Acidic air pollution and birds in Europe

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Evidence from a survey conducted by the European Continental Section of the International Council for Bird Preservation (ICBP–ECS) suggests that birds have not served as such good early warning indicators of ecological damage from acid precipitation as they have for damage from organochlorine pesticide use. Only a few highly specialized species have been badly affected, and then long after the impact was observed in other organisms. Some birds have even benefited from the superabundance of dead and decaying standing timber.

No one who is environmentally literate can today be unaware of the dire impacts of acidic air pollution on many lakes and forests throughout the northern hemisphere. In 1985, the ICBP European Continental Section carried out a survey to assess the consequences of acidic air pollution for birds and their habitats across Europe. The survey took the form of a simple questionnaire circulated to section chairmen during 1985–1986. Returns were received from 17 of the 29 sections concerned, including Sweden and the UK where the most active research is being carried out at present. These were compiled and an analysis presented at the ICBP-ECS Conference in 1987. The account presented here is a distillation of those aspects of the actual and potential effects European birds may experience from the environmental hazard posed by acidic air pollution and deposition, popularly referred to as 'acid rain'. During and subsequent to this project, more material has been published on this subject (see Bibliography), which has been incorporated in this paper where appropriate.

The ecology of acidic air pollution

It is neither appropriate nor necessary here to present a full description of the sources or chemistry of atmospheric acidification: these are fully documented in the publications listed in the bibliography. However, the basic processes involved are charted in Figure 1 as an aide-memoire. The following points are of particular importance.

(a) Atmospheric acidification results from the emission of several reducing molecules during combustion of fossil fuels and related photochemical processes, which reinforce each other (synergism) in a highly complex manner;

(b) Deposition of acidic material can be 'dry' (particulate matter) or 'wet' (molecules washed out through precipitation) and the pattern of deposition will vary according to the seasonal direction of prevailing winds and source of pollution (e.g. factories with tall chimneys throw their plumes higher, so the molecules travel further);

(c) The effects of atmospheric acidification vary from local episodes of high toxicity to widespread, low-level, long-term insidious poisoning. For example, acid molecules in more northern latitudes are chiefly deposited and accumulated in snowfall: when the snow melts in spring, there can be a sudden and very dangerous pulse of acidic water entering streams and lakes, resulting in high fish mortality. Acid aerosols in the form of mists and fogs form at high elevations, condensing on the vegetation and causing 'leaf burn' and bud disorders: conifers, being evergreen, are especially vulnerable in this respect. Over

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the last century, on the other hand, acid molecule concentrations in soils have been growing; once the latent buffering potential of a soil has been overloaded, an acid layer quickly forms, which prevents proper root growth (principally through leaching of crucial nutrient ions including potassium, magnesium and calcium, and release of toxic metal ions such as aluminium, manganese and cadmium), leading to the death of trees (especially conifers, which have shallow rooting systems) and the inhibition of natural regeneration by acid-sensitive plants.

Effects of acid pollution on European birds

While there is overwhelming evidence for the enormous ecological and economic damage to coniferous forests, fisheries, crops, livestock, monuments and human health resulting from acid pollution, the situation with respect to birds is far less clear. Even in areas where acid pollution occurs at a high concentration, there seems to be no evidence that acid pollution of itself necessarily leads directly to bird mortality in the same way that it is a precursor for poisoning of

