<u>EcoSim</u>

An ecological simulation game

Design Document:

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Background

Target Audience

Our target audience is middle school aged students from New York State, based on our curricular focus, however, this game and its educational objectives could be played by middle school aged children from across the United States.

Some specific learner characteristics:

Physiological

- Learners will primarily be young (11-15 years old) adults or adolescents (with standard gender distribution) in school classrooms.
- Assumed to be in good health with fully functioning sensory abilities.

Cognitive

- Advanced ability in reading, speaking and comprehending English.
- Formal Operational Stage (level 4) of Piaget's (1950) level of cognitive development, meaning abstract thought and logical reasoning are possible.

Educational Objectives

Overall Objectives:

- By constructing an ecological system, the player would learn fundamental characteristics of ecology and how ecological systems function.
- To obtain the higher order thinking skills and problem solving skills necessary to study diverse ecological systems.

We based the content of the game on New York State middle school science curriculum concepts. The concepts are divided into Key Ideas with a subdivision of performance indicators and major understandings. While we do not include every concept associated with each Key Idea, we include those that are within the scope of our content.

We are attempting to incorporate the following concepts: (New York State Education Department, pp 21-24)

Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

Introduction: All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. Organisms respond to internal or environmental stimuli.

Performance Indicator 5.1: Compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.

Major Understandings:

- 5.1b An organisms overall body plan and its environment determines the way that the organism carries out the life process.

- 5.1c   All organisms require energy to survive. The amount of energy needed and the method for obtaining this energy vary among cells. Some cells use oxygen to release the energy stored in food.
- 5.1d   The methods for obtaining nutrients vary among organisms. Producers such as green plants, use light energy to make their food. Consumers, such as animals, take in energy rich foods.
- 5.1e   Herbivores obtain energy from plants. Carnivores obtain energy from animals. Omnivores obtain energy from both plants and animals. Decomposers such as bacterial and fungi, obtain energy by consuming wastes and/or dead organisms.
- 5.1g   The survival of an organism depends on its ability to sense and respond to its external environment.

Performance Indicator 5.2: Describe the importance of major nutrients, vitamins and minerals in maintaining health and promoting growth, and explain the need for a constant input of energy for living organisms.

Major Understandings:

- 5.2a   Food provides molecules that serve as fuel and building material for all organisms. All living things, including plants, must release energy from their food, using it to carry on their life processes.
- 5.2e   In order to maintain a balanced state, all organisms have a minimum daily intake of each type of nutrient based on species, size, age, sex, activity, etc. An imbalance in any of the nutrients might result in weight gain, weight loss, or a diseased state.

Key Idea 6: Plants and animals depend on each other and their physical environment.

Introduction: An environmentally aware citizen should have an understanding of the natural world. All organisms interact with one another and are dependent upon their physical environment. Energy and matter flow from one organism to another. Matter is recycled in ecosystems. Energy enters ecosystems as sunlight, and is eventually lost from the community to the environment, mostly as heat.

Performance Indicator 6.1: Describe the flow of energy and matter through food chains and food webs

Major Understandings:

- 6.1a   Energy flows through ecosystems in one direction, usually from the Sun, through producers to consumers and then to decomposers. This process may be visualized with food chains or energy pyramids.
- 6.1b   Food webs identify feeding relationships among producers, consumers, and decomposers in an ecosystem.
- 6.1c   Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment.

Performance Indicator 6.2: Provide evidence that green plants make food and explain the significance of this process to other organisms

Major understandings:

- 6.2a Photosynthesis is carried on by green plants and other organisms containing chlorophyll. In this process, the Sun's energy is converted into and stored as chemical energy in the form of a sugar. The quantity of sugar molecules increases in green plants during photosynthesis in the presence of sunlight.
- 6.2b The major source of atmospheric oxygen is photosynthesis. Carbon dioxide is removed from the atmosphere and oxygen is released during photosynthesis.

