WebPanel 1. Additional methods for calculation of services and disservices of carnivores

Simulation of predator–prey dynamics

To simulate a simple predator–prey system, we used density-dependent predator–prey difference equations, with ratio-dependent predation rates and values based on wolf (*Canis lupus*) and moose (*Alces alces*) life-history characteristics that were developed and described by Eberhardt (1998). Specifically, this model calculated V_{t+1}, the prey abundance at each time-step, as:

$$V_{t+1} = V_t + d(V) \quad \text{(Equation 1)},$$

where V_t is the abundance of prey at the previous time-step and $d(V)$ is the change in prey abundance per time-step. Similarly, predator abundance (P_{t+1}) was calculated as:

$$P_{t+1} = P_t + d(P) \quad \text{(Equation 2)},$$

where P_t is the abundance of prey at the previous time-step and $d(P)$ is the change in prey abundance per time-step. Changes in predator and prey abundance were calculated as:

$$d(V) = V * (b * \left(1 - \frac{V}{K}\right) - a * P) \quad \text{(Equation 3)}$$

and

$$d(P) = c * a * V * P - d * P \quad \text{(Equation 4)},$$

where a is proportion of the prey (V) population eaten per predator, b is the intrinsic rate of increase of prey per time-step, c is the conversion rate of prey into new predators (P), d is the mortality rate of predators per capita, and K is the nutritional carrying capacity of the environment for prey. We also simulated the abundance of prey in the counterfactual (alternative) scenario (ie in the absence of predators) as:

$$V_{alternative(t+1)} = V_{alt.(t)} + V_{alt.(t)} * b * (1 - \frac{V_{alt.(t)}}{K}) \quad \text{(Equation 5)}.$$

Marginal value calculations

Constant and linear marginal values (MVs) are described in the main text and in WebTable 1. However, some costs and benefits may increase or decrease in a nonlinear fashion with animal abundance. We created nonlinear marginal relationships by assuming discrete exponential growth. Specifically, we assumed a minimum per-capita cost (*MCmin*) and benefit (*MBmin*) of 0.1*the maximum per-capita cost or benefit (*MCmax* and *MBmax*). We then calculated the marginal increase in cost with increasing abundance as:

$$MC = MCmin * \exp(\ln\left(\frac{MCmax}{MCmin}\right) * \frac{N}{Nmax}) \quad \text{(Equation 6)}$$

and the marginal decrease in benefit with increasing abundance as:

$$MB = MBmax * \exp(\ln\left(\frac{MBmin}{MBmax}\right) * \frac{N}{Nmax}) \quad \text{(Equation 7).}$$

This ensured that the minimum and maximum MVs were the same as for the linear marginal relationship.

Calculation of total predator and prey costs and benefits

Constant MVs

Under the assumption of constant MVs, the total cost and benefit of prey, *C*(*V*) and *B*(*V*), respectively, were calculated as $MCmax(V)*V_t$ and $MBmax(V)*V_t$, respectively. Likewise, the total cost and benefit of prey in the absence of predators, $C(V_{alt})$ and $B(V_{alt})$, respectively, used as the counterfactual scenario, were calculated as $MCmax(V_{alt})*V_{alt(t)}$ and $MBmax(V)* V_{alt(t)}$, respectively. The direct cost and benefit of predators, *C*(*P*) and *B*(*P*), respectively, were calculated as $MC(P)*P_t$ and $MB(P)*P_t$, respectively. The indirect cost and benefit of predators were calculated as the avoided costs and the foregone benefits of prey.

WebReference

Eberhardt LL. 1998. Applying difference equations to wolf predation. *Can J Zool* **76**: 380–86.