PEER MENTORING IN BIOLOGY AT NEW MEXICO STATE UNIVERSITY: A LESSON ON CONSERVATION BIOLOGY OF WHOOPING CRANES

AVIS JAMES, AUDREY TENORIO, ZACHARY CLIFFORD, AND RALPH PRESZLER

Peer leaders are utilized in the first semester "biology for science majors" course at New Mexico State University. This course has two 50 minutes lectures per week, plus one 75-minute mandatory peer-led workshop. The workshop activities address the materials covered in the lectures and are intended to give the students hands-on experience with the subject. This course is called "Natural History of Life," and, among other topics, covers ecology and conservation. What follows is a review of the lecture material and the activity that are provided to the peer leaders to understand logistic growth curves and conservation ecology of Whooping Crane populations. The original inspiration for this activity was from Goldman (2000). It has been developed in this form by Ralph Preszler and Avis James. Peer leaders Audrey Tenorio and Zachary Clifford helped with final edits and with presenting the activity to the 2015 Peer-Led Team Learning International Society conference.

Students would have attended an introductory lecture on understanding population growth curves before undertaking this activity. They can recognize both exponential and logistic growth curves and understand the mathematics that describe those curves.

A Lesson on Conservation Biology of Whooping Cranes

Whooping Cranes (*Grus americana*) are a large elegant bird species found in the United States and Canada. Standing 1.6 meters in height, the adult is the tallest native North American bird. Whooping Cranes came very close to extinction in the middle of the 20th century. In 1941 there were only 16 individuals remaining. At that point an international effort to save this species was launched. With insightful management decisions and with a good dose of luck, the species is still alive today. The good news is that the number of individuals has increased. However, this is still a critically endangered species due to the small size of the wild flocks.

A successful migratory flock has been established between Wood Buffalo National Park (Northwest Territory, Canada) and Aransas National Wildlife Refuge (Texas, U.S.A.). A cross-fostering experiment

attempting to establish a new migratory population that bred in the Rockies and over-wintered in the Bosque del Apache in New Mexico has failed. There is an experimental migratory population that is moved from a Wisconsin breeding area to winter in Florida each year. Seventeen birds of this experimental flock were killed in a storm in Florida on Feb. 2, 2007. Conservation efforts have re-established this migratory flock with two overwintering grounds.

In this exercise, you will work as members of an International Whooping Crane management team. Your group will consider the cost and the potential for success of alternative strategies for promoting the conservation and growth of one wild population.

The first step will be to calculate the projected growth of the population with regulation of hunting as the only management strategy. This will provide you with a set of baseline data. Secondly, your group will calculate the estimated effects of your choice of a variety of management options. Lastly, you will compare conservation strategies and discuss successful programs.

Step One:

In 1916, the Migratory Birds Treaty Act initiated a ban on hunting Whooping Cranes that is still in place today. Your group will use birth, death, and carrying capacity estimates from the middle of the 20th century to project the size of the wild Whooping Crane population every 10 years from 1940 until 2010.

The logistic model, $G = rN \left(\frac{K-N}{K} \right)$, predicts population growth. In this equation:

r is the per capita rate of increase, which is calculated as the birth rate (b)

minus the death rate (d),

N is the population size,

K is the carrying capacity of the environment (that is: the number of

individuals the environment can support).

You will use the table to record the projected values of the population every 10 years for 70 years. Our starting population size, N_{1940} is 20 birds. We have calculated the growth between 1940 and 1950 and added it to the initial size to provide you with the population size in 1950.

1. Calculate the projected population growth by working through the following steps and using Table 1. Follow the steps **a.** through **e.** to then extend your calculations through the decades until 2010.

$b = 0.90, d = 0.65, K = 150, N_{1940} = 20.$

a. Calculate r for Table 1 ($r = b\text{-}d$). Record r and K for each transition period.

b. Starting with the transition from 1950 to 1960, calculate and record rN, then calculate and record $\left(\frac{K-N}{K}\right)$.

c. Multiply the term that you just calculated $\left(\frac{K-N}{K}\right)$ by rN to get G (the number of individuals added to the population over the ten year period).

d. Add this number to the population size from the previous decade to get the population size in the next decade.

e. Repeat these calculations until you have reached 2010.

Table 1: Population growth with only the hunting ban.

