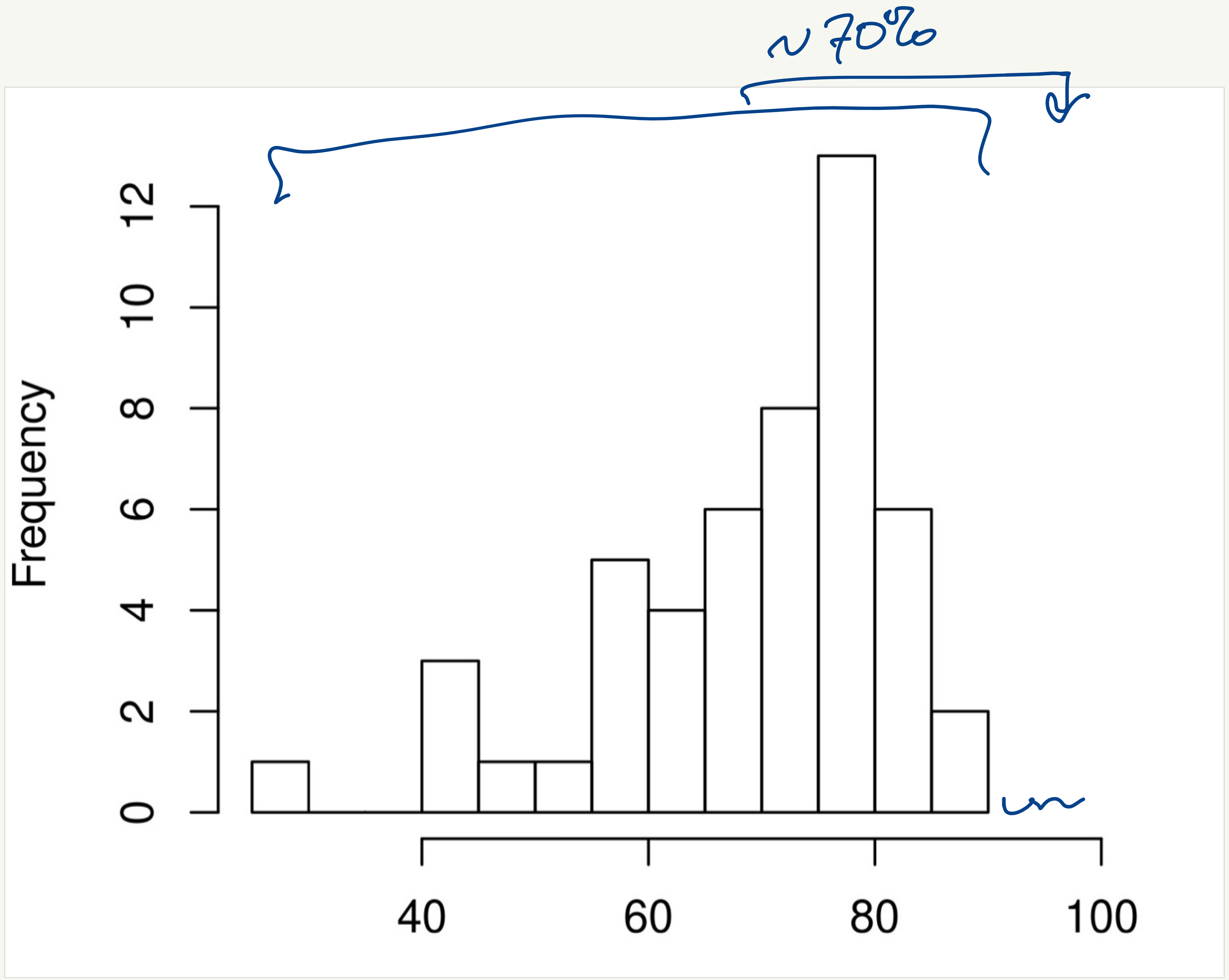
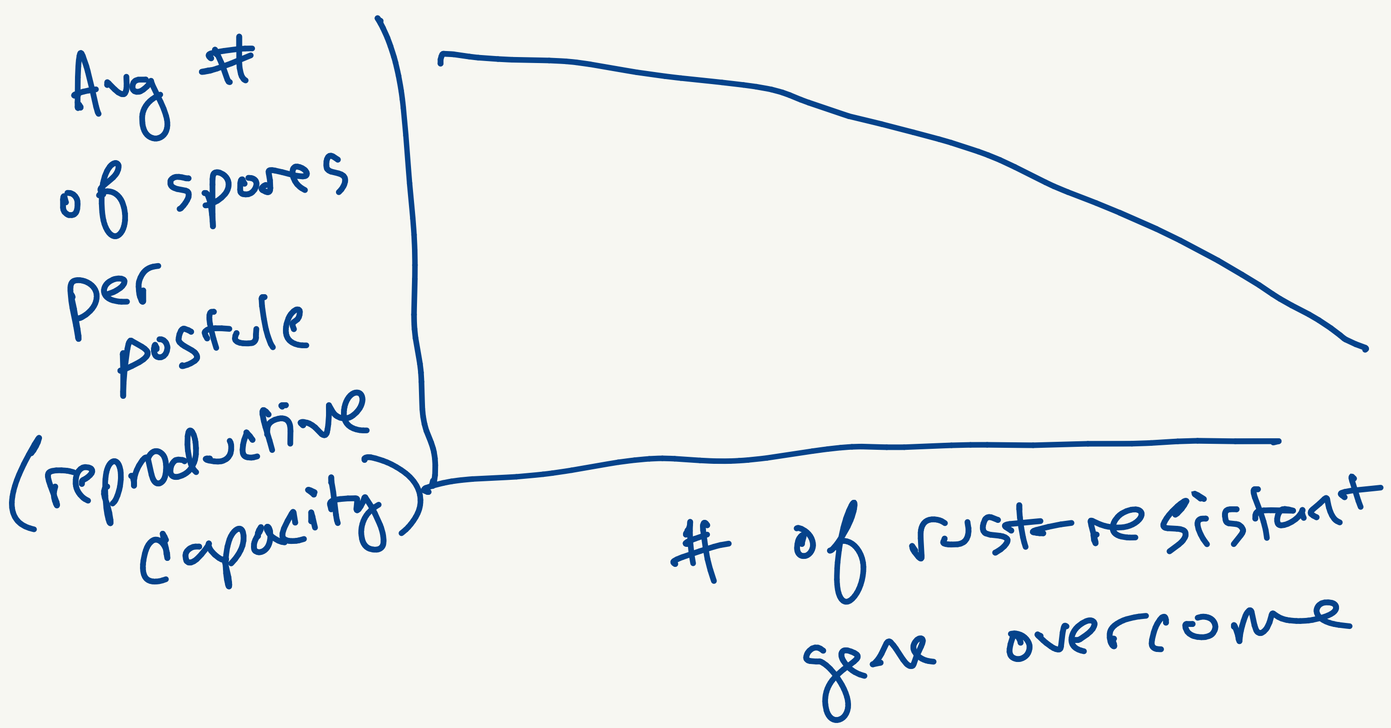

