Harvest Theory
MSY – Clarification and Consistency

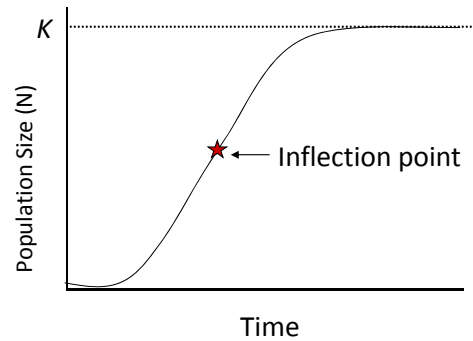## Dr. Kelley M. Stewart

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Harvest

- Capital reduction
  - To reduce the population below the unharvested density or carrying capacity.

- Sustained-yield harvesting
  - Harvested at the rate at which it bounces back. Used to maintain population at a particular density.
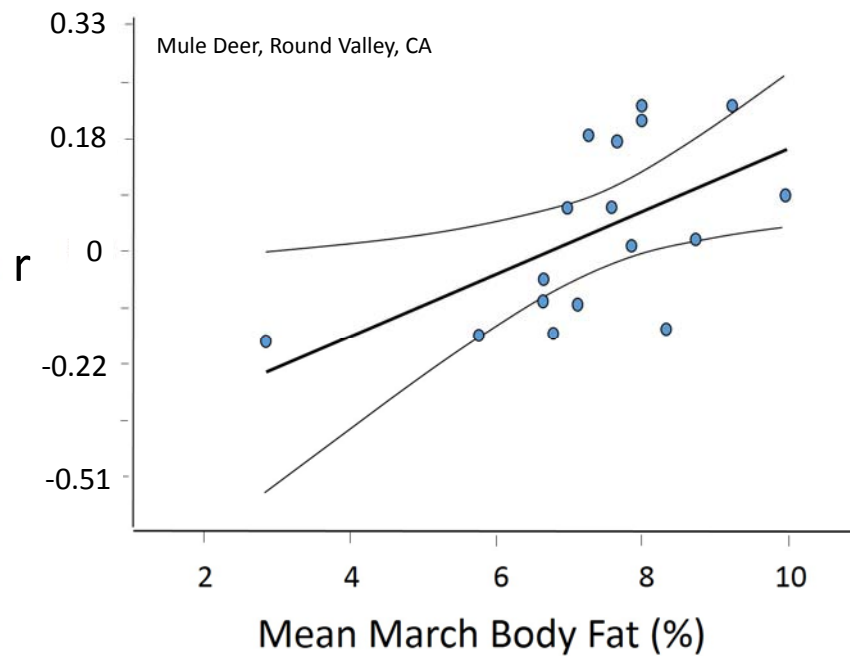
Density-Dependent Population Growth

At K, dN / dt = 0   because N = K

$$\frac{dN}{dt} = r N \frac{(K - N)}{K}$$

Population Size (N)

K ········· (dotted line)

Inflection point

Time

K = carrying capacity, births = deaths

Mule Deer, Round Valley, CA

r

0.33
0.18
0
-0.22
-0.51

2   4   6   8   10

Mean March Body Fat (%)

Monteith et al. 2014 J. Animal Ecology

Density-Dependent Growth

$$\frac{dN}{dt} = r\,N\,\frac{(K-N)}{K}$$

r_{max}

MSY

MSY

K

MSY

K

Population Size (N)

Recruitment Rate

Recruitment Number

Time

Population size (N) K

Population Size (N)