Year	N	r	K	rN	$\left(\frac{K-N}{K}\right)$	$G = rN\left(\frac{K-N}{K}\right)$
1940	20					
		0.25	150	5	0.867	4
1950	24					
1960						
1970						
1980						
1990						
2000						
2010						

Step Two:

The largest wild population of Whooping Cranes breeds in Wood Buffalo National Park in the Northwest Territories, Canada. This remote 4,480,700 hectare (ha) park was established in 1922 to protect a remnant herd of bison. Fortunately, it also contains the breeding grounds of Whooping Cranes. The

Wood Buffalo Park can support approximately 667 birds (or 333 pairs). The cranes migrate south through Canada and the U.S. to the wintering grounds at Aransas National Wildlife Refuge on the gulf coast of Texas.

Purchasing Land: In 1937, the federal government purchased 19,000 ha at Aransas for about half a million dollars and in 1960 the Audubon Society leased an adjacent 1,700 ha. At 250 birds, Aransas may now be reaching its carrying capacity for Whooping Cranes. Purchasing additional land would increase the carrying capacity (*K*) of Aransas National Wildlife Refuge.

In addition to carrying capacity considerations, there are mortality factors that impact Whooping Cranes throughout their range, from the Northern Territories of Canada to the Gulf Coast.

Infertility: Approximately 15% of Whooping Crane eggs are infertile. This may be due to the reduced genetic diversity resulting from inbreeding associated with very small populations. Females typically lay two eggs but normally only successfully raise a single offspring in a season. It is possible to collect these extra eggs and transfer them to nests with infertile eggs. This strategy improves the Whooping Crane birth rate.

Power lines: Collisions with power lines along the migration route also account for significant Whooping Crane mortality. Placing distracters on power lines reduces death rate.

Your group will be responsible for managing the wild population starting at its low point in the early 1940s. Managers were attempting to promote rapid growth of this population so that an unexpected event would be less likely to kill all the birds within the population.   You will make a series of management decisions, and you will use the logistic growth equation to project the demographic consequences of these decisions. Once you have run your simulations of Whooping Crane population growth, you will then revisit your recommendations concerning the management of this endangered species.

Imagine that your team has a budget of $20 million to spend in 2 budget periods for example:

10 million in budget 1 (1940 - 1979) & 10 million in budget 2 (1980 - 2010),

or 5 million in budget 1 (1940 - 1979) & 15 million in budget 2 (1980 - 2010),

or 15 million in budget 1 (1940 - 1979) & 5 million in budget 2 (1980 - 2010).

Your management options are listed below:

Replacing infertile eggs. The cost of this program is **$5 million for each budget period**.

　　Increases *b* by 0.5 during the budget period.

Hanging distracters on power lines. This **one-time** cost is **$10 million**.

　　Reduces *d* by 0.60.

Purchase 5,000 ha. at Aransas. This **one-time** cost is **$10 million**.

Increases *K* by 150.

Purchase 10,000 ha. at Aransas. This **one-time** cost is **$15 million**.

Increases *K* by 300.

2. **Describe your action plan:**

Budget 1: $ _____ Action: _____

How does your action plan change the parameters in the model?

$b = 0.90 +$ _____ = _____ $r = b\text{-}d =$ _____ - _____ =

$d = 0.65 -$ _____ = _____ $K =$ 150 + _____ = _____

Budget 2: $ _____ Action: (include lasting purchases from budget one: i.e. distracters and land)

_____

How does your action plan change the parameters in the model?

$b = 0.90 +$ _____ = _____   r = b-d = _____ - _____ =

$d = 0.65 -$ _____ = _____   K = 150 + _____ = __

3. Use Table 2 to calculate the theoretical effectiveness of your conservation plan.

Table 2: Population Growth after Conservation Interventions.

	Year	N	r	K	rN	$\left(\frac{K-N}{K}\right)$	G= $rN\left(\frac{K-N}{K}\right)$
B **U** **D** **G** **E** **T** **1**	1940	20					
	1950						
	1960						
	1970						
B **U** **D** **G** **E** **T**	1980						
	1990						
	2000						
	2010						

