\[ l_x = \text{age specific survivorship} \]
\[ m_x = \text{age specific fecundity} \]
\[ \Sigma l_x m_x = R_0 = \text{net reproductive rate} \]

\[ \frac{N_t}{N_0} = \lambda \quad \lambda = \text{finite rate of increase} \]

\[ N_t = N_0 \lambda^t \quad \lambda = \text{finite rate of increase} \]

\[ r = \text{per capita rate of increase} \quad r_{\text{max}} = \text{intrinsic rate of increase} \]

\[ N_t = N_0 \lambda^t \quad \lambda = e^r \quad N_t = N_0 e^{rt} \]
Practical Example on using population growth equations: The whooping crane
If 20 cranes were alive in 1941 and 425 existed in 2004, what is r?

What we know:

\( N_0 = 20 \)
\( N_t = 425 \)
\( t = 63 \)

And of course \( N_t = N_0 e^{rt} \)

So solve for \( r \)
425 = 20e^{r63}

425/20 = e^{r63}

\ln(425/20) = r63

\ln(425/20)/63 = r
If \( r \) is 0.046 and can be sustained for the foreseeable future, and the current flock contains 189 individuals how long will it take the population to double?

What we know:
\[
N_0 = 189 \\
N_t = 378 \text{ (2x189)} \\
r = 0.046 \\
\text{And of course } N_t = N_0 e^{rt} \\
\text{So solve for } t
\[378 = 189e^{0.046t}\]

\[\frac{378}{189} = e^{0.046t}\]

\[\ln\left(\frac{378}{189}\right) = 0.046t\]

\[\frac{\ln\left(\frac{378}{189}\right)}{0.046} = t\]
In 2002 there was one breeding pair, in 2003 it doubled. If it continues to double, how long will it take to reach 25 breeding pairs?

What we know:

\[ N_0 = 2 \]
\[ N_t = 25 \]
\[ \lambda = 2.0 \text{ and } \lambda = e^r \]

And of course \( N_t = N_0 e^{rt} \)

So solve for \( t \)
First, determine $r$

$$2 = e^r$$

$$\ln(2) = r$$

$$\ln(2) = r = 0.693$$

Now: $N_t = N_0 e^{rt}$

$$25 = 2e^{0.693t}$$

$$\ln(25/2) = .693t$$

$$\ln(25/2)/.693 = t$$
The Wisconsin/Florida migrating crane population became established in 2001, the first breeding pair will probably be 2010. Suppose an r of 0.05, in what year will there be 25 breeding pairs?

What we know:

$N_0 = 1$

$N_t = 25$

$r = 0.05$

And of course $N_t = N_0 e^{rt}$

So solve for $t$
\[ N_t = N_0 e^{rt} \]

\[ 25 = e^{.05t} \]

\[ \ln(25) = .05t \]

\[ \ln(25)/.05 = t \]

But of course, you have to add \( t \) to 2010 to get the answer.