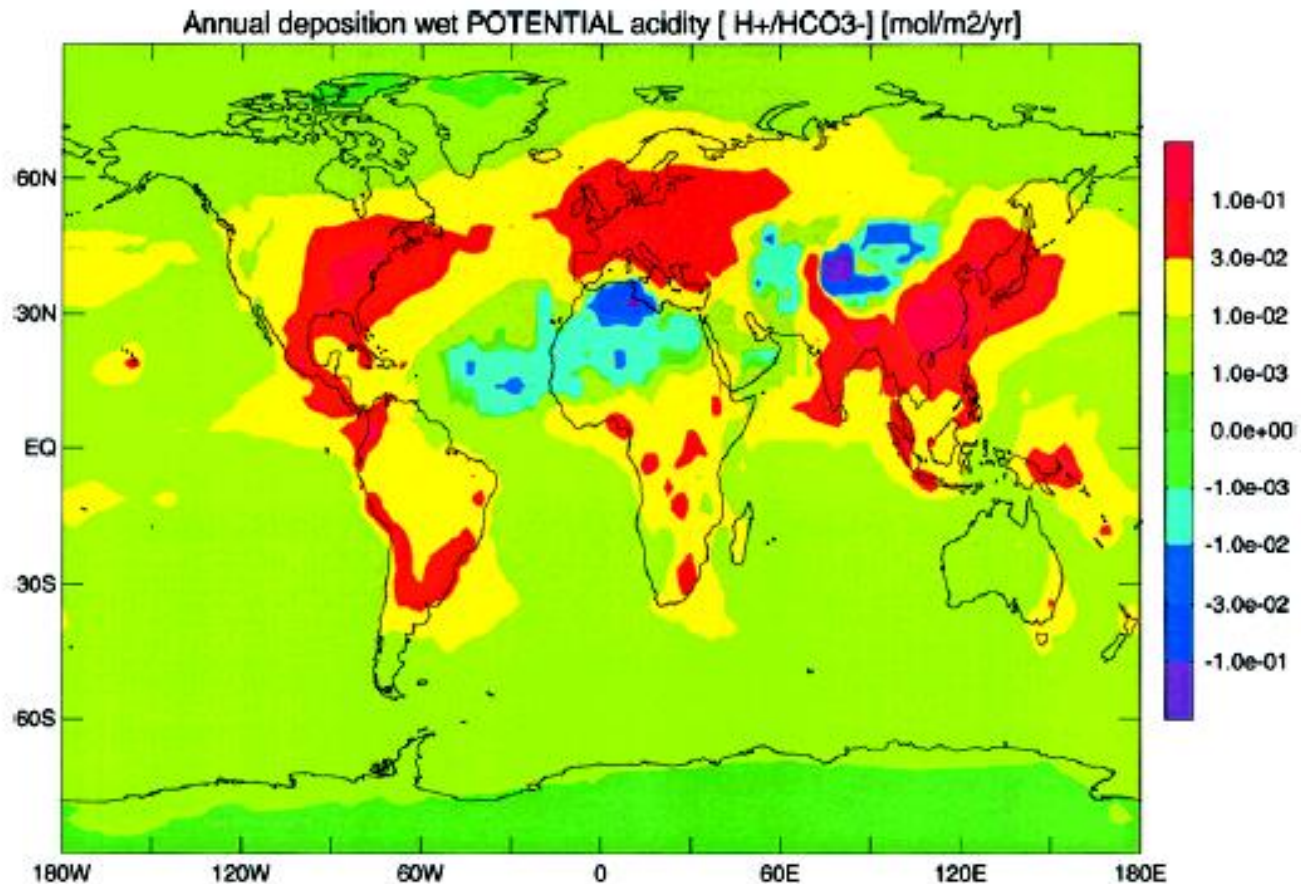
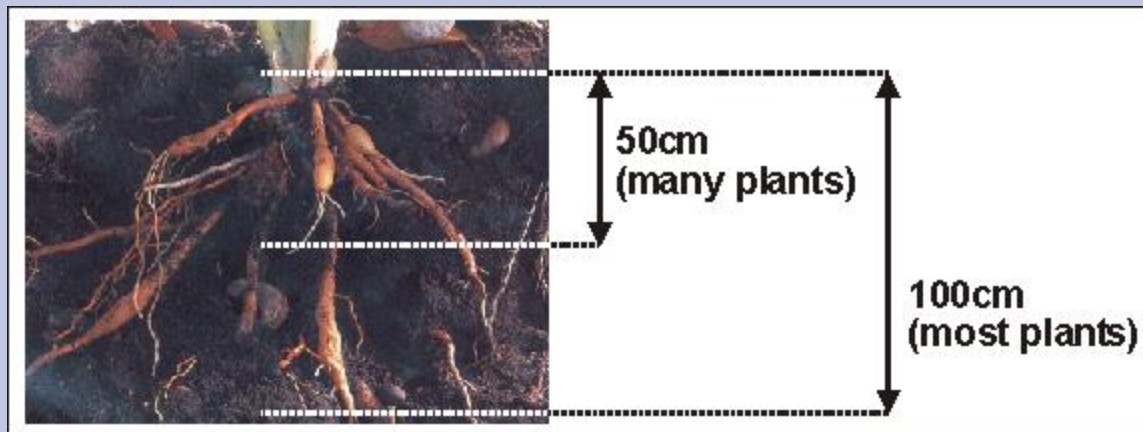


