Summary

Until the 1950s, habitat degradation, human persecution and human disturbances were the main factors responsible for the long-term population decline of the white-tailed eagle (*Haliaeetus albicilla*) in Europe. The reproduction of white-tailed eagle population was severely impaired by the “raptor pesticide syndrome”, due to the application of DDT in agriculture and forestry since the end of the 1940s. DDT, especially its main metabolite DDE, biomagnified into the food web and caused in top predators, as white-tailed eagles and ospreys (*Pandion haliaetus*), eggshell thinning and altered eggshell structures. These impaired eggshell characteristics induced egg breakage by the weight of breeding adults and embryo-mortality, caused by the altered gas exchange through the eggshell. These symptoms were considered to cause the long-term population decline of white-tailed eagles from the 1950s to the end of the 1970s. Contrarily to the white-tailed eagle, there was no prove for any impaired reproduction for the northern goshawk (*Accipiter gentilis*) during the period of DDT usage in Germany. The population dynamics of the northern goshawk were assumed to be mainly influenced by human disturbances and illegal persecution, especially in rural areas. Since the last decade northern goshawks colonized urban regions very successfully, favored by the year-round high abundances of feral pigeons, their main prey.

Because of the high persistence and the bioaccumulation characteristics, the insecticide DDT, as well as further chlorinated pesticides, like HCB, were banned in the 1970s and 1980s in most countries of Europe. Currently, lindane® (γ-HCH) is the only chlorinated insecticide tolerated in Germany. The polychlorinated biphenyls (PCB) that have a similar structures like DDT, were widely used for industrial purposes, because of their chemico-physico properties. The production and usage of PCB has been banned in Germany nowadays.

The potentially toxic heavy metals like lead (Pb), cadmium (Cd) and mercury (Hg) are ubiquitous. They are released into the environment by geological processes and up to several orders of magnitudes higher by anthropogenic emissions mainly by industry, traffic and waste combustion. Heavy metals were used as paint pigments and for batteries. Lead was used as petrol additive until the 1980s. Mercury compounds were used as seed dressings and fungizides and unintentionally, cadmium as part of phosphate-fertilizers in agriculture. Lead is in use for ammunition

and fishing weights.

These heavy metals induce above all:

- weight loss
- behavior alterations
- enzyminhibition
- anemia
- nephrotoxicity
- immunosuppression
- reproduction disorders
- CNS-symptoms
- teratogenic, carcinogenic and mutagenic effects

Only the lipophilic organic-Hg compounds accumulate in the food-web, like the organochlorines. They accumulate in adipose tissue and the nervous system (e.g. CNS). Nonorganic Pb, Cd and Hg accumulate in liver and kidneys, and Pb particularly in bones, instead of calcium.

In the present study, we examined organs of white-tailed eagles from Germany and Austria, as well as northern goshawks from different regions of Germany for their organ concentrations of chlorinated hydrocarbons and potentially toxic heavy metals.

In the pine forests of the regions of the former German Democratic Republic DDT was applicated by airplanes in high amounts to control a pest of the moth *Lymantria monacha* in the years 1983 and 1984, including Brandenburg and Mecklenburg-Western Pomerania. Finally, DDT was banned in the German Democratic Republic in 1988. Therefore, most samples of the white-tailed eagles found in these regions from 1990 to 2001 are representative for the period following the ban of DDT. The present study proved a significant decline of ΣDDT concentrations in liver tissue of 127 immature and adult white-tailed eagles collected between 1990 and 2001. This decline of ΣDDT concentrations in organs of eagles and the improved reproduction and the population increase of northern Germany in

recent years are discussed. The ratio of ΣDDT:ΣPCB in livers of eagles proved a stronger decline for ΣDDT than for ΣPCBs. There was no significant long-term trend for ΣPCBs in the same period. The concentrations for γ-HCH, PCB 28 and PCB 52 were negligible. The penta-, hexa-, heptachlorinated biphenyls (PCB 118, PCB 138, PCB 153, PCB 180) accumulate in hepatic and adipose tissue, respectively. Interpretation of these organ concentrations was difficult, because individual body condition revealed a strongly negative relationship with hepatic contaminant concentrations. During catabolic metabolism the stored body fat is metabolized and the lipophilic organochlorines are mobilized and distributed through the blood stream to highly metabolic active organs, e.g. the liver. Therefore birds with decreasing fat deposits had, in general, elevated concentrations of the lipophilic organochlorines in the liver. One adult white-tailed eagle, found dead in the year 1979, had concentrations for ΣDDT in the liver that were assumed for a lethal intoxication.

However, the present study proved that white-tailed eagles are at high risk for metal toxicosis. Twenty-eight percent (28%) out of 57 free-ranging white-tailed eagles from Germany and Austria had elevated lead concentrations in their liver, indicating lethal lead exposure. Numerous international investigations and some experimental studies proved that these fatal lead poisonings in birds of prey, e.g. white-tailed eagles, are solely attributable to the ingestion of lead ammunition. The strong acid gastric juice of raptors results in a higher solubility of metallic lead, favoring a higher intestinal absorption.

