

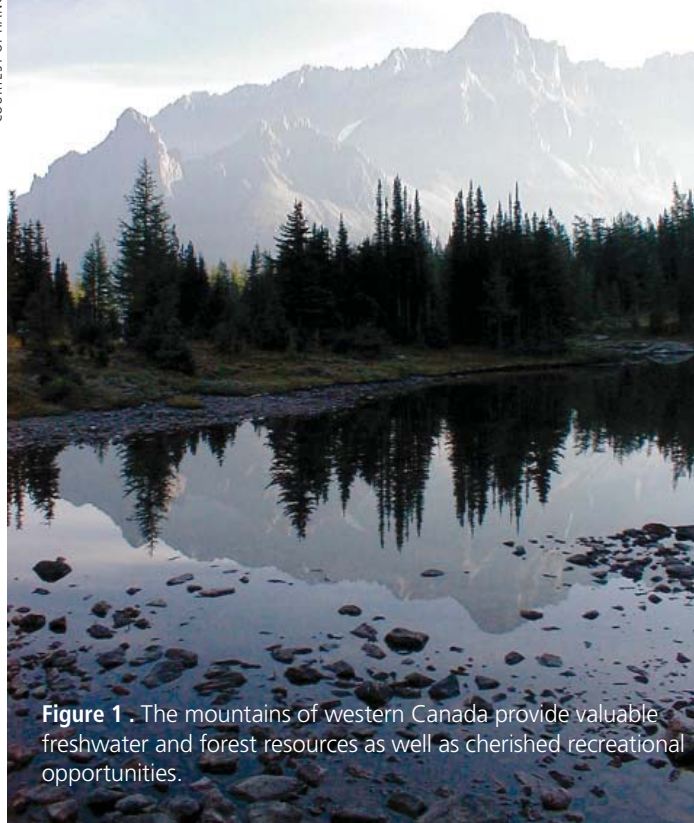


Figure 1 . The mountains of western Canada provide valuable freshwater and forest resources as well as cherished recreational opportunities.

Organic pollutant distribution in Canadian mountain parks

By Gillian Daly and Frank Wania

MOUNTAIN ENVIRONMENTS ARE IMPORTANT sources of freshwater and forest resources, contain areas of high biodiversity, and provide cherished recreational opportunities (fig. 1). Conservation of these resources and functions is the central objective of national parks in mountain regions. While some threats facing mountain environments, such as unsustainable use of natural resources and deforestation, can be avoided in national parks, other threats, such as climate change and chemical contamination, are more difficult to counter. Because of the large variability of environmental conditions in high-relief environments—caused by varying elevation and exposure—contaminant distribution within mountain regions is expected to be highly variable. Recent research in western Canadian mountain parks has provided new insight into the location of organic contaminant concentrations, and thus where exposure of organisms to those contaminants may be greatest. This insight can help park managers identify key hot spots—areas of elevated contaminant exposure—and communicate risks to the public (e.g., fish advisories). Identification of likely hot spots can also aid in the design of future research programs aimed at evaluating the ecotoxicological impact of elevated contaminant concentrations.

Contaminant hot spots

Hot spots develop when high contaminant input, for example through atmospheric deposition, combines with slow contaminant loss. Their location thus depends on source proximity, chemical properties (e.g., water solubility and degradability), and environmental conditions (e.g., temperature, precipitation, sur-

face cover, and winds). Previous research efforts in Europe and western North America have shown that diurnal mountain winds, in conjunction with low temperatures and high precipitation rates that enhance deposition at higher elevations, can lead to the convergence of persistent organic chemicals at higher elevations of midlatitude mountains (Daly and Wania 2005).

Investigators measured air, soil, and lichen contaminant profiles along elevational gradients in three western Canadian mountain parks—Mount Revelstoke National Park (British Columbia), Yoho National Park (British Columbia), and Banff National Park (Alberta) (fig. 2, next page)—to determine the extent to which different mountains exhibit different contaminant accumulation patterns with elevation (Daly et al. 2007a). Analysis and aggregation of meteorological data revealed prevailing winds from the west and southwest in all three parks. This implies that pesticides in the parks are much more likely to originate in the agricultural regions of Washington State and southern British Columbia than in the prairies to the east. The Mount Revelstoke transect on the western side of the continental divide receives high winter precipitation and does not extend beyond the tree line. The Yoho transect, also on the western side of the continental divide, traverses the Trans-Canada Highway and extends beyond the tree line up to 2,561 meters (8,402 ft) above sea level. The transect along Observation Peak in Banff National Park lies on the eastern side of the continental divide and receives the least amount of precipitation; its three highest sampling sites are above the tree line at 2,370 meters (7,775 ft) above sea level.