3 Forms of the Logistic Equation
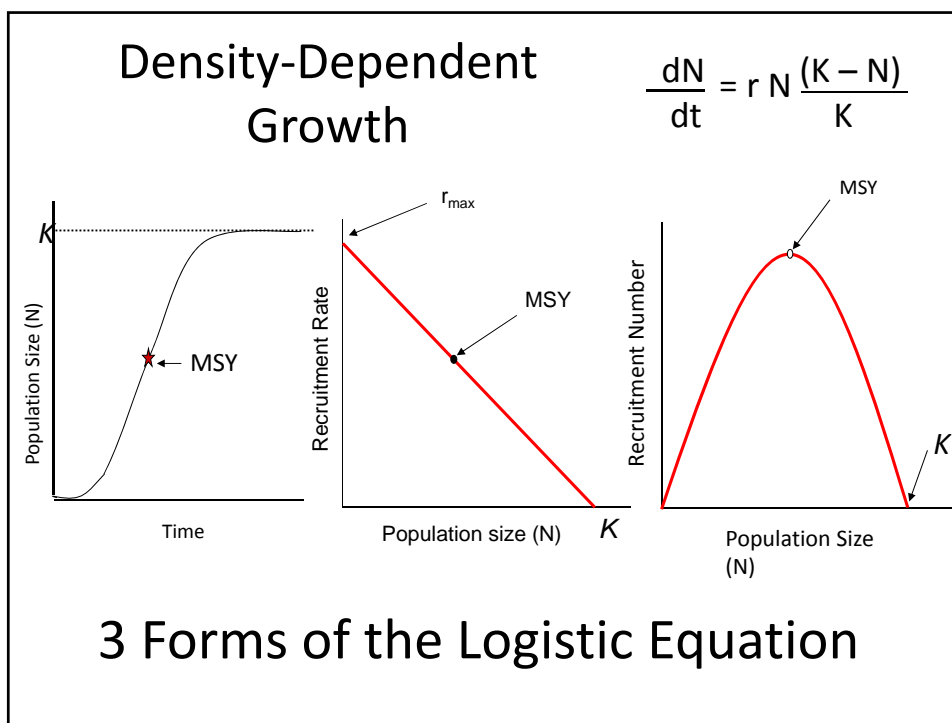
Logistic equation:

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right) \quad \text{or} \quad \Delta N = rN\left(1 - \frac{N}{K}\right)$$
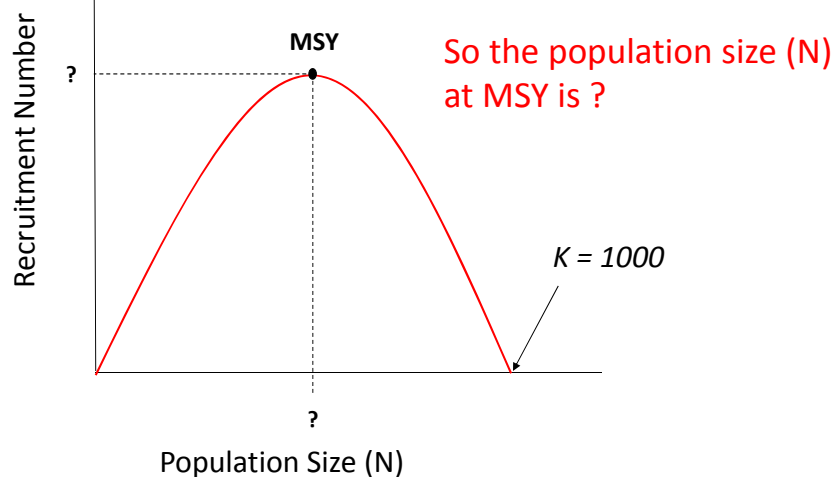
Maximum sustained yield:

$$MSY = \frac{K}{2} \quad \text{or} \quad MSY = \frac{rK}{4}$$

What is the discrepancy or which is correct?

What does MSY = ½ K mean?
a. number to be harvested at MSY?
b. population size at MSY?

MSY

So the population size (N) at MSY is ?

Recruitment Number

?

K = 1000

?

Population Size (N)

If population size at MSY = $\frac{K}{2}$, then to determine the number to harvest (e.g. yield) at MSY, substitute $\frac{K}{2}$ for N in the logistic equation.

$$MSY = r(\frac{K}{2})(\frac{K - \frac{K}{2}}{K}) = \frac{rK}{4}$$

What does $MSY = \dfrac{rK}{4}$ mean?

a. Number to be harvested at MSY?
b. Population size at MSY?

MSY

Recruitment Number

?

K = 1000

500
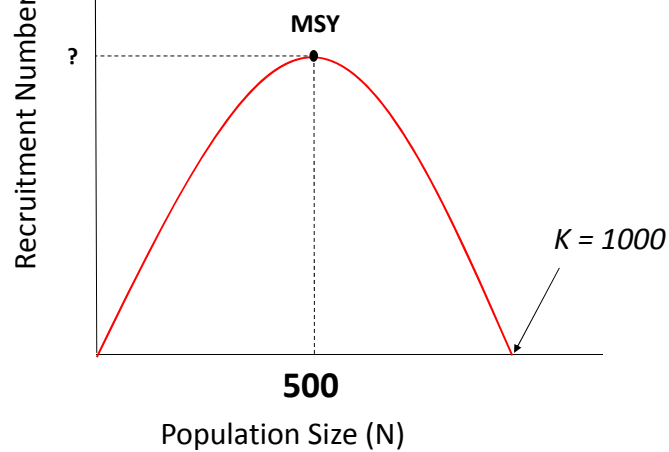
Population Size (N)

If r = 1.0 and the population size at MSY is 500

$$MSY = \frac{rK}{4}$$

$$= \frac{1.0(500)}{4} = 125$$

$$MSY = \frac{rK}{4}$$

MSY

125

Recruitment Number

K = 1000

500

Population Size (N)

$$MSY_{pop\ size} = \text{½ } K$$

$$MSY = \frac{rK}{4}$$

Sampling or measurement error

MSY

FRY –Fixed Removal Yield

125

Recruitment Number

K = 1000

500

Population Size (N)

$$MSY_{pop\ size} = \text{½ } K$$

$$MSY = \frac{rK}{4}$$

Recruitment Number

125

MSY

Sampling or measurement error

FRY –Fixed Removal Yield

IS THE POPULATION SIZE AT MSY ALWAYS ½ K?

K = 1000

500

Population Size (N)

$$MSY_{pop\ size} = \text{½ } K$$

McCullough 1995

Sex-biased harvest?

Additive mortality — Compensatory mortality

MSY

Recruitment Number (Number of Young) — Population Size (N)

Attempted recruits (fetal rates)

Actual recruits

K

McCullough 1979. The George Reserve Deer Herd: Population Ecology of a K-Selected Species