Chapter 8: Life histories

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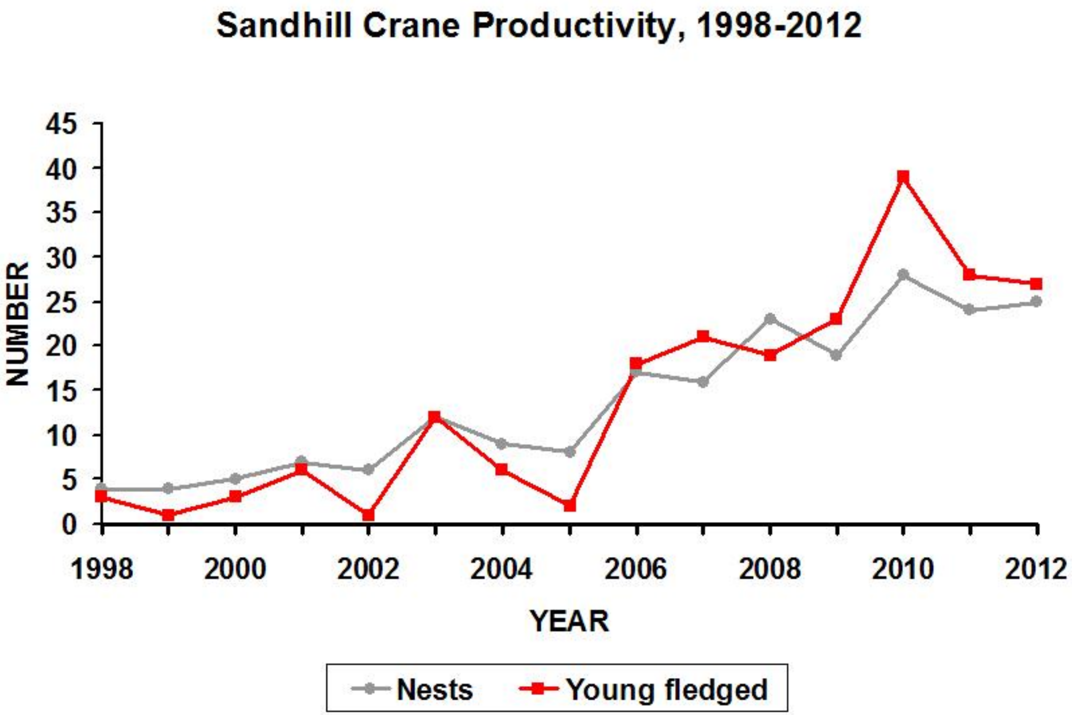
Doing (ecological) science: Explaining and predicting patterns using key biological processes!

Sandhill crane



Gymnogyps californianus

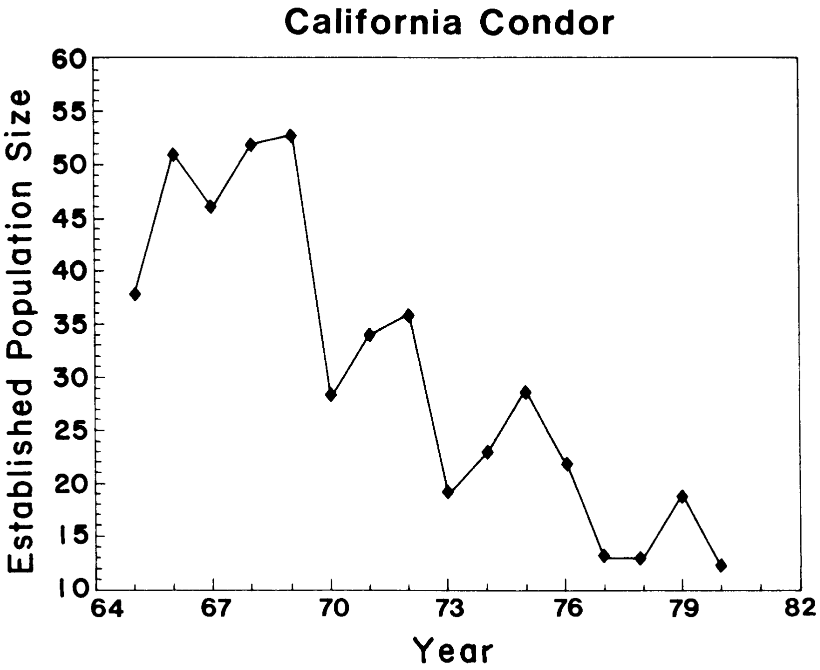


FIG. 7. Estimated total wild population of the California Condor, 1965–1980. Data are from October surveys as listed by Wilbur (1980) and Snyder and Johnson (1985).

Ursus arctos

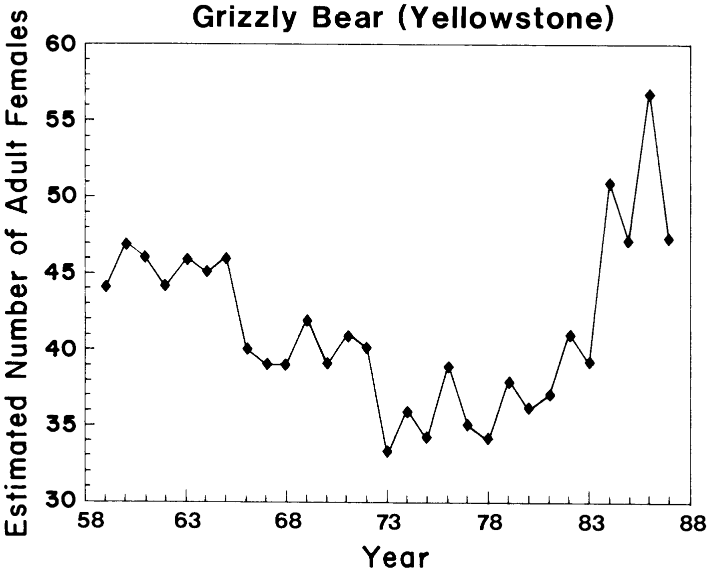


FIG. 5. Estimated number of adult females in the Yellowstone National Park grizzly bear population, 1959–1987. Data, listed by Eberhardt et al. (1986) and supplemented by recent figures, consist of a 3-yr moving sum of the yearly number of adult females seen with cubs.

