Lesson 8: Is the Island Royale a stable ecosystem for the wolf and moose populations?

Overview:

Purpose:

The purpose of this activity is to construct a scientific explanation to answer this question: "Is the Island Royale a stable ecosystem for the wolf and moose populations?"

This explanation can be answered by making many possible (and different) claims, but the explanation will need to draw on multiple lines of evidence (from the data packets, from case study updates and homework about the wolf and moose populations, and from the data from the model) and it will need to connect in multiple scientific principles (from the driving question board).

Target Learning Performances

- Construct a scientific explanation based on evidence from ecosystems and computer models to answer the question: "Is the Island Royale a stable ecosystem for the wolf and moose populations?"
- Present and evaluate competing arguments that the complex interactions in an ecosystem (Isle Royale) either A) are maintaining relatively consistent numbers and types of organisms in stable conditions or B) will result in a new ecosystem (unstable) due to changing environmental conditions. NGSS HS-LS2-6

Scientific Principles (re) Discovered in this Activity

- ***The fossil record shows that over the billions of years that life has been on Earth, most species that once lived have since gone extinct*.**

Description of the Lesson

The teacher reviews the homework and summarizes a final scientific principle from a class discussion about life on earth and the fossil record. The teacher introduces the structure of a scientific explanation and the goal of the summative assessment.

Then students work in teams to:

- summarize a list of scientific principles that are relevant to this argument.
- summarize data relevant to this argument.

Then students work individually to:

- annotate the population graph data from the population data for wolves and moose over 60 years.
- write a scientific explanation synthesizing this analysis.

Then students present in small groups or the whole class, defend their argument to their peers, and individually question and evaluate competing arguments.

Lastly students work individually to add a rebuttal to these alternate explanations into their scientific explanation.

Lesson Details:

Time 90-120 minutes

Materials

For the teacher

- The Isle Royale Case Site poster

Per student

- 1 packet of "In-class Handout 8.0: The Case Study Final Explanation" and extra copies of any of the other case study updates (or introduction) that students might need from missing/absent days they were assigned. All of these resources can be downloaded from the teacher dashboard page in WISE.

Teacher Guides | ScreenCast Videos | Student Work Viewer | Student Assignments

Student Assignments for the ModelSim Population Biology Unit

In-class Activity	In-class Steps or handout	Estimated Time	Out of class assignment based on this activity
1: Modeling Interactions In Ecosystems	1.1 to 1.8	60 min.	Reading 1.1 – Interactions In Ecosystems
2: Case Study – Isle Royale	In-class Handout 2.0: Case Study Introduction	60 min.	Homework 2.1 – Case Study Update #1
3: Competition Between Individuals	3.1 to 3.11	60 min.	Reading 3.1 – Competition for Limited Resources
4: Fluctuation and Stability (part 1)	4.1 to 4.11	60-90 min.	Reading 4.1 – Fluctuation and Stability
5: Fluctuation and Stability (part 2)	5.1 to 5.7	40-60 min.	Homework 5.1 – Case Study Update #2 – AND – Reading 5.2 – Environmental Change
6: Competition Between Populations	6.1 to 6.12	60 min.	Reading 6.1 – Competition Between Populations
7: Design a Population	7.1 to 7.9	60-90 min.	Homework 7.1 – Case Study Update #3 – AND – Reading 7.2 – Unchanging vs. Changing Designs
8: Scientific Explanation	In-class Handout 8.0: Case Study Preparing Your Explanation	60 min.	Final Explanation

Lesson Outline and Timing

Launch

- Review the case study and introduce the scientific explanation assignment. (2 min.)
- Review the parts of a scientific explanation and where students will need to look for this information. (8 min.)

Explore

- Assign small groups of students to work part 1 and 2: creating lists of the relevant scientific principles and data (30-50 min.)

Summarize

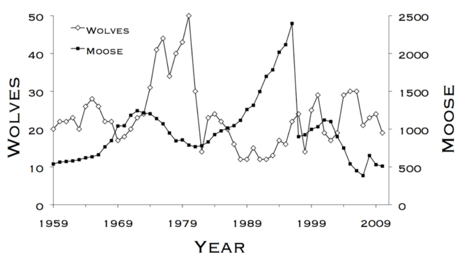
- Provide example of how to annotate the graphs (5 min)
- Assign students to individually work on annotating the graph (part 3 can be done at home or as in class assignment (0 – 25 min). This is a key part of the summative assessment.
- Assign students to individually work on constructing their scientific explanation (part 4 can be done at home or in class assignment (0-30 min). This is a key part of the summative assessment.

Present and Critique

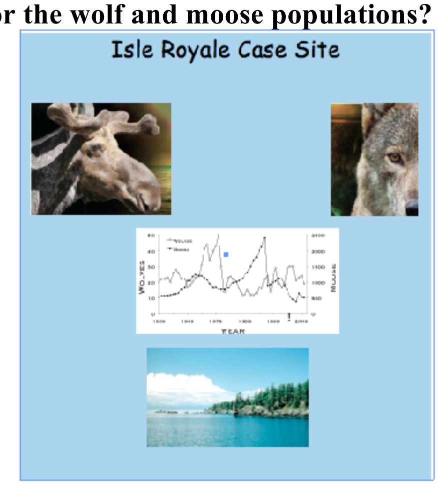
- Break up students into groups or whole class to present and critique selected presentations (part 5 and 6). This is a key part of the summative assessment. Doing this in small groups allows all students to present. Doing this as a whole class allows all students to build off each other's arguments and critiques. The later is recommended, but often time prohibitive. (35-50 min)
- Introduce the rebuttal piece of the scientific explanation - part 7. (5-10 min)
- Assign part 7 for student's to complete individually. This is a key part of the summative assessment.

