Lesson 4: How Do Sizes of Populations Change Over Time? (part 1)

Overview:

Purpose:

The purpose of this activity is to identify relative amounts of stability and change in population sizes over time, and describe these outcomes in terms of immediate and delayed affects between birth rates, death rates, and resource availability.

Connection to previous activities:

Students have experienced what an individual bug experiences in the computer simulation they will use today, when they drove a bug around the ecosystem in the previous activity. In that activity they were introduced to some of the modeling assumptions used in the computer model today. They had observed the unequal distribution of resources that emerges locally in the ecosystem when many bugs are interacting with the environment. They have described competition as an emergent outcome that can result either from intentional or unintentional interactions of individuals consuming a shared group of resources.

Learning Performances

- Use mathematical and computational representations from investigations to support explanations of factors that *do not* affect carrying capacity of ecosystems. NGSS HS-LS2-1

Scientific Principles (re)Discovered in this Activity

- Changes in resources available have a delayed affect on birth rates and death rates.
- Population sizes tend to move back towards a stable average value (or carrying capacity) in an ecosystem after temporary or modest disturbances in the environment.

Description

Students observe the behavior of a wobbling cereal box and use this to define characteristics of stable systems. Students are shown how to interpret the graphs in NetLogo models that are dynamically updating. They use the computer model to explore to determine that changing the initial number of bugs, introducing disease, or adding bugs during a run does not affect the stability of the ecosystem.

Through discussion, the teacher helps build consensus about some of ways that populations sizes change in ecosystems – exhibiting minor fluctuations, cyclical fluctuations, while remaining relatively stable under certain environmental conditions. They discuss how counterbalancing forces of deaths and births affect the amount of food available per individual in the ecosystem.

In their homework students interpret NetLogo model run graphs for stability and fluctuation and critique modeling assumptions of the NetLogo models. They analyze data from some real-world predator-prey ecosystems to determine the usefulness and validity of the computer model.

Lesson Details:

Time 90 minutes

Materials

Per Student

- 1 computer with Java 7 and Firefox installed.
- A student WISE account for the class period was already created.
- One large post-it note

For Teacher

- An empty cereal box (reuse it for each class or keep one new empty one for every class)
- A couple handful of coins
- Tape
- 3 Large index cards with the following written on them:
  - **Deaths** **Food available per Individual Bug** **Births**
- 2 pieces of different colored construction paper with the following written on them:
  - Amount of Competition for resources Size of Bug Population.
- Green and red white board makers

- 1 computer with Java 7 and Firefox installed and projector or large display screen for the teacher to display the computer model.
- The driving question board
- 1 piece of butcher paper or poster paper or space on the wall for students to stick the post it notes on.

Lesson Outline and Timing

Launch

- Review the driving question board and introduce today's lesson question– (2 min.)
- Student predictions (step 3.1) – (1 min.)
- Stability and fluctuation demonstration (cereal box) and class definition (step 3.2) - (7 min)

Explore – Exploration 1

- Sketch a graph prediction for population size change over time (step 3.3)– (2 min.)
- Teacher runs experiment (also a demo of how to interpret graphs)– (3 min).
- Students complete making sense questions (step 3.6) (5 min)

Explore – Exploration 2

- Students design experiment on initial bug population effects, conduct it, record observations, and analyze their results (step 3.7 though 3.11) – (10 min).

Explore – Exploration 3

- Students design experiment on initial bug population effects, conduct it, record observations, and analyze their results (step 3.12 though 3.16) – (10 min).

Summarize

- Class Index Card Modeling Activity Discussion – (15 min)
- Class Consensus Building Discussion – (15 min.)

Lesson Enactment Details

Launch:

Remind students of the discoveries they made related to their driving question. Tell students that they will continue using models today explore and discover more ideas to help answer the driving question. Tell students that they are going to be investigating the 3rd lesson question today and tomorrow, "How Do Sizes of Populations Change Over Time?"