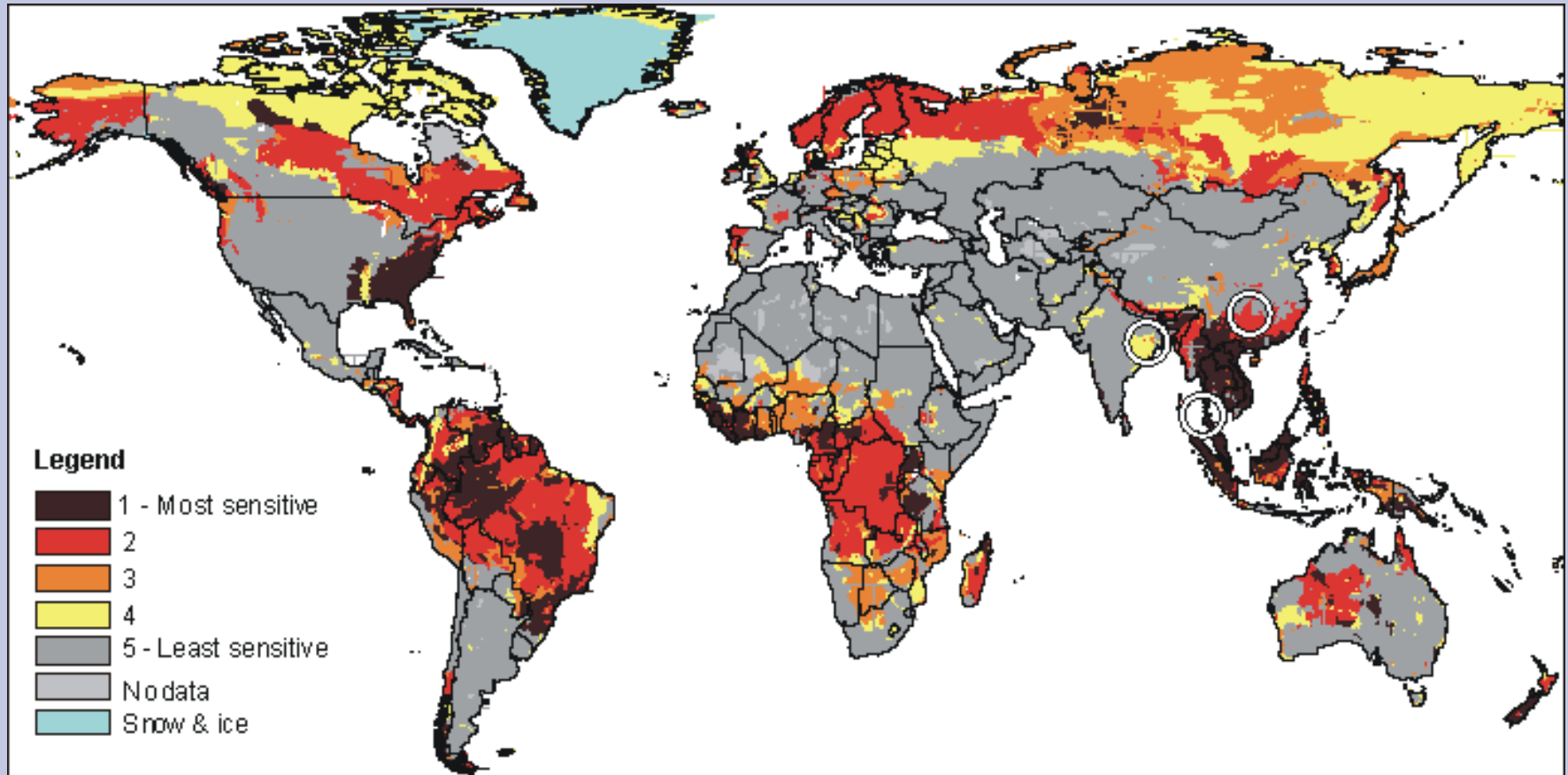
FIGURE 5. Annual wet deposition of potential acidity onto nitrogen saturated ecosystems according to eq 2. Positive values refer to H^+ , negative to HCO_3^- . The same color code is used as in Figure 4. The difference between the deposition of potential acidity (Figure 5) and acidity (Figure 4) is most pronounced in regions with high deposition of NH_3 , e.g. India and parts of South America. Unit: $mol\ m^{-2}\ a^{-1}$.

