BIOL 3340 Ecology Study Guide for Exam 2: Lecture 13: Population Regulation

Source: the lecture slides (text, figures and slide notes). No textbook.
Each heading is one Study Lab objective. [L13 s08] = Lecture 13, slide 8.
(teal italics) = plain meaning of the word before it. ⚠ **Do not mix up = a look-alike pair to keep apart.** **Amber dotted words** = names printed on the figure beside them.

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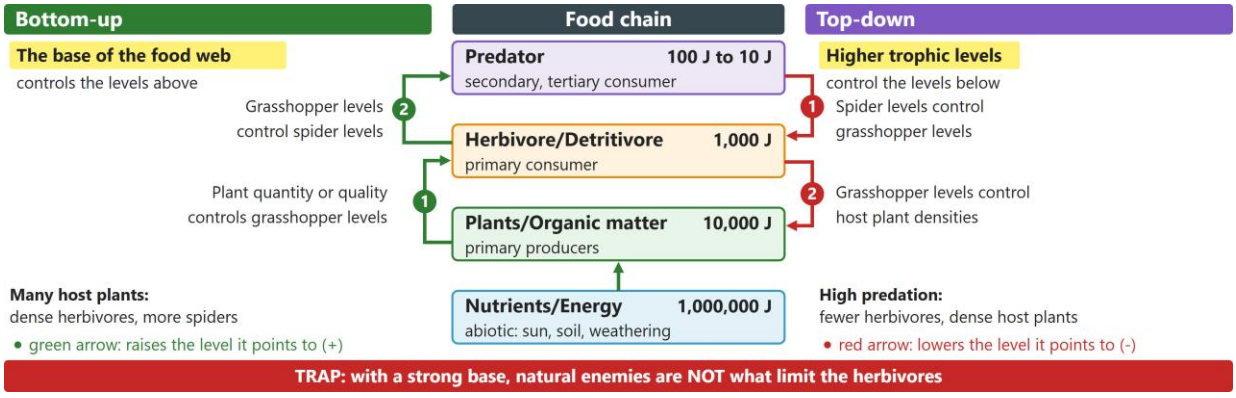
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L13.1 Trophic levels and the bottom-up vs top-down models

⚠ **Do not mix up: Bottom-up is NOT predator control: the food web base limits higher levels.** [L13 s05]

Bottom-up model: predicts that food or prey resources regulate herbivore and predator abundances. [L13 s03]
Top-down model: predicts that natural enemies are the key constraint on prey abundances. [L13 s03]



Bottom-up and top-down control along one food chain from nutrients to predators [L13 s05]

On the figure: Bottom-up · Top-down · Predator · Herbivore/Detritivore · Plants/Organic matter · Nutrients/Energy · grasshopper

Trophic levels *(steps in a food chain)*: **predator**, **herbivore/detritivore**, **plants/organic matter**, **nutrients/energy**. [L13 s04]
Predator: a secondary or tertiary consumer. [L13 s04]
Herbivore/Detritivore *(plant eater or dead matter eater)*: the primary consumer. [L13 s04]
Plants/Organic matter: primary producers, also called basal resources *(base food supply)*. [L13 s04]
Nutrients/Energy: usually from abiotic *(nonliving)* sources like the sun, soil, chemical weathering. [L13 s04]
Energy drops at each trophic level going up the pyramid. [L13 s04]
Bottom-up: the base of the food web controls the populations of higher trophic levels. [L13 s05]
Top-down: higher trophic levels control the trophic levels below. [L13 s06]
Bottom-up: host plant quantity or quality limits herbivore density, which limits predator abundance. [L13 s05]
Top-down: predators limit herbivores, and herbivores limit plant densities. [L13 s06]
Both ideas use host plant, **grasshopper** (herbivore) and spider (predator). [L13 s05, L13 s06]
Increased plant quantity or quality benefits herbivores and, in turn, predators. [L13 s05]

Predation of herbivores **increases** plant densities. [L13 s06]