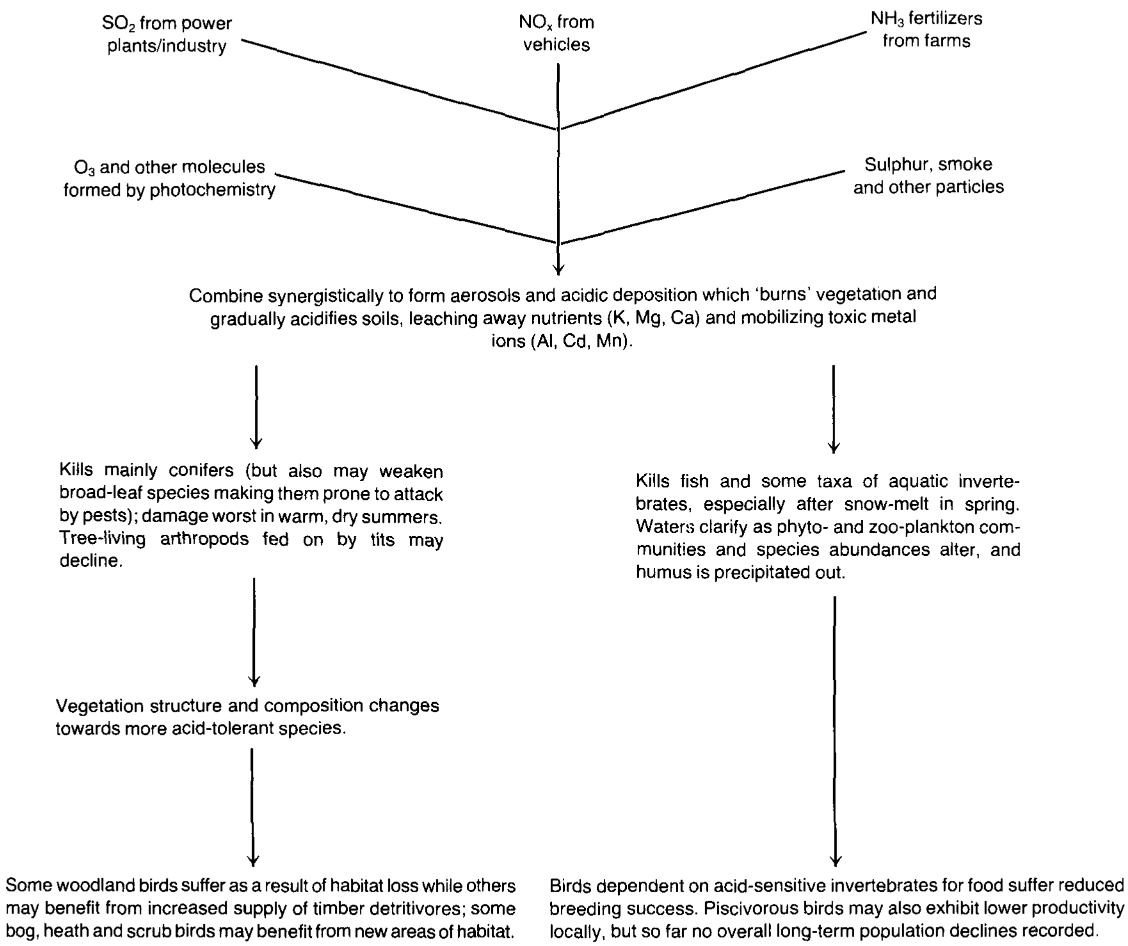

Figure 1. Diagram outlining some processes of the ecological effects of acid pollution.

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lichens, trees, aquatic invertebrates and fish; this contrasts with the demonstrable lethal effects suffered by birds from the careless use of pesticides. Although high levels of cadmium have been found in kidneys and livers of capercaillie *Tetrao urugallus* and black grouse *T. tetrix*, and aluminium in the tissues of pied flycatchers *Ficedula hypoleuca*, breeding close to acidic lakes in Sweden (possibly acquired through feeding on emergent aquatic insects), laboratory experiments have so far failed to link these elements with lower breeding success except at very high levels, when phosphorus is also low. To date, it has not been possible to pick up a bird carcass and say 'this bird died from acid rain', though, equally, one cannot dismiss acidification entirely as a contributory cause to local bird mortality.

If acid pollution poses an immediate threat to bird populations, it is through the more indirect effects of loss of food (including possible reduced calcium availability in the diet, thus affecting eggshell strength) and loss of habitat. The types of prey most affected are aquatic invertebrates and fish (particularly small species or younger age-classes of larger species).