Grus americana

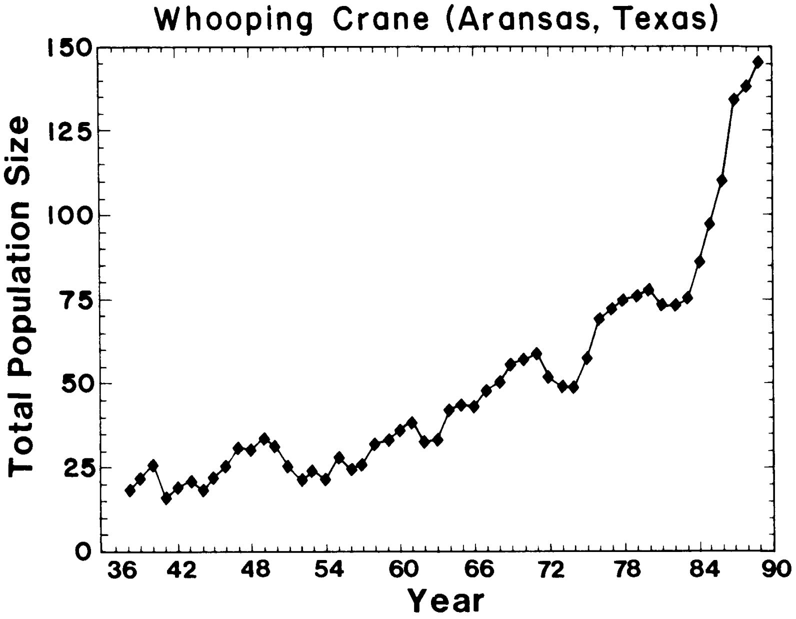
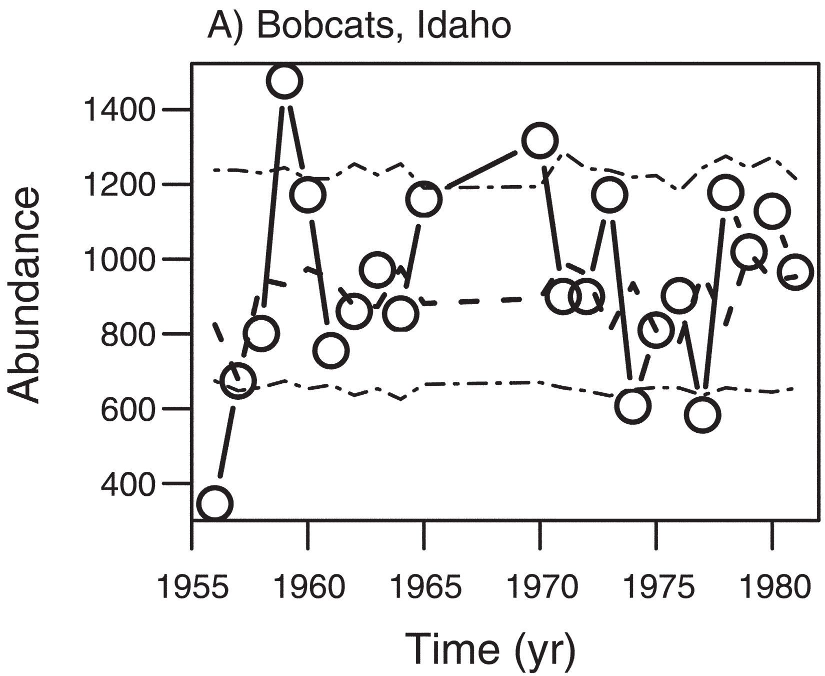


FIG. 4. Total size of the Aransas/Wood Buffalo Whooping Crane population, from 1938–1988. Data are from Boyce (1987), supplemented by more recent counts.

Lynx rufus


A) Bobcats, Idaho
Abundance
1400
1200
1000
800
600
400
1955
1960
1965
1970
1975
1980
Time (yr)

Arctocephallus gazella

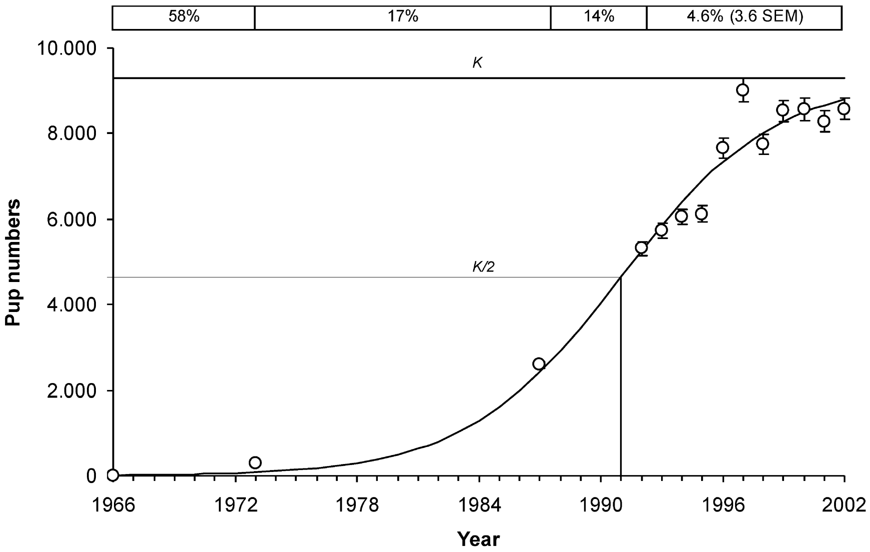
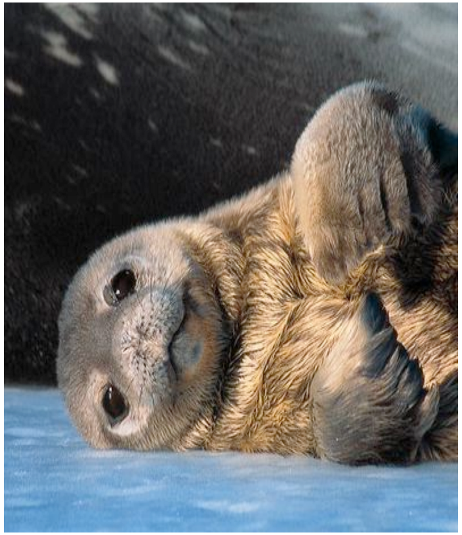
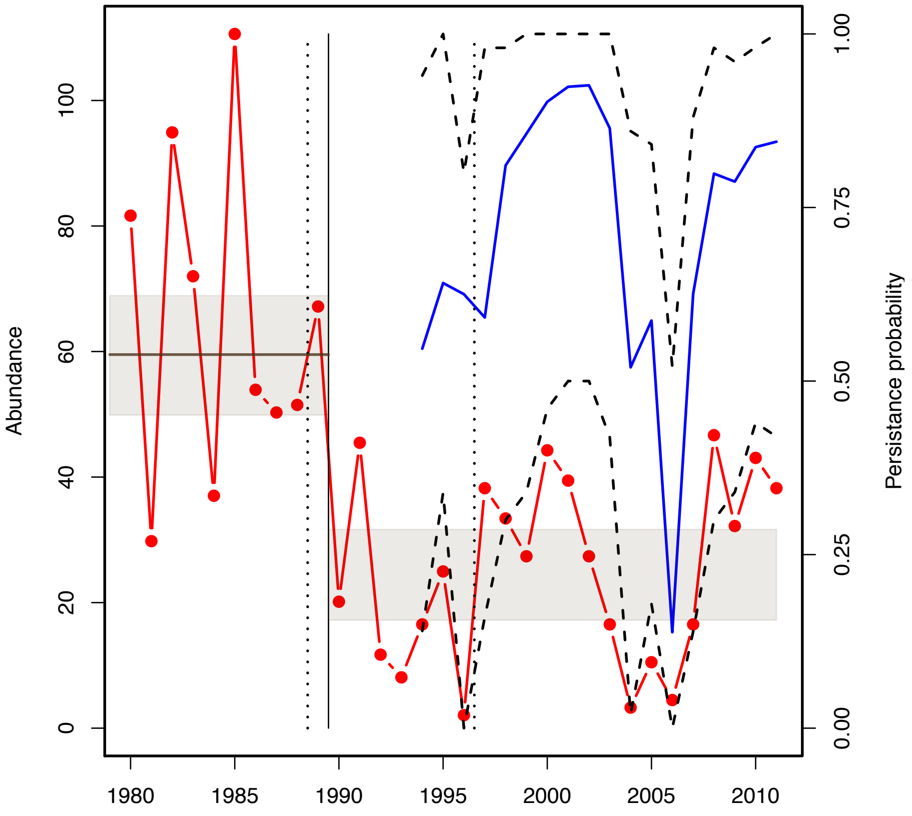


