Farming for Ecosystem Services

Dani Fegan, Susan Magnoli, and Bonnie McGill

What are ecosystem services?

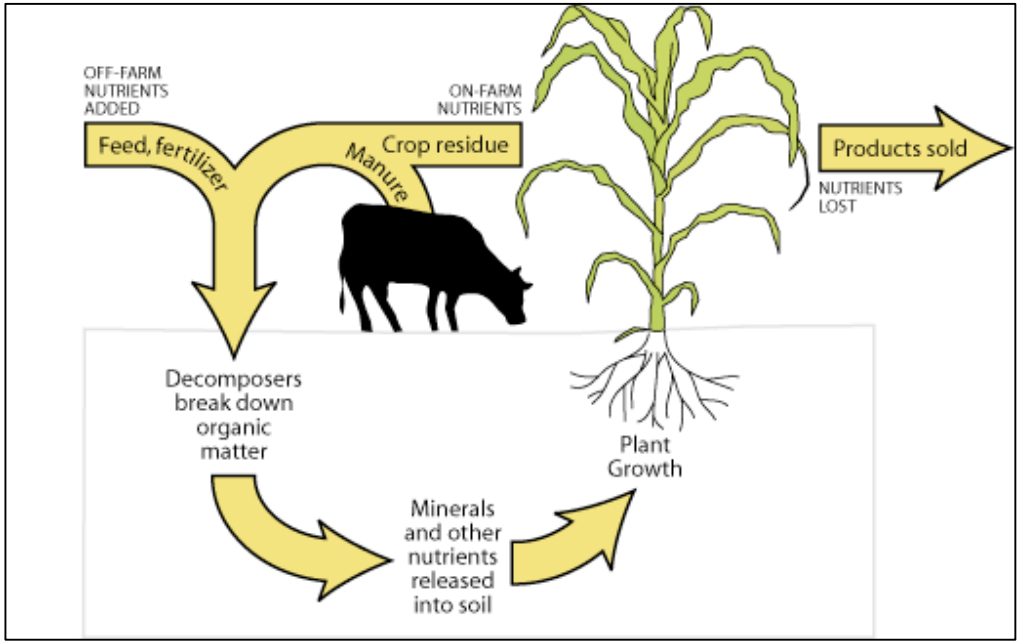
The benefits people obtain from ecosystems

- Supporting services
- Provisioning services
- Regulating services
- Cultural services

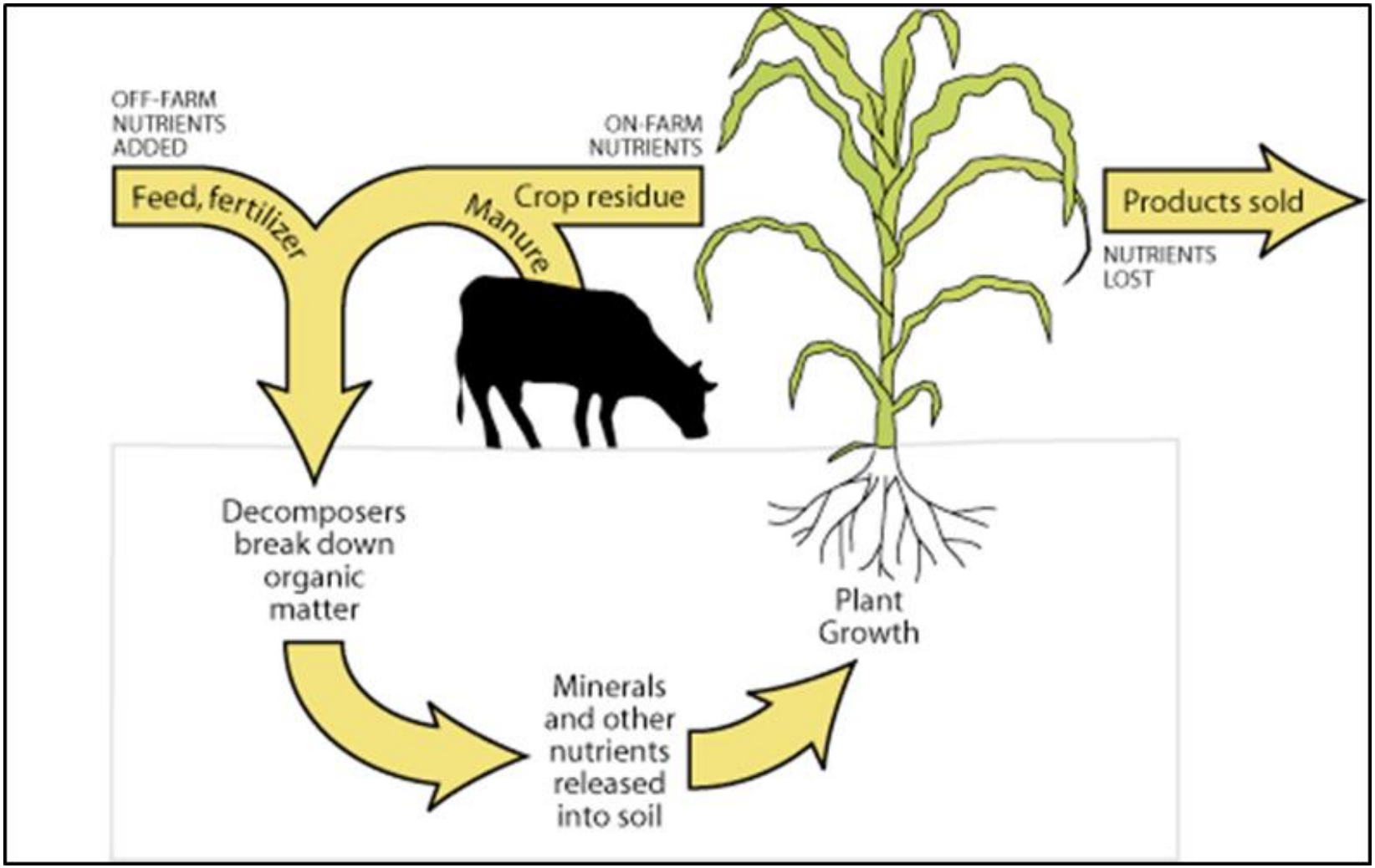
Supporting services

Services that are necessary for the production of all other ecosystem services

- Nutrient cycling
- Primary production
- Soil formation



http://polk.uwex.edu/agriculture/nutrient-management/



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Provisioning services

Products obtained from ecosystems

- Food
- Raw materials
- Water
- Energy
- Medicinal resources

Regulating services

Benefits obtained from the regulation of ecosystem processes

- Carbon sequestration and climate regulation
- Waste decomposition
- Purification of water and air
- Pest and disease control