Effects on insect-feeding birds

Whether or not an invertebrate is affected by acidification or elevated metal ion concentrations appears to be variable between taxa. This is probably because one notable effect of acidification is a fundamental change in the composition and abundance of the phytoplankton and zooplankton inhabiting the waterbody, so while some invertebrates benefit (e.g. Corixids and *Chaeoborus* spp.), others suffer. In general, however, overall productivity and biomass under acid conditions gradually declines, and invertebrate prey becomes scarcer at least in the short term.

Birds that are generalized invertebrate feeders (e.g. dabbling ducks or grey wagtails *Motacilla cinerea*) may therefore remain largely unaffected for some time, especially if competition for food is eased by the absence of fish. The one species that specializes on aquatic invertebrates known to be vulnerable to acidification is the dipper *Cinclus cinclus*. Dippers rely heavily on caddisfly (Trichoptera) larvae and mayfly (Ephemeroptera) nymphs during the breeding season, and these animals become fewer with increasing water acidity. Local declines of dipper populations have in fact been recorded in parts of Britain and West Germany. Here, some waters have become more oligotrophic owing to the increased acidity resulting from precipitation exacerbated by changed land-use (especially afforestation) in the catchment area.

Effects on fish-eating birds

Though riverine fish, particularly trout and salmon, are badly affected by acidification, it is in the standing waters of lakes where the problem is most severe and can sometimes lead to the total elimination of all fish species (11,000 of Sweden's 85,000 lakes are so affected). The prime cause of fish mortality is the ionic release of aluminium, an element that is extremely toxic to fish (and now implicated in the onset of Altzheimer's disease in humans), into the groundwater. Since smaller fish (both in terms of species and age) seem to suffer more than larger ones from higher aluminium concentrations, the more usual situation is for an acidified lake to support fewer, larger fish. How long these residual populations survive depends on many factors, varying from lake to lake.

A further effect of acidity in lakes is the precipitation of humus, leading to much clearer water. This effect can complicate the assessment of the extent of damage caused by acidification to birds dwelling on freshwaters because the transparent and sparkling acidified water is highly attractive to humans: many lakes are thus subjected to increased recreational activity and the ensuing disturbance can be as serious a problem as the reduced availability of food.

Obviously, piscivorous birds cannot utilize lakes or water-courses where fish have completely disappeared, but at the moment this seems to be a relatively rare phenomenon in Europe as a whole. The impact of reduced fish populations on fish-eating birds inhabiting an acidified waterbody seems to depend on their foraging behaviour. Thus, for diving species such as black-throated divers *Gavia arctica* and goosanders *Mergus merganser*, the increased clarity of water aids detection of fish, and so probably compensates for reduced abundance, at least for a time. Plunging species like ospreys *Pandion haliaetus*, kingfishers *Alcedo atthis* and common terns *Sterna hirundo*, on the other hand, do not benefit at all from the higher transparency of the water, and have to spend more time catching the fewer fish available. Ospreys in parts of Sweden have been shown to suffer reduced productivity, probably as a result of reduced fishing success, and fewer kingfishers have been counted on acidic streams than on non-acidic streams in upland Wales.

Effects of general habitat loss

It is self-evident that while conifer forests are dying across large parts of Scandinavia, northern Britain and central Europe, then the birds that depend on them for food and breeding may be facing the prospect of population declines and/or range contractions. Such species include the firecrest *Regulus ignicapillus*, crested tit *Parus cristatus*, siskin *Carduelis spinus*, citril finch *Serinus citrinella*, crossbills *Loxia* spp. and nutcracker *Nucifraga caryocatactes*. The corollary, however, is that the dead standing timber can provide additional habitat for relatively uncommon or rare species of woodpeckers (e.g. three-toed woodpecker *Picoides tridactylus*), and the broken tree cover and regeneration of acidophilous bog, heath or scrub vegetation may help birds like the black grouse, nightjar *Caprimulgus europaeus*, pipits *Anthus* spp., red-backed shrike *Lanius collurio* and grasshopper warbler *Locustella naevia* to name but a few.