Launch

Tell students that today they will prepare to write a scientific explanation that answers the question: **"Is the Island Royale a stable ecosystem for the wolf and moose populations?"** Add this question in large print to top of the Isle Royale Case Site poster. Add the graph of the wolf and moose population sizes to the poster too over the past 50 years.



Is the Island Royale a stable ecosystem for the wolf and moose populations?



Tell students that this is the final assessment for this unit of study. Remind students that a scientific explanation should include the following: (Later you will introduce another section, called "Rebuttal")

Claim:
- A single sentence that answers the question and specifically refers to the case, phenomena, details in the question.

Evidence
- Necessary and sufficient data to support the claim
- Possible sources for Evidence include:
  - Data from the computer modeling activities
  - Data from the graph above
  - Data from the the data/packets and case update you read

Reasoning
- Scientific principles and/or models you discovered in class that are:
  - Connected to the claim (i.e. s how are they relevant to this case)
  - Connected to one another (i.e. how one scientific principle is related to another one)

- What the data means (i.e. how does the data support your claim).

Explore

- Hand out a copy of the Case Study Population Biology Final Explanation assignment packet to each student.

- Read through the first page of the packet with the students together. Tell students that this packet is designed to help them get ready to complete their summative performance expecations for the unit. It is designed to help them show what they know and can do, by explaining a case study with quite a bit of complexity to it, but which can be explained using scientific principles they discovered. Tell students they will:
  - prepare to write a scientific explanation that answers the question: "Is Isle Royale a stable ecosystem for the wolf and moose populations?" (parts 1-3)
  - they will then write the explanation (part 4)
  - they will then present and defend the explanation (part 5)
  - they will critique the alternate explanations they hear (par 6)
  - they will then revise and extend their explanation and submit their work (part 7)

- Tell students that each step is outlined in their packet. Read through part 1 and 2 of the packet with students.

- Remind students that the scientific principles that are relevant are on the driving question board, but that they may decide that some, rather than all of these are more relevant than others. Remind students that the data from Isle Royale is not only on this graph, but also in all the data packets they have gotten over the unit. And data can be in the form of tables, graphs, journal, photographs, maps, etc… anything that refers to an observed outcome or effect. Also remind students that data from other homework can be used as well (examples from other real world ecosystems). Remind students that the experimental results from the model runs are also data that they can use in their argument.

- Give students a general sense of how many pieces/facets of data from this data source they need to include. Give students a general sense of how many scientific principles are needed from each lesson as well (For example: Is one principle related to competition and one related to interactions enough? or are you looking for multiple principles from multiple lessons?).

- Put students into small groups to work together to organize their notes for part 1 and 2.

Summarize:

- Briefly show examples of what students should be doing in part 3. These examples are included in this teacher manual. Don't zoom in enough show the details of the annotations, as the goal of showing these is to simply give students a sense of all the different ways in which they might chose to try to annotate and explain the trends and patterns in the graphs. Assign students to complete part 3.

- Read through part 4 and refer back to what is needed in a scientific explanation again on page 1 of their packets. Give students a general sense of how many pieces/facets of data they need to include in the explanation and how specific they need to be (For example: Do you want them to say something general related to a trend in the data such as "the population showed little fluctuation in the first decade data was recorded", or do you prefer they reference specific numbers/values/observations in the data such as "the population varied from 20 to 28 wolves in the 1960's"). Assign students to complete part 4.

Present and Critique:

- Once all students have completed part 3 and 4, tell students they will now share and critique each other's explanations. Read through parts 5 through 7.

- Determine how many students have differing claims:
  (a) the ecosystem is stable for both populations
  (b) the ecosystem is not stable for either population
  (c) the ecosystem is stable for the moose population, but not wolves.
  (d) the stability of the ecosystem for these populations depends on the time scale you consider.

- If there are enough students with differing claims, break up students into groups that have students with different claims. If there are not, keep the class together for whole class presentations. Each student must be able to hear two explanations and related arguments presented that are different than their own claim. This means that at least, a class would need to hear 4 total presentations.

- Once students have completed these presentations and critiques, assign the students part 7 of the packet. Tell students that they should revise their explanation and add to it to include a rebuttal to the counter-claims they heard. Go through what that includes from their packet.

Claim:

- A single sentence that answers the question and specifically refers to the case, phenomena, details in the question.

Evidence

- Necessary and sufficient data to support the claim
- Possible sources for Evidence include:
  - Data from the computer modeling activities
  - Data from the graph above
  - Data from the data/packets and case update articles you read