4. Plot your population growth curves for each budget period below. Make sure you label the axes of the graph.

Whooping Crane Population Growth
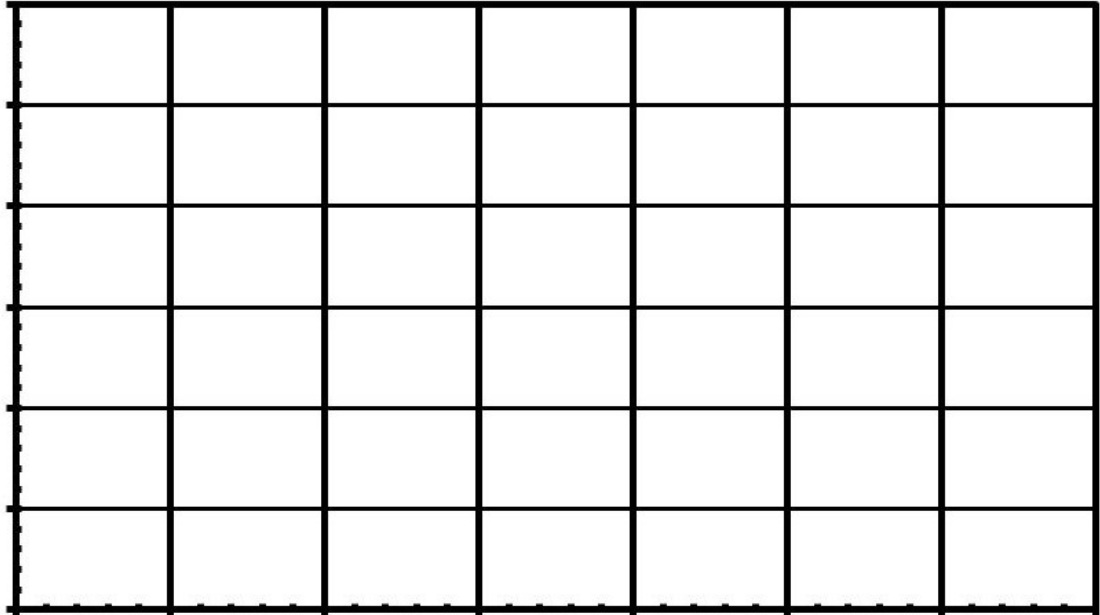
Step Three:

Comparisons across Groups

You will use comparisons across groups within your workshop session to evaluate the effects of a variety of conservation strategies.

5. a. *Draw your simulation results (Figure 1) on a whiteboard. Include what interventions you chose per budget period and the final population size.*

5. b. *Walk around the room and look at the other students' management strategies and results.*

6. Which management techniques influence *r*?

7. Which techniques influence *K*?

8. Conservation managers projecting population sizes of Whooping Cranes are concerned about increasing numbers as quickly as possible to reduce the time of low numbers that are very susceptible to disasters that could kill all of the birds. Identify the group whose simulated population had the fastest initial growth and most rapidly grew to greater than 50 individual birds. *What was the management strategy of this group?*

9. Managers also would like to adopt strategies that maximize the size of the population over the long term. Identify the group whose simulated population had the largest final population size. *What was the management strategy of this group?*

10. Suggest one more conservation intervention that might help save Whooping Cranes.

A Lesson on Conservation Biology of Whooping Cranes KEY

Table 1: Population growth with only the hunting ban. *2 points- 1 point for math between 1950 (r) 1960 (N), 1 point for 2010 (N).*

Year	N	r	K	rN	$\left(\frac{K-N}{K}\right)$	$G = rN\left(\frac{K-N}{K}\right)$
1940	20					
		0.25	150	5	0.867	4
1950	24.33					
		0.25	*150*	*6.08*	*0.84*	*5*
1960	*29*					
		0.25	*150*	*7.36*	*0.80*	*6*
1970	*35*					
		0.25	*150*	*8.84*	*0.76*	*7*
1980	*42*					
		0.25	*150*	*10.52*	*0.72*	*8*
1990	*50*					
		0.25	*150*	*12.42*	*0.66*	*8*
2000	*58*					
		0.25	*150*	*14.50*	*0.61*	*9*
2010	*57*					

2. **Describe your action plan:** *4 points, 1 point for correct spending allowance, 1 point for correctly matching budget and action, 0.25 points per parameter estimate.*

This is one example, other solutions are possible:

Budget 1: $ ____*5M*_____

Action: _____ *replace infertile eggs*_____

How does your action plan change the parameters in the model?

$b = 0.90 + $ _*0.5*_ $ = $ _*1.4*_ $r = b\text{-}d = $ _*1.4*_ $ - $ _*0.65*_ $ = 0.75$

$d = 0.65 - $ _*0*_ $ = $ _*0.65*_ $K = 150 + $ _*0*_ $ = $ _*150*_

Budget 2: $ ____*15M*_____

Action: (include lasting purchases from budget one: i.e. distracters and land) _____*buy 10,000 Hectares* _____

How does your action plan change the parameters in the model?