Ask students to think of pond or lake as an ecosystem like they did in activity 1. Ask students if the size of a population of fish in the pond would remain the same or would change from day to day? Week to week? Year to year? *Students will likely say it would change at some point due to deaths and/or births.*

Put these two ideas on the board:

- Reproduction increases the size of a population and
- deaths decrease it

Remind students that though this is true, that they have some scientific principles that tell them more about reproduction and death (at least from starvation). Review these two scientific principles with the students from lesson 2:

- When food becomes scarce, decreases in populations size are often delayed due to the stored food (fat) that organisms can use up
- when food becomes abundant increases in population size are often delayed, due to gestation time.

Ask students to think back to the last activity and make some predictions regarding the individuals in that ecosystem. Which bugs would be more likely to die and which ones would be more likely to reproduce, those with a lot of stored food energy or a little bit of stored food energy? *Students should say those with a lot of stored food energy would be more likely to have enough stored food to use as building blocks needed to make offspring, while those with very little stored food energy would be more likely to run out of what is left before eating again, and would die from starvation.*

Remind students that we discovered that in the last activity that some individuals will outcompete others. In this competition this means, that some individuals may reproduce and others won't, and some individuals will die and others won't, all based on how much food they have consumed. And since deaths and births don't happen at exactly the same instant for each individual, in part due to the amount of stored food energy they have, the population size may not be exactly the same from one day to the next.

Tell students that since they will be studying an ecosystem model on the computer similar to the one they experienced yesterday, but one in which population sizes might constantly be changing, they will need a way to describe the changes in populations size.

They may see change back and forth or fluctuation and they may also see stability in the population size.

Put both of these words on the board: **stable/stability** and **fluctuate/fluctuation**

Tell students that the ideas of stability and fluctuation are something that you want them to think about further.

Show them the empty cereal box. Ask for a volunteer who can give it a small enough push or tap at the top of the box so that the cereal box would wobble back and forth, but not tip over, and return to much the same position it started from. Have a volunteer come up and try (see the picture)

An empty cereal box

An empty cereal box, being given a small push that isn't enough to push it to a new stable state. When this push is released the box will wobble back and forth (fluctuate its position), but eventually return to nearly the same position it started at (its stable state).

Now ask them to describe what they saw happen. First ask if the saw any fluctuations or “back and forth” changes in the position of the box after you tapped it. Then ask them why the box ended up returning to nearly the same position as when it started. *Accept all answers.*

Ask students what would happen f you pushed it a little less hard? Test this with the students and emphasize that again the system was stable because it returned to much the same position it started in, even though it fluctuated around that position a bit after being pushed.

Ask if anything different might happen if you pushed it much harder. *Many students will say it will tip over.* Show them this phenomena, and say, that you pushed the box so hard that it was no longer stable, but if you had pushed it only a little bit it would have remained stable even if it fluctuated a bit before returning to a position close to its original position.

Tell students that what is meant by **stability**. It is the tendency for a system to fluctuate around an average state or to return to its original state if it experiences a disturbance. Unstable systems however, do not return to their original state when they experience a disturbance. Instead, they settle into a very different state or position.

Now ask students to predict how the stability and the fluctuations would change if you added some coins to the box. Show them this by adding two handful of coins. Then ask them how we could test and measure whether the system shows the same level of stability as before. *Accept all answers. Students may predict the system is less stable and tips over more readily. Or they may predict it is more stable by returning to its original position even with harder pushes.* Ask what might be different about the fluctuations they see when the system is given a small push. *Accept all answers (students may predict the fluctuations are greater or smaller. They might predict that they are slower or faster.* Test their predictions a couple of times with a student volunteer and ask them what they noticed.

Add a couple of handful of coins into the box

Now when being given the same small push as before that Isn't enough to push it to a new stable state. When this push is released the box will wobble back and forth (fluctuate its position), but eventually return to nearly the same position it started at (its stable state).

Remind students of the driving question, "How do populations change?" that today they will be investigating how population sizes change over time using a computer model of an ecosystem. As they do so, they may find it useful to record observations about the fluctuations and the stability in the size of the population.