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

Introduction: The number of organisms an ecosystem can support depends on the resources available and physical factors: quantity of light, air, and water; range of temperatures; soil composition. To ensure the survival of our planet, people have a responsibility to consider the impact of their actions on the environment.

Performance Indicator 7.1: Describe how living things, including humans, depend upon the living and nonliving environment for their survival.

Major Understandings:

- 7.1a A population consists of all individuals of a species that are found together at a given place and time. Populations living in one place form a community. The community and the physical factors with which it interacts compose an ecosystem.
- 7.1b Given adequate resources and no disease or predators, populations (including humans) increase. Lack of resources, habitat destruction, and other factors such as predation and climate limit the growth of certain populations in the ecosystem.
- 7.1c In all environments, organisms interact with one another in many ways. Relationships among organisms may be competitive, harmful, or beneficial. Some species have adapted to be dependent upon each other with the result that neither could survive without the other.
- 7.1e The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe.

Performance Indicator 7.2: Describe the effects of environmental changes on humans and other populations

Major Understandings:

- 7.2a In ecosystems, balance is the result of interactions between community members and their environment.

- 7.2b The environment may be altered through the activities of organisms. Alterations are sometimes abrupt. Some species may replace others over time, resulting in long- term gradual changes (ecological succession).
- 7.2c Overpopulation by any species impacts the environment due to the increased use of resources. Human activities can bring about environmental degradation through resource acquisition, urban growth, land-use decisions, waste disposal, etc.
- 7.2d Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources.

Game Implementations Recommendation (for teachers)

If this game were to be used in a school setting, we feel it would best supplement existing curriculum in regards to living and physical systems and environmental changes. This game touches on many aspects of curricular goals set by the New York State Education Department. One of our competing products is a simulation made by a company called explore E-Learning. This company creates "gizmos" as described later in this document. The gizmos are simulations that include a "student exploration guide" instead of formal rules of play, because they are not inherently games. In any case, we think that if teachers were to not only allow students to play this game, following the rules of play, but then to also develop a student exploration guide that matches their specific curriculum, then this game could be a useful bridge between content and context.

This game aims to increase the player's higher order thinking skills in regards to understanding complex ecosystems. Being mindful of the activity is one step towards acquiring these higher order skills (citation needed). Such a "student exploration guide" could encourage mindfulness of the activities and missions taking place within the game. The connection between the game and curricular activities is tricky, because of the mindset students may have in regards to games vs school work. (citation needed).

Description of Content (level or scope)

While we are not making it explicitly clear to the player, we based all of the elements in the game, including the animals, plants, and land characteristic on the Fire Island ecosystem from Long Island, NY. This choice was more of a design decision in order to limit the scope of our content and also allow for a cohesive, realistic ecosystem to be developed.

Characteristics about Fire Island to be included in the game: (nps.gov, 2009)
Land Formation:

- Fire Island is a barrier island or shoal – 32 miles across. We are representing the 32 miles of island on our screen in a small scale, but allude to the larger scale in the game.
- The island is has global warming issues. In general, low-lying coastal areas are in danger to global warming and "barrier islands are likely to disappear entirely in

some areas." (source) We are representing air quality levels as an indicator of global warming.

- Sand Dunes are critical to the health and sustainability of sandy beaches. The primary dune ridge (foredunes) lies adjacent to the shoreline. Secondary dune fields may lie further inland. Dunes may form anywhere that eolian processes (wind transportation) occur. Dunes provide much-needed protection to back-barrier environments (including human development) against severe wave, wind, and storm events. In addition, these geomorphic features provide critical habitat to a variety of migratory birds and mammals. We feature the importance of sand dunes in the game. (source)
- Contains Salt marsh - this vegetation has extensive root systems that enable them to withstand brief storm surges and buffer storm impacts on upland areas. Salt marshes act as filters. They are able to absorb nutrients and pollutants, reducing the amount that would otherwise run into both estuarine and coastal systems.
- Salt marshes are nursery grounds for important commercial and recreational fishes as well as other species that are a vital part of the estuarine food chain. Salt marshes are also valuable habitats for wading birds and waterfowl. They provide refuge for birds feeding on adjacent mudflat; breeding sites for waders, gulls and terns; a source of food for passerine birds in autumn and winter; and a feeding ground in winter for large flocks of geese and ducks.