Cultural services

Nonmaterial benefits people obtain from ecosystems

- Spiritual enrichment
- Cognitive development
- Recreation
- Aesthetic experiences

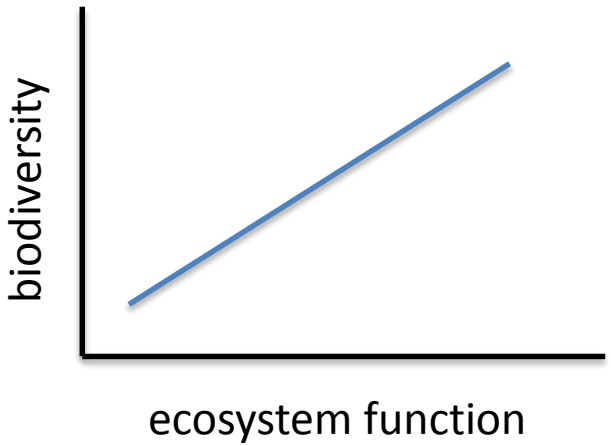
How do you put a price tag on nature?

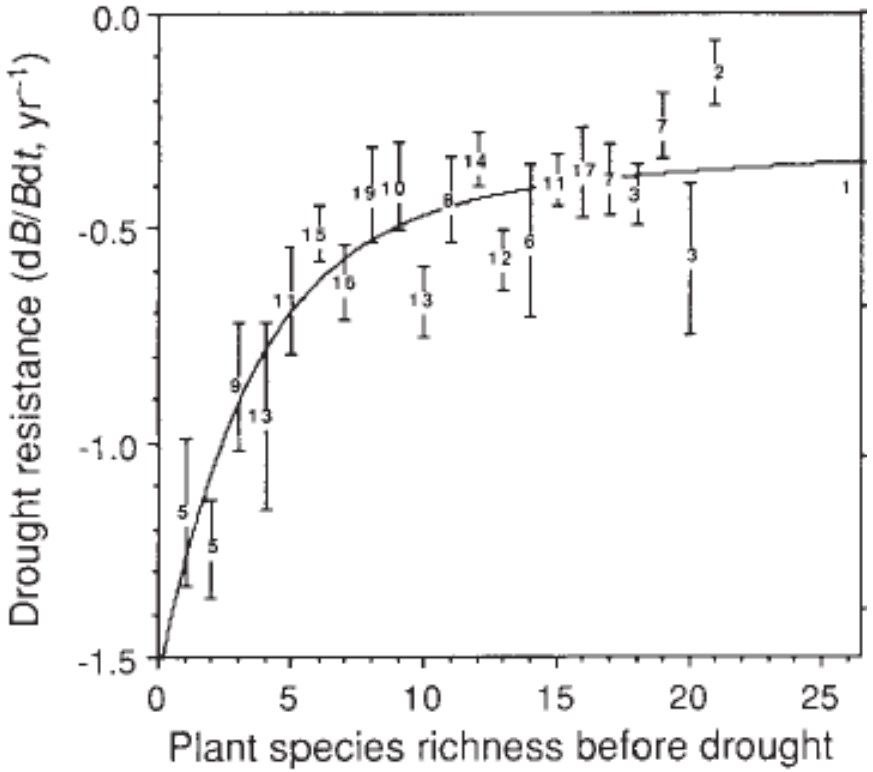
RADIOLAB

http://www.theguardian.com/environment/2010/dec/16/crucial-role-cities-honey-bee

http://www.radiolab.org/story/what-dollar-value-nature/

Biodiversity and ecosystem function





Tilman and Downing 1994

Biodiversity and ecosystem function

Biodiversity can increase:

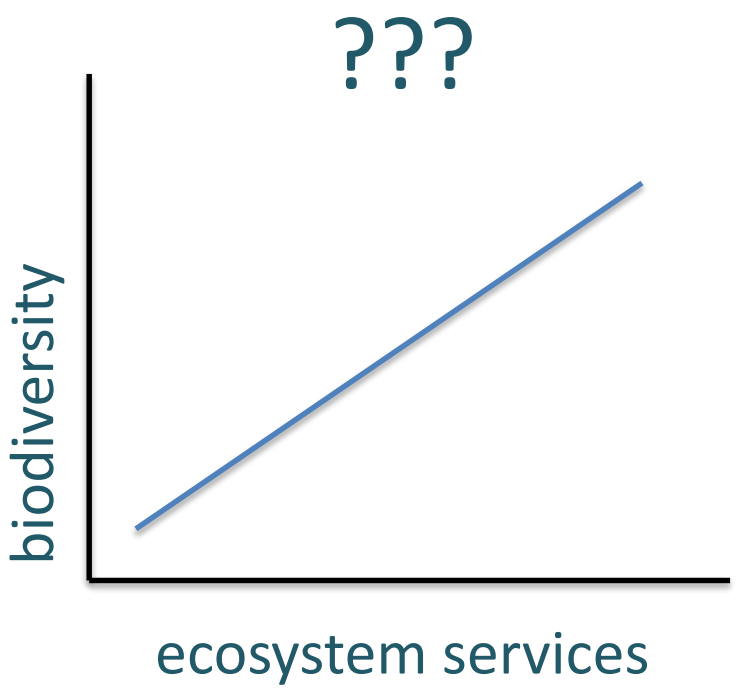
- Productivity
- Nutrient use and retention
- Community and ecosystem stability
- Invasion resistance

http://www.cedarcreek.umn.edu/about/gallery

Managing for ecosystem services

Can increasing biodiversity increase ecosystem services?