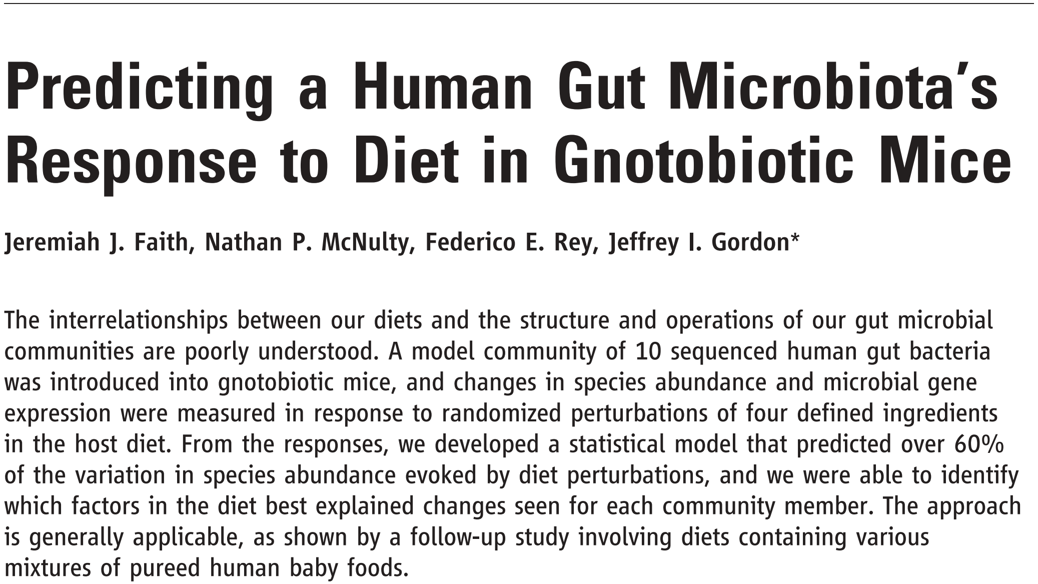
Fig. 4 Antarctic fur-seal pup production at Cape Shirreff and San Telmo Islets, South Shetlands (1966–2002) with 3% error bars. The *fitted line* corresponds to the logistic model parameterized by $K = 9294$; $t_{50} = 1991$; $r = 0.2625$. Also shown in *boxes* is the percent rate of increase for different periods and the standard error of the mean (*SEM*) for the series ranging from 1992 to 2002