- **Instruct students to complete step 4.1 and then** as you say and write down these two behaviors of a **stable system** on the board:

Stable systems:

1. May show **fluctuations**, or slight back and forth changes in the state of the system.
2. But tend to return to a similar state even after experiencing a minor disturbance.

Explore:

Tell students that the model they will be using will be very similar to the model they used before.

- Bugs that are randomly steered by the computer will walk through the ecosystem and consume grass, gaining energy when they walk over spots of grass.
- Grass will grow back after a time.

But tell students that two new types of interactions will occur in the bug population.

- One is that a bug will die if its energy ever decreases to 0.
- Another is that bugs will reproduce when they are old enough (20 ticks of the clock in the simulation) and if they have enough energy (10 energy units or more). When they create offspring, they split the energy they have amongst themselves and their offspring.

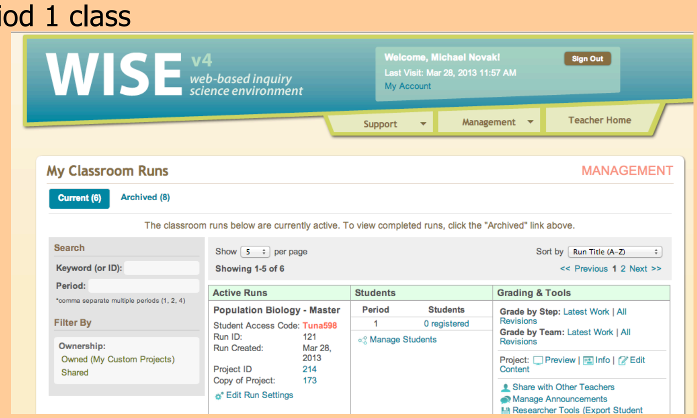
Tell students that you are going to start the new simulation with 30 bugs and that you will run the model in a moment.

- **Have students to complete step 4.2 and 4.3 and then wait a few minutes before continuing.**

Demonstrating the first model result (and how to interpret the graph in the model)

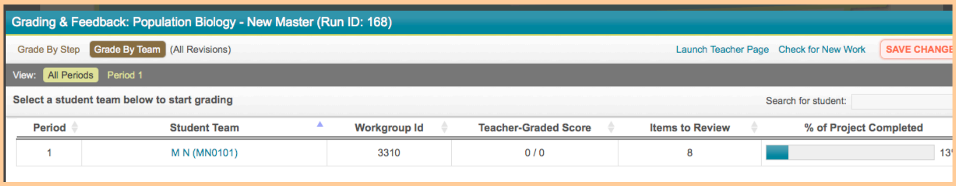
Model Demonstration Directions For the Teacher

1. You too will want to log into WISE in teacher mode, but will launch the same model the students will be using in later steps. Click on the Teacher Home tab. You will see a list of all the active runs you have started for each class period. For the current class that you are teaching. In the example below, the first row show the Student Activity for this Teacher's Period 1 class



2. Look for the Grading & Tools Column to the right. Under that look for the Grade by Step heading and click on the Latest Work link.