- Evidence from agriculture



Evidence from the KBS Long Term Ecological Research site

A 2008 publication by KBS scientists calculated how many *more* dollars per hectare a soybean farmer profited who used integrated pest management to control soybean aphids. Was it:

A) $10

B) $17

C) $24

D) $33

?

Woodlots promote pest control.

KBS LTER
Kellogg Biological Station
Long-term Ecological Research

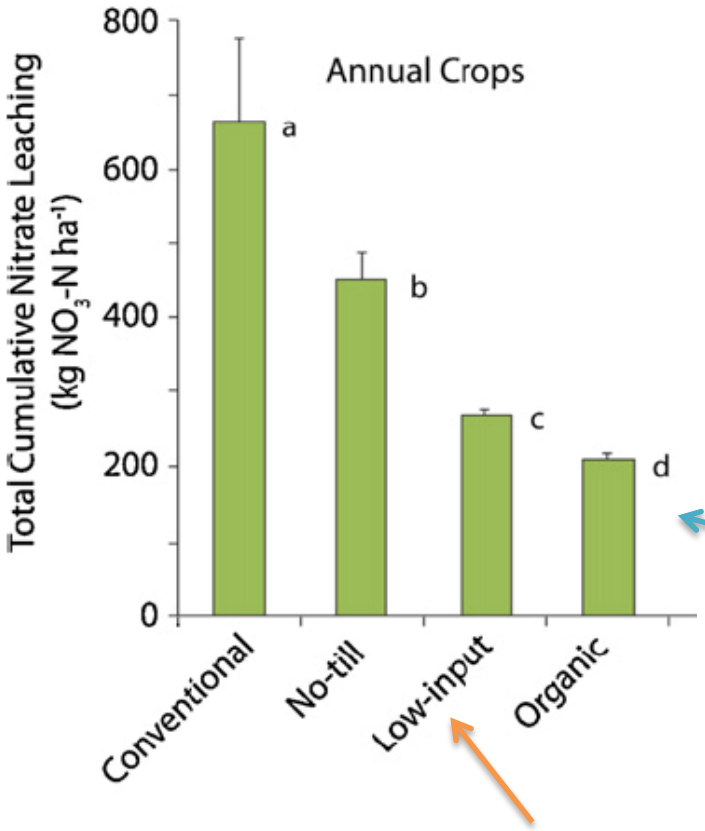
Temporal diversity

Corn yields increased with temporal crop diversity (rotation)

- Driven by legume nitrogen fixation in the spring before planting corn – compared to continuous corn.

KBS LTER
Kellogg Biological Station
Long-term Ecological Research

Nitrate leaching reduced by promoting ecosystem services



Where did the nitrate go?

- No-till: Build up organic matter
- Low-input: less N, cover crops produce organic N substrate ("slow release")
- Organic: relying solely on cover crop legumes for N, more weeds, which also take up N

No N fertilizer, just legume cover crop

Starter N, banded herbicides, and winter legume cover crop

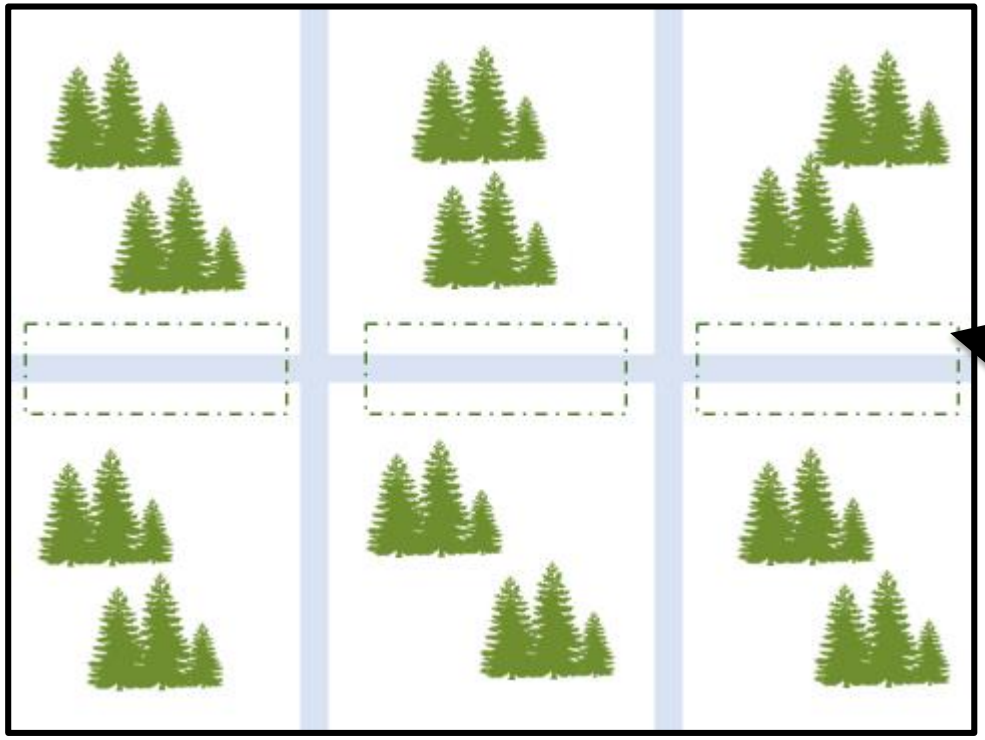
KBS LTER
Kellogg Biological Station
Long-term Ecological Research

“Croptions”
A Decision Making Game

How to play…

Soybean field & farmstead near the KBS LTER; Photo Credit: GP Robertson, MSU. http://lter.kbs.msu.edu/gallery/nggallery/gallery-page/area-farmscapes

Your task is to design a profitable farm.

