The assessment endpoint for this ecological risk assessment is the maintenance of self-sustaining wildlife populations. Measurement endpoints include the growth and survival of individual animals, reproductive success, and behavior.

**Exposure of Piscivorous Wildlife to Mercury**

Exposure was characterized in a progressive manner, with varying reliance on computer models for mercury deposition and fate. The objective of this analysis was to characterize the extent to which piscivorous wildlife are exposed to mercury originating from airborne emissions. Details on exposure assessment inputs, methods and results can be found in Volumes III and IV of this Report. Three general approaches were used, which are described as follows.

**1. Estimation of current average exposure to piscivorous wildlife on a nationwide basis.**

The first analysis was conducted without computer models. Estimates of current mercury exposure to selected piscivorous wildlife species were calculated as the product of the fish consumption rate and measured mercury concentrations in fish. This analysis was not intended to be a site-specific analysis, but rather to provide national exposure estimates for piscivorous wildlife. This analysis used mean total mercury measurements from two nationwide studies of fish residues and published fish consumption data for the selected wildlife species. The relative ranking of exposure in $\mu$g/kg bw/d of selected wildlife species was as follows: kingfisher > river otter > loon =osprey = mink $\geq$ bald eagle.

**2. Estimation of mercury deposition on a regional scale (40 km grid) and comparison of these deposition data with species distribution information.**

The second type of analysis was carried out on a regional scale. A long-range atmospheric transport model (RELMAP) was used in conjunction with the mercury emissions inventory provided in Volume II of this Report to generate predictions of mercury deposition across the continental U.S. Ecosystems subject to high levels of mercury deposition will be more exposed to mercury than ecosystems with lower levels of mercury deposition. The pattern of mercury deposition nationwide, therefore, will influence which ecoregions and ecosystems might be exposed to hazardous levels of mercury. Thus, predictions of mercury deposition were compared with the locations of major lakes and rivers, national resource lands, threatened and endangered plant species and the distributions of selected piscivorous wildlife species. Additionally, mercury deposition data were superimposed onto a map of surface waters impacted by acid deposition, because it has been shown that low pH values are often correlated with high levels of mercury in fish. The extent of overlap of selected species distributions with areas receiving high rates of deposition (>5 $\mu g/m^2$) was characterized.

Avian wildlife considered in this analysis included species that are widely distributed (kingfishers) and narrowly distributed (bald eagles, ospreys, and loons). All the birds selected were piscivores that feed at or near the top of aquatic food chains and are therefore at risk from biomagnified mercury. Two of the mammals selected for this analysis (mink and river otters) are piscivorous and widely distributed. The other mammal selected, the Florida panther, is not widely distributed but is listed as an endangered species. The Florida panther lives in an environment known to be contaminated with mercury and preys upon small mammals (such as raccoons), which may contain high tissue burdens of mercury. Results for each avian and mammalian species are summarized in Table ES-1.

Approximately 29% of the kingfisher's range occurs within regions of high mercury deposition. On a nationwide basis, mercury does not appear to be a threat to this species. However, kingfishers consume more mercury on a body weight basis than any other wildlife species examined.

**Table ES-1**
**Percent of Species Range Overlapping with Regions of High Mercury Deposition**

| Species | Percent of Range Impacted |
|---|---|
| Kingfisher | 29% |
| Bald Eagle | 34% |
| Osprey | 20% |
| Common Loon | 40% |
| Florida Panther | 100% |
| Mink | 35% |
| River Otter | 38% |

Although a recovery in the population of bald eagles has resulted in a status upgrade from "endangered" to "threatened" in five states (Michigan, Minnesota, Oregon, Washington and Wisconsin), bald eagle populations are still depleted throughout much of their historical range. Bald eagles can be found seasonally in large numbers in several geographic locations, but most of these individuals are transient, and the overall population is still small. Historically, eagle populations in the lower 48 states have been adversely impacted by the effects of bioaccumulative contaminants (primarily DDT and perhaps also PCBs). Approximately 34% of the bald eagle's range overlaps regions of high mercury deposition. Areas of particular concern include the Great Lakes region, the northeastern Atlantic states and south Florida.