Bull trout in Montana



Point estimates of change in community composition

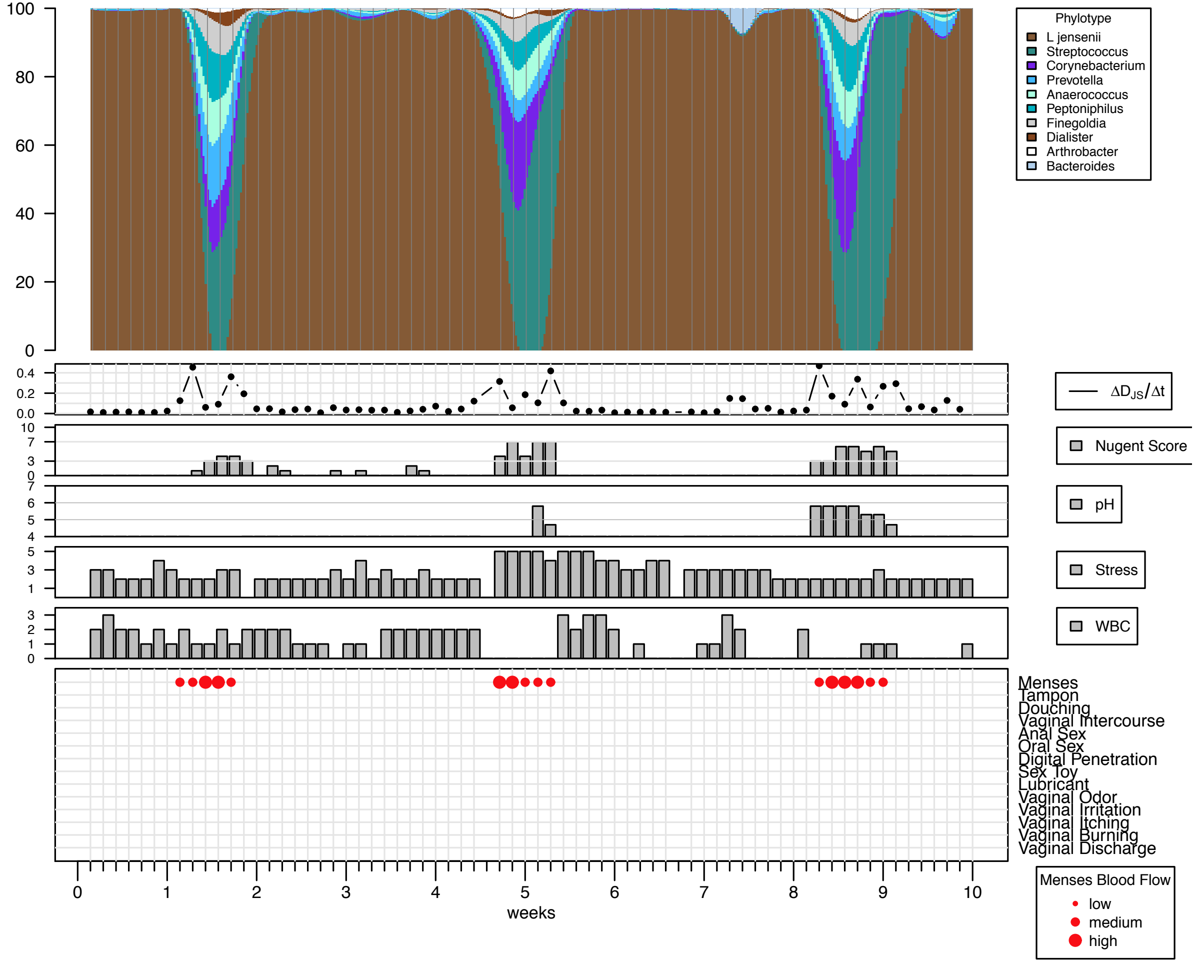


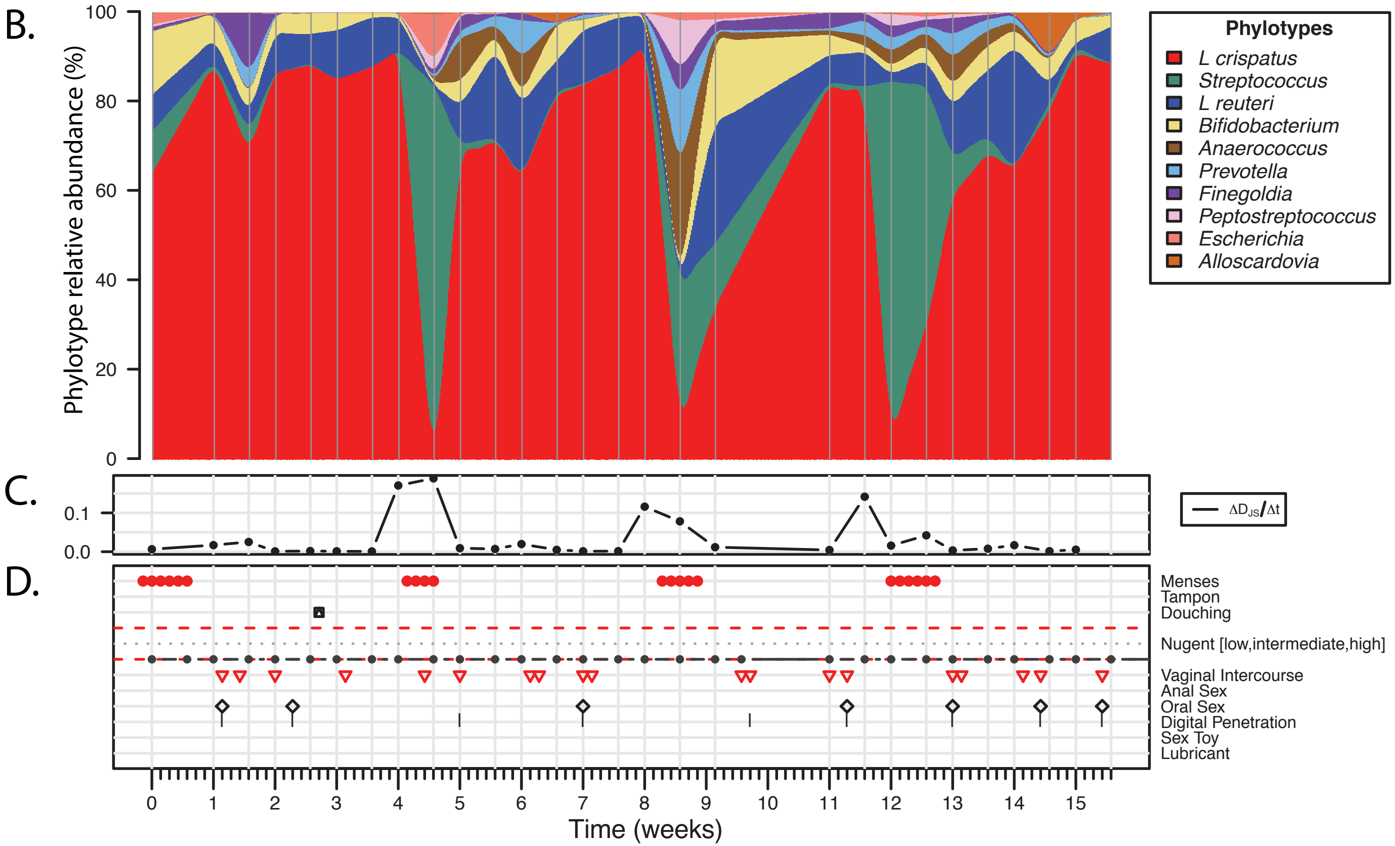
Predicting a Human Gut Microbiota's Response to Diet in Gnotobiotic Mice