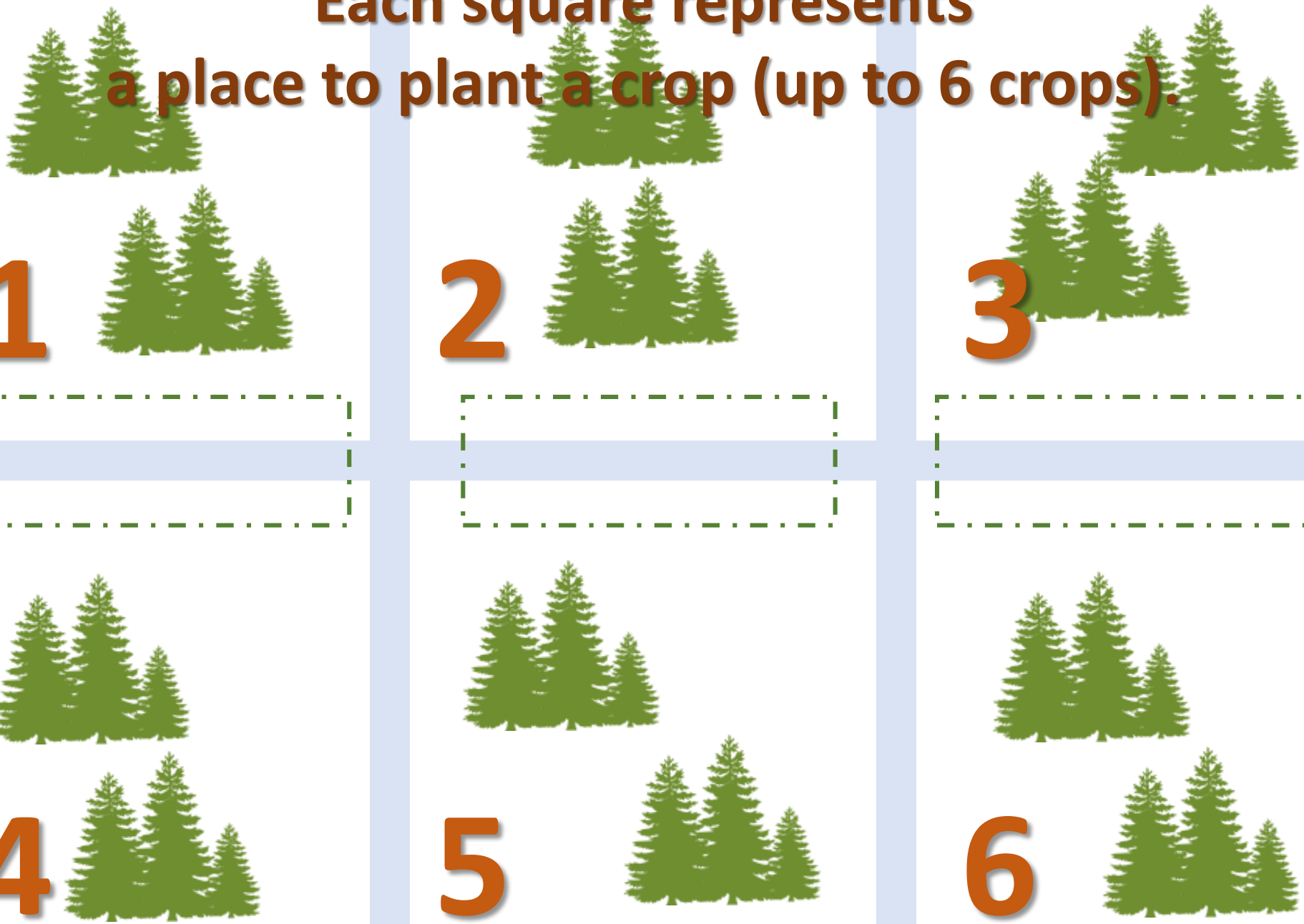


You begin with a parcel of land that is currently a woodlot.

These is enough room to plant six (6) crops.

- What will you put on your farm?
- Goal: grow food (for profits) while protecting ecosystem services (costs). Person with most money wins.
- If you run out of money, you are out of the game.

Each square represents
a place to plant a crop (up to 6 crops).



There are three (3) places on your land where you can install riparian buffer strips, floral strips, or bee hives (more info on that coming!).



1

2

3






Croptions Menu

At the beginning of the game everyone has $2,000. What you spend that money on is up to you. Choose wisely!

CROPTION	ECOSYSTEM SERVICES	ECOSYSTEM DIS-SERVICES	AGRONOMY NOTES	PRICE (per unit)	PROFIT per unit per year (if no climate or pest problems)	Additional profit if you have BEES
 WOODLOT	Habitat for pest predators (such as birds that eat grasshoppers), sequesters carbon	None	--	$0	$100	
 CORN	Low water use	High nitrogen runoff (water pollution)	Wind pollinated	$100	$400	
 TOMATOES	None	High water use; high nitrogen runoff (water pollution)	Require pollinators; sensitive to drought and late frost	$300	$500	$250
 BLUEBERRIES	Soil protection (little to no erosion)	High water use	Require pollinators; very sensitive to drought and late frost	$500	$800	$400
 PASTURE DAIRY COWS	Produce fertilizer (manure)	High water use; high nitrogen runoff (water pollution)	Sensitive to drought	$1,000	$2,000	
 RIPARIAN BUFFER STRIP	Water quality protection ("nitrogen sponge"); reduce erosion during rainstorms	None	Plant water-loving perennials and woody species from stream edge up slope to field edge.	$100	$0	
 FLORAL STRIP	Habitat for native pollinators, boosts yields for crops requiring pollination	None	Native perennial flowers. Requires annual burning to keep out woody species.	$100	$0	
 HONEY BEE HIVES	Pollination!	None	Woodlots & floral buffers promote native bees as well	$200	$100	

Tradeoff: corn is cheap to buy but "expensive" in nitrogen pollution in the end.

