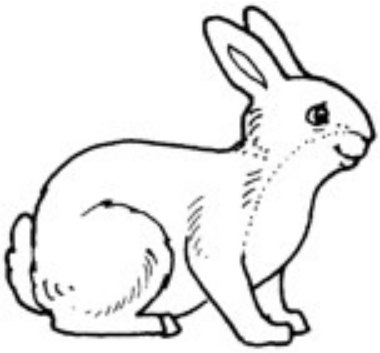
The Rabbit Scenario

Problem Statement

Tomorrow you are graduating from high school. You open one of your graduation cards from a friend and find that they have given you a gift of rabbits from Heifer International. This is what your card says:

Rabbits Get Results

A gift of rabbits to a family with little land and few resources yields remarkable results. From Chicago to Haiti to North Korea, families with Heifer rabbits are raising them on the back porch -or even in the kitchen. So long as they are warm and dry, rabbits thrive, and they love to eat leftover vegetables. In turn, families get nitrogen-rich manure to use on gardens or to sell as fertilizer. And since rabbits have up to 40 offspring a year, they provide families with steady sources of protein and income.



Here are my questions for you:

1. How many rabbits will there be by the time you graduate from college?
2. How would we model the growth of the rabbit population from a single gift from Heifer International?
3. How many people will benefit from this single gift?

When you are answering these questions state any assumptions that you make and provide a visual.

Here's how Heifer International works -from Heifer International (http://www.heifer.org)

A typical Heifer project consists of three essential components:

1. Livestock and other material goods
2. Training and extension work
3. Organizational development, which includes planning, management, record keeping, passing on the gift, reporting and evaluation.

First, Heifer helps a community group analyze their situation. They ask: What do we need? What are our resources? What would we like to see happen in five years? Then, they plan specific activities to achieve their goals.
At this point, the Heifer "living loan" becomes reality. Farmers prepare for their animals by participating in training sessions, building sheds, and sometimes planting trees and grasses.

Then the livestock arrives -bringing with it the benefits of milk, wool, draft power, eggs and offspring to pass on to another farmer.

Finally, the group evaluates its progress, and the cycle repeats as the group moves to more and more ambitious goals, each time visioning, deciding, implementing and reflecting.

Every family and community that receives assistance promises to repay their living loan by donating one or more of their animals offspring to another family in need. This practice of "Passing on the Gift" ensures project sustainability, develops community and enhances self-esteem by allowing project partners to become donors.

You can get involved in Heifer International several ways. One is to buy a "gift of animals" to be sent to another family. These gifts come in several forms including rabbits, camels, water buffalos, alpacas, llamas, silkworms and chickens, to name a few.

Rabbits

A litter of rabbit kits (baby rabbits) can be as small as a single kit, ranging up to 12 or 13; however there have been litters as big as 18.

The gestation period is 30–32 days.

- from `http://en.wikipedia.org/wiki/Rabbit` which referenced: Brown, Louise (2001). How to Care for Your Rabbit. Kingdom Books. p. 6. ISBN 9781852791674.

Student Success

UC Davis undergraduates persist at rates among the highest for all UC students. Among freshmen entering from 1995 to 1999, 91% returned fall quarter of their second year and 85% returned for their third year. UC Davis students also graduate at a very high rate. Among freshmen entering from 1988 to 1997, 79% completed a degree at UC Davis. Most freshmen who complete a bachelor's degree do so in just over four years; the average time required to complete a degree for freshmen entering UC Davis between 1993 and 1997 was 13 quarters. 43% of students who graduated did so within 4 years, 88% within 5 years and 97% within 6 years.

- from UCD Facts and Figures (`http://admissions.ucdavis.edu/facts_figures.cfm`)

Mathematics of Population Dynamics

Creating a Mathematical Model

Real World Problem : Start with a recognition of need.

Definition of Problem : A statement of the problem in the most concise terms that will adequately address the problem without putting undo restriction on the task to be undertaken and which will satisfy the real world problem.

- State the objectives in words using the simplest possible form.
- State any assumptions.

Build a Model: Separate the problem into a group of individual problems, operations or sequence of events which will lead to the complete solution.