A Method to Assess Terrestrial Ecosystem Sensitivity to Acidic Deposition

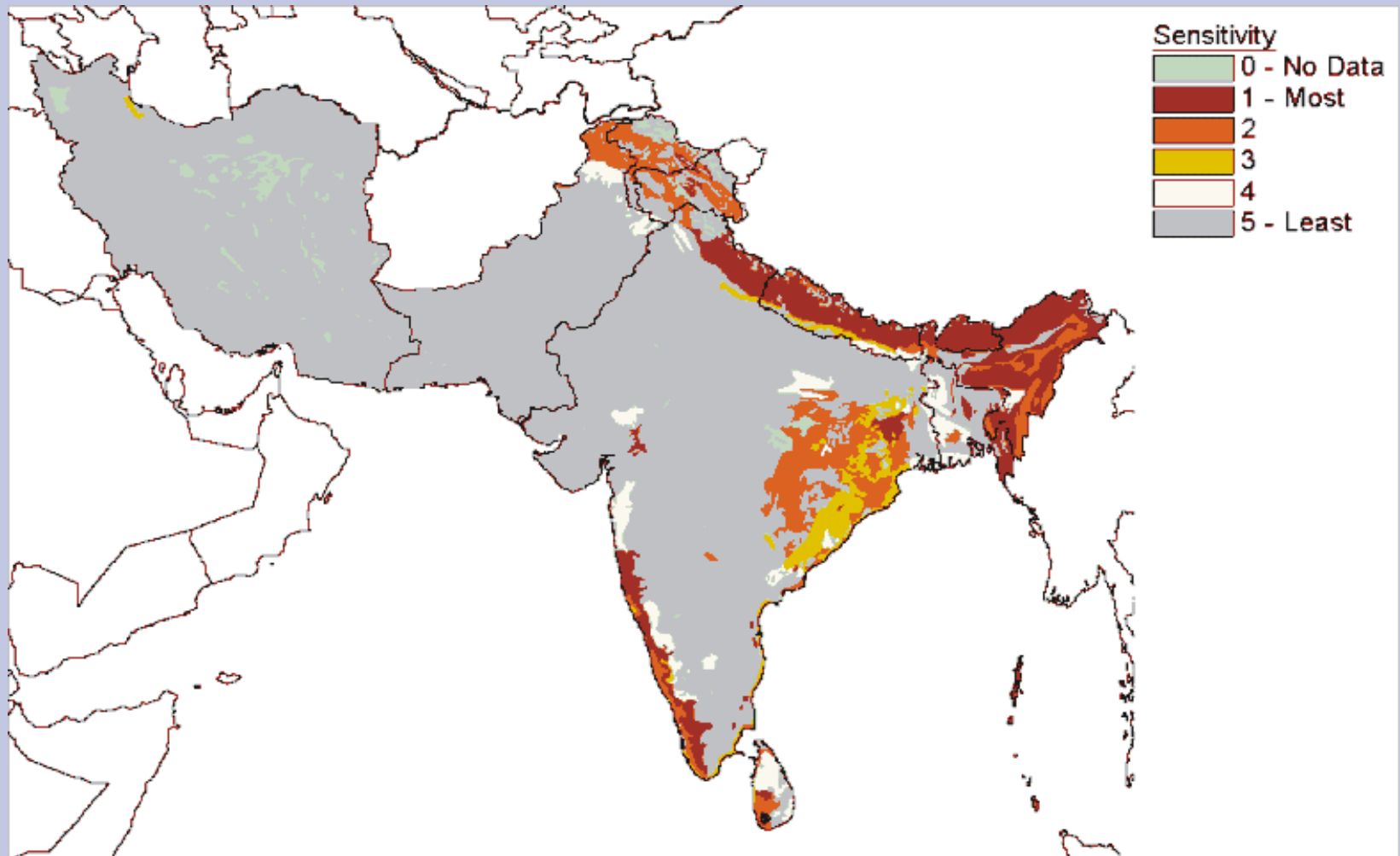
		Base Saturation % (mean over depth d)				
		0-20	20-40	40-60	60-80	80-100
CEC (Meq/100g)	10	1	1	2	3	5
	25	1	2	3	4	5
	>25	2	3	4	5	5