Reasoning

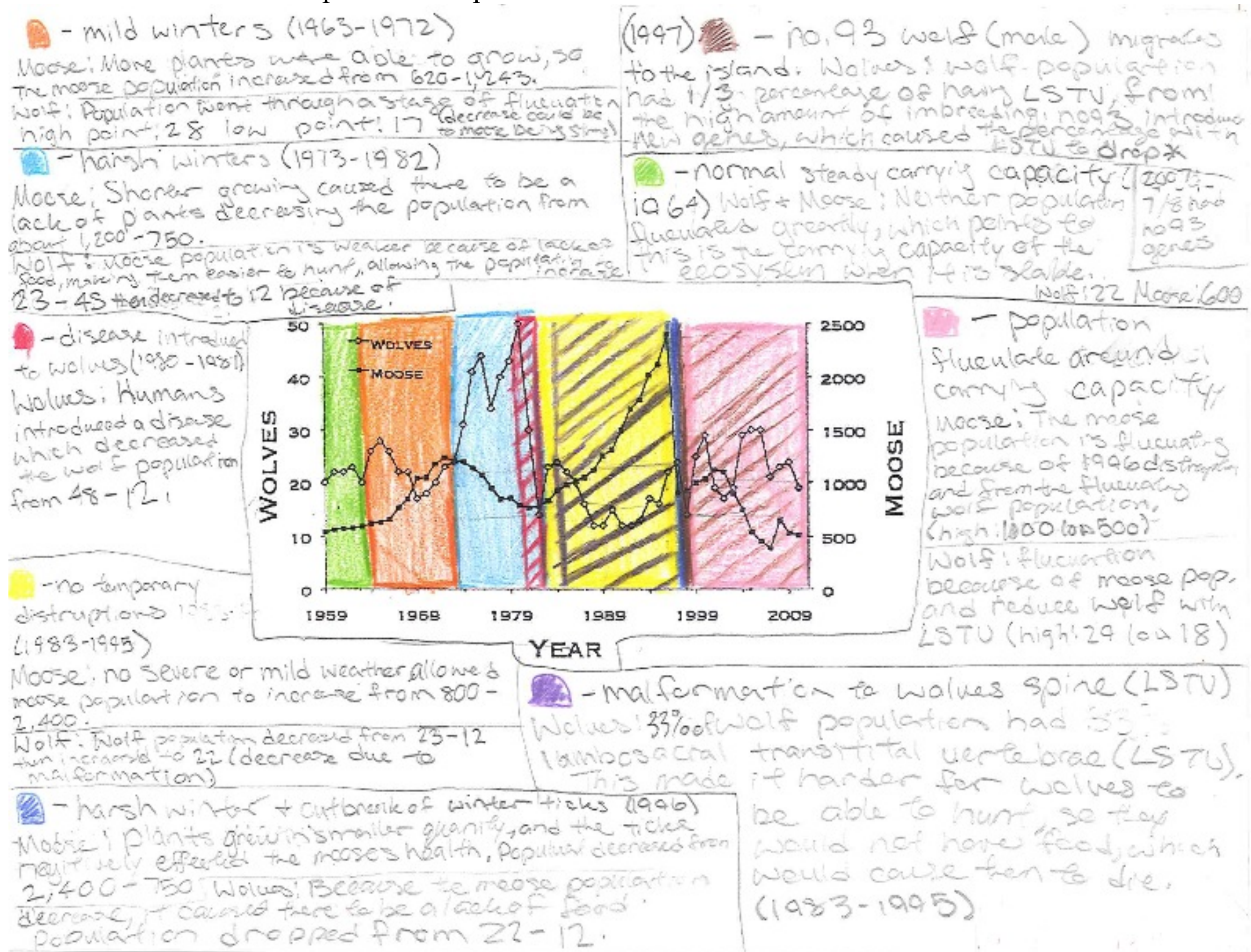
- Scientific principles and/or models you discovered in class that are:
  - Connected to the claim (i.e. s how are they relevant to this case)
  - Connected to one another (i.e. how one scientific principle is related to another one)
- What the data means (i.e. how does the data support your claim and not another)

Rebuttal

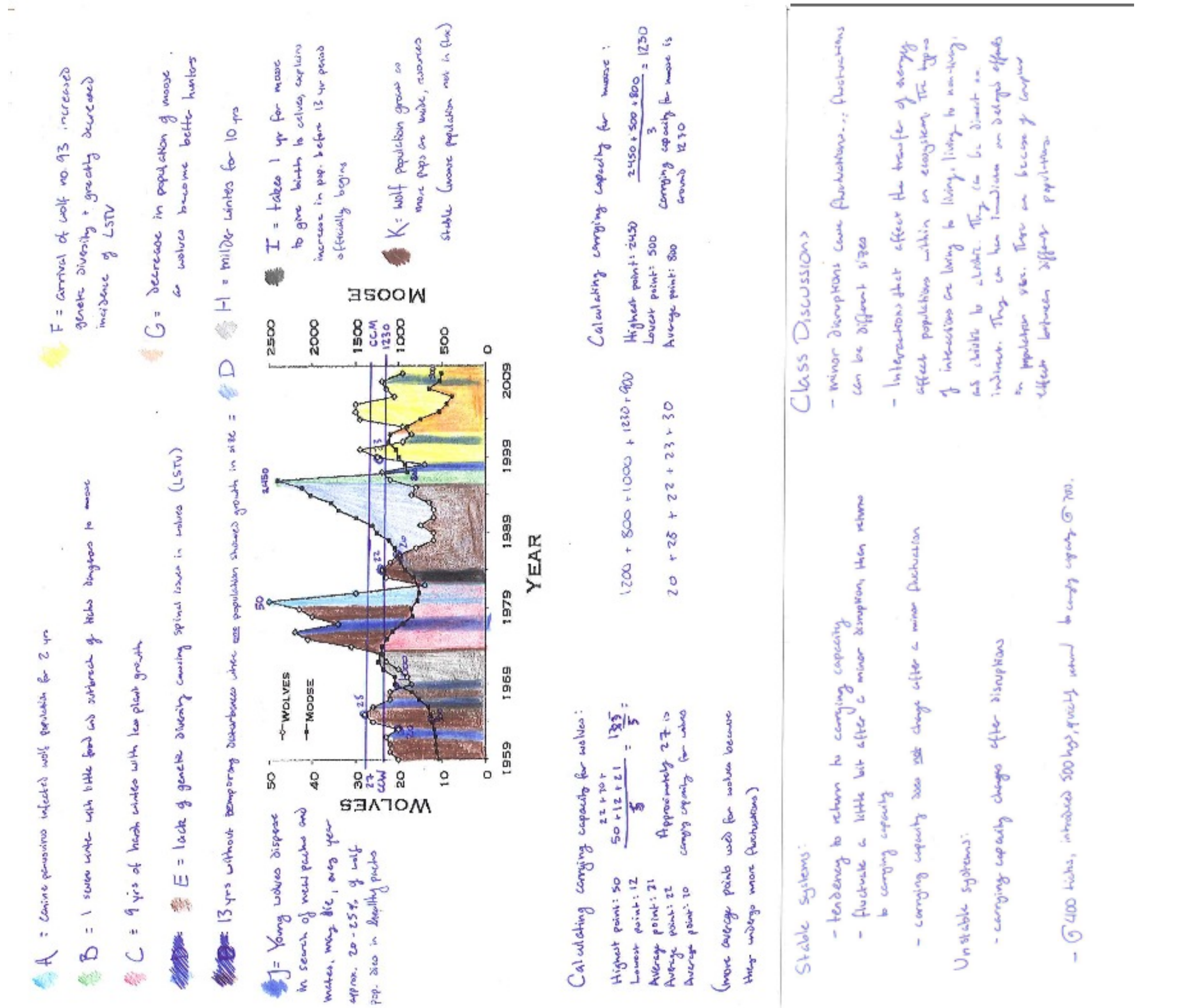
- A summary why alternate claims are not valid.
  - Introduce the alternate claim(s) and related argument(s).
  - Discuss ways the data might have been misinterpreted for the counter argument(s)
  - Discuss ways the scientific principles might have been misapplied for the counter argument(s).