3. The teacher Grading & Feedback page will come up. Click on Launch Teacher Page on the top right of the page.



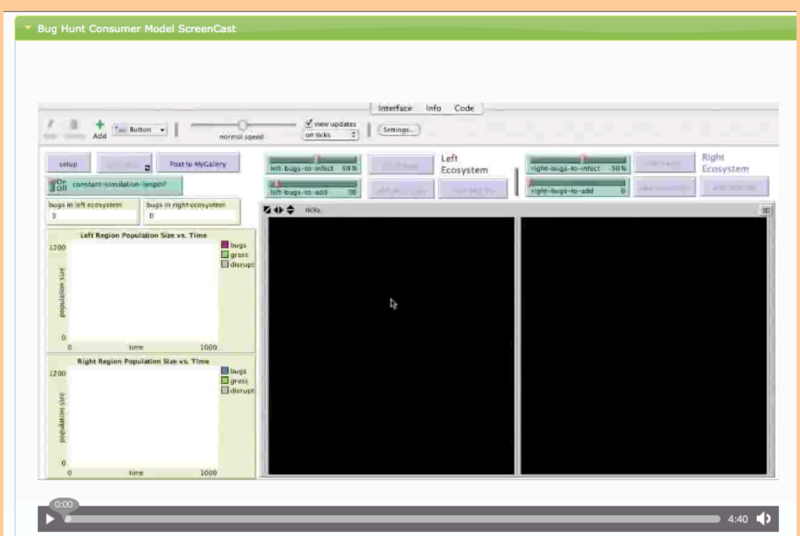
4. The teacher Grading & Feedback page will come up. Click on Launch Teacher Page on the top right of the page.

5. Play a screencast of a sample model run, by clicking on the ScreenCast Videos tab.

1. The teacher Grading & Feedback page will come up. Click on Launch Teacher Page on the top right of the page.

2. Play a screencast of a sample model run, by clicking on the ScreenCast Videos tab.

3. Click on the Bug Hunt Consumers Model ScreenCast menu item. Press the play button. Audio narration is provided



4. Press the play button. Audio narration is provided

- **Instruct students to complete step 4.4 and then wait a minute before continuing.**

You may wish to discuss the answers together before having them go on to work on the rest of the activity. The students should say this is stable system, 1) it show **fluctuations**, or back and forth changes in the state of the system, 2) but it maintains nearly constant average population size over time (a steady state)

- **Instruct students to complete Steps 4.5 to step 4.10 to run various experiments using this same model and record their results.** Leave 30 min. for the final discussion.

Summarize:

With 30 minutes left(out of 90 minutes set aside for this this lesson) have all students stop the simulations and join a class discussion around a index cards at the front of the room.

Ask students why removing grass temporarily or removing most of the bugs temporarily still led the ecosystem to return to the same stable state (In other words why did the bug population grow back to previous levels)? *Students should say that the bugs can still reproduce to return to their previous population levels. And students may say, it just may take a while for the grass growing there to grow back or to get eaten up.*

Using index cards for **Deaths** **Food available per Individual Bug** **Births** draw the following interaction model on the board.

up	immediate affect		delayed affect	
Deaths	------------->	**Food available per Individual Bug**	--------------->	**Births**
	<-------------		< ----------------	
	delayed affect		immediate affect	

Ask students what happens to the food per individual as the rate of bug death starts to increase. Raise the index card for **Deaths** . *Students should say that the food available per individual bug will go up.* Raise the card for ***Food available per Individual Bug*** Place a 1 in the green arrow.

up	immediate affect	up	delayed affect	
Deaths	------1----->	**Food available per Individual Bug**	------------->	**Births**
	<------------		< ----------------	
	delayed affect		immediate affect	

Ask students if this will cause size of the population to change. Students will say yes. Ask students if this will cause the amount of competition for resources to change in the population. Students will say yes. Tell students you'd like to visualize this too. Give one student a large piece of colored paper that says Amount of Competition for resources. Give another student a different pieces of colored paper that says Size of Bug Population.

Tell those students to keep to raise their papers above their heads when their amount goes up and bring it down to chest level as it goes down and keep it at face level when its in between. Have them start their papers at face level. Then ask the class, so as the death rate went up, what should we do to each of these papers to reflect that change. Students should say that Amount of Competition for resources should go down and Size of Bug

Population should go down.

Then ask students to think about what happens a bit later after the population has decreased and more food per individual is now available. How will that affect birth rates and death rates? *Students should say that the births will go up and deaths will go down.* Ask them why this might take a while to see an increase in the births, why doesn't increased food available immediately increase the births? *Students should say it takes a while to gather the food, or it takes a while to turn food into the cells/building blocks needed to grow the baby bugs inside mom.* Raise the index card for **Births** and lower the one for **Deaths** Put a 2 in both of the red arrows.

down	immediate affect	up	delayed affect	up
Deaths	**------1----->**	**Food available per Individual Bug**	**------2------>**	**Births**
	<----2-------		< ----------------	
	delayed affect		immediate affect	

Then ask the class, how to change the Amount of Competition for resources and Size of Bug Population cards. The class should say to raise both of these.