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Tradeoff: Cows are very profitable but sensitive to drought

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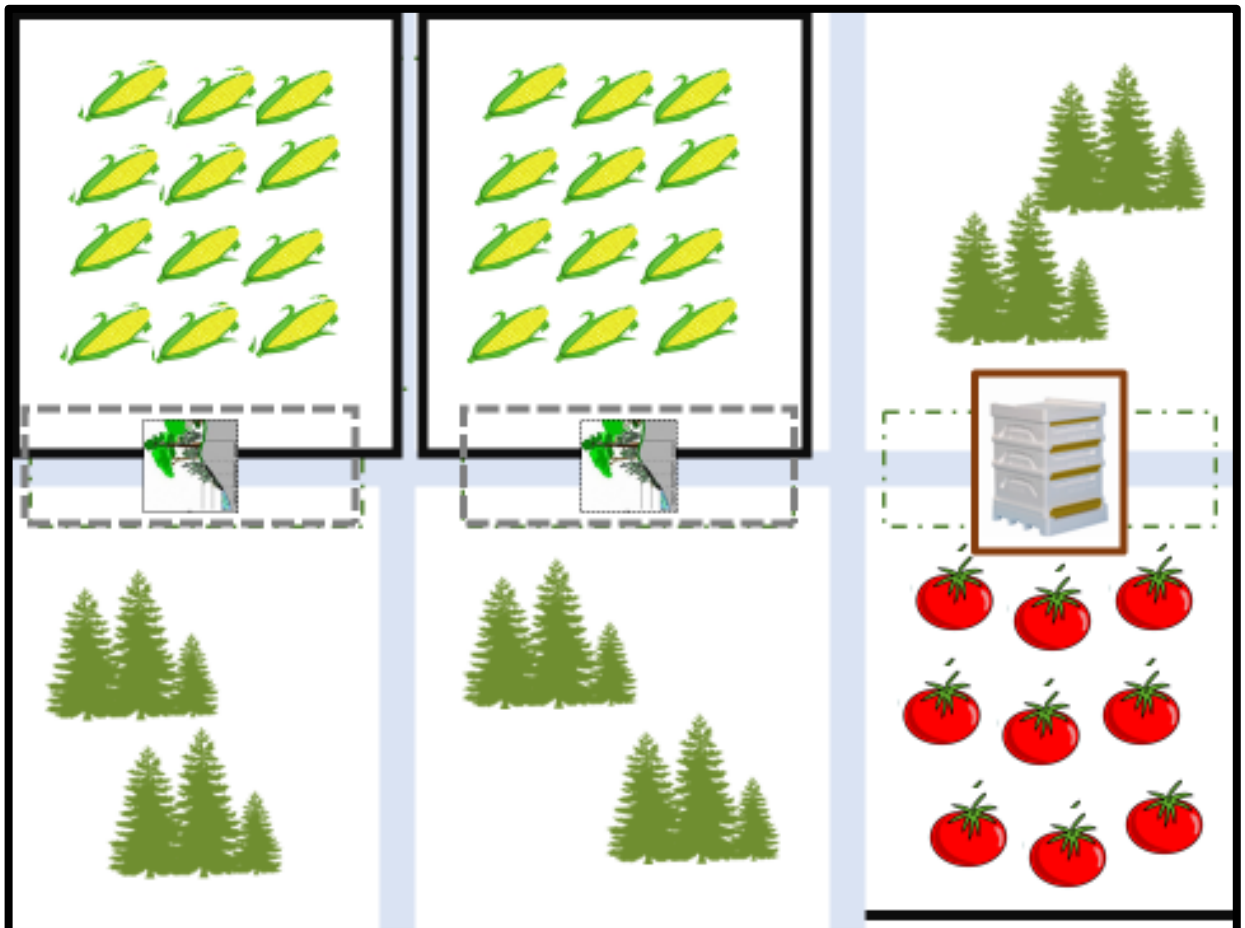
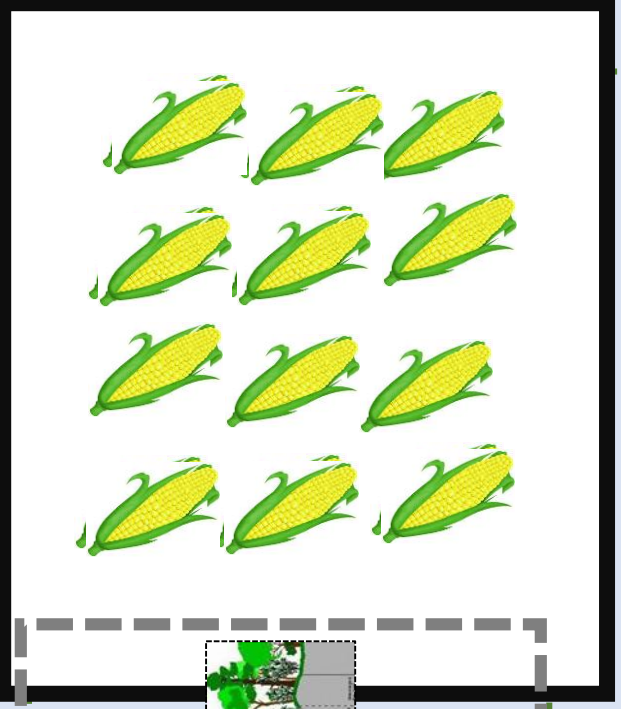
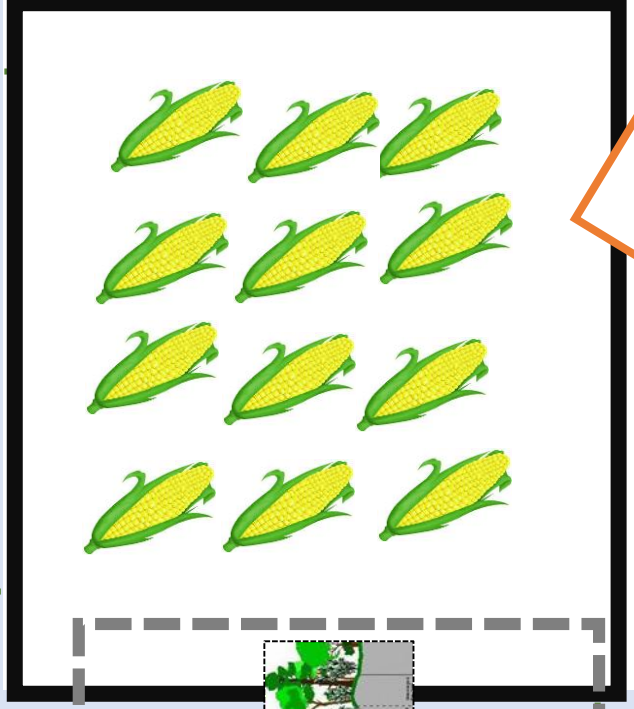
What tradeoffs can you find? How will this influence how you spend your $2000?