Nationwide, approximately 20% of the osprey's total range overlaps regions of high mercury deposition; however, a much larger fraction of the osprey's eastern population occurs within these regions. The osprey diet consists almost exclusively of fish. Osprey populations underwent severe declines during the 1950s through the 1970s due to widespread use of DDT and related compounds.

Nearly 40% of the loon's range is located in regions of high mercury deposition. Limited data from a study of a mercury point source showed that loon reproductive success was negatively correlated with exposure to mercury in a significant dose-response relationship. In some cases, mercury residues in fish collected from lakes used as loon breeding areas may exceed levels that, on the basis of this point source study, are associated with reproductive impairment. Loons frequently breed in areas that have been adversely impacted by acid deposition. An assessment of mercury’s effects on loon populations is complicated by the fact that decreases in surface water pH have been associated with both increased mercury residues in fish and declines in the available forage base.

All (100%) of the panther’s range falls within an area of high mercury deposition. Mercury levels found in tissues obtained from dead panthers are similar to levels that have been associated with frank toxic effects in other feline species. The State of Florida has taken measures to reduce the risk to panthers posed by mercury. Existing plans include measures to increase the number of deer available as prey in order to reduce the reliance of panthers on raccoons. Raccoons frequently feed at or near the top of aquatic food webs and can accumulate substantial tissue burdens of mercury. An evaluation of the risk posed by mercury to the Florida panther is complicated by the possible impacts of other chemical stressors, habitat loss, and inbreeding.

Approximately 35% of the range of mink habitat coincides with regions of high mercury deposition nationwide. Mink occupy a large geographic area and are common throughout the U.S. Given the opportunity, mink will prey on small mammals and birds. Many subpopulations, however, prey almost exclusively on fish and other aquatic biota. Due to allometric considerations, mink may be exposed to more mercury on a body weight basis than larger piscivorous mammals feeding at higher trophic levels. In several cases, mercury residues in wild-caught mink have been shown to be equal to or greater than levels associated with toxic effects in the laboratory.

River otter habitat overlaps regions of high mercury deposition for about 14% of the range for this species. River otters occupy large areas of the U.S., but their population numbers are thought to be declining in both the midwestern and southeastern states. The river otter's diet is almost exclusively of aquatic origins and includes fish (primarily), crayfish, amphibians and aquatic insects. The consumption of large, piscivorous fish puts the river otter at risk from bioaccumulative contaminants including mercury. Like the mink, mercury residues in some wild-caught otters have been shown to be close to, and in some cases greater than, concentrations associated with frank toxic effects.

**3. Estimation of mercury exposure on a local scale in areas near emissions point sources.**

A final analysis was conducted using a local-scale atmospheric fate model (GAS-ISC3), in addition to the long-range transport data and an indirect exposure methodology, to predict mercury concentrations in water and fish under a variety of hypothetical emissions scenarios. GAS-ISC3 simulated mercury deposition originating from model plants representing a range of mercury emissions source classes. The four source categories were selected based on their estimated annual mercury emissions or their potential to be localized point sources of concern. The categories selected were these: municipal waste combustors (MWCs), medical waste incinerators (MWIs), utility boilers, and chlor-alkali plants. To account for the long-range transport of emitted mercury, the 50th percentile RELMAP atmospheric concentrations and deposition rates were included in the estimates from the local air dispersion model. To account for other sources of mercury, estimates of background concentrations of mercury were also included in this exposure assessment.

These data were used to estimate the contributions of different emission source types to mercury exposure of selected wildlife species. It was concluded from this analysis that local emissions sources have the potential to increase significantly the exposure of piscivorous birds and mammals to mercury. Important factors related to local source impacts include quantity of mercury emitted by the source, species and physical form of mercury emitted, and effective stack height. The extent of this local contribution also depends upon watershed characteristics, facility type, local meteorology, and terrain. The exposure of a given wildlife species is also highly dependent upon the fish bioaccumulation factor, the trophic level(s) at which it feeds and the amount of fish consumed per day.

Although the accumulation of methylmercury in fish tissues appears to be highly variable across bodies of water, field data were determined to be sufficient to calculate representative means for different trophic levels. The variability can be seen in the distribution of the methylmercury bioaccumulation factors (BAF) for fish in trophic levels 3 and 4. These values, summarized in Table ES-2, are believed to be better estimates of mercury bioaccumulation in natural systems than values derived from laboratory studies.