Then ask students how we should change the food available per individual bug now that the size of the population has gone up. *Students should say that the food available per individual bug will go down.* Lower the card for ***Food available per Individual Bug***

down	immediate affect	down	delayed affect	up
Deaths	**------3----->**	**Food available per Individual Bug**	**-------2----->**	**Births**
	<----2-------		**< -------3---------**	
	delayed affect		immediate affect	

Point out that as population went up this had an immediate affect on the amount of food available. Add a three to both green arrows. But remind students that it takes a while for organisms to use up their stored food (to starve). Replace the 2 with a 4 in the red arrows

Ask students what eventually happens to the deaths and births as the food per individual available goes down. *Students should say that the deaths increase and births decrease. Move the card for* ***Deaths*** *up and the one for* ***Births*** *down.*

up	immediate affect	down	delayed affect	down
Deaths	**------3----->**	**Food available per Individual Bug**	**-------4------>**	**Births**
	<----4-------		**< ------3---------**	
	delayed affect		immediate affect	

Then ask the class, how to change the Amount of Competition for resources and Size of Bug Population cards. The class should say to lower both of these.

Tell students to notice how this teeter totter (back and forth) affect on births and deaths going up and down in response to the food available per individual bug, has a delayed effect on births and deaths. Ask students to explain what type of cycle this leads to in the size of the bug population. Ask students if they saw evidence of this in their graphs. *Students should be able to provide examples of the cyclical fluctuations they saw in some* *graphs, particularly right after a temporary disturbance.*

Point out to students how deaths and births are counterbalancing forces that change the food per individual available Also point out , that the number of individuals affects this avg. food available per individual. Which factor (births or deaths) is having a greater factor on the ecosystem, depends on the number of individuals already alive and the amount of food per individual currently available. The strength of each counterbalancing effect changes as the level of competition for food changes, so that the avg. amount of food per individual remains relatively stable. This in turn leads the number of bugs in the population to remain relatively stable (and to return to its carrying capacity) when there are fluctuations in population size.

Ask students if every bug is always equally successful at finding enough food to stay alive at the same time? To reproduce? If some bugs are more successful than others, and the bug that is most successful at one time might not be the same bug most successful at another time, what other features of the graph could be explained by this ongoing competition for resources. *Students may say that other minor fluctuations might be due to this.*

Summarize:

Remind students that the main question for the lesson study that they are studying is “"How do sizes of population change over time?"

- **Have student’s complete step 4.11**

Ask students to talk in groups of 4 for two minutes to create a single piece of paper that summarizes their ideas. Have students write this idea on a large piece of paper or a large post it note in dark pen/marker. Have each group post their paper on the board.

With the papers displayed for the class to look at together, lead a consensus building discussion. Facilitate the movement and reorganization/clustering of the ideas students brought up, under the 2 headings listed below.

This consensus building discussion and reorganization of the student descriptions of their discoveries will help students condense and summarize the big ideas from the day's lesson. If an idea that students suggest doesn't fit under these areas, don't leave it out. Rather, emphasize that the idea shared is another interesting discovery and that the main ideas that the students are responsible for knowing and reusing in future explorations are the ones organized under the 4 areas listed. Try to write the 4 categories in the student's own words, and using their own papers if possible. You may want to consider posting these big ideas in class, having students summarize these ideas now (or later) in their notes. Either way, try to use the students own words and the way the class expresses the ideas listed below, without feeling it is necessary to use this exact wording. Examples of possible student responses they might contribute on their sheet or post it note are shown in italics. Ask students whether they agree or disagree with how the ideas or organized and whether this summary helps pull out the main points they discovered.