Conclusions

A number of points emerged from the documentation collected by the ICBP-ECS. The first is that despite the abundance of ornithologists in Europe and the amount of census work that is carried out, so far no regional, let alone national, bird populations (as opposed to those of discrete localities, such as dippers inhabiting acid-sensitive areas of upland Wales) have been shown to be threatened principally as a direct result of acid air pollution. This situation may change if and when a census of the internationally important osprey breeding population in Sweden is carried out; there has not been a count since the early 1970s, when the impact of acidification was still fairly limited and unrecognized.

In fact, birds have performed poorly as early indicators for environmental damage caused by acidic air pollution: marble statues, fish and lichens have been much more sensitive. Instead, birds have generally proved themselves to be quite robust in terms of adjusting to the altered habitats and food sources. This phenomenon, incidentally, has also been observed in other similar circumstances of habitat alteration: the almost total loss of elms, *Ulmus* spp. as a major component of British hedgerows as a result of Dutch Elm Disease, for example, apparently did not significantly threaten any bird population.

It may be that the poor reproduction noted in some populations of birds using acidified habitats is compensated by better survival of other progeny raised in unaffected areas, especially if the species is migratory, in as much that intraspecific competition for food and territories in the winter quarters and at stop-over sites may be reduced. Moreover, migratory species breeding in northern snow-bound latitudes may not arrive on the breeding grounds until after the spring surge of acid water has passed, thus escaping exposure during the period of highest toxicity in the environment.

Nevertheless, while ornithologists do not seem to be able to lend any more weight to the already considerable evidence for the environmental damage caused by acid air pollution, there is a clear feeling of unease about the future for some bird species, especially in those countries most affected by acid air pollution (Table 1). There is certainly no room for complacency as soils become ever more incapable of supporting sub-surface organisms, from microbes to earthworms, essential for healthy tree growth and as food for moorland species like ring ouzels *Turdus torquatus*. In large parts of Europe, acidification is overtaking snow and wind damage as the single most important cause for tree dieback. Some ICBP sections, moreover, were concerned that they did not possess sufficient information about how to detect possible damage to birds and their habitats from acid air pollution.

A further perspective on the issue that can only

Table 1. List of European countries most and least affected by acid pollution, according to ICBP European Sections and bibliographic sources.

Most affected countries	Least affected countries
Austria	Greece
Belgium	Iceland
Czechoslovakia	Ireland
East Germany	Malta
Finland	Turkey
Norway	
Poland	
Soviet Union	
Sweden	
Switzerland	
West Germany	

be briefly mentioned here is that acid air pollution could be regarded as no more than one symptom of a more fundamental and serious problem, namely the lack of environmentally safe and integrated energy policies in Europe as a whole. For instance, a shift away from coal-fired power stations (as a source of acid air pollution) and nuclear power stations (following the Three Mile Island and Chernobyl incidents) in the UK could lead to greater promotion of schemes for tidal barrages on estuaries vital for huge populations of wintering waterbirds.

At their 1987 meeting, the ICBP-ECS felt that rather little hard information about acid pollution and its effects on birdlife across Europe as a whole had emerged, although intuitively it seemed that serious impacts were in progress. Therefore the ICBP-ECS passed two recommendations to improve bird conservation efforts in this area:

- To devise and institute a system of regular sample censuses for birds clearly likely to suffer from acid air pollution, taking into account factors such as habitat loss and intrinsic fecundity, and linked to existing research projects, e.g. divers (Gaviidae), herons (Ardeidae), osprey (*Pandion haliaetus*), dipper (*Cinclus cinclus*).
- To promote implementation and strengthening of existing international agreements concerning the control of air pollution (e.g. the UN Economic Commission for Europe Convention on Long Range Transboundary Air Pollution, 1983 and the EEC Council Directive 84/360 on the Combating of Air Pollution from Industrial Plant), as well as new legislation under preparation.

The Swedish National Section of ICBP is co-ordinating activities relating to these recommendations and further enquiries can be addressed to ICBP-ECS Acid Rain Project, ICBP-Sweden, SNF, Box 6400, S-11382, Stockholm.

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This report is based on the responses to questionnaires from 17 of the 29 Sections which comprise the ICBP European Continental Section; these are held by the ICBP-ECS Secretary, c/o RSPB, The Lodge, Sandy, Beds. In addition, the following sources have been used.

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