

Raptor Population Ecology

1. Divide the class into groups of three or four.
2. Explain that each group is going to analyze the results from a ten-year raptor study. Each group will be assigned a different study to analyze involving different raptor species. Students will write a brief synopsis about their assigned raptor species including the following information: range, habitat, diet, incubation, description, and status. Students should locate a photograph of the raptor to include in their research.
3. Review the definitions listed in the background and the procedure for calculating population size, carrying capacity, annual change in population size, and maximum rate of population increase.
4. Instruct students to read all the background information on the study provided them, calculate the population size, carrying capacity, maximum rate of population increase, and the annual change in population size for each year of the study. All calculated totals should be rounded to the nearest 100th and documented on the raptor chart provided. Note: For convenience, information given in the background is already listed on the chart.
5. Instruct students to answer the questions on their sheets regarding their study analysis.
6. Create a mock raptor convention for students to display the results of their study. Each student group will act as representatives from their particular study and present their research. The teacher will check the calculations for accuracy using the teacher's guide.

Raptor Population Ecology

NAME _____

Population ecology is a major sub-field of ecology that deals with the dynamics of species populations and how these populations interact with the environment.

One of the first laws of population ecology is the Thomas Malthus' exponential law of population growth. This law states that:

"...a population will grow (or decline) exponentially as long as the environment experienced by all individuals in the population remains constant."

This premise in population ecology provides the basis for formulating predictive theories and tests that follow. Simplified population models usually start with four key variables including death, birth, immigration, and emigration. Mathematical models used to calculate changes in population demographics and evolution hold the assumption (or null hypothesis) of no external influence.

BACKGROUND INFORMATION ON FORMULAS

Population (N): A group of individuals of one species that live in a particular geographic area.

Carrying Capacity (K): The maximum population size that can be supported by the available resources.

Biotic Potential (r_{\max}): The maximum rate of natural increase that can possibly occur under ideal circumstances (unlimited resources, space, no predators, no parasites, etc.). It is very difficult to calculate the biotic potential for a species since these optimal circumstances rarely occur.

ΔN : The number of organisms added to a population within a unit of time.

CALCULATIONS FOR ACTIVITY

Population Calculations:

- The initial population for the first year of each study is stated and listed on the raptor chart. During the course of this activity other designated populations will appear on the raptor chart. The reasoning for these new population totals are listed in the background section of each study.

- ΔN represents the number of new organisms coming into a population. The ΔN totals calculated at the end of each year and must be added to the population. (See ΔN calculation section below). The calculated sum represents the new population total for the subsequent year. For example: If the population for the first year of the study is 20 individuals and the ΔN was calculated to be 2. Then the population for the second year of the study will be 22 individuals.

Carrying Capacity Percentage Calculations:

- The carrying capacity is stated with each study.
- The following equation will be used to determine what percentage of the carrying capacity (K) is still available for population growth: $(K-N)/K$. For example: If the population (N) is 20 individuals and the carrying capacity (K) is 50 individuals, then 60% of the carrying capacity is left. $50-20/50 = 0.6 \times 100 = 60\%$.

Biotic Potential Calculations (r_{max})

- The initial biotic potential is stated with each study. However, this is the maximum rate of increase a species can gain. Each study included in the activity begins with a certain population. That population reduces the biotic potential (r_{max}) because they are taking up space and resources. Therefore the r_{max} value must be calculated for each year because the population fluctuates.
- The biotic potential value is calculated by multiplying the initial r_{max} stated with each study (this is the optimal rate that the species could grow at) by the carrying capacity percentage. The r_{max} value is multiplied by the carrying capacity percentage because there is already an initial population taking up resources and space. Therefore a new r_{max} value must be found to accommodate the existing population. For example, if it was stated that r_{max} was 0.05 or 5% (this is the optimal rate of increase) and the carrying capacity percentage was calculated to be 0.4 (40% of the carrying capacity left in the environment), then the new r_{max} value is 0.02 or 2%. $(0.4)(0.05) = 0.02$ or 2% Interpretation of Results: The initial population could increase every year by 5%, but since there is already a population in the environment, the rate of increase has been reduced to 2%. This new r_{max} value takes into account the existing population.

ΔN Calculations:

- This is the number by which the population will increase by at the end of each year. It is calculated by multiplying the r_{max} value (this is the r_{max} value that takes into account the existing population, NOT the optimal r_{max} value stated initially) by the population. For example: If (N) is 20 individuals and the r_{max} value was calculated to be 0.05 or 5%, then the number of individuals to be added to the population is 1. $(0.05)(20) = 1.0$. Then one individual must be added to next year's population.