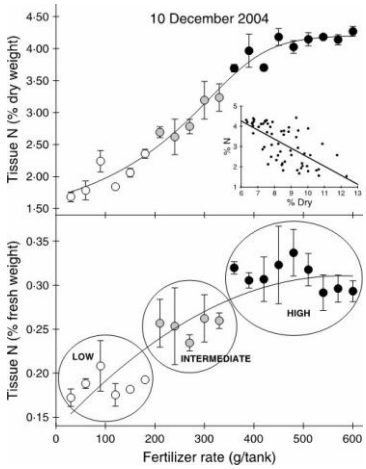
Bottom-up vs top-down (grasshopper, spider, plant)

Idea	Bottom-up	Top-down
Control comes from	Base of the food web	Higher trophic levels
Step 1 of control	Plants control grasshoppers	Spiders control grasshoppers
Step 2 of control	Grasshoppers control spiders	Grasshoppers control host plants
A high level gives	Many host plants: dense herbivores, more predators	High predation: fewer herbivores, dense host plants

Table source: [L13 s05, L13 s06]

L13.2 Evidence for bottom-up control: water hyacinth and weevils

⚠ **Do not mix up: Fertilized water hyacinth shows bottom-up control: food quality limits weevils, not predators.** [L13 s09, L13 s10]



Plant tissue nitrogen rises as the fertilizer rate rises [L13 s09]

On the figure: fertilizer · high

Water hyacinth and weevils (Neochetina bruchi and Neochetina eichhoriniae): evidence for bottom-up control of herbivore populations. [L13 s08]

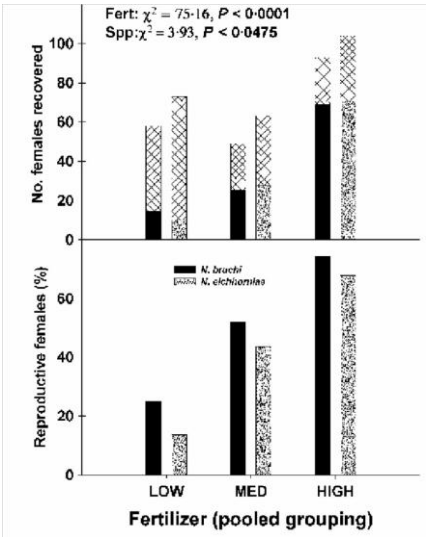
Water hyacinth grown with **fertilizer** has higher nitrogen in its tissues. [L13 s09]

Higher abundances of female weevils were found in **high** fertilizer treatments. [L13 s10]

And a greater percent of those **females** were **reproductive**. [L13 s10]

The fertilizer was N, P, K *(nitrogen, phosphorus, potassium)*. [L13 s10]

1. Fertilizer is added to the water hyacinth. [L13 s09, L13 s10]
2. Nitrogen in the plant tissue rises. [L13 s09]
3. More female weevils are found, and more of them are reproductive. [L13 s10]

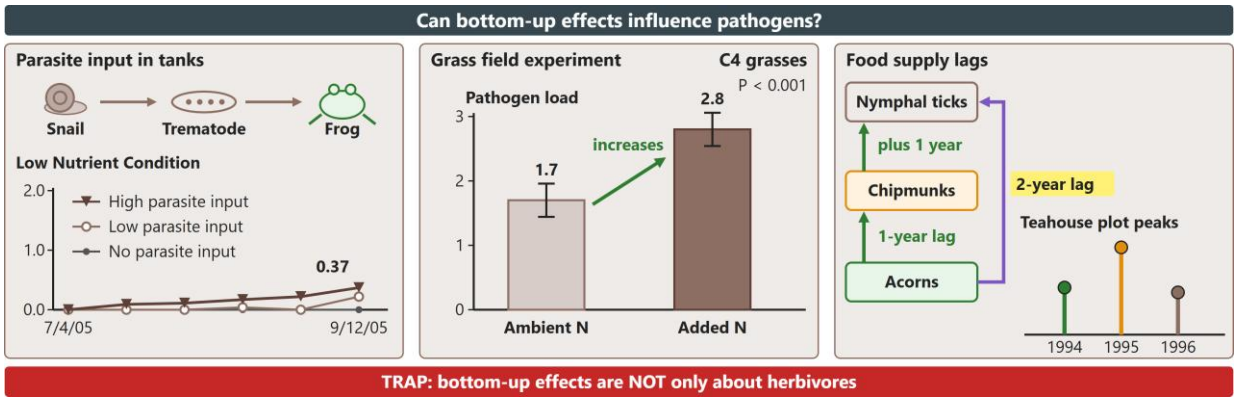


More female weevils, and a greater percent reproductive, at high fertilizer [L13 s10]