Now, design your farm!

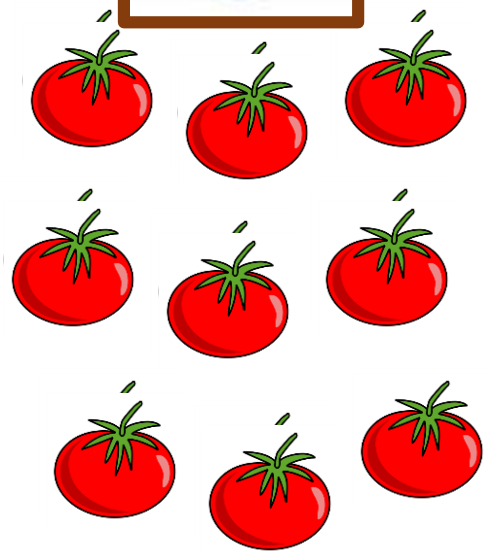
Collect game pieces (cards) for the croptions you bought.
Lay them out on your farm however you choose.





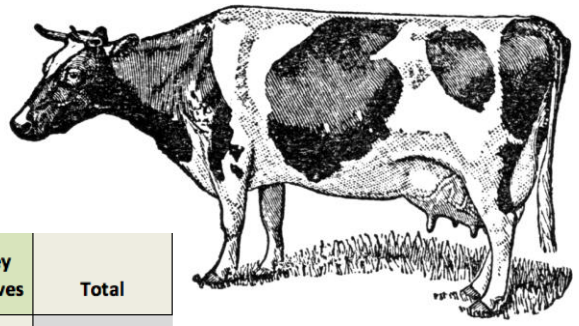


Notice that you can choose to leave land as a woodlot!



An example farm design

Year 1



YEAR 1

	Woodlot	Corn	Tomatoes	Blue-berries	Pasture dairy cows	Riparian buffer strip	Floral buffer strip	Honey bee hives	Total
Price per unit	$0	$100	$300	$500	$1,000	$100	$100	$200	
No. of units I bought									
I paid (price x no. of units)									
YEAR 1 PROFITS									
Profit per unit	$100	$400	$500	$800	$2,000	$0	$0	$100	
...if I have at least 1 bee hive touching that unit, I also get:			$250	$400					
Profit before costs (profit x no. of units)									
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CLIMATE COST RATES:									
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YEAR 1 COLUMN SUB-TOTALS (total of all dashed outline boxes in each column)									
YEAR 1 eNd GAME PENALTIES (penalties for downstream nitrogen pollution)									
for units without RIPARIAN BUFFER		-20%	-10%		-50%				
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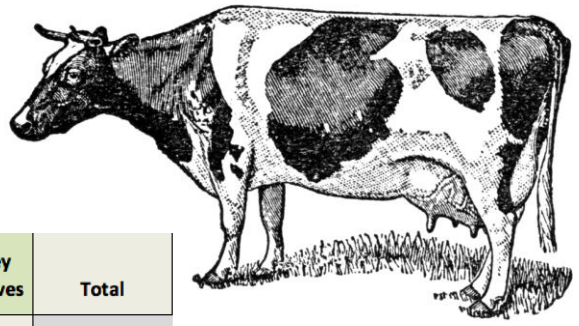
Penalty total (column sub-total x % penalty)									↓ subtotal
New column sub-total (subtract penalty where applicable)									
YEAR 1 Grand Total									$2,000 - subtotal = $

Enter the number of each croption type you are buying

Year 1



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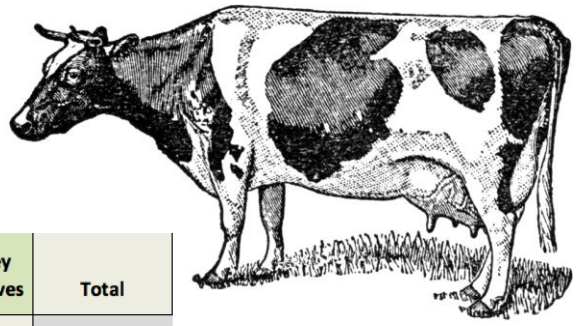
YEAR 1 Grand Total									$2,000 - subtotal = $

Calculate the total price you paid for each croption type. Remember you only have $2,000. (Any farm units left open are woodlots.)

Year 1



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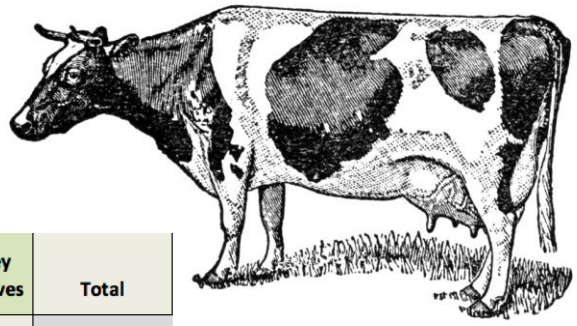
YEAR 1 Grand Total									$2,000 - subtotal = $

Additional profit if you have bee hives (ecosystem service!!!)

One year has passed already! Calculate how much you profited—*before climate and pest/disease costs.*

Year 1



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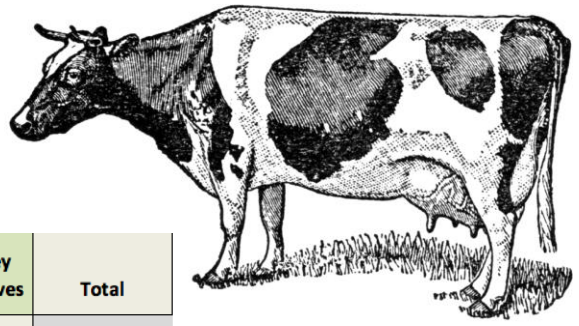
YEAR 1 Grand Total									$2,000 - subtotal = $

Draw a climate card for the class. Get the climate cost rates from your teacher for that particular climate event (copy them here).