Global Map of Terrestrial Ecosystem Sensitivity to Acidic Deposition

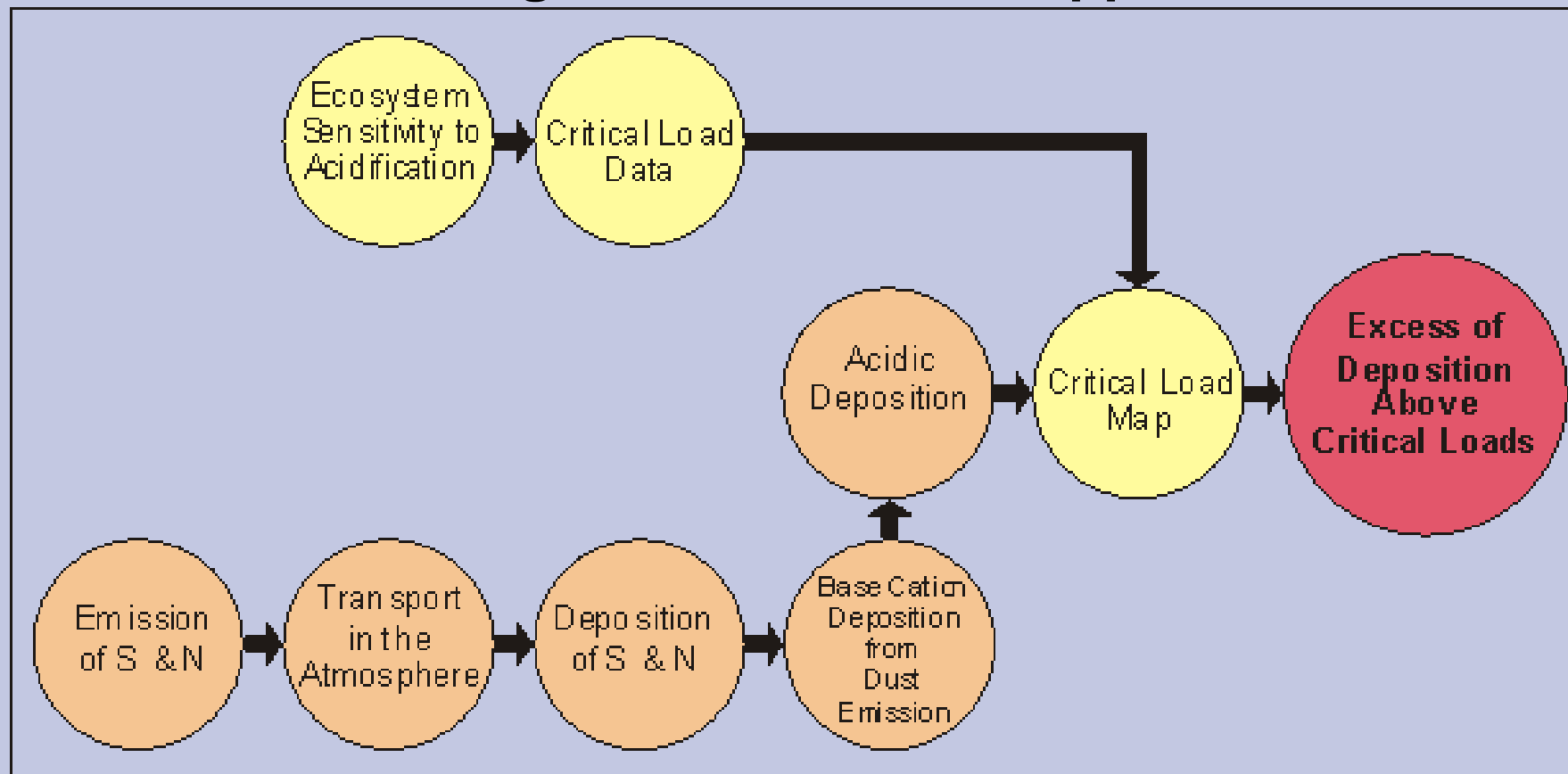


Terrestrial Ecosystem Sensitivity to Acidic Deposition in South Asia

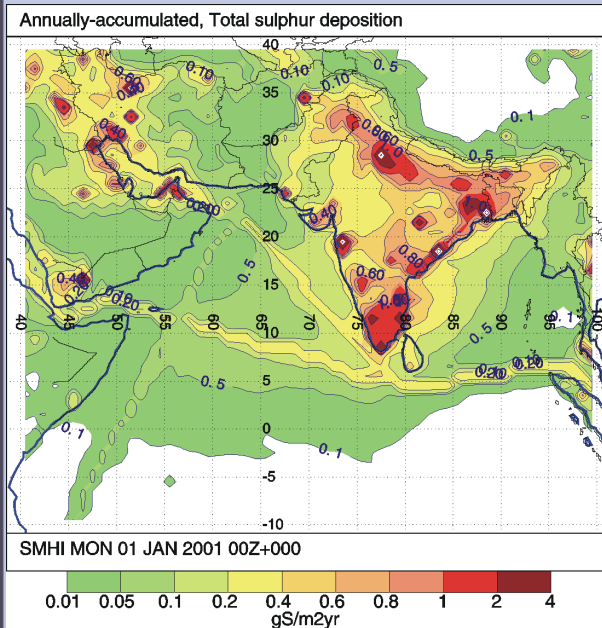


Source: Kuylenstierna *et al.* 2001

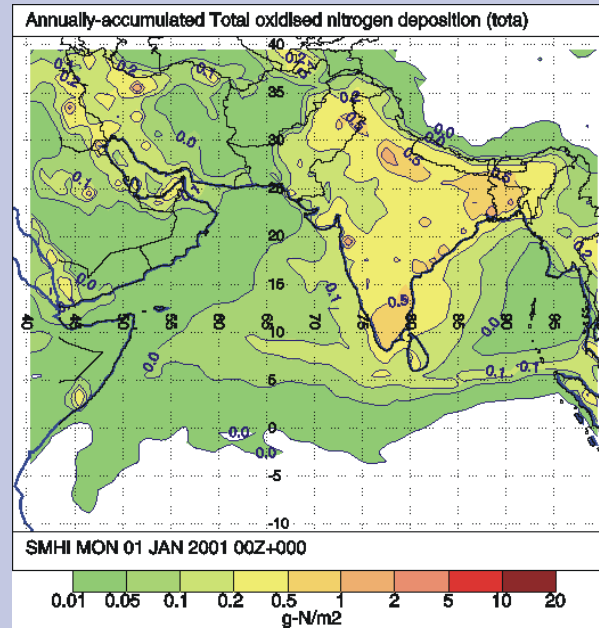
Calculating Risk of Ecosystem Damage Using the Critical Load Approach



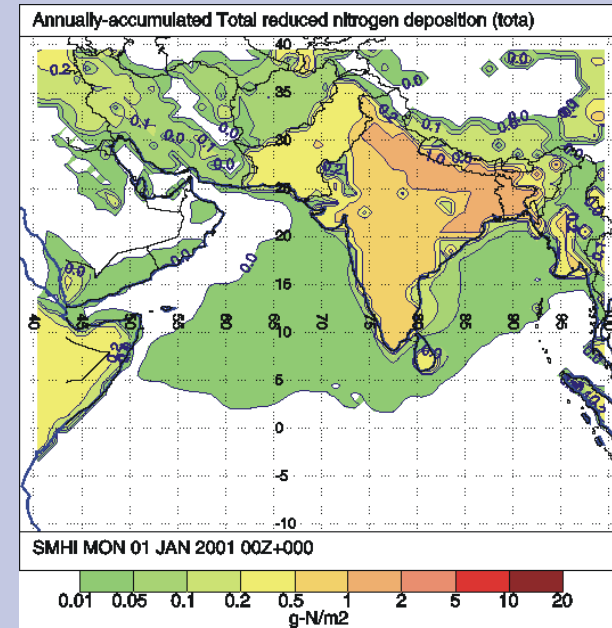
Acidic deposition in South Asia during 2001 using the MATCH model