- Collect these 3 artifacts together to assess student performance toward meeting the two culminating performance expectations for this unit:
  - The revised scientific explanation with the rebuttal included
  - The annotated graphs
  - The last page of the student activity packet (a record of the critique of other explanations)

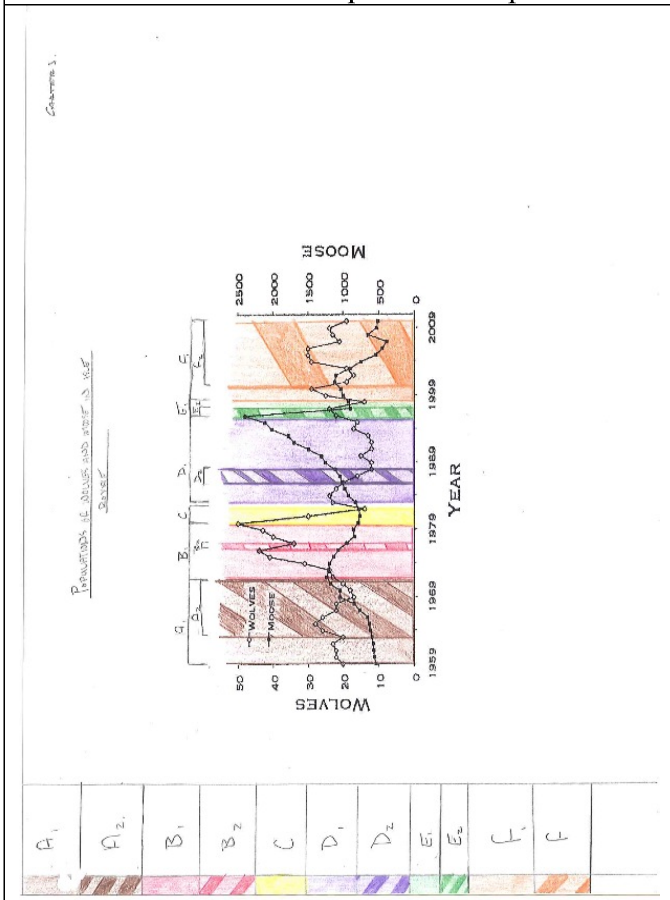
Student A – Annotated Population Graph



Student 2 – Annotated Population Graph



Student 3 – Annotated Population Graph Continued



A_1 - Lasts between approximately 1959 - 1972. During this time period, Isle Royal had mild winters. The moose population grew due to more vegetation in the winters.

A_2 - ≈1964 - 1972. Wolf population experiences fluctuation. Rises by 10 wolves between two years, then experiences a drop lasting 4 years. After drop, slowly recovers.

B_1 - ≈1971 - 1980. For 9 consecutive years, winters were very harsh. Because of this much foliage died in winters and moose didn't have much food. Moose, in turn, slowly lowered in terms of population. Wolves increased because moose grew weaker from malnutrition.

B_2 - ≈1976. Relatively harsh decrease in wolf population.

C - ≈1979-1981. Humans inadvertently introduced canine parvovirus to wolf population. Affected wolves for two consequtive years. This decrease in wolves allowed moose population to gradually rise. In 1982, wolf population began to recover from disease.

D_1 - ≈1983-1996. 13-year period without any temporary disturbances or environmental changes. Wolves exhibit new carrying capacity after disease. Moose show large growth.