~70%
Frequency
0
2
4
6
8
10
12
40
60
80
100

13.4

Host defenses and parasite counter-defenses have a cost

Wild Flax vs. Rust pathogen



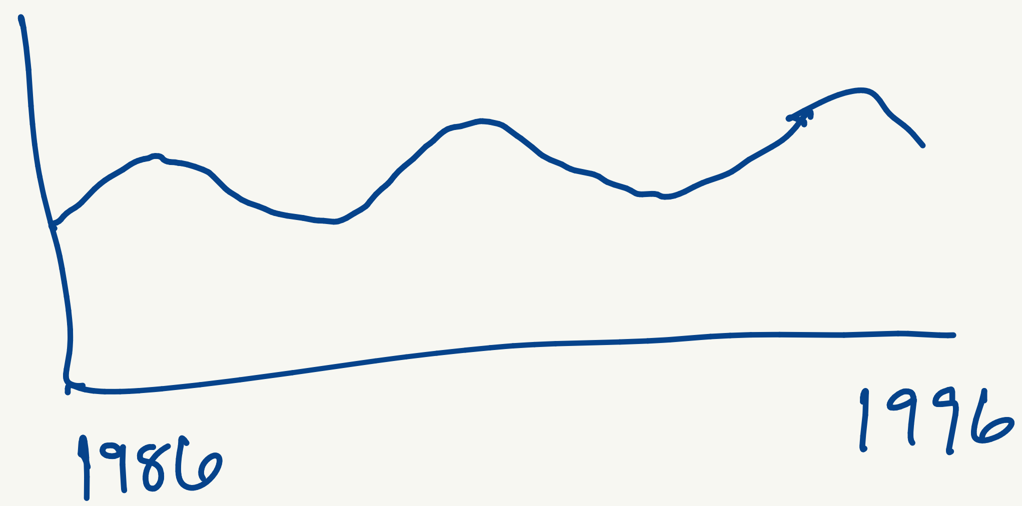
Tradeoff between virulence and rate of reproduction

What are the ecological effects of ~~pasites~~ parasites?