Sulphur

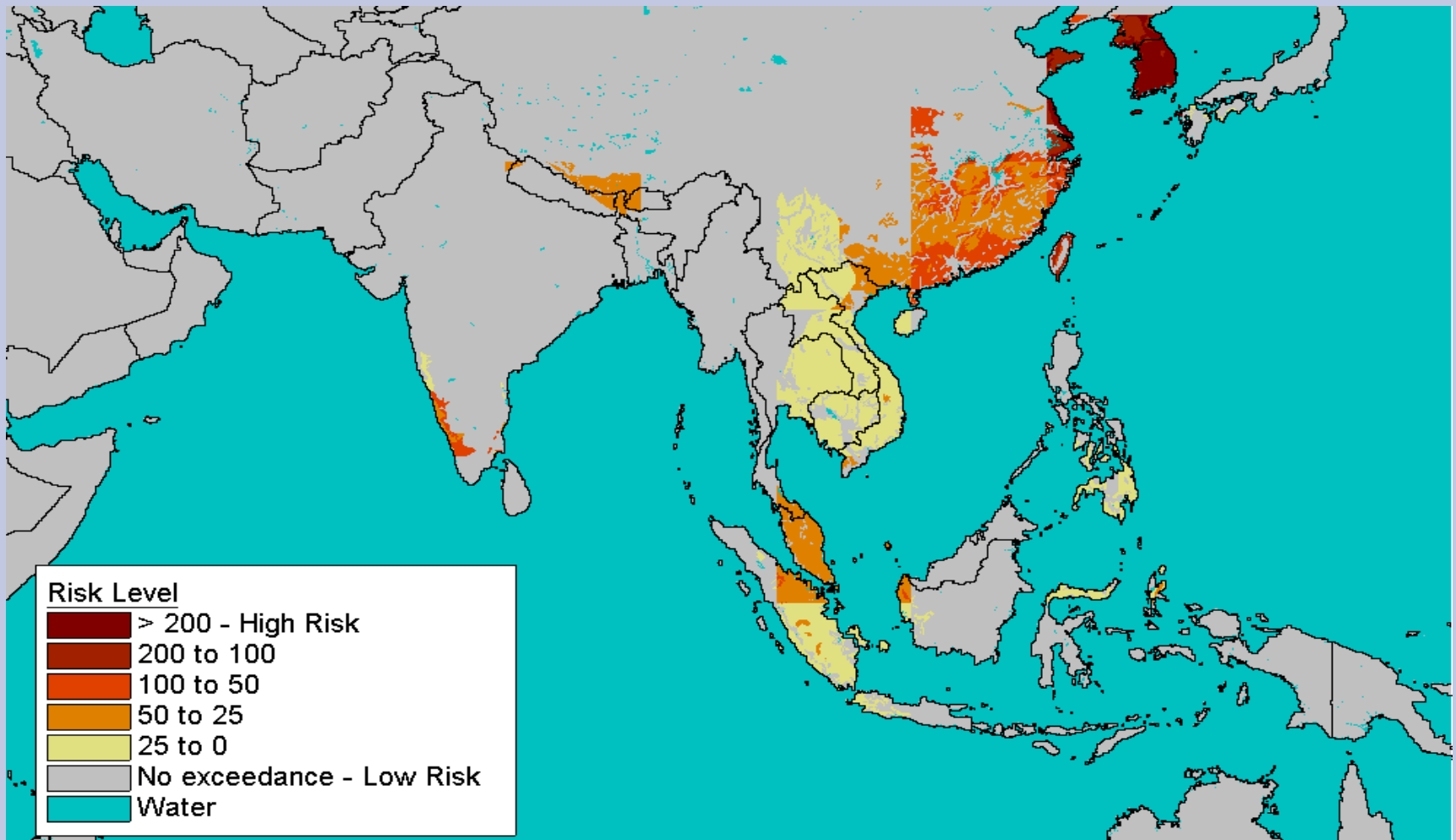


Oxidized Nitrogen

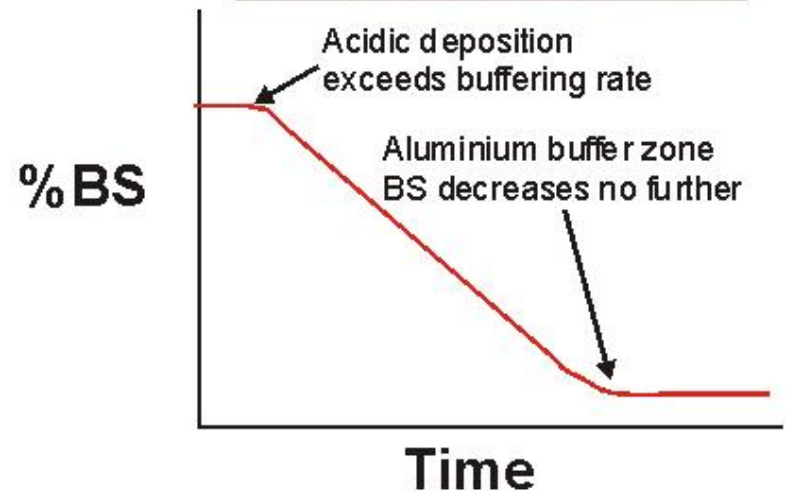
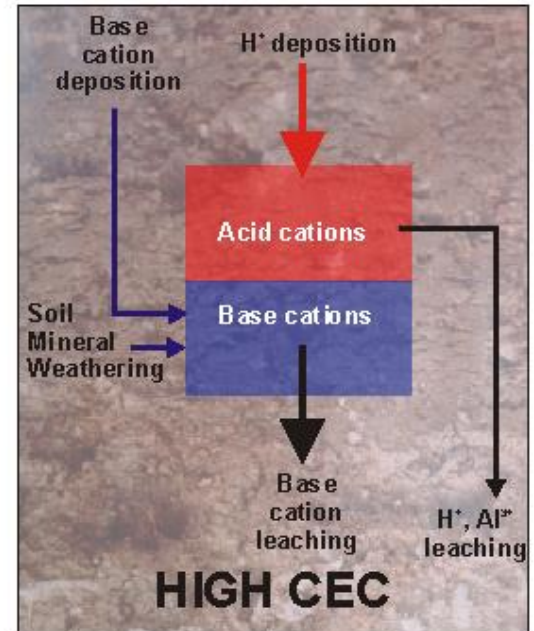
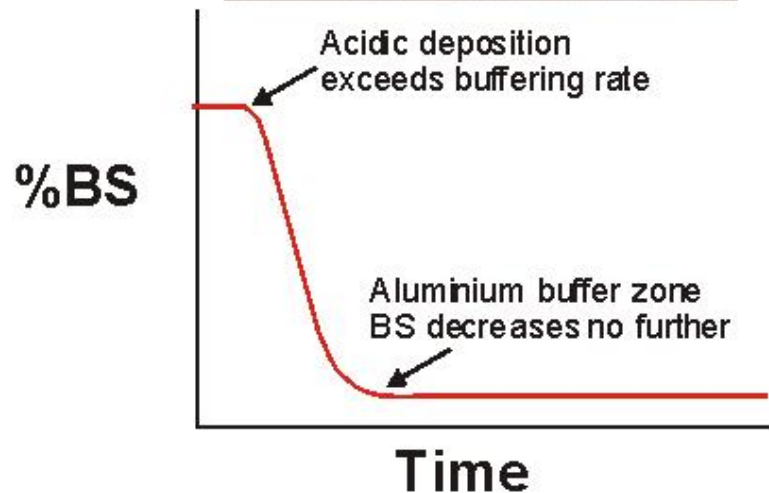
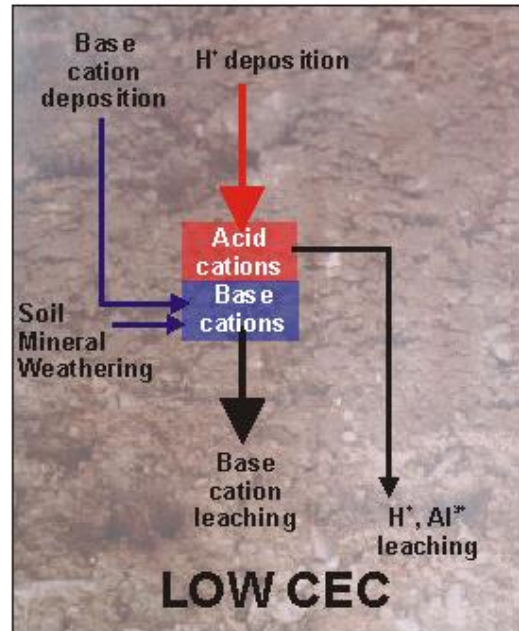