- Think of possible solutions:
  - brainstorm
  - consult others
  - Do research (library, internet)
  - Study past problems.
- Think about solutions for each of the steps. Don't throw away any ideas at this point, often something that appears absurd will lead to a different point of view.
- Generate additional solutions:
  - Try inversion (push vs. pull, dark instead of light), take your previous thoughts and see if you can think of them again from a different angle.
  - Change the normal order of things: make round things square, make horizontal things vertical.
  - Combine ideas, review all previous solutions and see if some can be combined.

Evaluation:
- Itemize the advantages and disadvantages of each solution. Review the list of parameters that are important to the design and rate each solution on some scale for each of the parameters.
- Go over your ideas with a review team, a superior or one of your co-workers. It is surprising how explaining an idea to someone else will spur thoughts that had not come to you before.

Simulation/Analysis: Make a detailed sketch of the apparent solution of the problem. It is important that before one gets too far in the design that this sketch be to scale, you can make bad judgments if important features are missed due to incorrect size relations.

Evaluation: Review the design in light of your original problem and assumptions. Does it meet the objectives? Is it competitive? What is good about it? What can be improved? You can do your evaluation by consulting others, doing research, comparing to other models, looking at real world data, and specifying the conditions when your model works.

This Analysis- Evaluation can be a cycle. Continue doing both until the best model is developed.

Presentation: Show your design in the very best manner possible to give your ideas the best possible chance for success. Go the extra mile in your presentation to best highlight all of your hard work.

Reminders for the Mathematical Modeling Process: Cite your references, refer to your assumptions, do a summary.

1 Mathematics of Population Dynamics

1.1 Definitions

Population A group of individuals of the same species that have a high probability of interacting with each other.

Population Dynamics Study of biological populations.

1.2 Rabbit Population Models - Testing Assumptions

How would we model the growth of the rabbit population from a single gift from Heifer International? Let's think about how a high school graduation gift of rabbits will grow by the time you graduate from college. State any assumptions that you make and provide a visual.

1.2.1 Some Additional Things to Consider

- What assumptions did we make when we made this model?
- Graphing: Adding a visual always can make the point more clear.
- Age-Structured Population Growth

1.3 Deer Population Models - Creating our Own Models

When President Theodore Roosevelt created the Grand Canyon National Game Preserve on November 28, 1906 he set aside the finest deer herd in America. In doing so, he unintentionally wrote the first chapter of a harsh lesson whose impact is felt to this day in every deer management plan on the continent.

The million-acre game preserve included and roughly outlined the Kaibab North Plateau just north of the Colorado River in Northwestern Arizona. This enormous mesa was home to some 3,000 Rocky Mountain mule deer, splendid animals, outstanding in their large size and massive antlers. The deer had evolved in almost genetic isolation; their range, devoid of flowing streams, was buffered by deep canyons and open desert. The plateau had been the traditional hunting grounds of the Navajos and Paiutes, who in earlier days had gathered there each autumn to collect their winter supplies of deerhides. In those days the Kaibub was a botanists paradise. Groves of pine, fir, and aspen bordered broad grassy meadows that sparkled in the warmer months with patches of wildflowers.
- From The Terrible Lesson of the Kaibab by James B. Trefethen.
In the early years of this preserve the rangers:

- Banned all hunting
- Systematically removed all predators
- Allowed continued shared grazing with the deer and range livestock

The deer initially thrived (their numbers doubled) but then the range began to decline even with decreases in the range livestock permits. The summer plants became over foraged, as did the winter growth resulting in lack of food for the winter.

Problem Statement: You are the ranger responsible for managing the Grand Canyon National Game Preserve Rocky Mountain mule deer population. Use your experience from Oh Deer to create a range management plan that is supported by a mathematical model.

Suggestions for Further Reading

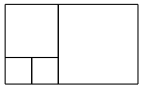
- Hastings, A. 1997. *Population Dynamics.* Springer-Verlag, New York.
- Edelstein-Keshet, L. 1988. *Mathematical Models in Biology.* McGraw-Hill, Boston.

A Special Kind of Rectangle

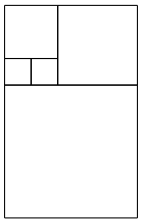
Start with two adjoined 1x1 boxes

On top of both of these draw a square of size 2 (=1+1).

We can now draw a new square - touching both a unit square and the latest square of side 2 - so having sides 3 units long;



and then another touching both the 2-square and the 3-square (which has sides of 5 units).

