• Eco-evolutionary feedbacks and the fundamental theorem of natural selection

• What is carrying capacity \((K)\)?

• What is \(s\), the selection coefficient? Is it a constant?

• Does the additive genetic variance for fitness depend on \(s\)?

\[
V_A = 2pq[a + d(q - p)]^2
\]

\[
a = \frac{W_{11} - W_{22}}{2}
\]

\[
d = \frac{1 - 2h}{a}
\]

\[
V_A = 2pq[q - h(q - p)]^2 (W_{11} - W_{22})^2
\]

\[
V_A = 2pq[q - h(q - p)]^2 s^2 W_{11}^2
\]
• “It is a patent oversimplification to assert that the environment determines the numbers of each of organism which it will support.” (Fisher 1958, p. 45)

• “The numbers must indeed be determined by the elastic quality of the resistance offered ...” (Fisher 1958, p. 45)
• “The rate of increase in fitness of any organism at any time is equal to its genetic variance for fitness at that time.” (Fisher 1958, p. 37)

\[ \Delta \bar{W}_{ns} = \frac{V_A}{\bar{W}}, \]

• “... the theorem is exact only in idealized populations, in which fortuitous fluctuations in genetic composition have been excluded, ...” (Fisher 1958, p. 38)
• “Any net advantage gained by an organism will be conserved in the form of an increase in the population, rather than in increase in the average Malthusian parameter, which is kept by this adjustment always near zero.” (Fisher 1958, p. 51)
• Derive the total change in mean fitness due to Natural Selection and due to environmental deterioration.

• Derive $V(A)$ for fitness.

• Consider a life-history model.
Density-dependent selection

\[ b_{22} - a_{22}N \]

\[ b_{11} - a_{11}N \]

\[ K_{22} = \frac{(b_{22} - d_{22})}{a_{22}} \]

\[ K_{11} = \frac{(b_{11} - d_{11})}{a_{11}} \]

Fig. 1
\[ \Delta \overline{W}_{ns} = \overline{W}'|E - \overline{W} | E \]

Change in fitness due to natural selection

mean fitness at time 1 given envir. 1

mean fitness at time 2 in envir. 1

\[ \Delta \overline{W}_{ec} = \overline{W}'|E' - \overline{W}' | E. \]

Change in fitness due to environmental change

mean fitness at time 2 given envir. 1

mean fitness at time 2 in envir. 2

Total change in fitness due to natural selection

\[ \Delta \overline{W} = \Delta \overline{W}_{ns} + \Delta \overline{W}_{ec} \]

From Frank and Slatkin: Fisher’s fundamental theorem of natural selection. TREE 1992
Fig. 3
• Eco-evolutionary feedbacks

Key points. positive feedback between $N$ (ecology) and $p$ (evolution).

1. The allele spreads: increase in $p$.


3. Increases in $N$ increases the strength of selection: increase in $s$.

4. Increases in $s$ cause greater increases in $p$.

![Diagram showing eco-evolutionary feedbacks]

- Increase in $p$ leads to increase in $s$, which in turn increases $N$, and vice versa.
There must be more examples of eco-evolutionary feed backs. Fill in the blanks

1. ______________________________________

2. ______________________________________

3. ______________________________________

4. ______________________________________

5. ______________________________________
What is the effect of coevolution on disease spread?

Table 1. Infection matrices for (A) the matching allele model (MAM), and (B) the inverse matching allele model (IMAM).

<table>
<thead>
<tr>
<th>Parasite genotype</th>
<th>Parasite fitness on host genotype $i$</th>
<th>$R_0i$</th>
<th>$p_i(R_0i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$B$</td>
<td>$B$</td>
<td>$B h_1$</td>
</tr>
<tr>
<td>2</td>
<td>$B$</td>
<td>$B$</td>
<td>$B h_2$</td>
</tr>
<tr>
<td>3</td>
<td>$B$</td>
<td>$B$</td>
<td>$B h_3$</td>
</tr>
<tr>
<td>4</td>
<td>$B$</td>
<td>$B$</td>
<td>$B h_4$</td>
</tr>
</tbody>
</table>
Let $B = \text{parasite fecundity.}$
Let $h_i = \text{frequency of host genotype } i$
Let $p_i = \text{frequency of parasite genotype } i \text{ (which infect } h_i)\text{)}$

Derive parasite fitness ($R_0$). \text{Hint:} \text{cov}(x, y) = E[xy] - E[x]E[y]  
\text{cov}(x, y) = (\text{mean of products})-(\text{product of the means})
A. Vir=0.6

B. Vir=0.7

C. Vir=0.8

Red line ($R_0$) above black line indicates a positive covar.

Red line ($R_0$) below black line indicates a negative covar.

black line = $B/H$

Lively (2016) American Naturalist
A. 

Genera4on

N of individuals

B. 

Freq. of Infection

Asex

Sex

C. 

R₀ or N of exposures

N exposures

B/H

Generation
Beta = 5

- Clone
- Sexuals
- Propagules/host
- Virulence
- Freq. infection

Freq. or Vir.