Ammonium

Estimated Risk of acidification



Time Development of Acidification in the soils



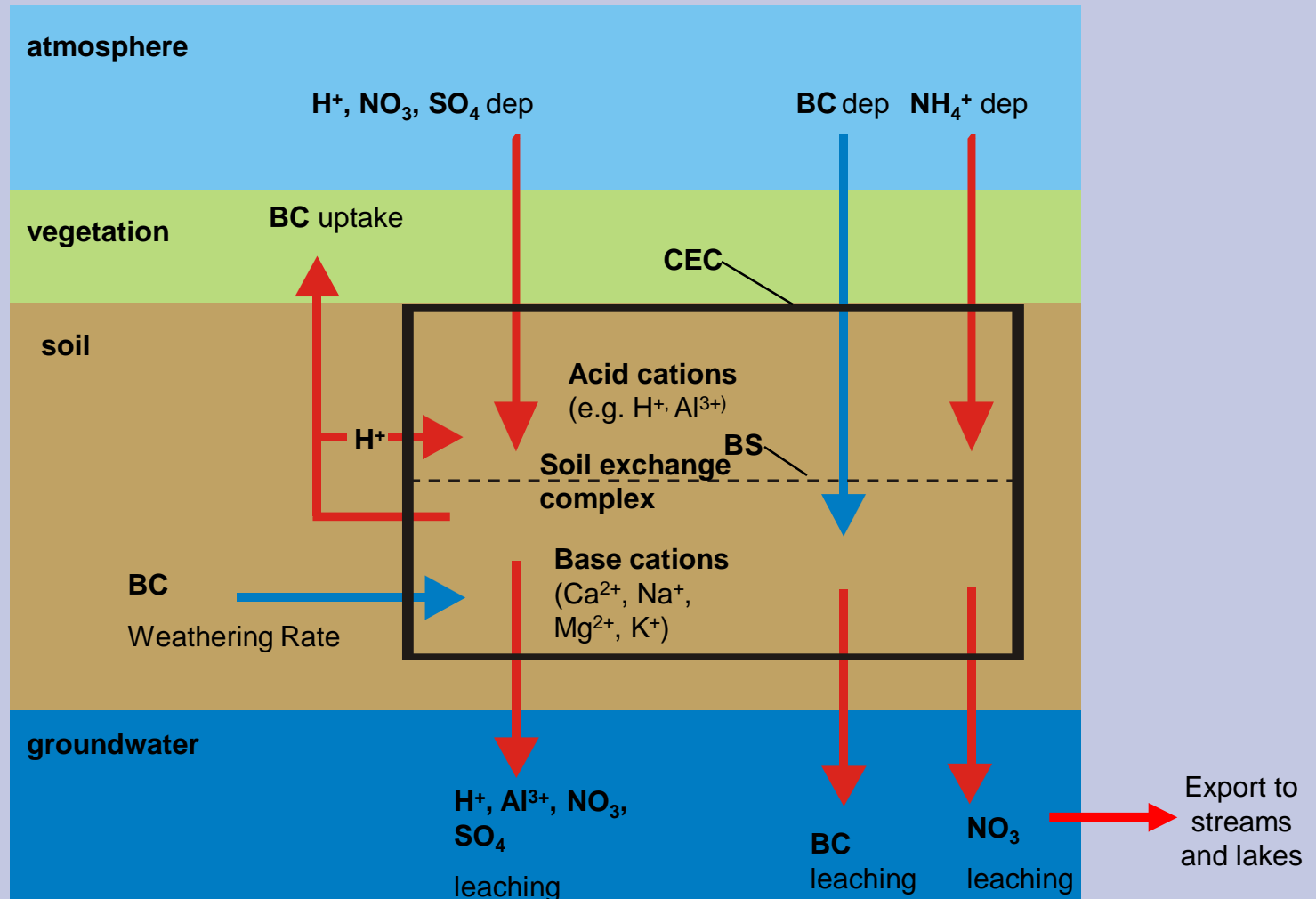
Estimating the time development of soil acidification damage