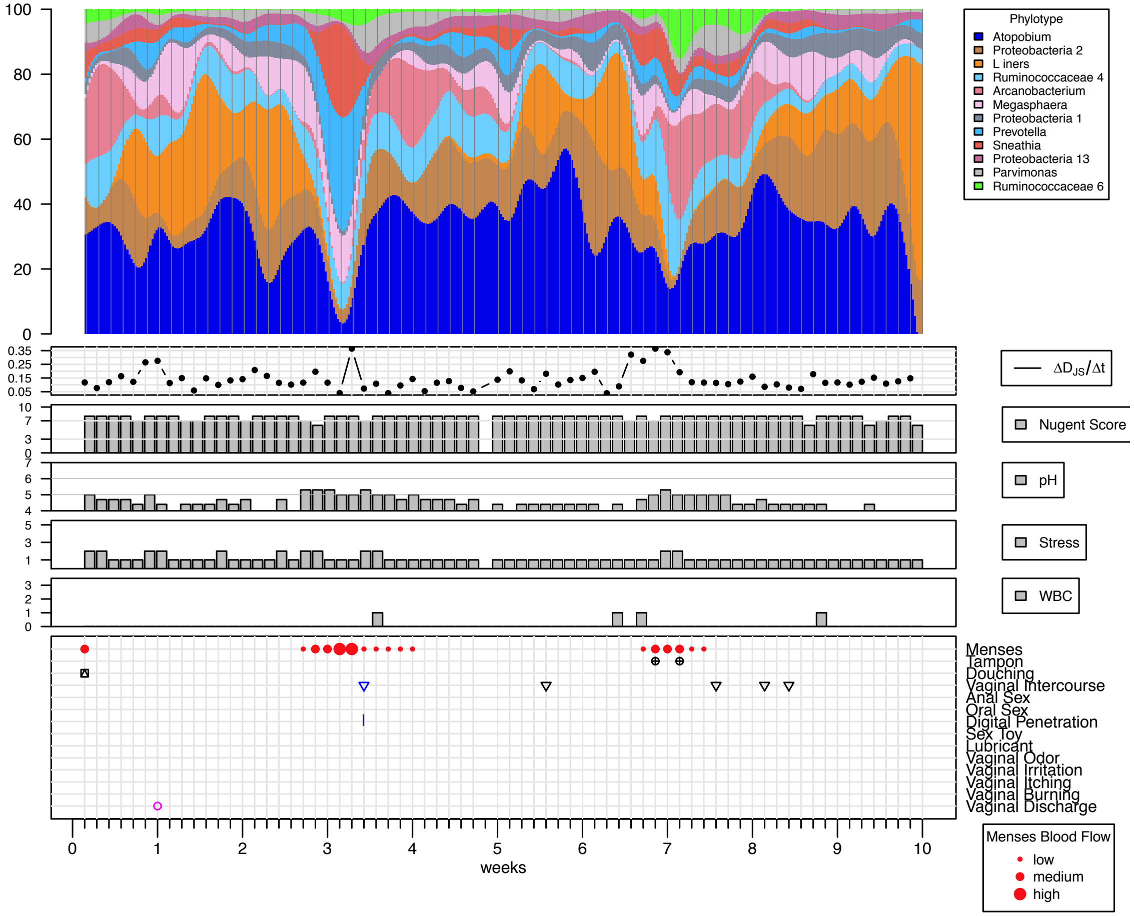
Jeremiah J. Faith, Nathan P. McNulty, Federico E. Rey, Jeffrey I. Gordon*

The interrelationships between our diets and the structure and operations of our gut microbial communities are poorly understood. A model community of 10 sequenced human gut bacteria was introduced into gnotobiotic mice, and changes in species abundance and microbial gene expression were measured in response to randomized perturbations of four defined ingredients in the host diet. From the responses, we developed a statistical model that predicted over 60% of the variation in species abundance evoked by diet perturbations, and we were able to identify which factors in the diet best explained changes seen for each community member. The approach is generally applicable, as shown by a follow-up study involving diets containing various mixtures of pureed human baby foods.

Faith et al. Science 333, 101 (2011)


100
80
60
40
20
0
Phylotype
L jensenii
Streptococcus
Corynebacterium
Prevotella
Anaerococcus
Peptoniphilus
Finegoldia
Dialister
Arthrobacter
Bacteroides
0.4
0.2
0.0
ΔD_JS/Δt
10
7
3
0
Nugent Score
7
6
5
4
pH
5
3
1
Stress
3
2
1
0
WBC
Menses
Tampon
Douching
Vaginal Intercourse
Anal Sex
Oral Sex
Digital Penetration
Sex Toy
Lubricant
Vaginal Odor
Vaginal Irritation
Vaginal Itching
Vaginal Burning
Vaginal Discharge
0
1
2
3
4
5
6
7
8
9
10
weeks
Menses Blood Flow
low
medium
high


B.
100
80
60
40
20
0
Phylotype relative abundance (%)
Phylotypes
🟥 L crispatus
🟩 Streptococcus
🟦 L reuteri
🟨 Bifidobacterium
🟫 Anaerococcus
🟦 Prevotella
🟪 Finegoldia
🟪 Peptostreptococcus
🟥 Escherichia
🟧 Alloscardovia
C.
0.1
0.0
ΔD_JS/Δt
D.
Menses
Tampon
Douching
Nugent [low,intermediate,high]
Vaginal Intercourse
Anal Sex
Oral Sex
Digital Penetration
Sex Toy
Lubricant
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Time (weeks)