Figure 2. Investigators sampled air, soils, and lichens for contaminants along three transects in Mount Revelstoke National Park, Yoho National Park, and on Observation Peak in Banff National Park (British Columbia and Alberta, Canada).



Concentrations of organochlorine pesticides in the air were fairly uniform across and between the three mountain transects, suggesting no significant local sources within the parks, and efficient atmospheric mixing on a regional scale (fig. 3). Revelstoke had consistently higher pesticide concentrations in soil than Yoho and Observation, likely driven by greater precipitation on the western side of the continental divide. In the Revelstoke transect, soil concentrations of the insecticides α -HCH, dieldrin, endosulfan-I, and endosulfan-II and the herbicide dacthal showed a statistically significant increase with elevation. Such increases in soil concentrations with elevation are likely a result of cold precipitation at higher elevation being more efficient in washing contaminants out of the atmosphere than warm precipitation occurring in the valley (Daly et al. 2007b). Investigators observed the highest pesticide concentrations in soil along the Yoho and Observation transects at intermediate elevations. Pesticide concentrations on these two transects were significantly correlated with the soil organic carbon (OC) content. Soil OC content showed greater variation in the Yoho and Observation transects than in Revelstoke; OC content dropped severely above the tree line. Overall, the findings suggest that contaminant concentrations in soil will increase along with precipitation up the mountain slope until the retentive capacity of the soil declines (i.e., when OC content drops off above tree line). Therefore, contaminant hot spots in mountain soils will likely be found where precipitation and contaminant re-

tention are greatest (i.e., on the windward side of mountains and below tree line). Different patterns may be observed in vegetation, where contaminant uptake by gas absorption may be more important than wet deposition.

Whereas the above measured pesticides are not used within the parks, polycyclic aromatic hydrocarbons (PAHs) are emitted from cars, buses, and trucks traveling along traffic arteries in the mountain parks, and are also produced during forest fires. Investigators measured PAHs along the Observation, Yoho, and Revelstoke transects (Choi et al. in press). The air and soil concentrations were strongly correlated with proximity to traffic arteries. In particular, greatly elevated PAH levels were measured in air and soil sampled close to the Trans-Canada Highway in Yoho National Park. Concentrations along the Observation and Revelstoke transects decreased with elevation, which is also consistent with increasing distance from the roads at the bottom ends of the transects. The relative abundance of different PAHs changed with elevation, with heavier PAHs being more abundant in the valley. This again is consistent with a source location in the valley.



Figure 3. Using passive air samplers, investigators found fairly uniform concentrations of pesticides in the mountains of western Canada.

Management implications and research opportunities

The implication for contaminant hot spots in mountain parks is the need to distinguish between contaminants from in-park sources and contaminants transported into the park over short or long range. Depending on the sources, contaminants are likely to display widely divergent distribution patterns with elevation. An understanding of prevailing winds and likely sources is vital in designing monitoring campaigns for specific chemicals within a park. In addition to field studies, model calculations can help explain how chemical properties and elevational gradients in temperature, precipitation, and soil organic matter influence contaminant exposure in mountains.

Research in the mountains of western Canada continues, along with large collaborative research efforts such as WACAP (http://www.nature.nps.gov/air/Studies/air_toxics/wacap.cfm) in the western United States and EMERGE (<http://www.mountain-lakes.org/emerge/index.html>) and MonarPOP (<http://www.monarpop.at/>)

in Europe. These projects aim to provide decision makers with an overall understanding of contaminant fate in mountain environments so that appropriate policy and management measures can be taken at the level of the park manager, or on a regional, national, or larger (i.e., transboundary) scale. Research efforts can identify which contaminants are present in each park, where they are accumulating, and whether they pose an ecological threat (Daly et al. 2007b). Communication between researchers and park managers can create a better understanding of public-health and wildlife-health concerns in the parks and aid in the communication of potential risks to park users.

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