1. Sensitive soil type is chosen for which required data are available
2. The net annual acidifying input to the soil is calculated from:

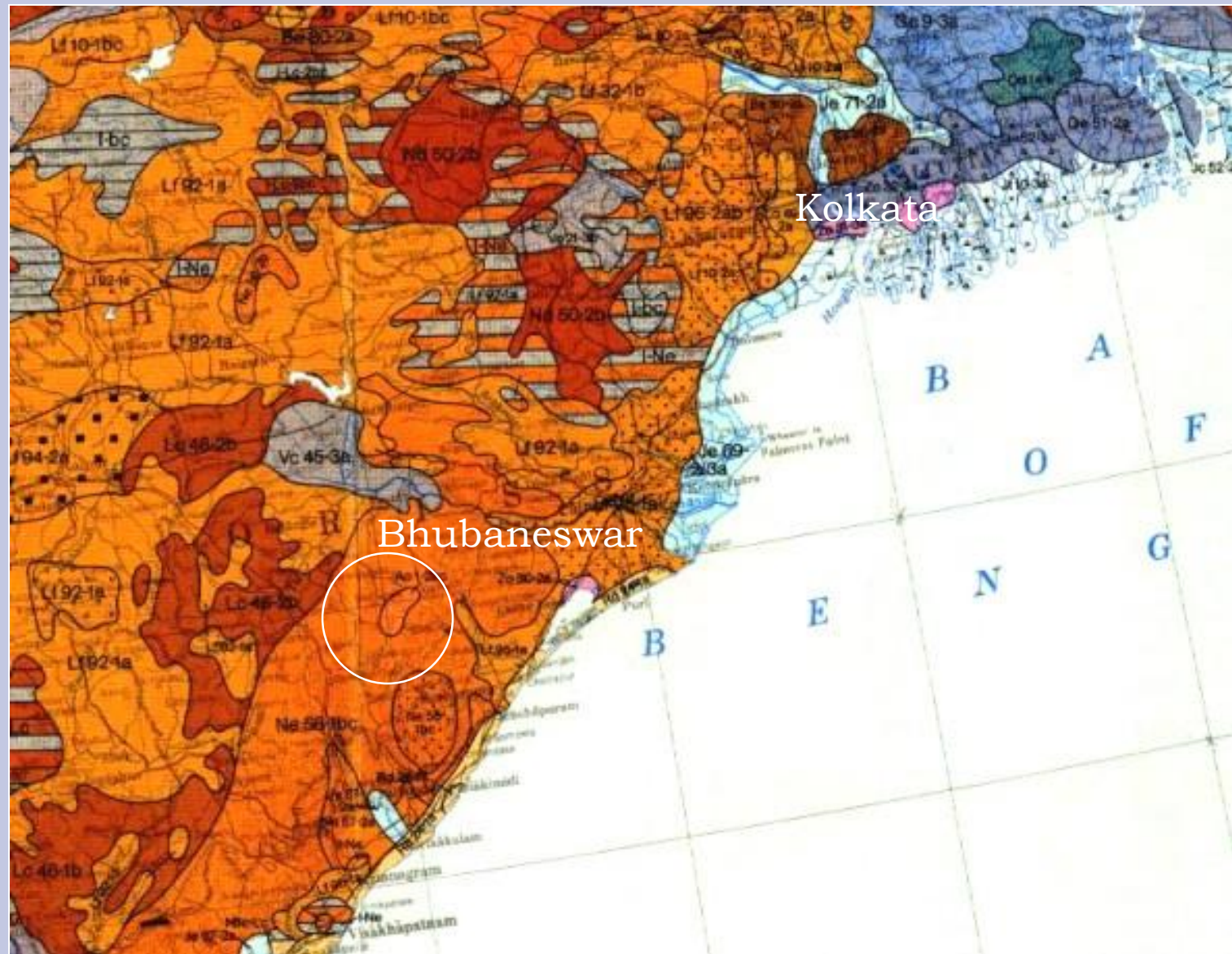
$$H^+_{\text{input}} = 2SO_4^{2-}_{\text{dep}} + fNO_3^-_{\text{dep}} + fNH_4^+_{\text{dep}} + \text{Vegetation}_{\text{uptake}} - 2Ca^{2+}_{\text{dep}} - WR$$

where f is the proportion of N deposition that leaches from the soil (all values are calculated in meq/m²/yr)