$b = 0.90 + $ _*0*_ $ = $ _*0.90*_ $r = b\text{-}d = $ _*0.90*_ $ - $ _*0.6*_ $ = $ _*0.25*_

$d = 0.65 - $ _*0*_ $ = $ _*0.65*_ $K = 150 + $ _*300*_ $ = $ _*450*_

3. Use Table 2 to calculate the theoretical effectiveness of your conservation plan.

4 points: 2 points for 1970 (N), 2 points for 2010 (N).

Table 2: Population Growth after Conservation Interventions.

	Year	N	r	K	rN	$\left(\dfrac{K-N}{K}\right)$	$G = rN\left(\dfrac{K-N}{K}\right)$
B **U** **D** **G** **E** **T** **1**	**1940**	20					
			0.75	*150*	*15.00*	*0.87*	*13*
	1950	*33*					
			0.75	*150*	*24.75*	*0.78*	*19*
	1960	*52*					
			0.75	*150*	*39.23*	*0.65*	*26*
	1970	*78*					
			0.75	*150*	*58.39*	*0.48*	*28*
B **U** **D** **G** **E** **T** **2**	**1980**	*106*					
			0.25	*450*	*26.48*	*0.76*	*20*
	1990	*126*					
			0.25	*450*	*31.55*	*0.72*	*23*
	2000	*149*					
			0.25	*450*	*37.22*	*0.67*	*25*
	2010	*174*					

4. Plot your population growth curves for each budget period below. Make sure you label the axes of the graph. **3 points, 1 for numbering and labeling axes correctly, 2 for plotting results.**

Figure 1: Population Growth after Conservation Interventions.

B1 eggs; B2 10,000 ha (no eggs)
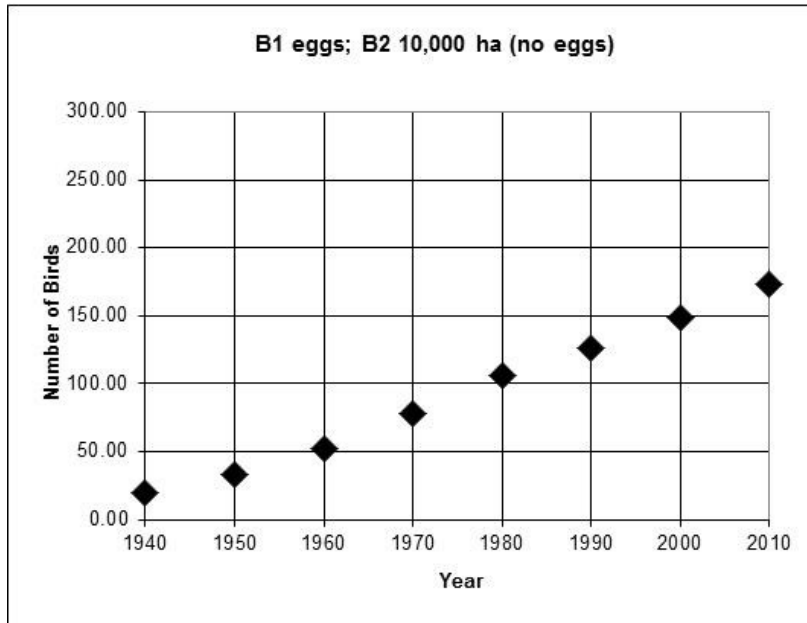
see graph key for other results.

6. 2 points: *Anything that influences birth and death rates: base ban on hunting, hanging distractors on power lines, and replacing infertile eggs.*

7. Which techniques influence *K*? **2 points**

Purchasing land (5000 or 10,000 hectares).

The peer leader should make note of the strategies that are being investigated.