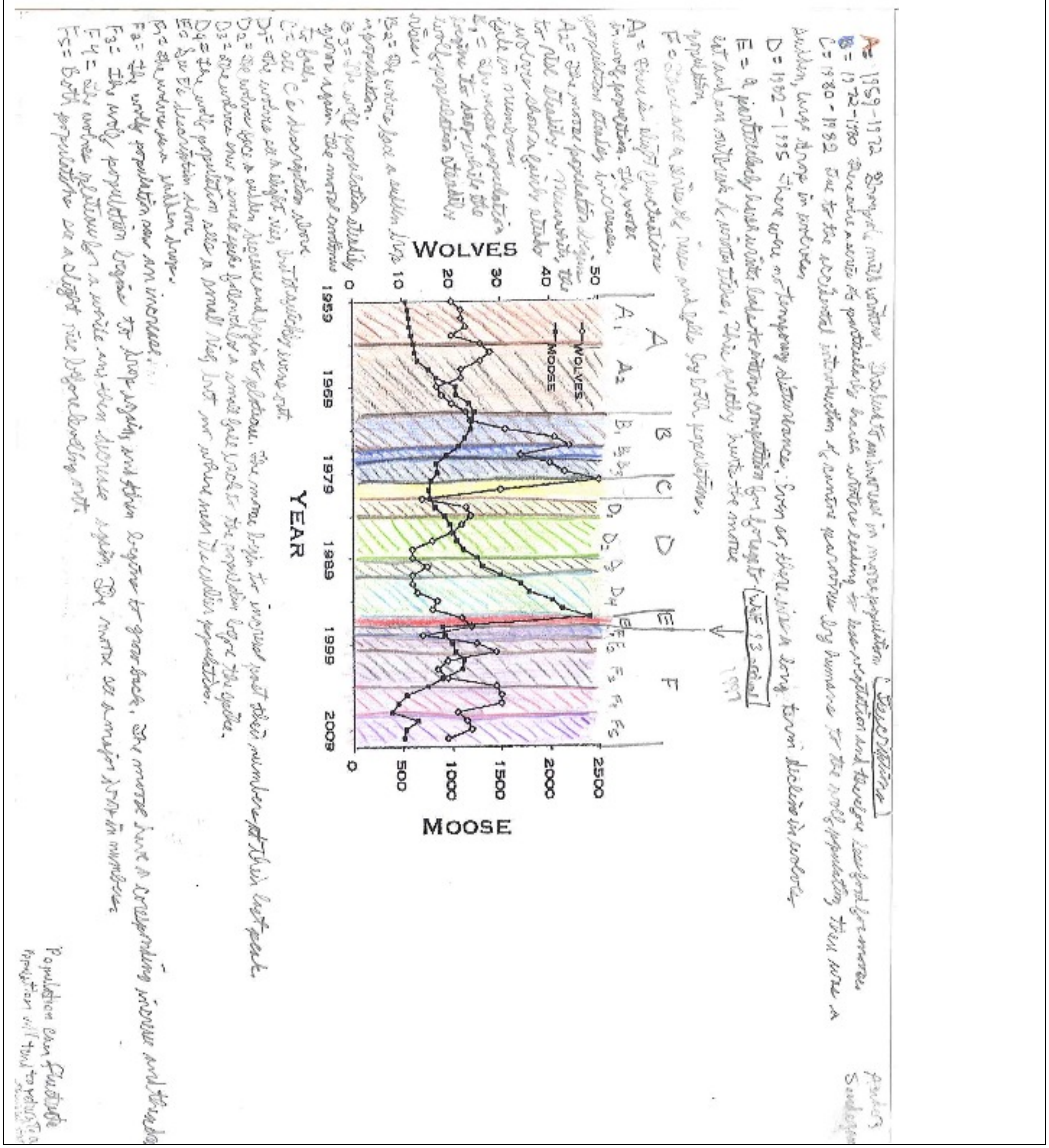
D_2 - ≈1986-1988. Wolves decrease over two years and show a new carrying capacity. Wolves decrease due to inbreeding and passing on unhealthy traits due to low genetic diversity. Climate becomes main predator of wolf population.

E_1 - ≈1995-1998. Wolf and moose populations decrease greatly. Wolves decrease after as a delayed effect of moose population drop. Moose population drop due to competition for foliage and high rise in ticks, which negatively impact moose health.

E_2 - ≈ 1995- 1996. Moose population fell ≈1750 moose. Possibly caused by environmental change. Carrying capacity falls to a same as in 1969.

F_1 - ≈ 1998-2010. A wolf from Canada came across to Isle Royal. Introduced new genetics to wolves, which increased wolf population. By 2010 more than

Student 4 – Annotated Population Graph



Student A – Example Scientific Explanation.

On Isle Royale, the moose population is stable, but the wolf population is not. In order for a population to be considered stable, two things have to be true. First, the population has to have fluctuation in population. Second, the population will return to carrying capacity after fluctuation from a minor disturbance.

During 1963-1972, Isle Royale has a series of mild winters. This leads to longer growing seasons, providing more vegetation for the moose to eat. This makes it easier for the moose to find food, making the population slowly rise up. At this time, the wolf population on the island begins to fluctuate. During this period of time, the wolves actually drop below their carrying capacity, and don't return to carrying capacity. With this being said, the wolf population is not stable. In our activities we did, all of the populations of bugs returned to carrying capacity after a minor disturbance. On Isle Royale, the wolf population does not do this. In reading 6.1, it states that high peak cycles occur when one population depends on another single population for a food source. On Isle Royale, the wolf population only has one source of food, the moose. The high peak cycles are supposed to be regular with equal wave length. In the wolf population on Isle Royale, the wolf population experiences sporadic highs and lows with no real rhythm. This means that the wolf population is not stable.

Between 1974 and 1981, Isle Royale experiences nine harsh winters in a row. Because of this, it leads to shorter growing seasons for the vegetation on the island. This means that the moose don't have as much food as they normally would. The shorter growing seasons don't provide as much food for the moose. After 1981, you see the moose population begins to return to their carrying capacity. After a minor disturbance, the fluctuation in carrying capacity returns to stability. This is one reason why the moose population is stable. In our activities, we used bugs as our model population. I introduced a minor disturbance, a fire. At first, the population went down. After a short while, the model population returned to carrying capacity. In conclusion, the moose population is stable by reasoning.

In 1989, the wolf population experiences genetic mutations because of inbreeding. This leads the wolf population to have bad legs. Because of this, the wolves can't run as fast or as well as they use to. This causes the moose population to rise. During this time, the wolf population is very low below its carrying capacity. In our activities, the bug population returned to carrying capacity after a fire which eliminated a lot of food. In the wolf population on Isle Royale, they do not return to carrying capacity, after this disturbance. This means that the wolf population is not stable.

Some might say that both populations are not stable on Isle Royale, but the evidence proves otherwise. First, the moose population returns to carrying capacity many times after a temporary disturbance. As I stated before, the wolf population never reach carrying capacity again after a minor disturbance. Even after a series of harsh winters, the moose population goes back to its carrying capacity. This being said, it's proven that the moose population is stable, but the wolf population is not.