Calculate how much the climate cost you for each croption type (rate x number of units)

Year 1



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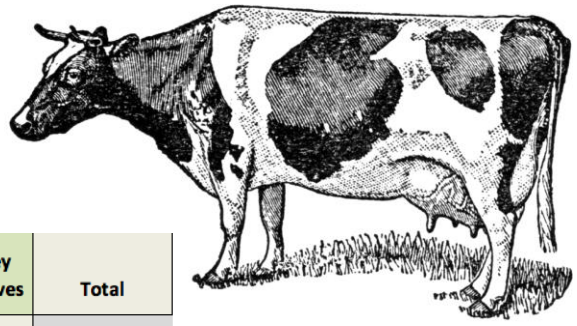
Repeat for pest/disease costs

Calculate the sub-total for each column: (red cell + profit – costs)

Year 1



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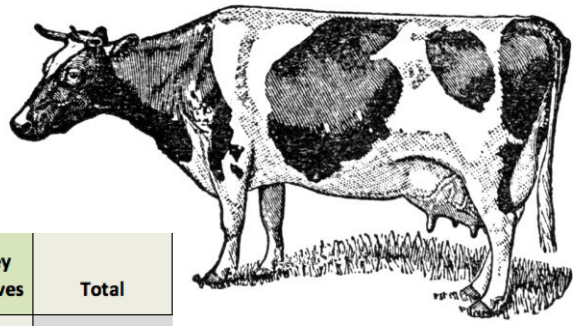
Now you are penalized for nitrogen pollution if you raised cows or grew corn or tomatoes.

You are penalized at this lower rate if you have riparian buffers (ecosystem service!!!)

Year 1



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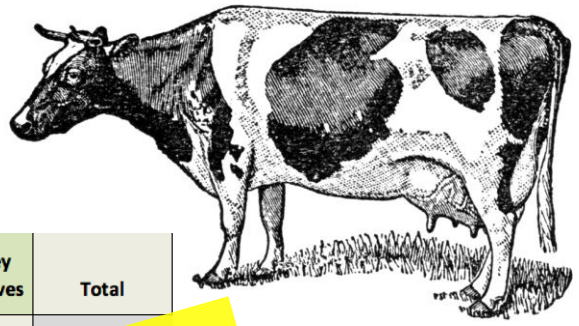
Calculate your eNd game penalty by multiplying the % penalty by the column sub-total.

Now calculate the new sub-total for each column (green cell – penalty (if applicable)

Year 1



YEAR 1	Woodlot	Corn	Tomatoes	Blue-berries	Pasture dairy cows	Riparian buffer strip	Floral buffer strip	Honey bee hives	Total
Price per unit	$0	$100	$300	$500	$1,000	$100	$100	$200	
No. of units I bought									
I paid (price x no. of units)									
YEAR 1 PROFITS									
Profit per unit	$100	$400	$5[illegible]		$2,000			$100	
...if I have at least 1 bee hive touching that unit, I also get:			$250						
Profit before costs (profit x no. of units)									
YEAR 1 CLIMATE COSTS									
CLIMATE COST RATES:									
Climate costs sub-total (cost x no. of units)									
YEAR 1 PEST/DISEASE COSTS									
PEST/DISEASE COST RATES:									
Pests/disease costs sub-total (cost x no. of units)									
YEAR 1 COLUMN SUB-TOTALS (total of all dashed outline boxes in each column)									
YEAR 1 eNd GAME PENALTIES (penalties for downstream nitrogen pollution)									
for units without RIPARIAN BUFFER		-20%	-10%		-50%				
for units with RIPARIAN BUFFER		-10%	-5%		-30%				
Penalty total (column sub-total x % penalty)									↓ subtotal
New column sub-total (subtract penalty where applicable)									
YEAR 1 Grand Total									$2,000 - subtotal = $

How did you do? Did you make any money? How will you design your farm differently next year???

Add up all the column sub-totals to get an overall sub-total.

Now find out how you made out in Year 1, $2,000 – subtotal.

Year 2

YEAR 2 - *stay the same or change it up?*	Woodlot	Corn	Tomatoes	Blue-berries	Dairy cows	Riparian buffer strip	Floral buffer strip	Honey bee hives	Total
Price per unit	$0	$100	$300	$500	$1,000	$100	$100	$200	
No. of units I bought									
I paid (price x no. of units)									
Total no. units I have (units bought in Year 1 + new units in Year 2)									
YEAR 2 PROFITS									
Profit per unit	$100	$400	$500	$800	$2,000	$0	$0	$100	
...if I have at least 1 bee hive touching that unit, I also get:			$250	$400					
Profit before costs (profit x total no. of units)									
YEAR 2 CLIMATE COSTS									
CLIMATE COST RATES:									
Climate costs sub-total (cost x no. of units)									
YEAR 2 PEST/DISEASE COSTS									
PEST/DISEASE COST RATES:									
Pests/disease costs sub-total (cost x no. of units)									
YEAR 2 COLUMN SUB-TOTALS red cell - profit - costs									
YEAR 2 eNd GAME PENALTIES (penalties for downstream nitrogen pollution)									
for units without RIPARIAN BUFFER		-20%	-10%		-50%				
for units with RIPARIAN BUFFER		-10%	-5%		-30%				
Penalty total (column sub-total x % penalty)									↓ subtotal
New column sub-total (subtract penalty where applicable)									
YEAR 2 Grand Total	(Year 1 total) - subtotal = $								

If you have money, you can buy new units (get a new farm layout sheet). Be sure pay only for the NEW units you bought.

How many total units of each croption do you have (Years 1 + 2)? Use this for all the following calculations.

Calculate your profits—*before climate and pests/disease hit.*

Draw a climate card, get the cost rates from your teacher. Calculate how the climate affected your units.

Draw a pest/disease card, get the cost rates. Calculate how the pest/disease affected your units.

