Populations

AP Environmental Science ▪ Unit 3

AP Environmental Science

What we will cover

1 Strategies

Generalists, specialists, r and K

r-selected: many young, fast recovery

K-selected: few young, slow recovery

r fills disturbed places; *K* stays near capacity.

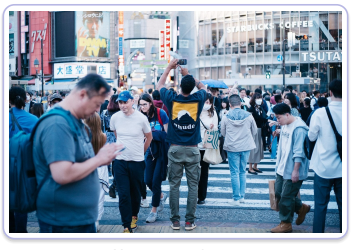
2 Survivorship

Survivorship curves

A **survivorship curve** 存活曲线 shows the fraction alive at each age:

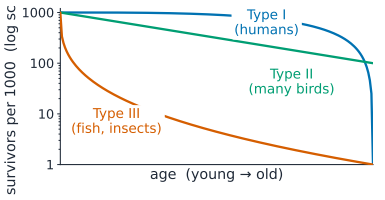
- **Type I**: die old (humans)
- **Type II**: steady rate (birds)
- **Type III**: die young (oysters)

Type III goes with *r*-selection; Type I with *K*-selection.



Human pop density

Type I, II, and III survivorship curves



AP Environmental Science · U3 · Type I/II/III survivorship curves

Type I, II, and III survivorship curves on a log scale

3 Carrying capacity

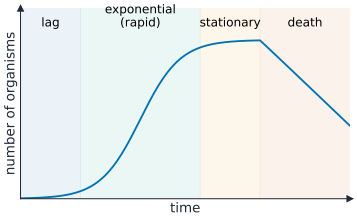
Carrying capacity

Carrying capacity 环境容纳量 K is the most an environment can support. Populations overshoot then die-off; limiting factors set K.

J-curve → S-curve; K itself shifts with the weather.

Carrying capacity limits wildlife populations

Population growth levels off at the carrying



Population growth levels off at the carrying capacity of the environment

Carrying capacity, and what happens past it

carrying capacity 环境容纳量	K – the maximum population an environment can support long-term
approaching K	growth slows as resources per individual fall – the logistic curve flattens
overshoot 超越	a population may exceed K when resources are temporarily abundant
then a die-off 种群崩溃	the excess cannot be supported, and numbers crash – sometimes below K
what sets K	the scarcest resource: food, water, nesting sites, or space
and it moves	K is not a constant – a wet year or a new technology raises it

K is a property of the environment, not of the species. That is why a habitat's degradation lowers it even when the population has not changed.

Population Growth and Resource Availability

With abundant resources a population grows **exponentially 指数增长** (J-curve).

As resources become limited, growth slows to **logistic 逻辑斯蒂增长** (S-curve), leveling at K.

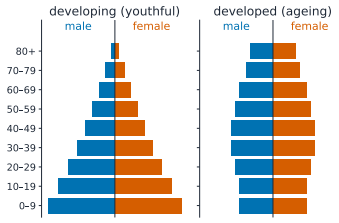
4 Age structure

Age structure diagrams

The shape of an **age structure diagram** 年龄结构图 predicts the future:

A big **pre-reproductive** 繁殖前期 group guarantees growth even if births fall today (population momentum).

Population pyramids of a developing and a



Population pyramids of a developing and a developed country

5 Fertility

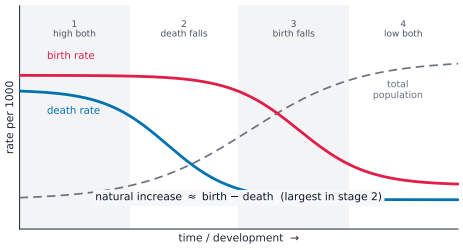
Fertility and the demographic transition

Total fertility rate 总和生育率 (TFR) is children per woman.

- **replacement** 更替水平生育率 ≈ 2.1
- doubling time (rule of 70): $t = \frac{70}{r}$

As a country industrializes, deaths fall first, then births – the **demographic transition** 人口转变.

The four stages of the demographic transition



The four stages of the demographic transition

Human Population Dynamics

Human population growth depends on **birth rate**, **death rate**, and **migration**.

> Rapid growth strains resources and increases the **ecological footprint** 生态足迹.

Exam tips

- Use the **rule of 70**: doubling time $\approx 70 \div$ growth-rate(%); a growth rate is (births $-$ deaths) per 1000 $\div$ 10.
- Read **age-structure diagrams**: a wide base predicts rapid growth, even bars a stable population.
- Contrast **r-selected** (many offspring, little care) and **K-selected** (few, much care) strategies.
- Know the **demographic transition** stages and what lowers birth rates (education, family planning, development).
- A falling **growth rate** still means growth – the population only shrinks when deaths exceed births.

Generalist and Specialist Species

A **generalist** 广适性物种 can live in many habitats and eat many foods (raccoon, cockroach) – flexible, so it copes well with change.

> A **specialist** 狭适性物种 needs specific conditions or foods (panda, koala) – efficient in a stable habitat but very vulnerable if that habitat changes.

K-Selected and r-Selected Species

- *r*-**selected** species produce **many** offspring with little care, mature fast, and have short lives (insects, weeds). They colonize quickly and boom-and-bust.
- *K*-**selected** species produce **few** offspring with much care, mature slowly, and live long (elephants, humans).

6 Recap

Worked example – the rule of 70

A country's population grows at 2% per year. Find its doubling time, and the growth rate that would halve it.

- Rule of 70: doubling time $= \dfrac{70}{\%\text{ growth rate}}$
- $= \dfrac{70}{2} = 35$ years
- To halve the doubling time to 17.5 years you would need $70/17.5 = 4\%$.
- Growth is exponential: a small rate change moves the doubling time a long way.

> Doubling time $= 70/r$ works for anything growing exponentially – population, GDP, energy use. Put r in as a percent, not a decimal.

Unit 3 – key takeaways

1. **Strategies**
   generalist vs specialist; r (many young) vs K (few)
2. **Survivorship**
   Type I late death, II steady, III early death
3. **Capacity**
   K; overshoot then die-off; J-curve to S-curve
4. **Human pop.**
   age structure shape; TFR ≈ 2.1; the transition

Check yourself

1. Is a panda a generalist or a specialist?
2. Which survivorship type fits an oyster?
3. What TFR keeps a population steady?
4. At $r = 2\%$, what is the doubling time?

Answers **1.** specialist **2.** Type III **3.** about 2.1 **4.** $70/2 = 35$ years