On the figure: females · reproductive · fertilizer · high

L13.3 Bottom-up effects on pathogens

⚠ **Do not mix up: Bottom-up is NOT only about herbivores: more nutrients also raised pathogen load.** [L13 s14]



Nutrients raise parasite infection in tanks, pathogen load on grasses, and tick lags [L13 s15]

On the figure: parasite input · C4 grasses · pathogen load · Acorns · Chipmunks · ticks

Question: can bottom-up effects influence pathogens *(disease-causing organisms)*? [L13 s11]

More **parasite input** in the tanks meant more infection. [L13 s12, L13 s13]

Eutrophication *(nutrient enrichment)* affected amphibian infections by Ribeiroia trematodes in the same tank experiment. [L12 s35]

C4 grasses *(one type of grass)*: added nitrogen raised **pathogen load**. [L13 s15]

Acorns, chipmunks and ticks: the arrows between them carry lags. [L13 s14]

Acorn, chipmunk, tick lags

Link	Lag
Acorns to chipmunks	1 year
Chipmunks to nymphal ticks	1 year
Acorns to ticks overall	2 years

Table source: [L13 s15]

L13.4 Bottom-up control in stream food webs and trophic dead ends

⚠ **Do not mix up: Bottom-up boosts do NOT always reach predators: dead end taxa stop the gain.** [L13 s19]

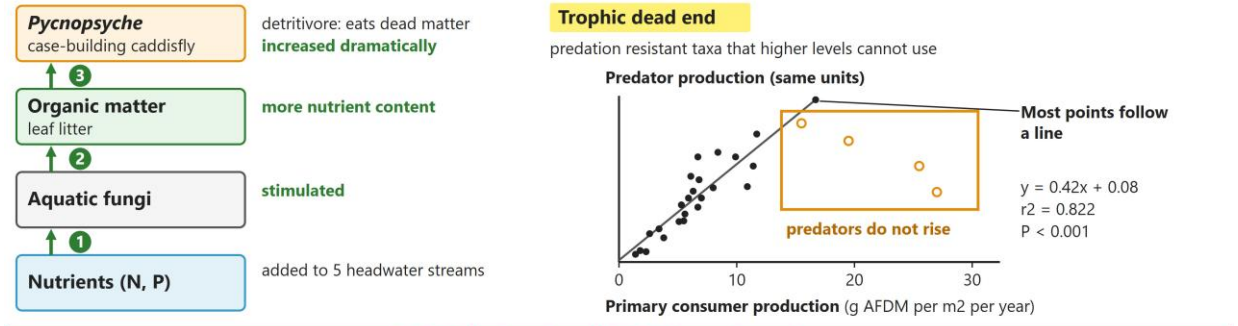
Stream experiment: nutrients (N, P) were added to **5** headwater *(streams near their source)*. [L13 s16]

Effects were measured on organic matter (leaf litter) and aquatic insects. [L13 s16]

Nutrients stimulated aquatic fungi from the bottom up. [L13 s17]

Organic matter had **increased** nutrient content. [L13 s17]

Populations of aquatic detritivores **increased**. [L13 s17]



Nutrients lift fungi, leaf litter and caddisflies, but predators do not rise [L13 s17]

On the figure: Pycnopsyche · Aquatic fungi · Organic matter · leaf litter · Trophic dead end · Nutrients (N, P)

1. Nutrients (N, P). **2.** Aquatic fungi. **3.** Leaf organic matter. **4.** Detritivore caddisfly. [L13 s17, L13 s18]

An important detritivore here is **Pycnopsyche** spp.. [L13 s18, L13 s19]

It is a **case-building caddisfly** *(aquatic insect with a protective case)* that eats dead organic matter. [L13 s18]

These populations **increased** dramatically with nutrient addition. [L13 s18]

Trophic dead end: predation resistant taxa *(kinds of organisms)* in a level that higher levels cannot use. [L13 s19]

Dead end taxa raise primary consumers but not predators. [L13 s19]

L13.5 Top-down control: lake, sea otter and the average effects

⚠ **Do not mix up: Fertilizer does NOT significantly raise herbivores on average: predator effects are stronger.** [L13 s24]