Student B – Example Scientific Explanation.

A. Through the data that has been collected for Isle Royale from 1959 to 2009, I have determined that Isle Royale is a stable environment. But how would we classify something as stable? For us, a stable environment is an environment that has a carrying capacity, the environment fluctuates due to minor disturbances, but it always returns to its carrying capacity.

B. In 1997 shown on the graph, the wolf population increases continually for two years from a population of 13-154 wolves all the way up to 29-30 wolves. This increase was due to the fact that in 1997, a Canadian wolf, known as wolf no.93, walked across the frozen lake that surrounded Royale, and began to live there. Recently there had been genetic diseases among the wolves due to inbreeding, but introduction of the new wolf brought new genes, which in a under a year, showed improvement in the wolf population. Even though the wolves had a disease, the new wolf helped bring the population closer back to the carrying capacity, better proving stability. Something similar has been shown in our Hubnet Model, where the disturbances on the bugs effected the population, but they still eventually returned back to their carrying capacity.

C. Between the years of 1963 to 1972, the moose population increased from 620 to 1243. Then the next nine years the moose population decreased from 1243 to nearly 750. These events happened like this: Through 1963 to 1972, there were mild winters, which increased vegetation, giving the moose more food. The next nine years experienced harsh winters each year, shortening the growing seasons for food. The first event made the moose population fluctuate away from the carrying capacity, but the second event actually helped the population by bring it back down nearly to its carrying capacity. This situation was also shown in the Hubnet Model when my group member and I did an experiment in which we introduced a fire at the beginning of the experiment, which removed nearly all vegetation in the area. The bugs required the vegetation for food, so it would be expected for them to die off or nearly go extinct. However, the fire actually helped in a way, because the bugs went to carrying capacity afterwards instead of dying off.

D. Between 2001 and 2007 the moose population decreased from about 1100 to roughly 350. Then the remaining years show that they appear to begin to stabilize. This situation is the result of six years of harsh winters, which reduce the amount of food available to the moose, thus reducing there population. These six years were 2001 to 2007. The remaining years contained no disturbances, so the moose population slowly began to stabilize. This helps show that disturbances (minor) in population cause fluctuations in populations, but the populations return back to carrying capacity. The whole of the Hubnet Model additionally helps prove this through the experiments that we did in class. We used different kinds of disturbances, but each time the population of the bugs would return to their carrying capacity.

E. Now, some might say that my theory is wrong. They might say that Isle Royale isn't stable, due to the fact there are so many disturbances in both species, causing their populations to be erratic. They are correct in the sense that there many disturbances, but they are minor disturbances. Each disturbance only affects the specie(s) for a limited amount of time, not long enough to be considered a long term disruption. After the disturbances, the species' populations return or begin to return their carrying capacity, which only proves that Isle Royale IS A STABLE ENVIRONMENT!

Student C – Example Scientific Explanation.

Isle Royale is stable, concerning the populations of moose and wolves because the populations fluctuate due to minor disturbances, can return to a carrying capacity after minor disbranches and experience a new carrying capacity after a major disturbance. These are the definition of stability.

When a minor disturbance occurs, stable populations fluctuate. The populations of wolf and moose fluctuate in many instances. One example of a fluctuation occurred during the years 1972-1981 a series of harsh winters occurred. At the beginning of this minor disturbance (1972) the moose population was approximately 1100 individuals and the wolf population was 22 individuals. Moose population decreased due to food being killed by the cold. Wolves increased due to an abundance of unhealthy moose, which the wolves had an easier time hunting. The reason that the wolf population did not plummet was because that there were still enough moose to support all of the wolves.by the end of these harsh winters, the moose population had dropped to approximately 750 individuals. One year before the end of the harsh winters a disease called canine parvovirus was introduced into the ecosystem killing many wolves, although the year before the wolf population had increased to 49 individuals. These changes in population are minor fluctuations due to a minor disturbance (excluding the canine parvovirus incidence at this time, will address later). As in our NetLogo models when a very stable population was affected by a minor population the populations fluctuated. Therefore, when minor disturbances occur the population have the ability to fluctuate.

When minor disturbances and fluctuations occur, stable populations are able to return to a set carrying capacity. An example of when the populations returned to carrying capacity occurred in 1959-1972, there were no disruptions. The carrying capacity of the moose seemed to be at about 1100 individuals after the minor disturbance of harsh winters in '72-'81. The population increased from the 750 low back to a 1100 in only 7 years with no disturbances. This quick return to carrying capacities show that moose population is stable. The exact opposite occurred with the wolf population. Before 1972, it had a carrying capacity of 21 which increased to 49 during '72-'81. After '81 the population lowered again to 16 and fluctuated around the population of 21. That means the wolves are returning to carrying capacity. This data supports that there were fluctuations during a minor disturbance and after the disturbance the populations returned to approximately what their numbers were before the disturbance quickly. As in our NetLogo models when we introduced a minor disturbance the populations returned to their carrying capacities. Therefore, when fluctuations occur the populations tend to return to carrying capacity.

When a major disruptions occur, the population is temporarily unstable but sets itself to a new carrying capacity. An example of this occurred once in moose and once in wolves. For wolves it occurred in 1980 with the introduction of the canine parvovirus. Before the virus, the wolves had a carrying capacity of approximately 43. After the two years in which the virus was extremely active, the population dropped from a maximum 49, minimum 35 to a maximum 23, minimum 15. They fluctuated around 19 for the next few years stabilizing to a new carrying capacity. The instance for the moose occurred in 1996 with an extremely harsh winter. Before the harsh winter the moose population had been increasing to a carrying capacity of 2500 individuals. After this single year of harsh cold. The population dropped to approximately 900. In the following years the population began fluctuation to a new carrying capacity of approximately 500. This occurred because when the environment changes, as in our NetLogo models carrying capacity is affected. Also according to the Introduction to Class Case Study packet. Moose populations suffer in harsh winters due to lack of food. Therefore, when a major disturbance occurs, the population arrive at a new carrying capacity.