The white-tailed eagles, and other raptors, are exposed to lead ammunition through foraging of shot-crippled and therefore handicapped prey, e.g. waterfowl, and scavenging of shot game or gut piles. We assume that shot game may have been placed intentionally in the fields to support the eagles during the winter season or to get some short distance spots for wildlife photographers.

We measured mercury concentrations in organs, which were far below the concentrations reported in studies conducted during the period when organo-mercury compounds were used as seed-dressings. Whereas these studies reported lethal concentration during the 1970s, we could not prove any lethal concentrations. The concentrations for cadmium were in general two up to ten magnitudes higher in kidneys than in liver tissue. All cadmium concentrations were considered to be harmless for birds.

One out of 62 examined northern goshawks was diagnosed for lethal lead

poisoning. Two further goshawks had lead concentrations in their organs, which were indicative for acute lead exposure, one of both was euthanized because of the severe symptoms of lead poisoning, e.g. paralyzed legs.

Northern goshawks from Berlin and Brandenburg had significantly higher hepatic concentrations for ΣDDT than birds from Lower Saxony. These higher DDT concentrations in goshawks from regions of the former German Democratic Republic were assumed to result from application of DDT in the years 1983 and 1984 in Brandenburg and the overall late ban of DDT in these regions. Furthermore, we discuss the manufacturing of DDT in Berlin during the past as a local source for the extraordinary high ΣDDT concentrations in some “urban” goshawks from Berlin. Highly contaminated feral pigeons in Berlin were suspected as vectors for these high levels of chlorinated contaminants in the livers of goshawks.

Comparing the adult goshawks from Berlin, females had higher hepatic concentrations of ΣDDT and higher chlorinated PCBs than the males.

Similar to the white-tailed eagles we proved a strong relationship between individual body condition and organ concentrations for the lipophilic organochlorines. Beside the three goshawks with high lead concentrations, all other metal concentrations in livers and kidneys were harmless and in the range of background contaminations. The organ distributions for cadmium is similar to those described for the white-tailed eagle.

Since the 1980s, the population of the endangered white-tailed eagle is steadily increasing in northern and eastern Europe. International experts expect the population of northern Germany to colonize suitable and yet unoccupied habitats in western and southern parts of Germany and in the Netherlands. The present study clearly proved a decline for ΣDDT in organs of 145 white-tailed eagles since the year 1979, which may have contributed to the increased breeding success since the mid 1980s. The findings of the extraordinary high mortality of white-tailed eagles caused by lead poisoning was supported by more than 160 investigated white-tailed eagles from Germany found between 1979 and 2002. About 25% of these 160 eagles had hepatic lead concentrations, which are known for lethal lead exposure in birds of prey.

This high mortality through lead poisoning impairs immature birds as well as adult white-tailed eagles mainly during the winter season and early spring, including

the main hunting season of Germany and Austria from October to January. The white-tailed eagle is a long-lived species, which starts breeding in general at an age of five years. Therefore, the high mortality caused by lead poisoning of even adult and experienced birds was assumed to slow down the process of colonization of suitable habitats outside the present distribution area in Germany, with its center in Mecklenburg-Western Pomerania, Brandenburg, Saxony and eastern Schleswig-Holstein.

The only solution to prevent lead poisoning in birds of prey and waterfowl caused by the ingesting of lead ammunition are demands for a mandatory ban or a final ban of lead shot at least in wetlands. In the USA, Canada, certain regions of Australia and some European countries lead shot for hunting waterfowl in wetlands was banned during the 1990s. The first ban for hunting waterfowl with lead shot was initiated in the USA in the year 1991. The Netherlands and Denmark established a total ban for lead shot. In Germany, the Federal Ministry of Food, Agriculture and Forestry and the German Hunting Association (DJV) have issued a common recommendation promoting the use of lead-free shot for hunting waterfowl in 1993. However, actually only the two counties Lower Saxony and Schleswig-Holstein banned the use of lead shot for hunting waterfowl in wetlands.

The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) developed under the Convention on the Conservation of Migratory Species of Wild Animals (CMS), also commonly known as the Bonn Convention, contains a resolution with the paragraph 4.1.4 “Parties shall endeavour to phase out the use of lead shot for hunting in wetlands by the year 2000”. The AEWA entered into force on 1 November 1999.

The Organisation for Economic Co-operation and Development (OECD), as part of its Risk Management Programme, and the recommendation No. 28 from 1991 of the Convention on the Conservation of European Wildlife and Natural Habitats, this convention is also known as the Bern Convention, concerns the use of non-toxic shot in wetlands.

There are high-quality commercially available non-toxic alternatives to lead shot, like steel-shot and further non-lead shot shell products, which are not to be discussed at this point.