Experimental lake: largemouth bass were removed from one side of the lake. [L13 s21]

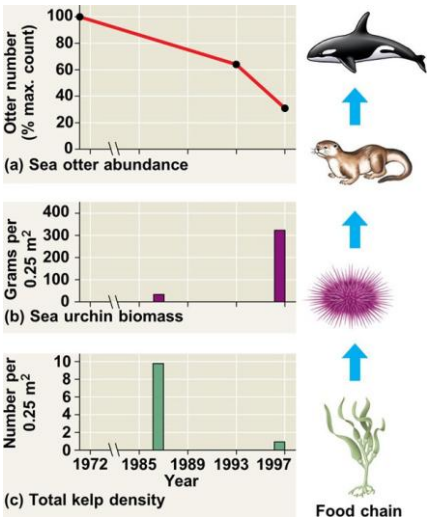
Question: which side of the lake had the bass removed? [L13 s21]

Answer: the left chain has no bass; the right chain has bass on top. [L13 s22]

Marine example: increasing predation from killer whales **decreased** otters, **increased** sea urchins, **decreased** **kelp**. [L13 s23]

Memory aid: enemy of my enemy is my friend. [L13 s23]

Average strength of effects: average results across **23** different studies. [L13 s24]



Otters fall, urchins rise and kelp falls over time [L13 s23]

On the figure: otter · urchin · kelp

Fertilizer comparison: effects of fertilizers in systems with and without predators. [L13 s24]

Predator removal comparison: effects of predator removal with and without fertilizer. [L13 s24]

Red dots are effects on **plants**; blue dots are effects on **herbivores**. [L13 s24]

Effects of predator removal (**top-down**) are stronger on herbivores than fertilizer effects (**bottom-up**). [L13 s24]

Adding predators **decreases** herbivores and **increases** plants. [L13 s24]

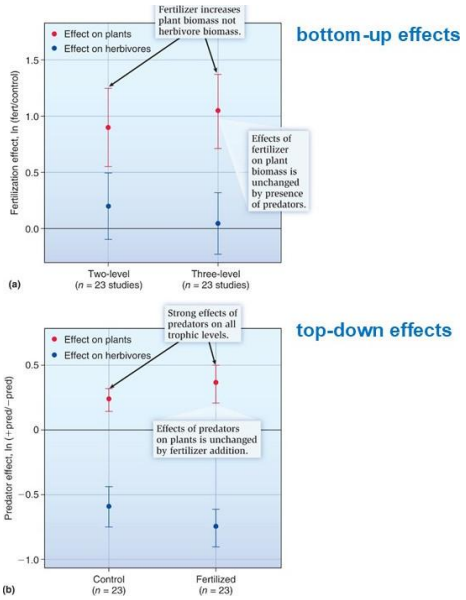
Adding fertilizer does not significantly **increase** herbivores, ON AVERAGE. [L13 s24]

Fertilizer **increases** plant biomass, not herbivore biomass. [L13 s24]

Fertilizer effect on plant biomass is unchanged by the presence of predators. [L13 s24]

Predators have strong effects on all trophic levels. [L13 s24]

Effects of predators on plants are unchanged by fertilizer addition. [L13 s24]



Average effects on plants and herbivores: fertilizer above, predators below [L13 s24]

On the figure: bottom-up · top-down · herbivores · plants

Killer whale, otter, urchin, kelp

Level	Change
Sea otter	Decrease
Sea urchin	Increase
Kelp	Decrease

Table source: [L13 s23]

L13.6 Trophic cascades

⚠ **Do not mix up: A trophic cascade is NOT a direct effect: predators help plants indirectly.** [L13 s26]

Trophic cascade: top-down effects cascade *(ripple)* to lower trophic levels. [L13 s25]

Predators typically reduce prey abundance, which benefits the next trophic level down. [L13 s25, L13 s26]

More simply: consumer effects on resources at the food web base (basal resources). [L13 s25]

A cascade is **indirect control** of lower trophic levels by top-down effects. [L13 s26]