100
80
60
40
20
0
Phylotype
Atopobium
Proteobacteria 2
L iners
Ruminococcaceae 4
Arcanobacterium
Megasphaera
Proteobacteria 1
Prevotella
Sneathia
Proteobacteria 13
Parvimonas
Ruminococcaceae 6
0.35
0.25
0.15
0.05
ΔD_JS/Δt
10
7
3
0
Nugent Score
7
6
5
4
pH
5
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1
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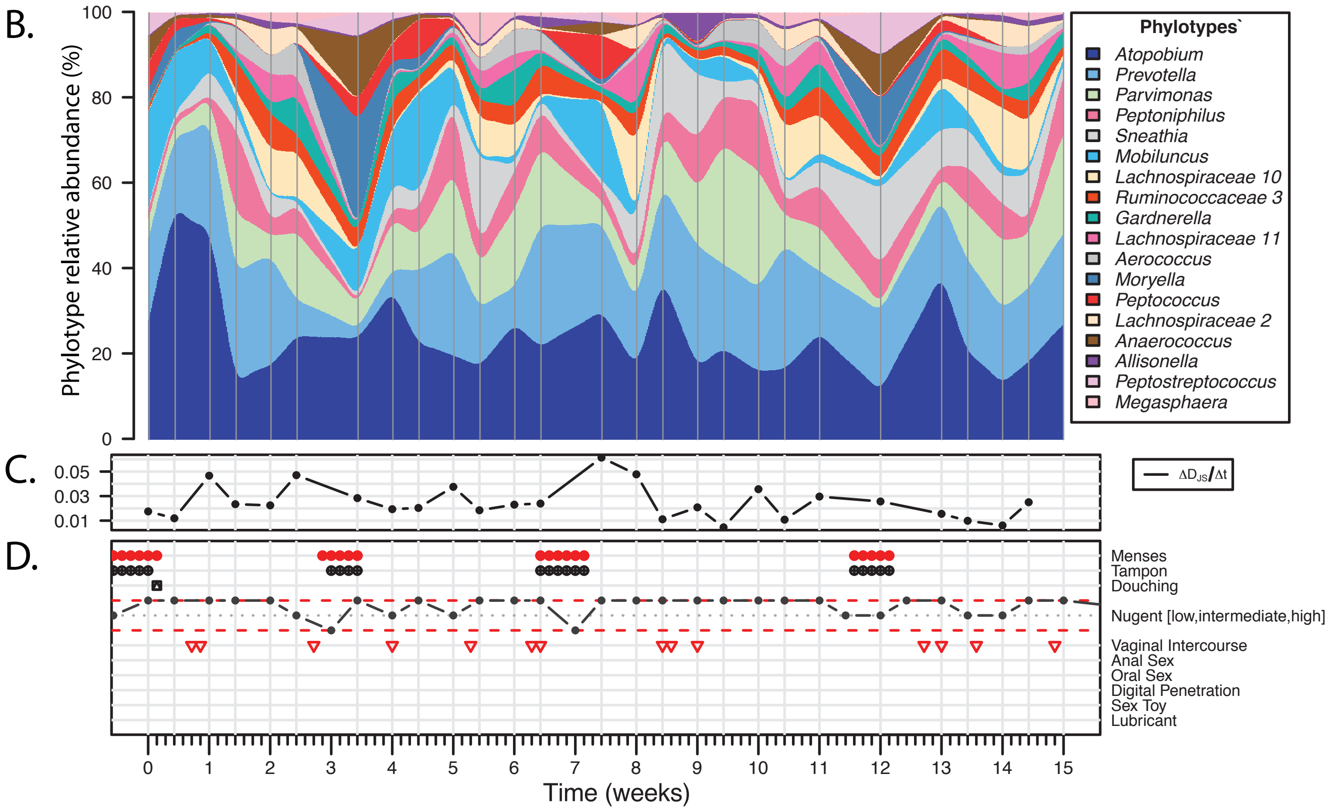
B.
Phylotype relative abundance (%)
100
80
60
40
20
0
Phylotypes`
Atopobium
Prevotella
Parvimonas
Peptoniphilus
Sneathia
Mobiluncus
Lachnospiraceae 10
Ruminococcaceae 3
Gardnerella
Lachnospiraceae 11
Aerococcus
Moryella
Peptococcus
Lachnospiraceae 2
Anaerococcus
Allisonella
Peptostreptococcus
Megasphaera
C.
0.05
0.03
0.01
ΔD_JS/Δt
D.
Menses
Tampon
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1
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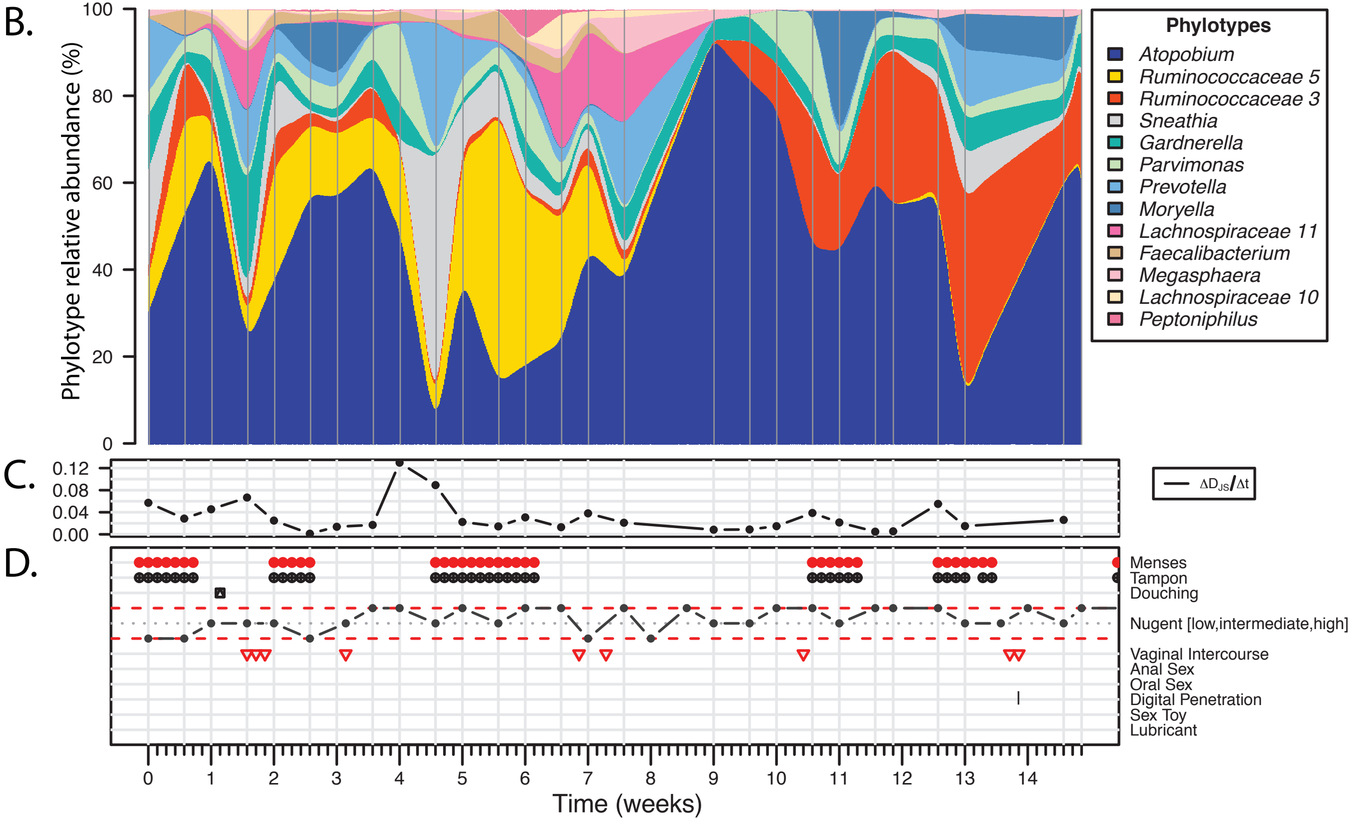
12
13
14
15
Time (weeks)