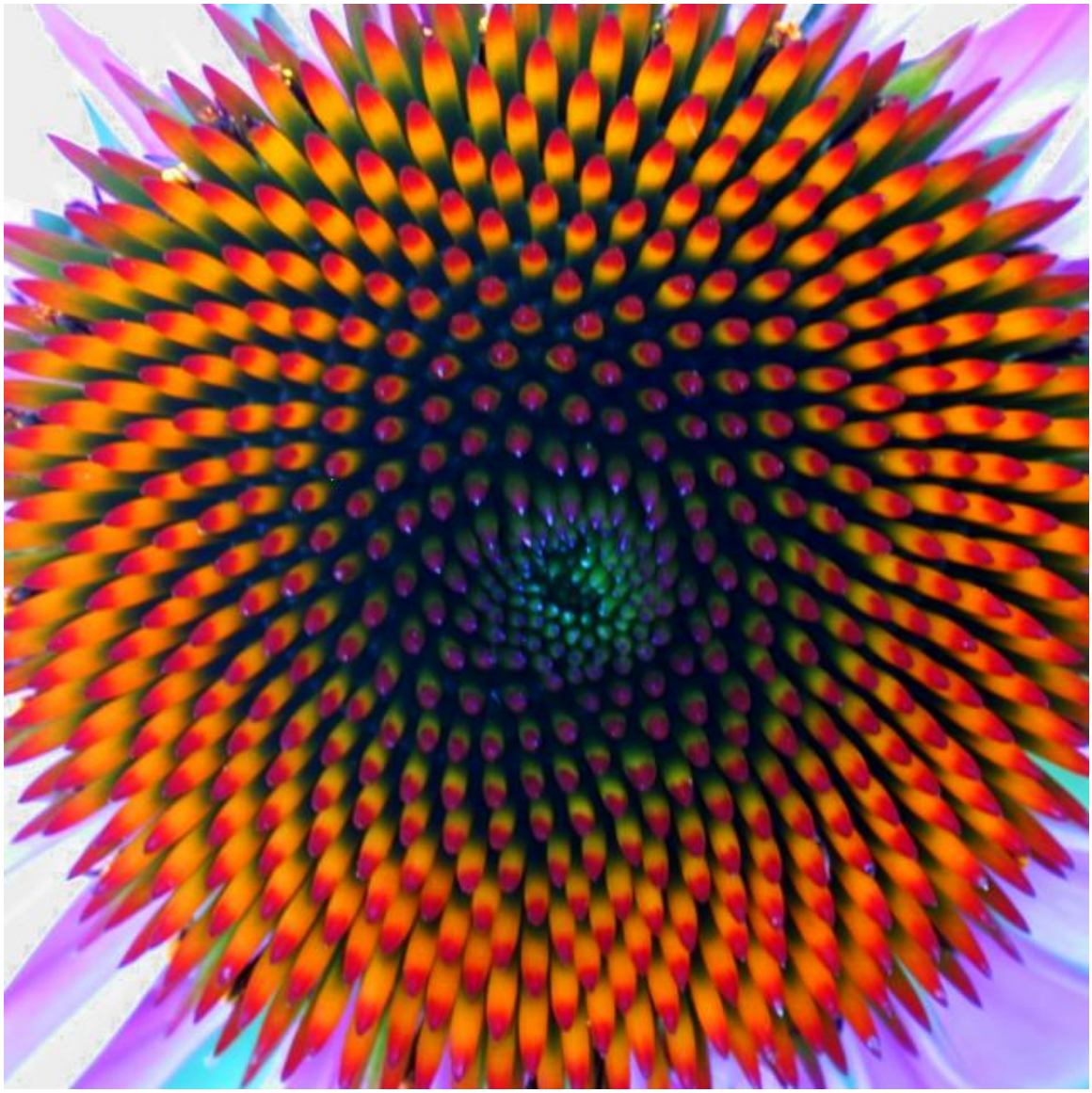


Questions to Consider?

- What size do you think the next several squares will be? What will the resulting rectangle look like?

- Do you see a pattern
- Have you seen this pattern before?
- How do you think this related to mathematics or biology?

Presented by: Brandy Wiegers, brandy@msri.org



Questions to Consider?

- Do you see a pattern
- Have you seen this pattern before?
- How do you think this related to mathematics or biology?

Presented by: Brandy Wiegers, brandy@msri.org