8. 1 point: *Varies by strategies selected in each class. The most rapid results come from increasing r (eggs and distractors).*

9 1 point: *Varies by strategies selected in each class. The greatest population increase in our time frame are a result of increasing both r and K.*

10. 1 point: *Add feeding stations, remove predators, parasites or competitors, establish alternative sanctuaries, etc.*

Simulation 1

Hunting ban only

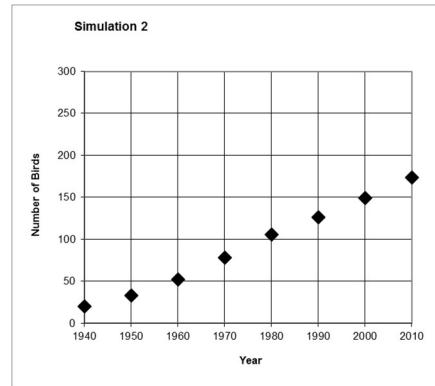| Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.25	150	5.00	0.87	4
1950	24					
		0.25	150	6.08	0.84	5
1960	29					
		0.25	150	7.36	0.80	6
1970	35					
		0.25	150	8.84	0.76	7
1980	42					
		0.25	150	10.52	0.72	8
1990	50					
		0.25	150	12.42	0.67	8
2000	58					
		0.25	150	14.49	0.61	9
2010	67					

Simulation 1: Hunting Ban
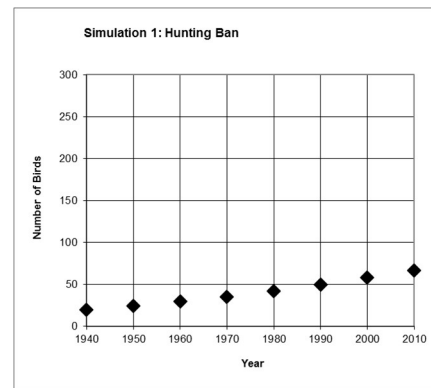
The remaining simulations include the hunting ban.

Simulation 2

14

Name_____

Budget 1: eggs, Budget 2: buying 10,000 ha. (no eggs)

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.75	150	15.00	0.87	13
1950	33					
		0.75	150	24.75	0.78	19
1960	52					
		0.75	150	39.23	0.65	26
1970	78					
		0.75	150	58.39	0.48	28
1980	106					
		0.25	450	26.48	0.76	20
1990	126					
		0.25	450	31.55	0.72	23
2000	149					
		0.25	450	37.22	0.67	25
2010	174					

Simulation 2

Simulation 3

Budget 1: buying 10,000 ha., Budget 2: eggs, land previously purchased

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.25	450	5.00	0.96	5
1950	25					
		0.25	450	6.19	0.94	6
1960	31					
		0.25	450	7.66	0.93	7
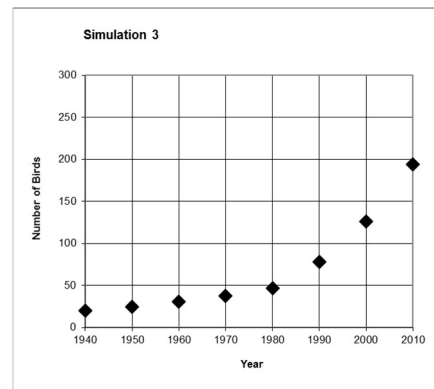
Simulation 3

1970	38				
		0.25	450	9.44	0.92	9
1980	46				
		0.75	450	34.81	0.90	31
1990	78				
		0.75	450	58.23	0.83	48
2000	126				
		0.75	450	94.37	0.72	68
2010	194				

Simulation 4

Budget 1: power lines, Budget 2: eggs, power lines previously purchased

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.85	150	17.00	0.87	15
1950	35					
		0.85	150	29.52	0.77	23
1960	57					
		0.85	150	48.81	0.62	30
1970	88					
		0.85	150	74.41	0.42	31
1980	119					
		1.35	150	160.01	0.21	34
1990	152					
		1.35	150	205.34	-0.01	-3
2000	149					
		1.35	150	201.45	0.01	1
2010	150					
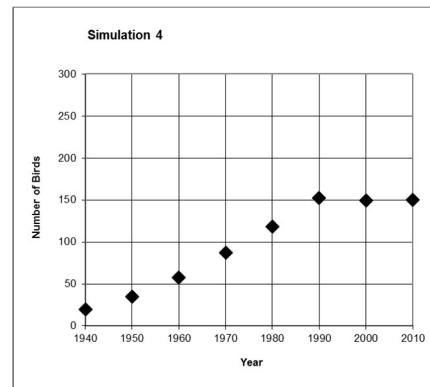
Simulation 4