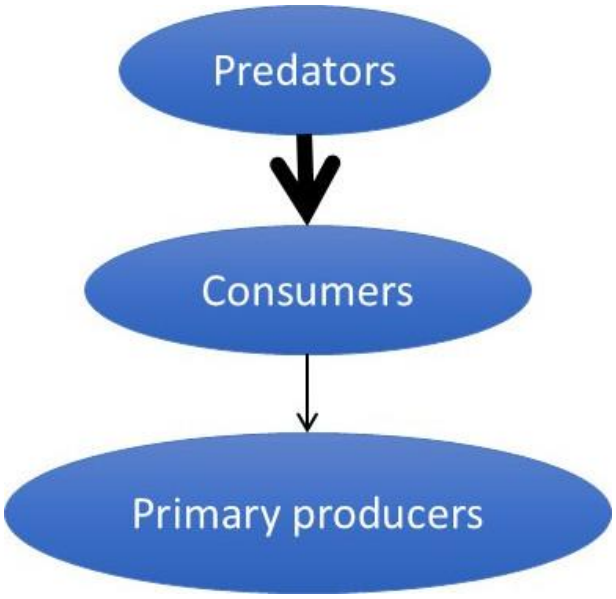
> **1.** Predators reduce **consumers**. [L13 s26]
>
> **2.** With fewer consumers, plants **increase** in biomass or abundance. [L13 s26]

Question: explain top-down effects with and without a secondary consumer (top predator). [L13 s27]

Rule: a predator lowers its prey and benefits the level below. [L13 s25, L13 s26]

Applying the rule: with bass, small fish fall, zooplankton rise, phytoplankton fall; without bass, the reverse. [L13 s26, L13 s28, L13 s29]

Only the presence of bass differs; every change comes from the rule. [L13 s28]



Predators reduce consumers, which lets primary producers increase [L13 s26]

On the figure: Predators · Consumers

The rule applied to the two lake chains

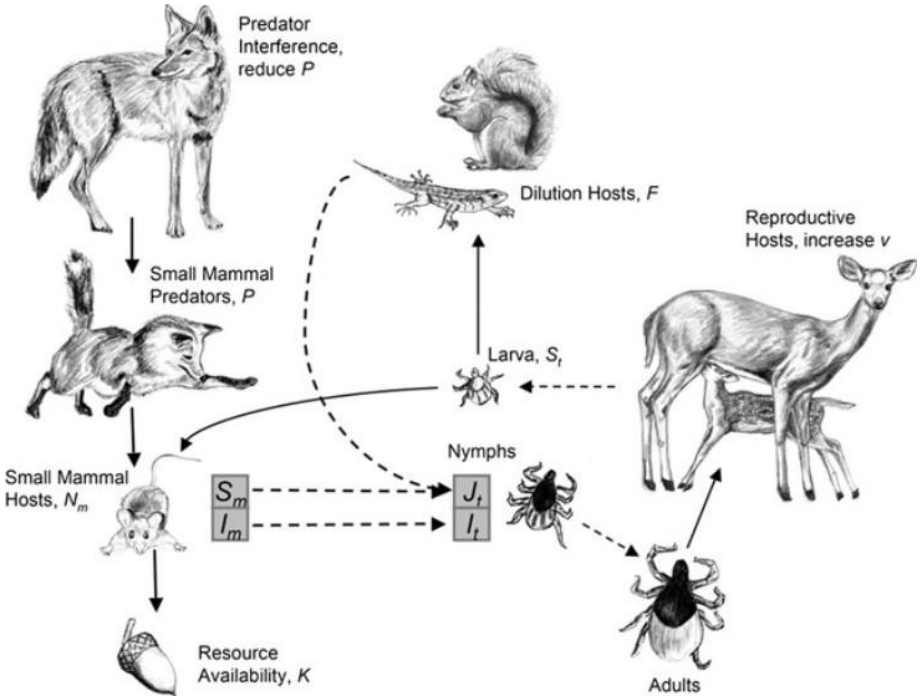
Level	No bass (left chain)	Bass (right chain)
Bass	Absent	Present
Small fish (minnows)	Top predator	Reduced by bass
Zooplankton (water fleas)	Reduced by small fish	Benefits: **increases**
Phytoplankton (algae)	Benefits: **increases**	Reduced by more zooplankton

Table source: [L13 s25, L13 s26, L13 s28, L13 s29]

L13.7 Trophic downgrading and zoonotic disease (Lyme)

⚠ **Do not mix up: Trophic downgrading means top-down interactions are becoming LESS common, not more.** [L13 s29]