The underlined statement is the suggested category. The non-bold italics statements are possible student ideas. The bold italics statement can serve as another way to summarize what is common amongst the student ideas and each underlined category.

Conclusions & Big Ideas:

As a class: : How do the sizes of populations change over time?

<u>Why they fluctuate….</u>

- <u>Variation in resource distribution</u>
  - *Example student idea: Some creatures are lucky to find food before others*
  - *Example student idea: The amount of resources near each individual isn't the same.*
  - ***Summarize with this idea: Because resources aren't always equally distributed near every individual all the time, some individuals will sometimes be able to get more resources than others.***

- <u>Changing birth rates and death rates → changes population size</u>
  - *Example student idea: When bugs start dying faster, than bugs are born, the population size will go down.*
  - *Example student idea: Sometimes more bugs are born than other times.*
  - *Example student idea: How fast the bugs are dying changes.*
  - ***Summarize with this idea: Changes in birth and death rates change the size of a population.***

<u>Why they remain relatively stable…</u>

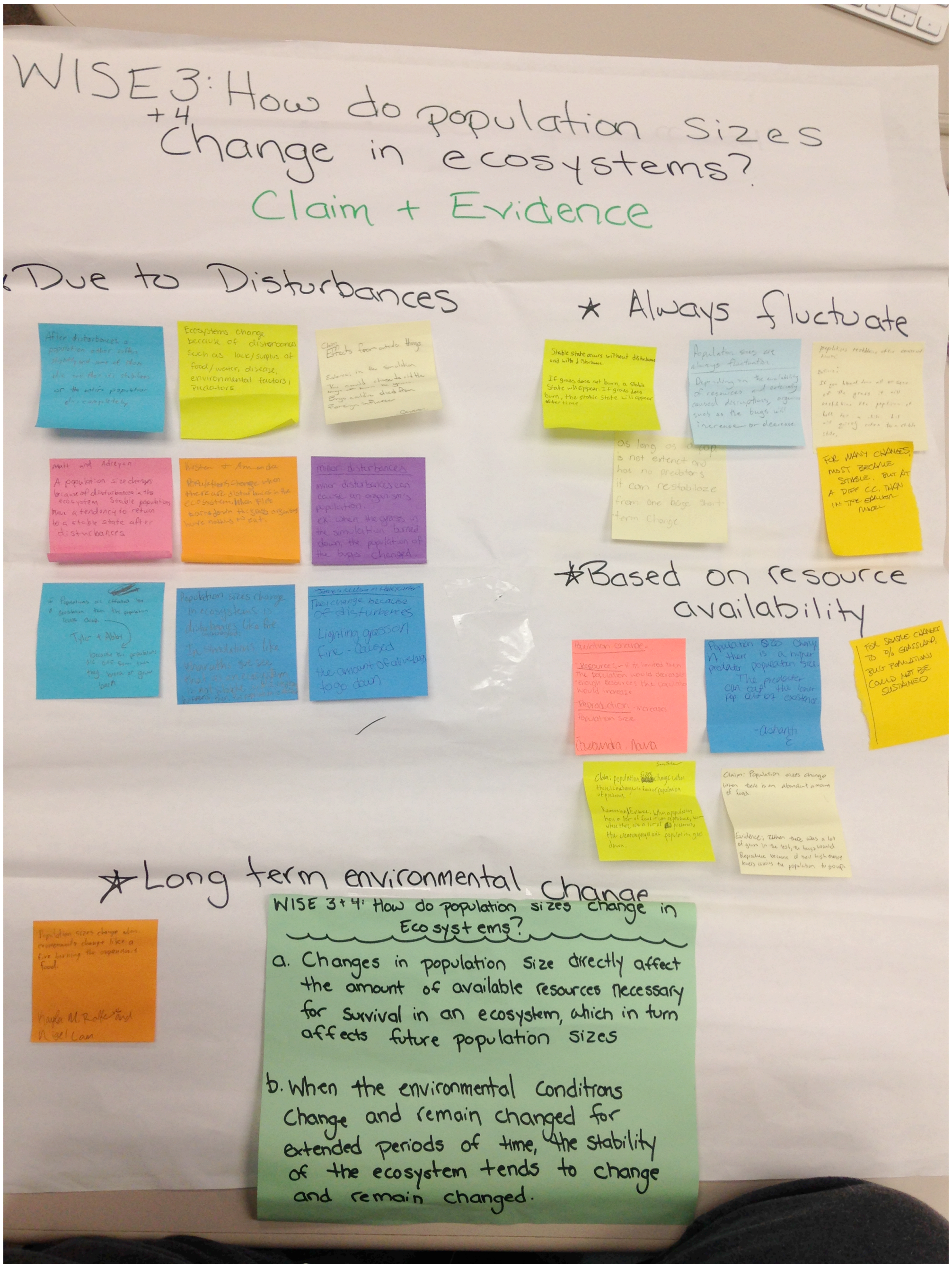
- <u>Changes in population size → resources availability (competition),→ changes birth & death rates</u>
  - *Example student idea: When there is a lot of food per individual, the rate of births is higher than the rate of deaths.*
  - *Example student idea: When there is little food per individual the rate of death is higher than the rate of births.*
  - *Example student idea: Deaths and births are indirectly affect each other.*
  - *Example student idea: Deaths eventually lead to a delayed outcome of more births.*
  - ***Connect these idea to the prior ones: Changes in resources available have a delayed affect on birth rates and death rates. Changes in these rates push the population size back towards a stable value (or average size called the <u>carrying capacity</u>). Populations tend to return to previous carrying capacities after temporary disturbances in the environment.***