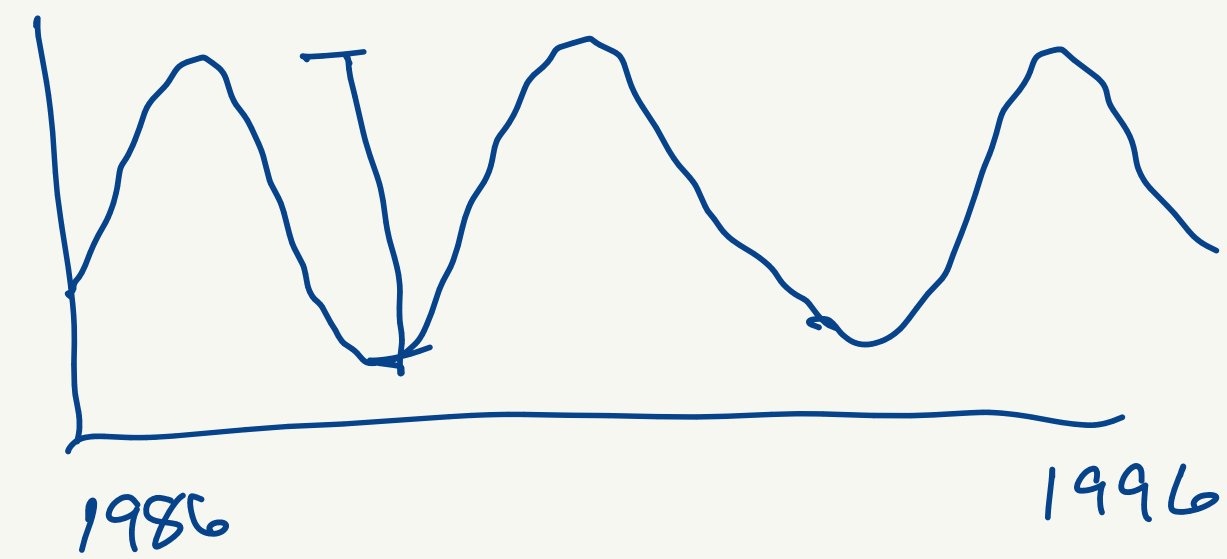
- extinction
- reduced ranges
- Influence host population cycles

ex) American Chestnut Blight
1904 4 billion
1940 a few individuals
↓ squirrel populations
extinction 7 moth spp.
↓ Deer, Coopers hawks, Cougars, bobcats

Grouse populations



w/nematodes



- elimination of nematode parasites does not eliminate cycles but changes their amplitudes

Disease Dynamics

- Track the state of the host individuals w/in a population

Susceptible

Infected

Recovered ~ lifetime immunity

$$S \rightarrow I \rightarrow R$$

$$S + I + R = N$$

(*) Assume that pathogen dynamics are much faster than host pop. dynamics

S = Density of susceptible individuals

I = Density of Infected individuals

- When should we expect a disease to spread within a population

- For a disease to spread, S individuals must encounter I individuals

Encounter rate should be proportional to $S \cdot I$

- Disease transmission is $\beta S I$

β is the transmission rate

If Disease transmission is βSI then the density of infected individuals I should grow w/ βSI

$$\frac{dI}{dt} = \beta SI - \gamma I$$

Recovery rate

When should the disease be expected to spread?

$$\frac{dI}{dt} > 0 \,?$$

$$S \xrightarrow{\beta SI} I \xrightarrow{\gamma I} R$$

$$S_T = \frac{\gamma}{\beta}$$

threshold value of the density of susceptible individuals

$$\beta SI - \gamma I > 0$$

$$\beta S\cancel{I} > \gamma \cancel{I}$$

$$\beta S > \gamma$$

$$\boxed{S > \frac{\gamma}{\beta}}$$

when $S_T > \frac{\gamma}{\beta}$ the disease spreads

when $S_T < \frac{\gamma}{\beta}$ the disease does not spread

$$\frac{dI}{dt} = \beta S I - \gamma I$$

$$S_T = \frac{\gamma}{\beta}$$

Recovery rate / transmission rate

Social distancing

if recovery rate is higher, then S_T is larger

if the transmission rate is higher, then S_T is smaller

Disease growth: $S_T > \frac{\gamma}{\beta}$

Disease decline: $S_T < \frac{\gamma}{\beta}$

Add some Realism

S · become infected via contact

I recover at a fixed rate γ and have lifetime immunity

R

recovery rate, then the avg amount of time that individuals are infected is $\frac{1}{\gamma}$

we track the size of compartments over time

Total number of individuals is constant:

$$N = S + I + R$$

λ = the force of infection

per-capita rate at which susceptible individuals acquire infection. λ is not constant... the more infected individuals there are, the greater the force of infection. $\lambda(I)$

Let's consider the function $\lambda(I)$

Composed of 1) transmission rate $\beta \leftarrow \frac{1}{[\text{time}]}$

2) Interaction term: proportion of infectious individuals $\frac{I}{N} = \frac{I}{S+I+R}$

$$\begin{cases} \frac{dS}{dt} = -\lambda(I)S = -\beta\frac{I}{N}S & \lambda(I) = \beta\frac{I}{N} \\ \frac{dI}{dt} = \lambda(I)S - \gamma I = \beta\frac{I}{N}S - \gamma I \\ \frac{dR}{dt} = \gamma I \end{cases}$$

pandemic