Others might say that the ecosystem is not stable because the fluctuations are so large that is does not meet the requirements to be stable. This is not true because each of those fluctuations has a definite cause and they return to a carrying capacity afterwards, therefore, the population meets the definition of stability. Some of the causes included a genetic disease but the wolves are still able to sustain the population, so it did not affect the stability of the population.

Student D

Isle Royale is a stable ecosystem for the wolf and moose ecosystem. This is because a stable ecosystem is defined as a population which can fluctuate but tends to return to a similar place, the carrying capacity of the ecosystem for that given creature. It is also important to note that short term disturbances are able to make the population fluctuate more, and long term disturbances are able to change the carrying capacity of the environment. Either of these can occur while still having an environment be stable as long as the populations eventually return to the carrying capacity from before the event. Isle Royale shows through this that it is a stable ecosystem because it has a carrying capacity which the moose and wolf populations tend to return to when they are not effected by disturbances, because the populations, when faced with a short term disturbance, will tend to fluctuate and start to return to their original carrying capacity, and because the populations, when faced with a long term disturbance, will tend to fluctuate and return to a new carrying capacity, but eventually lose the effects of the long term event and return to the original carrying capacity.

The first point that makes Isle Royale a stable ecosystem that the wolf population and the moose population have carrying capacities. For much of the time period viewed during this case study, various short term or long term effects affecting either one population or another make it hard for a carrying capacity to be declared. If an event is having an immediate (or long term) effect on one population or another, that population will not be representative of the carrying capacity. Due to this, there are only two sections of time that can be viewed in the case study to figure out the carrying capacity. The first is at the very beginning, from the years 1959 to around 1964. The other is the section at the very end, around 2003 through 2009. In both situations, the populations are not being influenced by any event. From 1959 to 1964, the wolf population varied, going from twenty to around twenty-two, then up to twenty-three, followed by a drop back down to twenty. As for the moose, they increase very slightly over time, but the population stays around five hundred. From 2003 through 2009, the wolf population the wolf population started out increasing drastically, from around twenty-two earlier to around thirty. It holds that sized population for three years, and then dropped just as drastically to around twenty-three wolves. In the following years, the population increased to about twenty-four wolves and then dropped again to twenty. The moose population showed the inverse. They saw a drastic decrease from 2006 to 2007, the lowest point being around three hundred moose. They then saw an increase in 2008 to around six hundred and then a following drop back to around five hundred the next year. Although these changes in population may seem arbitrary, they fluctuate back and forth around a certain size, the carrying capacity. Within the models that we did for class, we saw a similar trend. For example, when we first were testing the model, we had only two elements, the grass and the bugs. We found that when the bugs were allowed to start eating the grass, the population would increase immediately as it ate all the grass and then decrease again as the population found that there wasn't any more grass to eat. In did these repeatedly, fluctuating back and forth with the amount of grass that was available. They would not stop and level out at a specific point, but would instead fluctuate above and below a general population, each fluctuation getting steadily smaller and closer until it had minimal fluctuation, which was the point where it reached a carrying capacity. Even in cases where the fluctuations aren't shrinking at a regular rate, we found through our models and readings that the carrying capacity could be decided by examining the average of the fluctuations. Therefore, considering the population at both points in the case study, the carrying capacity for the wolves seems to be around twenty-two wolves, and the carrying capacity for the moose appears to be around five hundred moose. These populations are the points at which the population would want to return after events that change its population.

The second point that makes Isle Royale a stable environment is that the population will tend to try to return to its normal carrying capacity after short term events occur. This can be seen at several points throughout the case study. These includes times such as during 1980 to 1984 and 1996 to 2010. During 1980 to 1982, a disease called canine parvovirus struck the wolf population. This led to a drastic decrease in wolves from nearly fifty wolves down to around thirteen within the two year period. In the following two year period, from 1982 to 1984, there was an increase in wolves to about twenty-three wolves, back towards the carrying capacity. The wolf population then started to go down, but was affected by another event before it could fully fluctuate back to the original carrying capacity. In 1996, there was a particularly harsh winter and a major outbreak in winter ticks which led to the moose population dropping from around two thousand four hundred (it will be explained later why the moose population was so large at the time) to around one thousand. The moose then began to grow again, reaching nearly one thousand two hundred, and then it dropped back down to around three hundred over a period of years. It continued to fluctuate like this at even smaller intervals around the earlier established carrying capacity, around five hundred moose. The wolves, starting in 1997, faced a sudden drop in numbers from around twenty-five to around fifteen. This corresponds with the moose drop, suggesting it was due to the lack of prey. The wolves then saw a rise, peaking at around twenty-nine in 2000 before dropping due to another event from 2000 to 2004. This drop takes the wolf population down to eighteen individuals at its lowest point. After the event, the population responds by growing again, reaching about thirty members before dropping again down towards twenty in 2007. It continued after that point to grow and shrink around twenty-two members. Both of these cases acted like the models that were considered stable models in class. In the models in class, an ecosystem would be constructed, usually only just containing bugs and grass. After the population became somewhat stable, a short term event would be introduced to the ecosystem. When the event, such as adding more bugs, occurred in the models, the population would increase from the original carrying capacity of around two hundred seventy to about three hundred seventy. This initial increase would lead to a responding decrease, and then the decrease would lead to an increase. This would continue on until it reached back to the carrying capacity it first had. From this, the class came to the conclusion that a stable environment will have the population eventually return back to the carrying capacity after a short term event leads to its change. Since the populations in Isle Royale did this, eventually returning to the original carrying capacity, it can be said that it is in fact stable.