Add only these three scientific principles to the driving question board:

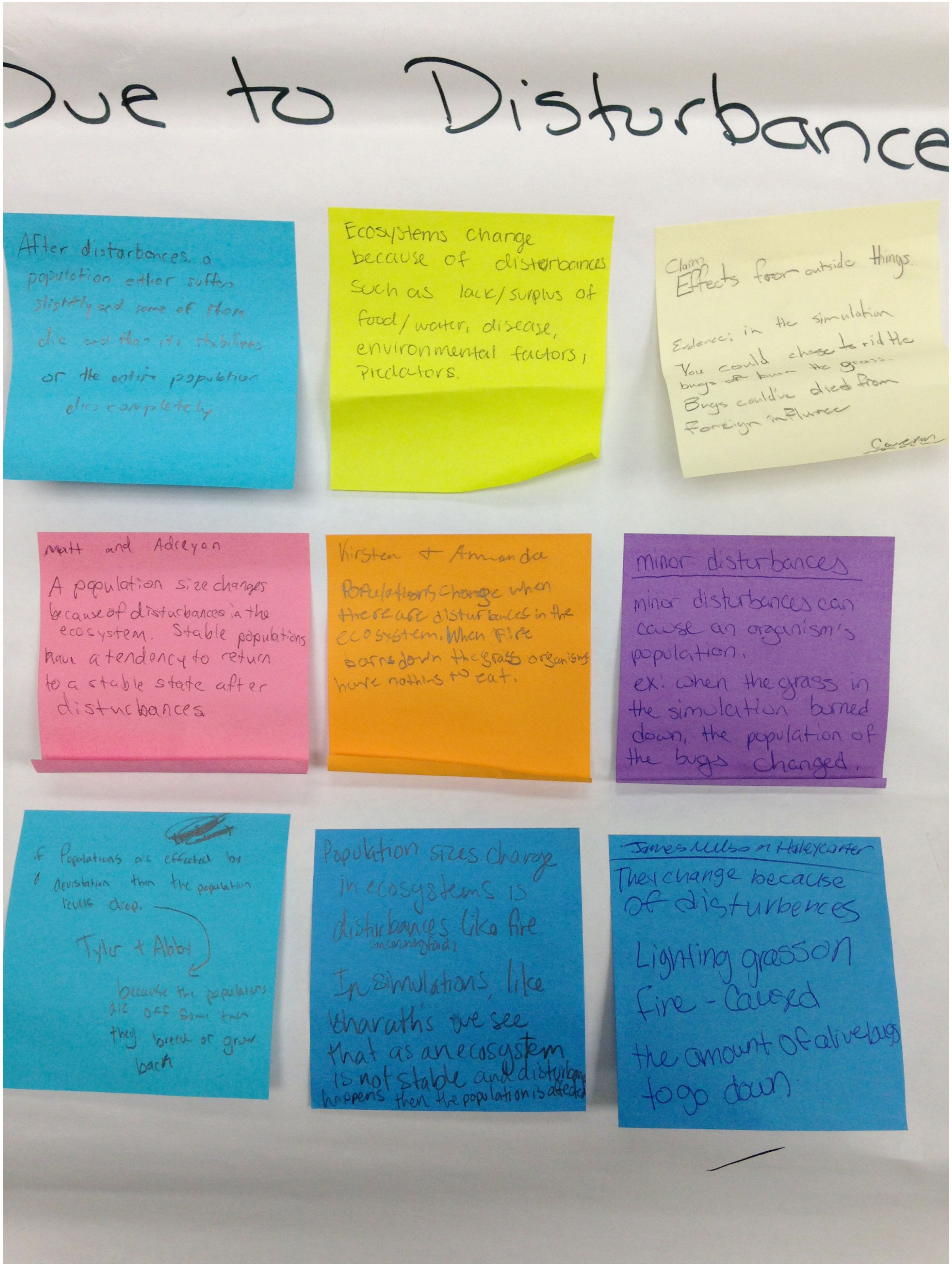
- *Changes in resources available have a delayed affect on birth rates and death rates.*
- *Population sizes tend to move back towards a stable average value (or carrying capacity) in an ecosystem after temporary or modest disturbances in the environment.*