> **Trophic downgrading** of earth: top-down interactions are becoming less common. [L13 s29]
>
> Loss of key top-down interactions completely changes ecosystem structure. [L13 s29]
>
> **In water**, examples: sea otter and kelp, Pisaster and mussels, bass-zooplankton-phytoplankton, sharks. [L13 s29]
>
> **On land**, examples: arctic fox and seabirds, jaguar and rainforest herbivores, wolves and elk. [L13 s30]
>
> Also on land: woody vegetation, wildebeest and rinderpest. [L13 s30]
>
> **On land too**: the same loss of top-down control also occurs on land. [L13 s30]



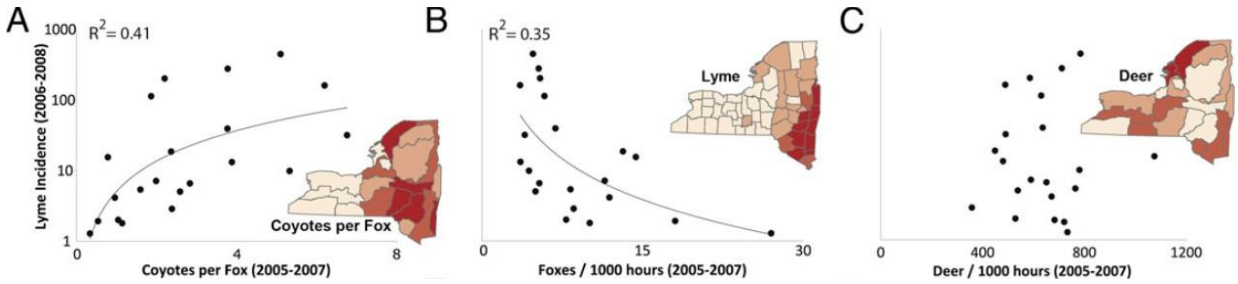
Lyme disease chain from coyote to fox, mouse and acorn, with tick stages [L13 s31]

On the figure: larva · nymphs · adults

Top-down control and zoonotic disease *(animal disease that infects people)*: the Lyme disease example. [L13 s31]

Restructuring of predator communities across the globe may have unintended consequences for human disease risk. [L13 s31]

The tick stages on the diagram are **larva**, **nymphs** and **adults**. [L13 s31]



Lyme incidence rises with coyotes per fox, falls with foxes, no trend with deer [L13 s32]

On the figure: coyotes per fox · foxes · deer · Lyme

Lyme incidence rises with more **coyotes per fox**. [L13 s32]

Lyme incidence falls with more **foxes**. [L13 s32]

Deer show no clear fitted trend with Lyme incidence. [L13 s32]

The Lyme disease chain has four levels: coyote, fox, mouse, acorn. [L13 s31, L13 s33]

Remove a top predator and its prey rise while the level below falls. [L13 s34, L13 s24, L13 s26]

Example: more killer whale predation, fewer otters, more urchins, less kelp. [L13 s34, L13 s23]

Top-down has the stronger effect on herbivores than bottom-up fertilizer, on average. [L13 s34, L13 s24]

Predator versus parasite: predation means immediate mortality; parasitism may not kill, or takes time. [L13 s34, L12 s10]

Predator versus parasite: the parasite exploits the host; the predator kills and consumes it. [L13 s34, L12 s10]

Predator versus parasite: predators are often larger than prey; macroparasites are smaller than the host. [L13 s34, L12 s11]

Predator versus parasite: each predator eats many prey; one host supports a few to many macroparasites. [L13 s34, L12 s11]

Frog limb malformations: the claim that **increased** pond contaminants cause them is false. [L13 s34, L12 s25, L12 s35]

> The malformed frog is shown with **Ribeiroia** trematode infection. [L13 s34, L12 s25, L12 s35]
>
> Eutrophication *(nutrient enrichment)* affected these Ribeiroia infections; contaminants are not named as the cause. [L12 s35]

Lyme disease chain: each level and its label

Label on the diagram	Organism or food
Predator interference, reduce P	Coyote
Small Mammal Predators, P	Fox
Small Mammal Hosts, Nm	Mouse
Resource Availability, K	Acorn
Dilution Hosts, F	Squirrel and lizard
Reproductive Hosts, increase v	Deer and fawn

Table source: [L13 s31]