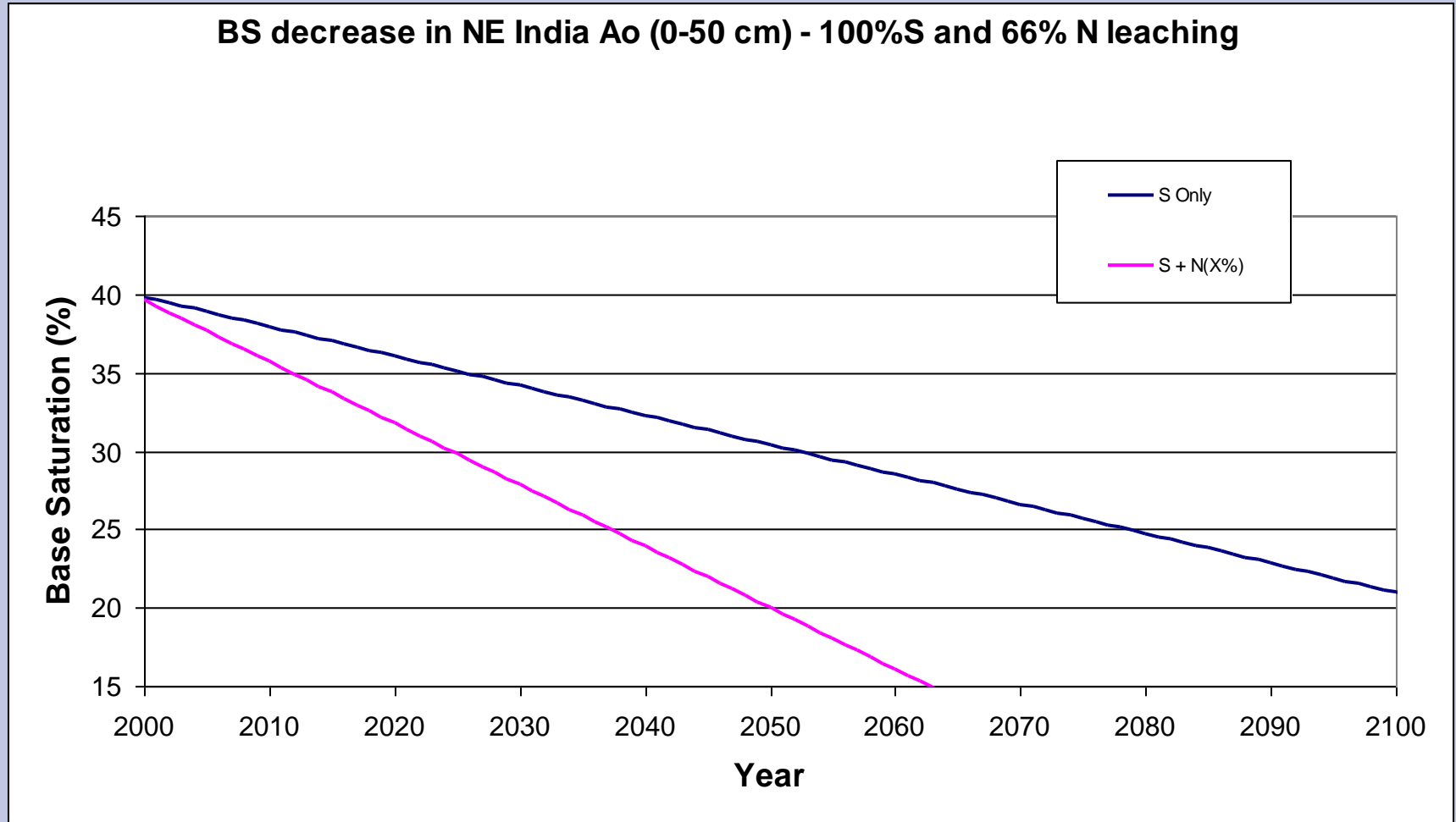
The soil acidification process



FAO Soil Map of the world for NE India



Time development of acidification damage for an Acrisol in NE India





Acidification in South Asia?

1. No evidence of acidification effects yet
2. Potential areas at risk: e.g. Western Ghats, NE India, Himalayas, Bangladesh, wet zone of Sri Lanka have sensitive soil types
3. Areas of high ammonium deposition may be especially at risk e.g. NE India
4. Whether acidification potential is realised or not depends on air pollution emission trends, soil properties and management



What actions can be taken?

Soils potentially at risk in each country must be identified and:

- relevant soil parameters measured
- pollutant load and its origins determined
- fate of nitrogen deposition in soil plant system and leaching determined
- management of the site studied e.g litter removed?



Next steps in Malé process?

1. Research required at national level on sensitive soils
2. Manual will be distributed in near future through NIAs

In Europe extensive and expensive liming was carried out to maintain buffering capacity of ecosystems





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Chinese proverb:

‘A **clever** man learns from his mistakes....

....a **wise** man learns from other people’s’

