Predation, Behavior, and Landscape Change: Understanding the Proximate and Ultimate Causes of Decline in Vancouver Island Marmots (*Marmota vancouverensis*)

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Extended Abstract: Restoration of endangered species depends on successfully identifying and reversing causes of decline. This may be straightforward if only a single causal factor is involved, but is made much more difficult if multiple factors act unpredictably over different periods or over different scales. In this paper, I consider the causes of decline of North America's rarest mammal, the Vancouver Island marmot (*Marmota vancouverensis*).

The Vancouver Island marmot was first listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1978. Its population expanded during the 1990s but recently declined to near extinction in the wild. The species inhabits natural subalpine meadows, which are rare in the landscape (comprising < 1% of the occupied range) and are embedded in a rapidly changing forest matrix. I used GIS-based habitat measurements and data from mark-recapture and radio-telemetry studies to elucidate population trends over time.

Tagged females generally first bred as four-year-olds and thereafter produced litters of 3–4 pups in alternate years. About a third of females aged two years or older bred. Breeding rates did not change over the periods of expansion (1980s–1993) and decline (1994–2003), although there was considerable between-site and between-year variation.

Resightings of tagged marmots over the 1987–1993 and 1994–2003 periods suggested declining survival, both for pups (61% vs. 43%) and adults (78% vs. 72%). Radiotelemetry conducted since 1992 allowed recovery of marmot remains in 25 cases. Predation was the largest cause of mortality (84%), with wolves (*Canis lupus*) and cougars (*Puma concolor*) causing most deaths (at least 64%). Some marmots (4%) were killed by golden eagles (*Aquila chrysaetos*), 16% were killed by unknown predators which probably included the above species, 4% died from unknown causes, and 12% died in winter. Most deaths occurred in August or September (64%). On a daily basis, the risk of dying was approximately 10 times higher in August (0.448%) and 4 times higher in September (0.196%) than it was from spring emergence through 31 July (0.050 %). The risk of death during hibernation was extremely low (0.015%). Current survival rates (~74%) are insufficient to maintain marmots in the wild without reinforcement.

Marmot declines were correlated with declining black-tailed deer (*Odocoileus hemionus*) populations and increasing cougar and wolf indices. I suggest that high predation rates upon

marmots are the by-product of a significantly altered predator-prey system. Predator responses have been both numerical (altered abundance) and functional (altered behavior). In the short term, restoration of marmot populations will depend on continued successful captive-breeding, releases, and reduction of predation rates. In the long term, recovery of a self-sustaining population of Vancouver Island marmots may require new approaches to forest management that result in a more natural balance of predators and deer.