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Study 1: bald eagle *Haliaeetus leucocephalus*

Carrying capacity (K): 5,000 Maximum rate of increase (r_{max}): 0.05 Population (N): 1,000

Background:

During the third year of the study there was immigration. The population increased to 3,200.

During the fifth year of the study there was emigration. The population decreased to 2,000.

During the seventh year of the study there was immigration. The population increased to 4,000.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | $(K-N)/K$ | r_{MAX} | ΔN |
|------|-------|-----------|-----------|------------|
| 1 | 1,000 | | | |
| 2 | | | | |
| 3 | 3,200 | | | |
| 4 | | | | |
| 5 | 2,000 | | | |
| 6 | | | | |
| 7 | 4,000 | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

- A. Which year of the study came closest to the carrying capacity?
- B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
- C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
- D. Graph the results of the study.

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Study 2: great horned owl *Bubo virginianus*

Carrying capacity (K): 3,500 Maximum rate of increase (r_{max}): 0.05 Population (N): 750

Background:

During the fourth year of the study there was immigration. The population increased to 2,250.

During the sixth year of the study there was emigration. The population decreased to 1,700.

During the eighth year of the study there was immigration. The population increased to 3,200.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | (K-N)/K | r_{MAX} | ΔN |
|------|-------|---------|-----------|------------|
| 1 | 750 | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | 2,250 | | | |
| 5 | | | | |
| 6 | 1,700 | | | |
| 7 | | | | |
| 8 | 3,200 | | | |
| 9 | | | | |
| 10 | | | | |

- A. Which year of the study came closest to the carrying capacity?
- B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
- C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
- D. Graph the results of the study.

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Study 3: red-tailed hawk *Buteo jamaicensis*

Carrying capacity (K): 10,000 Maximum rate of increase (r_{max}): 0.04 Population (N): 6,000

Background:

During the third year of the study there was immigration. The population increased to 8,400.

During the fifth year of the study there was emigration. The population decreased to 5,500.

During the eighth year of the study there was immigration. The population increased to 7,000.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | (K-N)/K | r_{MAX} | ΔN |
|------|-------|---------|-----------|------------|
| 1 | 6,000 | | | |
| 2 | | | | |
| 3 | 8,400 | | | |
| 4 | | | | |
| 5 | 5,000 | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | 7,000 | | | |
| 10 | | | | |

- A. Which year of the study came closest to the carrying capacity?
- B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
- C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
- D. Graph the results of the study.

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Study 4: screech owl *Otus asio*

Carrying capacity (K): 1,000 Maximum rate of increase (r_{max}): 0.03 Population (N): 575

Background:

During the fourth year of the study there was emigration. The population decreased to 300.

During the sixth year of the study there was immigration. The population increased to 575.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | (K-N)/K | r _{MAX} | Δ N |
|------|-----|---------|------------------|-----|
| 1 | 575 | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | 300 | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | 700 | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

A. Which year of the study came closest to the carrying capacity?

B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?

C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?

D. Graph the results of the study.

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Study 5: barn owl *Tyto alba*

Carrying capacity (K): 5,000 Maximum rate of increase (r_{\max}): 0.06 Population (N): 2,750

Background:

During the fourth year of the study there was immigration. The population increased to 4,000.

During the seventh year of the study there was emigration. The population decreased to 3,500.

During the ninth year of the study there was immigration. The population increased to 3,950.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | $(K-N)/K$ | r_{\max} | ΔN |
|------|-------|-----------|------------|------------|
| 1 | 2,750 | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | 4,000 | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | 3,500 | | | |
| 8 | | | | |
| 9 | 3,950 | | | |
| 10 | | | | |

A. Which year of the study came closest to the carrying capacity?

B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?

C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?

D. Graph the results of the study.

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Study 6: golden eagle *Aquila chrysaetos canadensis*

Carrying capacity (K): 2,500 Maximum rate of increase (r_{\max}): 0.05 Population (N): 1,000

Background:

During the third year of the study there was emigration. The population decreased to 750.

During the sixth year of the study there was immigration. The population increased to 1,500.

During the ninth year of the study there was immigration. The population increased to 2,000.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | (K-N)/K | r_{\max} | ΔN |
|------|-------|---------|------------|------------|
| 1 | 1,000 | | | |
| 2 | | | | |
| 3 | 750 | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | 1,500 | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | 2,000 | | | |
| 10 | | | | |

A. Which year of the study came closest to the carrying capacity?

B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?

C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?