Once these ideas in the bold have been agreed upon by the class make sure they have been added to the orange section of your driving question board. Add them either in the abbreviated form (e.g. "limited resources necessary for survival" or the fuller form of the idea "All ecosystems have a limited amount of resources necessary for survival for living things"). One easy way to do this is to move the butcher paper or poster paper that you had been using to keep track of the ideas and tape it under the lesson question for today. An example of this is shown below:

Once these ideas in the bold have been agreed upon by the class make sure they have been added to the question board. Here are example student post-its from 9th grade regular biology classroom from this lesson and the next one. (special thanks to the first pilot teacher: Kate Cook in Dayton, OH):



Notice that the big ideas on the green sheet can take a very different syntax and focus than the ones suggested in the teacher manual. This teacher used her own student's ideas and language to craft summaries of their discoveries as they converged on trying to express the scientific principles suggested in the teacher guide


Due to Disturbance
After disturbances, a population either suffers slightly and some of them die and then it's stabilizes or the entire population dies completely
Ecosystems change because of disterbances such as lack/surplus of food/water, disease, environmental factors, Predators.
Claim Effects from outside things
Evidence: in the simulation You could choose to rid the bugs or burn the grass. Bugs could've died from Foreign influence
Matt and Adreyan
A population size changes because of disturbances in the ecosystem. Stable populations have a tendency to return to a stable state after disturbances
Kirsten + Amanda
Populations change when there are disturbances in the ecosystem. When fire burns down the grass organisms have nothing to eat.
minor disturbances
minor disturbances can cause an organism's population.
ex: when the grass in the simulation burned down, the population of the bugs changed.
if Populations are effected by devistation then the population levels drop.
Tyler + Abby
because the populations die off some then they breed or grow back
Population sizes change in ecosystems is disturbances like fire
In simulations, like Wharaths we see that as an ecosystem is not stable and disturbance happens then the population is affected
They change because of disturbences
Lighting grass on fire - Caused the amount of alive bugs to go down.

Homework: **Assign the homework (reading 4.1) for tonight.** PDFs of the homework is available on the teacher resource page for the unit. Simply click on the blue link for each activity under the student assignments section to download the pdf of the homework.

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