

Top-down Versus Bottom-up Effects

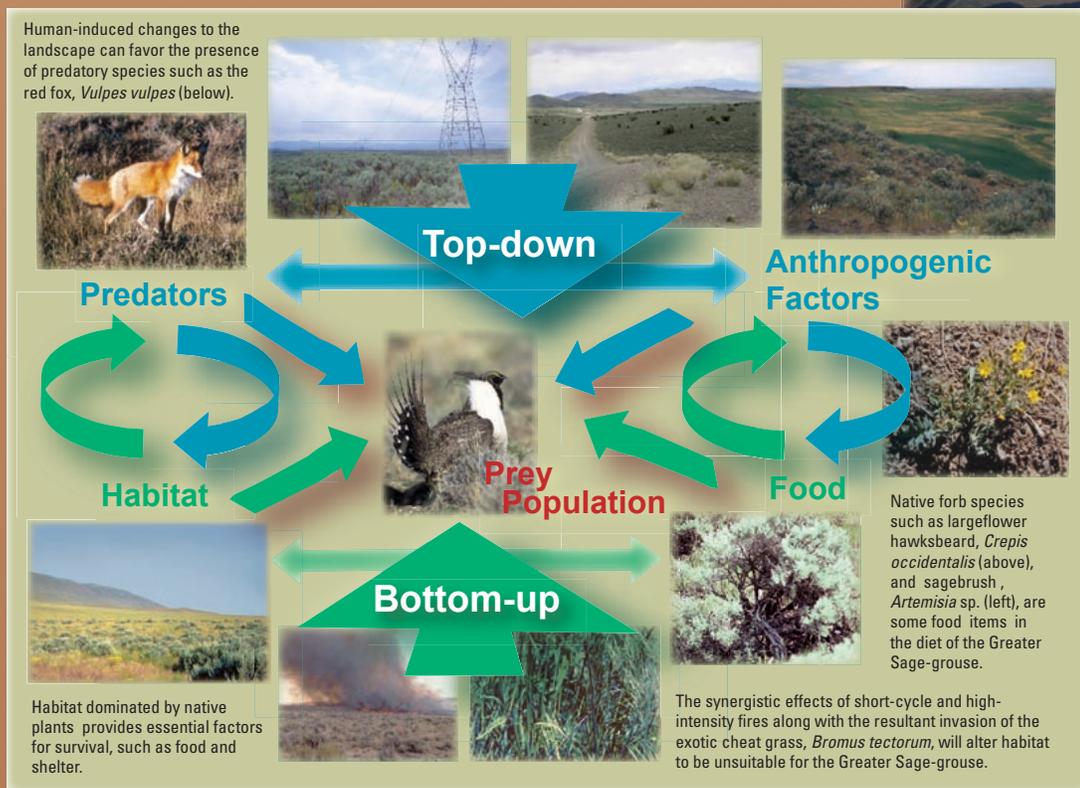
An important question in ecology is how food web interactions vary through time and space. Population ecologists and conservation biologists study population dynamics of organisms by calculating the magnitude and direction of species-specific population growth rates. This measure of population fluctuation is derived from demographic factors such as birth, death, emigration, and immigration, which are regulated by factors such as climate, stochastic events (i.e., rare but extreme weather patterns such as severe flooding), predators, parasites and social structure. Merging the influences of each regulatory factor and the complex interactions among them helps population ecologists form hypotheses regarding “top-down” versus “bottom-up” population regulatory processes. Top-down (consumer) regulatory processes are said to occur when, for example, predators keep prey populations at levels below the population size that would be observed in the absence of predators. If on the other hand, factors such as food and/or habitat availability are the main drivers explaining population fluctuations, a population is said to be regulated by bottom-up (resource) regulatory processes. Populations can also be regulated by both processes, either through a seasonal shift from one process to the other, or when both processes act in concert.

Whether top-down or bottom-up processes are the major factor influencing the regulation of populations is uncertain. The answer may depend on the ecosystem (e.g., marine versus terrestrial), but it is generally assumed that bottom-up regulatory processes are most important in explaining vertebrate population fluctuations. However, top-down regulatory processes may override bottom-up regulatory processes in cases where ecosystems are exposed to atypical disturbance such as human-induced habitat alterations. These anthropogenic

factors may influence (i) top-down regulatory processes by altering habitat or food sources to a degree that will allow predator populations to increase, (ii) bottom-up processes by increasing habitat loss and exploitation to a threshold above which the habitat becomes unsuitable for given species, or (iii) both top-down or bottom-up processes may be altered. Understanding how anthropogenic factors influence the top-down/bottom-up regulatory processes will help ecologists predict how humans are affecting landscapes and environmental changes.

Suggested Readings

- Bolger, D. T. 2001. Urban birds: population, community, and landscape approaches. Pages 155-177 in *Avian ecology and conservation in an urbanizing world* (J. M. Marzluff, R. Bowmann and R. Donnelly, eds.). Kluwer Academic, Norwell, MA.
- Gratton, C. and R. F. Denno. 2003. Seasonal shift from bottom-up to top-down impact in phytophagous insect populations. *Oecologia* 134: 487-495.
- Sinclair, A. R. E. and J. R. Krebs. 2002. Complex numerical responses to top-down and bottom-up processes in vertebrate populations. *Philosophical Transactions of the Royal Society of London, Series B* 357: 1221-1231.
- Worm, B. and R. Myers. 2003. Meta-analysis of cod-shrimp interactions reveals top-down control of oceanic food webs. *Ecology* 84: 162-173.



This chart depicts the top-down and bottom-up processes, and the interactions among them, that potentially regulate a prey population. We used the Greater Sage-grouse as an example to illustrate how anthropogenic factors can influence both top-down and bottom-up regulatory processes.