The third point that makes Isle Royale a stable environment is that when the populations are faced with a long term event, they may have their carrying capacity temporarily changed, but the carrying capacity eventually returns to its original size before the event. This happens several times over the course of the case study, but there are two main times in which the population's changes due to it are fairly obvious and unaffected by other events. The first period is from 1964 to 1972. The second is from 1984 to 1999. From 1964 to 1972, there were a series of relatively mild winters. This meant that the moose population began to increase because there was more vegetation available and they had more access to water for longer. The moose are much safer from wolves when they are in water than anywhere else. Over this period, the moose rose from around five hundred to about one thousand two hundred. The larger amount of vegetation growth and safety from the wolves temporarily raised the carrying capacity, allowing the population to rise without having a counter fluctuation back down. As for the wolves, without as much opportunity to hunt, their numbers went down from around twenty-eight in 1965 to its lowest at around sixteen in 1969. Later, from around 1972 to 1980, there was a series of particularly harsh winters. The conditions inverted. The moose began to see a steady decline from around one thousand three hundred in 1980 to around seven hundred fifty in 1980. The wolves saw an increase in members, increasing from its lowest in 1969 to nearly fifty by 1980. If the rate of decline had continued, the moose would have soon reached their original carrying capacity, but the next long term event struck at that time. In the other period, from 1984 to 1999, the readings said that the wolves began to have a drastic increase in offspring with malformations due to inbreeding. This led to the wolf population decreasing drastically for a period of time and the moose population increasing drastically, since the wolves had a much harder time hunting and surviving. The wolves, starting with around twenty-three individuals in 1984, dropped down to around twelve. They stayed like this for around five years, with the exception of one blip in 1990. Meanwhile, the moose population skyrocketed, increasing from around one thousand in 1984 to two thousand four hundred in 1996. The wolves, even with malformations, began to grow due to the sheer numbers of moose. From 1994 to 1997, they increased from around twelve to twenty-three. After that point, the moose population decreased due to the harsh winter and outbreak of winter ticks. The wolves reacted to this, but not before the introduction of an important element. In 1997, a new lone alpha wolf crossed the frozen water to Isle Royale. This single wolf soon was breeding with the wolves on the island. Since he was not native to the area, he did not have the genetic mutations that had become prevalent on the island. When the wolves decreased in response to the moose, and then they increased again, the new genetics was able to deal with the issue arising from the increase in abnormalities. The wolf population could increase correctly again, and this is seen from 1998 to 2000 when the population increased from thirteen to thirty. From there, the results were like what was discussed in the short term event section, where both the wolf population and the moose population eventually returned to the earlier carrying capacity. In our lessons, the condition with the wolves could most closely be associated with the model in which invasive species were introduced into an environment. The environment would start out at a stable point with bugs and grass. An invasive species would be added in with a different trait. The two species would then compete, and whichever species had the traits that benefited the most would eventually lower the other population to a point of extinction. This would then become a new, stable state. In this case, it is not competition between different species, but between different characteristics in a species. The wolves without malformations that descended from the new wolf were able to survive better than those that did, leading to them populating the environment. The new stable state was not in fact a new state, but the old state being returned to once the genetic mutation was removed that kept it set lower. The populations would return to their former carrying capacities after the event was dealt with, so the ecosystem was still stable.

Someone may argue that this ecosystem is not stable due to a series of small changes in the data that occur throughout the study. In areas like 1990 to 1991 and 1999 to 2003, the populations would have sudden increases or decreases without being connected to an event. One might argue that, if this ecosystem is stable, there should be no sudden, seemingly random changes in the population. To address this, such events may appear seemingly random, but are in fact just as much short term events as any of the events addressed in the second paragraph. These events are not caused by changes in climate or the strike of disease, but can instead be explained using the behaviors of the animals and how they interact. For example, in 1990, during the time when the wolves had the mutations, the wolf population sees a sudden increase from its earlier status at twelve to the new size of fourteen. The following year, the population drops back down to twelve. On its own, this event seems random. Yet, if the moose population is also monitored at that time, it can be seen that in the year before the population spike, the moose had a large increase in numbers, from one thousand to one thousand two hundred. This new population had to consist entirely of calves. Also, in the following year, the moose growth is actually below average for that time period, only growing by about fifty. This suggests that many of the new calves from the previous year did not survive. This, therefore, could explain the sudden rise and fall in the wolves. In a year when the moose had a particularly high birth rate, the wolves were able to hunt the calves rather than the adults. The calves are easier to hunt and are much less dangerous. The wolves, even with malformations, were able to hunt easier and to grow in population because of it. When the size of the calf population decreased due to hunting and the calves' growth, the population could no longer support the size of the wolves. This led to the wolves decreasing again. These kinds of situations can be found surrounding each of the seemingly random changes. In 1999 to 2003, the wolf population dropped greatly and then increased again. This could be explained by a reoccurrence of the malformation genes. In some of the cases, it relates back to the principles that the class found surrounding how animals interact. These two are an example of predator versus prey interaction, where each directly influences the other because they each are limited by the population size of the other. Since they rely on each other, changes in one can lead to some drastic changes in the other. Other changes can be explained by principles of competition. Competition occurs to a limited set of resources. It leads to consequences, usually the increase of one population at the disadvantage of another, such as in 1999 to 2003. At any rate, these events are able to be logically explained using the established principles as well as the behaviors know to wolves and moose. Since these each can be explained, they cannot be used against Isle Royale in arguing whether it is or is not a stable ecosystem. Furthermore, since it is able to be said that Isle Royale has a steady carrying capacity for both wolves and moose, that the populations will return to that capacity after faced with a short term event, and that the populations will eventually return to that carrying capacity when faced with a long term event, even if the long term event temporarily changes that carrying capacity, it can stated that Isle Royale is in fact stable.