D. Graph the results of the study.

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Study 7: Harris hawk *Parabuteo unicinctus*

Carrying capacity (K): 5,000 Maximum rate of increase (r_{\max}): 0.04 Population (N): 3,750

Background:

During the fourth year of the study there was emigration. The population decreased to 2,500.
During the seventh year of the study there was emigration. The population decreased to 1,750.
During the ninth year of the study there was immigration. The population increased to 2,000.
Note: Answers need to be rounded to the nearest 100th.

| Year | N | $(K-N)/K$ | r_{\max} | ΔN |
|------|-------|-----------|------------|------------|
| 1 | 3,750 | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | 2,500 | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | 1,750 | | | |
| 8 | | | | |
| 9 | 2,000 | | | |
| 10 | | | | |

- A. Which year of the study came closest to the carrying capacity?
- B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
- C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
- D. Graph the results of the study.

*Note: All values for population, carrying capacity, and biotic potential are fictional. They do not represent actual values.

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Study 8: osprey *Pandion haliaetus*

Carrying capacity (K): 4,000 Maximum rate of increase (r_{\max}): 0.06 Population (N): 100

Background:

During the third year of the study there was immigration. The population increased to 1,000.

During the sixth year of the study there was immigration. The population increased to 1,300.

During the eighth year of the study there was immigration. The population increased to 2,250.

Note: Answers need to be rounded to the nearest 100th.

| Year | N | $(K-N)/K$ | r_{\max} | ΔN |
|------|-------|-----------|------------|------------|
| 1 | 100 | | | |
| 2 | | | | |
| 3 | 1,000 | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | 1,300 | | | |
| 7 | | | | |
| 8 | 2,250 | | | |
| 9 | | | | |
| 10 | | | | |

A. Which year of the study came closest to the carrying capacity?

B. Which year(s) of the study was the increase in raptor population less than or equal to 2%?

C. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?

D. Graph the results of the study.

Raptor Population Ecology Answer Sheet

Study 1: bald eagle *Haliaeetus leucocephalus*

| | | | | |
|----|-------|------|------|----|
| 1 | 1,000 | 0.8 | 0.04 | 40 |
| 2 | 1,040 | 0.79 | 0.04 | 42 |
| 3 | 3,200 | 0.36 | 0.02 | 64 |
| 4 | 3,264 | 0.35 | 0.02 | 65 |
| 5 | 2,000 | 0.6 | 0.03 | 60 |
| 6 | 2,060 | 0.6 | 0.03 | 62 |
| 7 | 4,000 | 0.2 | 0.01 | 40 |
| 8 | 4,040 | 0.2 | 0.01 | 40 |
| 9 | 4,080 | 0.2 | 0.01 | 41 |
| 10 | 4,121 | 0.2 | 0.01 | 41 |

1. Which year of the study came closest to the carrying capacity?
10th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
3rd, 4th, 7th, 8th, 9th, and 10th years
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
1st and 2nd years

Study 2: great horned owl *Bubo virginianus*

| | | | | |
|----|-------|-----|------|----|
| 1 | 750 | 0.8 | 0.04 | 30 |
| 2 | 780 | 0.8 | 0.04 | 31 |
| 3 | 811 | 0.8 | 0.04 | 32 |
| 4 | 2,250 | 0.4 | 0.02 | 45 |
| 5 | 2,295 | 0.3 | 0.02 | 46 |
| 6 | 1,700 | 0.5 | 0.03 | 51 |
| 7 | 1,751 | 0.5 | 0.03 | 53 |
| 8 | 3,200 | 0.1 | 0.01 | 32 |
| 9 | 3,232 | 0.1 | 0.01 | 32 |
| 10 | 3,264 | 0.1 | 0.01 | 33 |

1. Which year of the study came closest to the carrying capacity?
10th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
4th, 5th, 8th, 9th, and 10th years
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
1st, 2nd and 3rd years

Study 3: red-tailed hawk *Buteo jamaicensis*

| | | | | |
|----|-------|-----|------|-----|
| 1 | 6,000 | 0.4 | 0.02 | 120 |
| 2 | 6,120 | 0.4 | 0.02 | 122 |
| 3 | 8,400 | 0.2 | 0.01 | 84 |
| 4 | 8,484 | 0.2 | 0.01 | 85 |
| 5 | 5,500 | 0.5 | 0.02 | 110 |
| 6 | 5,610 | 0.4 | 0.02 | 112 |
| 7 | 5,722 | 0.4 | 0.02 | 114 |
| 8 | 5,836 | 0.4 | 0.02 | 117 |
| 9 | 7,000 | 0.3 | 0.01 | 70 |
| 10 | 7070 | 0.3 | 0.01 | 71 |

1. Which year of the study came closest to the carrying capacity?
4th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
every year of the study (1-10)
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
None of the years had 75% or more of the carrying capacity left