Year 2

YEAR 2 - *stay the same or change it up?*	**Woodlot**	**Corn**	**Tomatoes**	**Blue-berries**	**Dairy cows**	**Riparian buffer strip**	**Floral buffer strip**	**Honey bee hives**	**Total**
Price per unit	$0	$100	$300	$500	$1,000	$100	$100	$200	
No. of units I bought									
I paid (price x no. of units)									
Total no. units I have (units bought in Year 1 + new units in Year 2)									
YEAR 2 PROFITS									
Profit per unit	$100	$400	$500	$800	$2,000	$0	$0	$100	
...if I have at least 1 bee hive touching that unit, I also get:			$250	$400					
Profit before costs (profit x total no. of units)									
YEAR 2 CLIMATE COSTS									
CLIMATE COST RATES:									
Climate costs sub-total (cost x no. of units)									
YEAR 2 PEST/DISEASE COSTS									
PEST/DISEASE COST RATES:									
Pests/disease costs sub-total (cost x no. of units)									
YEAR 2 COLUMN SUB-TOTALS red cell - profit - costs									
YEAR 2 eNd GAME PENALTIES (penalties for downstream nitrogen pollution)									
for units without RIPARIAN BUFFER		-20%	-10%		-50%				
for units with RIPARIAN BUFFER		-10%	-5%		-30%				
Penalty total (column sub-total x % penalty)									↓ subtotal
New column sub-total (subtract penalty where applicable)									
YEAR 2 Grand Total									(Year 1 total) - subtotal = $

Calculate your subtotal for each column.

Calculate your eNd game penalties.

Calculate your new sub-total and overall subtotal.

Year 2

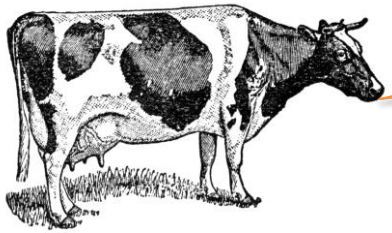
YEAR 2 - *stay the same or change it up?*	Woodlot	Corn	Tomatoes	Blue-berries	Dairy cows	Riparian buffer strip	Floral buffer strip	Honey bee hives	Total
Price per unit	$0	$100	$300	$500	$1,000	$100	$100	$200	
No. of units I bought									
I paid (price x no. of units)									
Total no. units I have (units bought in Year 1 + new units in Year 2)									
YEAR 2 PROFITS									
Profit per unit	$100	$400	$500	$800	$2,000	$0	$0	$100	
...if I have at least 1 bee hive touching that unit, I also get:			$250	$400					
Profit before costs (profit x total no. of units)									
YEAR 2 CLIMATE COSTS									
CLIMATE COST RATES:									
Climate costs sub-total (cost x no. of units)									
YEAR 2 PEST/DISEASE COSTS									
PEST/DISEASE COST RATES:									
Pests/disease costs sub-total (cost x no. of units)									
YEAR 2 COLUMN SUB-TOTALS red cell - profit - costs									
YEAR 2 eNd GAME PENALTIES (penalties for downstream nitrogen pollution)									
for units without RIPARIAN BUFFER		-20%	-10%		-50%				
for units with RIPARIAN BUFFER		-10%	-5%		-30%				
Penalty total (column sub-total x % penalty)									↓ subtotal
New column sub-total (subtract penalty where applicable)									
YEAR 2 Grand Total									(Year 1 total) - subtotal = $

Calculate your grand total: Year 1 total (from other score card) – overall subtotal.

Gallery walk

- Write your Year 2 Grand Total on your farm sheet and set it face up on your desk.
- Walk around and look at how your classmates designed their farms and how much money they made (or didn’t make)!

Let's discuss!



- Initial reactions or reflections on the game?
- Were you surprised by any outcomes?
- How would your farm have fared if a different climate or pest/disease card had been drawn?
- How can we grow enough food while protecting ecosystem services (beyond those actions described in the game)?
- Why is it difficult for farmers to protect *all* ecosystem services?
- How do you think climate change affects how farmers make decisions?

Climate costs: RAIN

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows
CLIMATE COSTS	per unit				
Torrential **rain**	-$30	-$120	-$90	-$150	$0
*...if torrential rain & have **riparian buffers cost is only***	-$10	-$40	-$30	-$80	$0

or

Riparian buffers soak up nitrogen before it reaches streams and rivers (ecosystem service)!!!!

Note: No climate or disease/pest costs for woodlot, riparian buffer, or floral buffer.

Climate costs: DROUGHT

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows
CLIMATE COSTS	per unit				
Drought	$0	-$40	-$280	-$400	-$600

or

Note: No climate or disease/pest costs for woodlot, riparian buffer, or floral buffer.

Climate costs: LATE FROST

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows
CLIMATE COSTS	per unit				
Late **frost**	$0	$0	-$90	-$250	$0

Note: No climate or disease/pest costs for woodlot, riparian buffer, or floral buffer.

Pest/disease costs: LOCUSTS

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows	
PEST/DISEASE COSTS	per unit					
Plague of **locusts**	$0	-$200	-$250	-$400	-$1,000	or
...if have woodlot cost is only	$0	-$80	-$100	-$160	$0	

Woodlot provides habitat for birds and other animals that eat locusts (ecosystem service)!!!!

Note: No climate or disease/pest costs for woodlot, riparian buffer, or floral buffer.

Pest/disease costs: HONEY BEE COLONY COLLAPSE

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows
PEST/DISEASE COSTS	per unit				
Honey bee colony collapse	$0	$0	-$250	-$400	$0
...if have floral buffer strip cost is only	$0	$0	-$50	-$80	$0

or

Floral buffer strip promotes a large native bee population, not affected by the honey bee colony collapse, so your tomatoes and blueberries still get pollinated (ecosystem service)!!!!

Pest/disease costs: MAD COW DISEASE

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows
PEST/DISEASE COSTS	per unit				
Mad cow disease	$0	$0	$0	$0	-$2,000

Note: No climate or disease/pest costs for woodlot, riparian buffer, or floral buffer.

Pest/disease costs: CORN BORERS

	Woodlot	Corn	Tomatoes	Blue-berries	Grass-fed dairy cows	
PEST/DISEASE COSTS	per unit					
Corn borers	$0	-$50	$0	$0	$0	or
...if have woodlot	$0	-$10	$0	$0	$0	

Woodlot provides habitat for birds and other animals that eat corn borers (ecosystem service)!!!!

Note: No climate or disease/pest costs for woodlot, riparian buffer, or floral buffer.