B.
Phylotype relative abundance (%)
0
20
40
60
80
100
Phylotypes
Atopobium
Ruminococcaceae 5
Ruminococcaceae 3
Sneathia
Gardnerella
Parvimonas
Prevotella
Moryella
Lachnospiraceae 11
Faecalibacterium
Megasphaera
Lachnospiraceae 10
Peptoniphilus
C.
0.12
0.08
0.04
0.00
ΔD_JS/Δt
D.
Menses
Tampon
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Nugent [low,intermediate,high]
Vaginal Intercourse
Anal Sex
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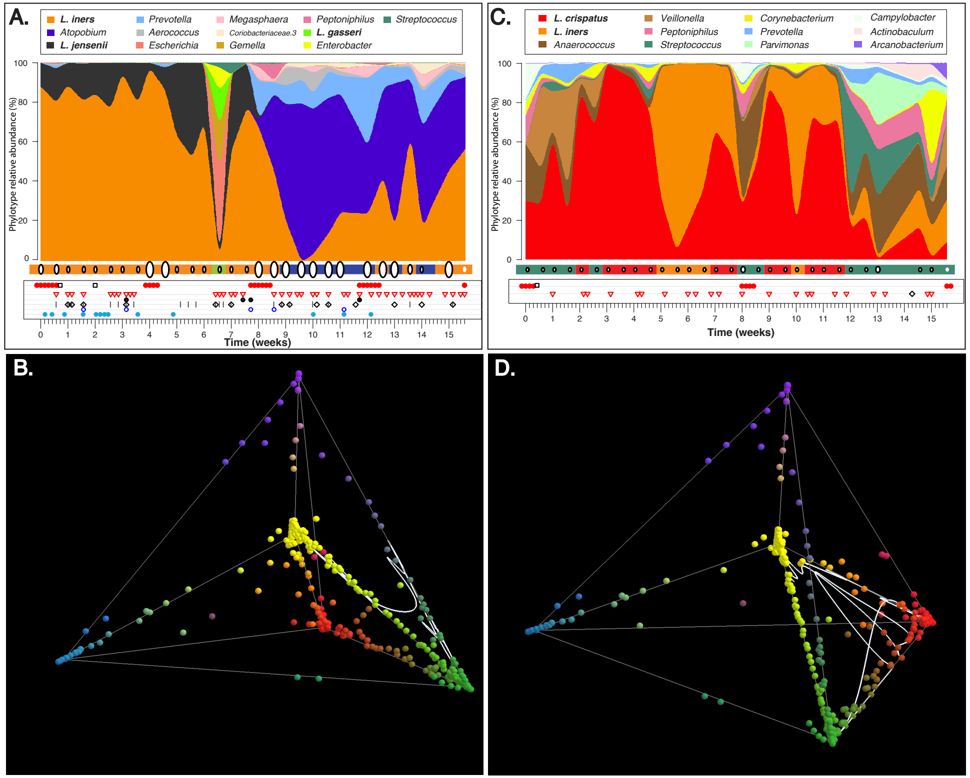
Lubricant
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Time (weeks)



Gajer et al, 2012: (PRINCIPAL COMPONENT ANALYSIS: Reduce dimensionality of system and view it!)

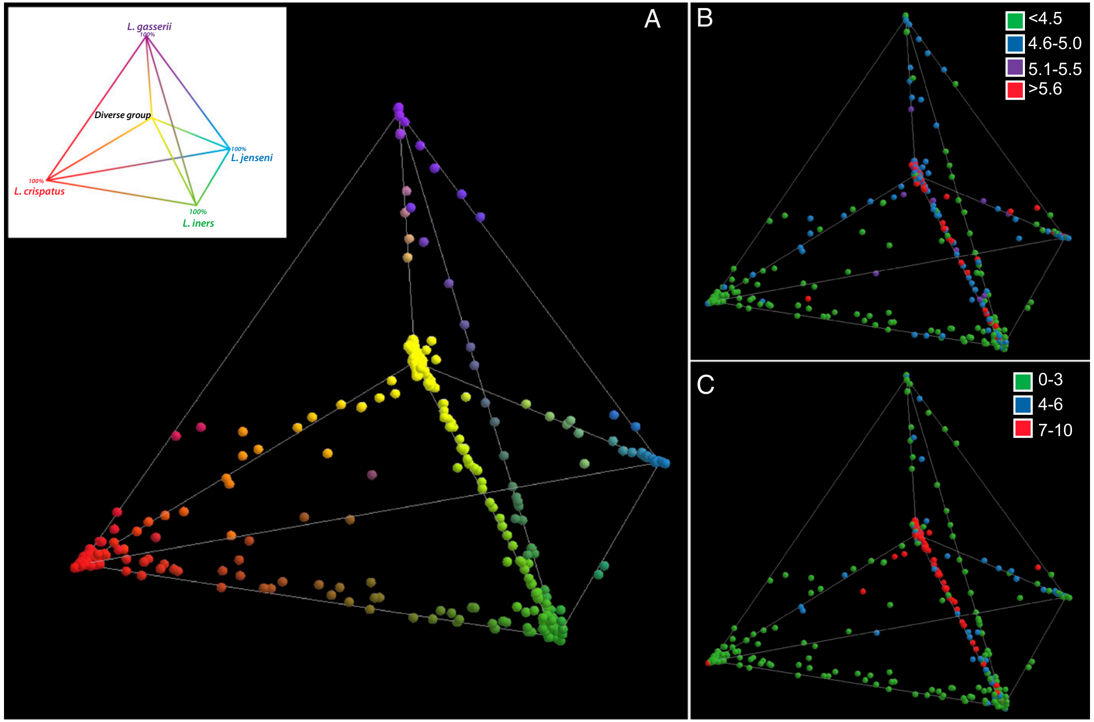


Fig. 4. Relationships among vaginal bacterial communities visualized by principal component analysis in which the relative abundances are expressed as proportions of the total community and displayed in 3D space. Communities dominated by species of *Lactobacillus* and representing community groups I, II, III, and V are shown at each of the four outer vertices of the tetrahedron, with communities of group IV at the inner vertex and shown in the *Inset*. (*A*) Each point corresponds to a single subject and was colored according to the proportions of phylotypes in each community. (*B*) pH of each vaginal community shown in *A*. (*C*) Nugent score category of each vaginal community shown in *A*.