Simulation 5

Budget 1: eggs, Budget 2: power lines & eggs

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.75	150	15.00	0.87	13
1950	33					
		0.75	150	24.75	0.78	19
1960	52					
		0.75	150	39.23	0.65	26
1970	78					
		0.75	150	58.39	0.48	28
1980	106					
		1.35	150	143.02	0.29	42
1990	148					
		1.35	150	199.73	0.01	3
2000	151					
		1.35	150	203.42	0.00	-1
2010	150					
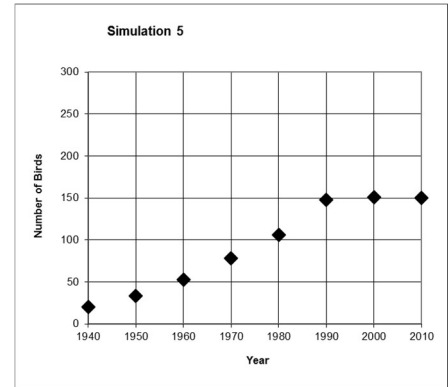
Simulation 5

Simulation 6

Budget 1: power lines, Budget 2: power lines & buying 5,000 ha

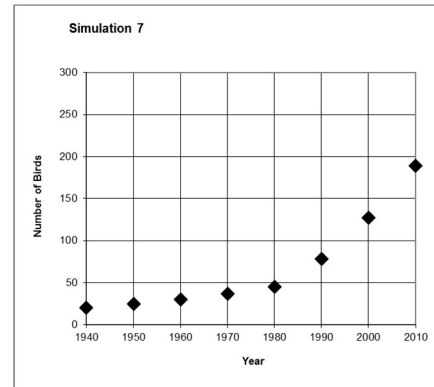| Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.85	150	17.00	0.87	15
1950	35					
		0.85	150	29.52	0.77	23
1960	57					
		0.85	150	48.81	0.62	30
1970	88					
		0.85	150	74.41	0.42	31
1980	119					
		0.85	300	100.75	0.60	61
1990	179					
		0.85	300	152.55	0.40	61
2000	241					
		0.85	300	204.65	0.20	40
2010	281					
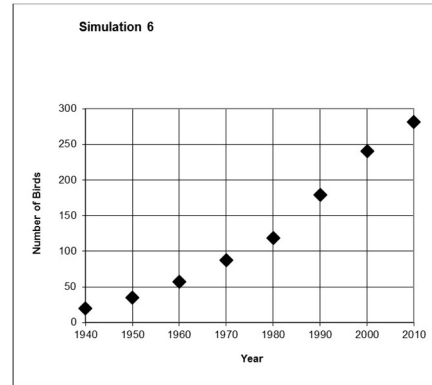
Simulation 6

Name_____

Simulation 7

Budget 1: buying 5,000 ha., Budget 2: power lines & previously purchased 5,000 ha.

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.25	300	5.00	0.93	5
1950	25					
		0.25	300	6.17	0.92	6
1960	30					
		0.25	300	7.58	0.90	7
1970	37					
		0.25	300	9.29	0.88	8
1980	45					
		0.85	300	38.49	0.85	33
1990	78					
		0.85	300	66.26	0.74	49
2000	127					
		0.85	300	107.95	0.58	62
2010	189					

Simulation 7

Simulation 8

Budget 1: eggs, Budget 2: eggs & buying 5,000 ha.

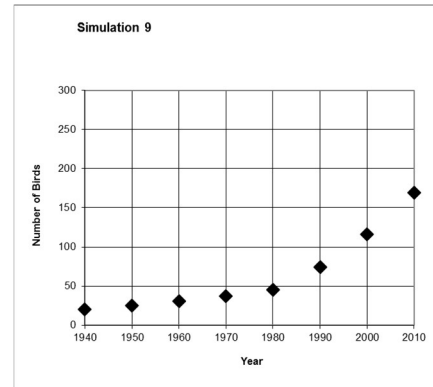| Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.75	150	15.00	0.87	13
1950	33					
		0.75	150	24.75	0.78	19
1960	52					
		0.75	150	39.23	0.65	26
1970	78					
		0.75	150	58.39	0.48	28
1980	106					
		0.75	300	79.45	0.65	51
1990	157					
		0.75	300	118.00	0.48	56
2000	213					
		0.75	300	160.09	0.29	46
2010	260					
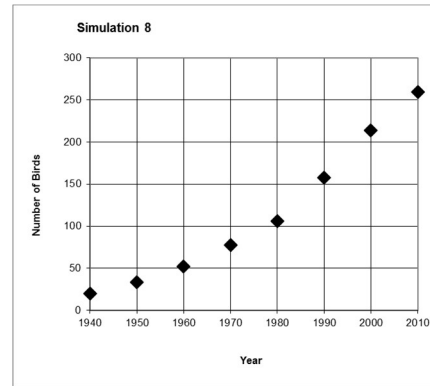
Simulation 8

Simulation 9

Budget 1: buying 5,000 ha., Budget 2: eggs & previously purchased 5,000 ha.