Study 4: screech owl *Otus asio*

| | | | | |
|----|-----|-----|------|---|
| 1 | 575 | 0.4 | 0.01 | 6 |
| 2 | 581 | 0.4 | 0.01 | 6 |
| 3 | 587 | 0.4 | 0.01 | 6 |
| 4 | 300 | 0.7 | 0.02 | 6 |
| 5 | 306 | 0.7 | 0.02 | 6 |
| 6 | 700 | 0.3 | 0.01 | 7 |
| 7 | 707 | 0.3 | 0.01 | 7 |
| 8 | 714 | 0.3 | 0.01 | 7 |
| 9 | 721 | 0.3 | 0.01 | 7 |
| 10 | 728 | 0.3 | 0.01 | 7 |

1. Which year of the study came closest to the carrying capacity?
10th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
every year of the study (1-10)
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
None of the years of the study had 75% or more of the carrying capacity left

Study 5: barn owl *Tyto alba*

| | | | | |
|----|-------|-----|------|----|
| 1 | 2,750 | 0.5 | 0.03 | 83 |
| 2 | 2,833 | 0.4 | 0.02 | 57 |
| 3 | 2,890 | 0.4 | 0.02 | 58 |
| 4 | 4,000 | 0.2 | 0.01 | 40 |
| 5 | 4,040 | 0.2 | 0.01 | 40 |
| 6 | 4,080 | 0.2 | 0.01 | 41 |
| 7 | 3,500 | 0.3 | 0.02 | 70 |
| 8 | 3,570 | 0.3 | 0.02 | 71 |
| 9 | 3,950 | 0.2 | 0.01 | 40 |
| 10 | 3990 | 0.2 | 0.01 | 40 |

1. Which year of the study came closest to the carrying capacity?
6th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, and 10th
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
None of the years of the study had 75% or more of the carrying capacity left

Study 6: golden eagle *Aquila chrysaetos Canadensis*

| | | | | |
|----|-------|-----|------|----|
| 1 | 1,000 | 0.6 | 0.03 | 30 |
| 2 | 1,030 | 0.6 | 0.03 | 31 |
| 3 | 750 | 0.7 | 0.04 | 30 |
| 4 | 780 | 0.7 | 0.04 | 31 |
| 5 | 811 | 0.7 | 0.04 | 32 |
| 6 | 1,500 | 0.4 | 0.02 | 30 |
| 7 | 1,530 | 0.4 | 0.02 | 31 |
| 8 | 1,561 | 0.4 | 0.02 | 31 |
| 9 | 2,000 | 0.2 | 0.01 | 20 |
| 10 | 2020 | 0.2 | 0.01 | 20 |

1. Which year of the study came closest to the carrying capacity?
10th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
6th, 7th, 8th, 9th, and 10th
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
None of the years of the study had 75% or more of the carrying capacity left

Study 7: Harris hawk *Parabuteo unicinctus*

| | | | | |
|----|-------|-----|------|----|
| 1 | 3,750 | 0.3 | 0.01 | 38 |
| 2 | 3,788 | 0.2 | 0.01 | 38 |
| 3 | 3,826 | 0.2 | 0.01 | 38 |
| 4 | 2,500 | 0.5 | 0.02 | 50 |
| 5 | 2,550 | 0.5 | 0.02 | 51 |
| 6 | 2,601 | 0.5 | 0.02 | 52 |
| 7 | 1,750 | 0.7 | 0.03 | 53 |
| 8 | 1,803 | 0.6 | 0.02 | 36 |
| 9 | 2,000 | 0.6 | 0.02 | 40 |
| 10 | 2040 | 0.6 | 0.02 | 41 |

1. Which year of the study came closest to the carrying capacity?
3rd year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
1st, 2nd, 3rd, 4th, 5th, 6th, 8th, 9th, and 10th years
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
None of the years of the study had 75% or more of the carrying capacity left

Study 8: osprey *Pandion haliaetus*

| | | | | |
|----|-------|-----|------|----|
| 1 | 100 | 1 | 0.06 | 6 |
| 2 | 106 | 1 | 0.06 | 6 |
| 3 | 1,000 | 0.8 | 0.05 | 50 |
| 4 | 1,050 | 0.7 | 0.04 | 42 |
| 5 | 1,092 | 0.7 | 0.04 | 44 |
| 6 | 1,300 | 0.7 | 0.04 | 52 |
| 7 | 1,352 | 0.7 | 0.04 | 54 |
| 8 | 2,250 | 0.4 | 0.02 | 45 |
| 9 | 2,295 | 0.4 | 0.02 | 46 |
| 10 | 2,341 | 0.4 | 0.02 | 47 |

1. Which year of the study came closest to the carrying capacity?
10th year
2. Which year(s) of the study was the increase in raptor population less than or equal to 2%?
8th, 9th, and 10th years
3. Which year(s) of the study was there 75% or more left until the carrying capacity was reached?
3rd year