Ravel et al 2011, www.pnas.org/cgi/doi/10.1073/pnas.1002611107

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- Managing the world fisheries?!

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Generality… 1) gives us applicability to a wide array of problems, 2) forces us to focus on identifying key processes that can be targeted for management, prediction and understanding.

Let’s see an example

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Well, many examples in fact. . .

Life histories of organisms are bound to drive changes in population sizes

The assumption of continuous births that the book uses in chapters 12 and 13 later on does not work well for many organisms. In fact, models in which reproduction occurs in discrete-time are much easier to read and interpret. Here's some life histories of organisms with discrete-time reproduction

- **Plants:** Herbs often flower in their first year and then die after setting seed. These are monocarpic plants.
  - Many monocarpic plants are annuals, few are long lived. Many bamboos are long-lived, flower once and then die. Others have flowering times of 1,3,11,15,30,48 and 60 years. One Japanese species *Phyllostachys bambusoides* waits 120 years to flower!!
  - Some bamboo species also synchronize reproduction within cohorts!. The Spring 1983 simultaneous mass flowering and death of *Fargasia spathacea* and *sinarundinarioa fangiana* resulted in the starvation and eat of many pandas.
  - *Agave deserti*, also monocarpic, lives 20 to 25 years before flowering. Also reproduces via clones!

Insects

Semelparity is for animals what monocarpy is for plants (where does this strange name comes from?). Semelparous insects can be

- Univoltine: one generation per year (Mayflies)
- Bivoltine: two generations per year
- Multivoltine: multiple generations per year

Some semelparous insects are long lived (13 and 17 year cycles!). Can you think of a semelparous vertebrate? There are no semelparous birds! All birds are iteroparous. Strong climatic conditions can drive synchrony. For example, the largest breeding area for the Greater Snow Geese *Chen caerulescens* is on Bylot Island in Canada. 1n 1957, 15000 birds nested in the area and ALL egg laying started on 8 June, stopped on 20th June and hatching occurred between 8-13 July.

There are 9 small marsupials in the genera *Antechinus* and *Phascogale* that are semelparous. Males become sexually active after 11 months and die exactly 3-4 weeks later. All of them. Births are highly synchronized. These species live in very predictable environments with precise insect blooms (global warming???)

Organizing all this info using key dichotomies in reproductive strategy and developmental rate

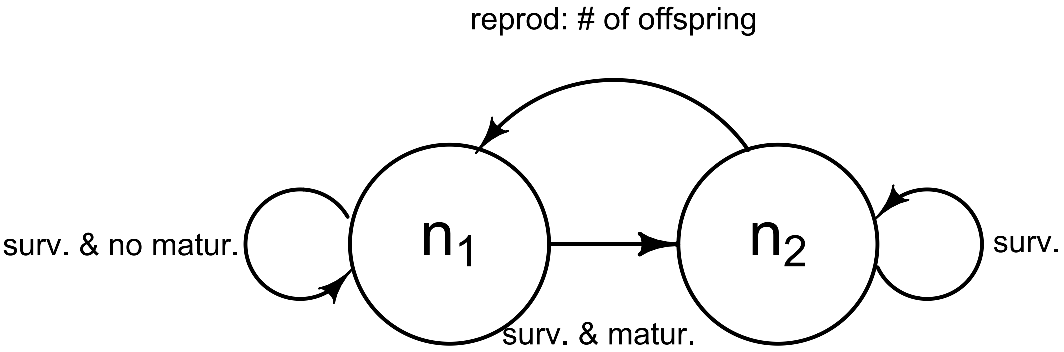
- **Reproductive stragegy** can be classified as semelparous (reproducing only once) or iteroparous (reproducing multiple times)
- **Development** can be classified as precocious (rapid development to maturity) or delayed

Crossing these two biological dichotomies gives us a very general set of combinations of life-histories

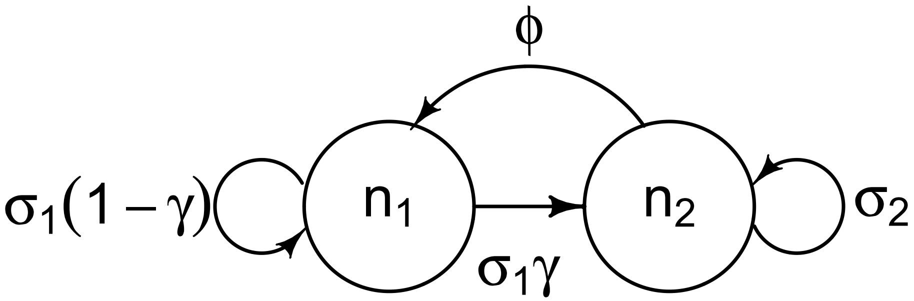
Life cycles table

Developmental strategy	**Reproductive strategy**	
	Semelparous	**Iteroparous**
Precocious	annual plants and insects with rapid development and 1 reproduction	small mammals and birds that begin reproduction young but live many years
Delayed	Periodical cicadas, bamboos that reproduce only once but take many years to do so	organims with long pre-reproductive periods and then survive and reproduce for many years

Life cycle graph: youngs and adults



Life cycle graph



σ_1, σ_2 : denote the fraction of juveniles and of adults alive at time t that survive to time $t+1$

γ : the fraction of surviving juveniles that mature to become adults

ϕ : the number of juveniles at time $t+1$ that are produced by one adult at time t

Modeling the basic discrete life-cycle

The basic life cycle consists of two stages: reproducing adults and non-reproducing juveniles. Let

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γ : the fraction of surviving juveniles that mature to become adults

ϕ : the number of juveniles at time $t+1$ that are produced by one adult at time t

Now, let's write a mathematical model that tracks the changes in the number of adults and juveniles (Board notes now...)