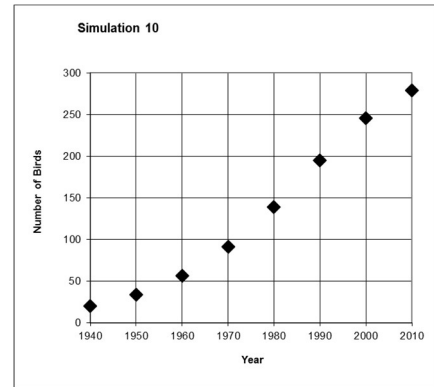| Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.25	300	5.00	0.93	5
1950	25					
		0.25	300	6.17	0.92	6
1960	30					
		0.25	300	7.58	0.90	7
1970	37					
		0.25	300	9.29	0.88	8
1980	45					
		0.75	300	33.96	0.85	29
1990	74					
		0.75	300	55.58	0.75	42
2000	116					
		0.75	300	86.97	0.61	53
2010	169					

Simulation 9

Simulation 10

Budget 1: eggs & buying 5,000 ha., Budget 2: eggs and previously purchased 5,000 ha.

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.75	300	15.00	0.93	14
1950	34					
		0.75	300	25.50	0.89	23
1960	57					
		0.75	300	42.46	0.81	34
1970	91					
		0.75	300	68.29	0.70	48
1980	139					
		0.75	300	103.96	0.54	56
1990	195					
		0.75	300	145.91	0.35	51
2000	246					
		0.75	300	184.38	0.18	33
2010	279					

Simulation 10

Simulation 11

Budget 1: buying 10,000 ha. and eggs, Budget 2: nothing

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		0.75	450	15.00	0.96	14
1950	34					
		0.75	450	25.75	0.92	24
1960	58					
		0.75	450	43.59	0.87	38
1970	96					
		0.75	450	72.06	0.79	57
1980	153					
		0.25	450	38.19	0.66	25
1990	178					
		0.25	450	44.49	0.60	27
2000	205					
		0.25	450	51.22	0.54	28
2010	233					
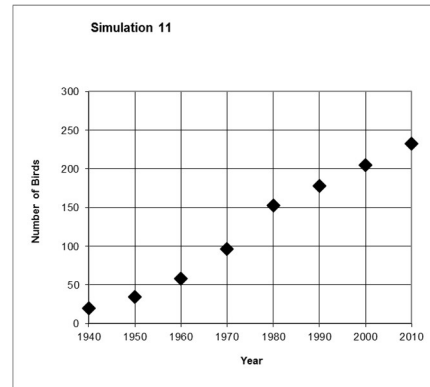
Simulation 11

Simulation 12

Budget 1: powerlines and eggs, Budget 2: eggs

Year	N	r	K	rN	(K-N)/K	G= rN((K-N)/K)
1940	20					
		1.35	150	27.00	0.87	23
1950	43					
		1.35	150	58.59	0.71	42
1960	85					
		1.35	150	114.80	0.43	50
1970	135					
		1.35	150	181.92	0.10	18
1980	153					
		1.35	150	206.88	-0.02	-4
1990	149					
		1.35	150	200.84	0.01	2
2000	150					
		1.35	150	203.06	0.00	-1
2010	150					
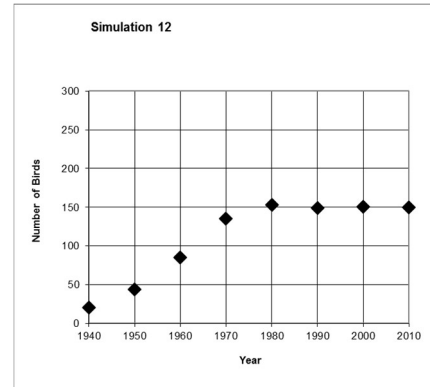
Simulation 12

Name_____

References

Free Whooping Crane Gallery: https://www.savingcranes.org/

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