Flora and Fauna to be featured in the game:

- Amphibians - including American Bullfrogs. Frogs will be very sensitive in the ecosystem. Since they are an important ecological indicator, they will die quicker if there is an imbalance.
- Fish - Includes Killifishes. They are a major component of the fish fauna of salt marsh habitats.
- Mammals – Including White tailed deer, Cottontail Rabbit, Common Raccoon, and Red Fox.
- Rodents – Including White footed deer mouse
- Marine Mammals – Including Harbor Seals
- Birds - Includes Ospreys. These predatory birds feed mainly on fish, but also feed on rodents and amphibians.
- Insects - Includes Odonates (dragonfly). Dragonflies are considered by scientist to be excellent indicators of wetland ecosystem health and condition. We aren't allowing the player to add insects, they will exist if the ecosystem is functioning correctly.
- Shrubs – Includes Beach Heather, Bearberry Bush, and Wax Myrtle. These three shrubs are native to Fire Island and northeastern coastal environments in general.
- Grasses – Including common grasses, the island also includes Smooth Cordgrass (wetland grass), Inland Saltgrass (wetland grass) and Beach Grass (grass). The wetland grasses are specific to the salt marsh regions.
- Trees – including Pitch Pine, Maple and Birch.

Market Analysis (review of competing solutions)

Sim Earth:
http://en.wikipedia.org/wiki/SimEarth

Sim Earth is life simulation game designed by Will Wright, and published in 1990 by Marxis. In this game, players create a planet by controlling a wide variety of elements. The player can vary the planet's atmosphere, temperature, and landmasses, then place life forms on the planet to let them evolve. Allowing the life forms to evolve into sentient beings with advanced civilizations is the overall challenge of the game. The development stages of the planet can be reverted and repeated, until the planet "dies" 10 billion years after its creation, the estimated time when the Sun will become a red giant and kill off all of the planet's life. (Wikipedia, 2009)

The game differs from what we are designing with our EcoSim game. Sim Earth allows the player to control a comprehensive number of elements including atmospheric gases, continental drift, and the rate or reproduction and mutation of life forms. In our game, we are limited the player controllability to just flora and fauna within the existing environment. The environmental constraints are very rigid, as well as the scale of a roughly 30 mile wide barrier island. There are a number of environmental disasters featured in Sim Earth, similar in nature to those we will implement in EcoSim's game missions, including fires, weather events, and pollution. Sim Earth uses resources to control all game elements called "energy units," and similarly in our game we are using "DNA points" to emphasize the focus on controlling life forms specifically. One of the features of SimEarth is that all of the multi-cellular organisms are on equal footing – that is they are all capable of developing into intelligent life forms (from snails, to whales). Because we are aiming to teach curricular ecological understandings, we are limiting game features to those that exist in nature. Sim Earth touches on ecological indicators such as bacteria and insect populations, as well as the dynamic interactions between living things and the environment; however, the game does feature fictional elements that add a layer of complexity that our game does not feature. From what we have gathered from unofficial sources is that this game was critically lauded, but not well received publicly.

Forest Ecosystem:
http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=639

Explore E Learning is an organization that produces "online simulations to power inquiry and understanding." In addition reviewing their Forest Ecosystem, it is worth analyzing their goals as an organization. They refer to all of the simulations as "Gizmos" which they describe on their website as:

- Fun, easy to use, and help students develop a deep understanding of challenging concepts through inquiry and exploration.
- Research-based, flexible tools used by teachers across all 50 states in a wide variety of ways. Gizmos are ideal for small group work, individual exploration, and whole class instruction using an LCD projector or interactive whiteboard.
- Designed to supplement your existing curriculum. Gizmos are correlated to state curriculum standards and over 200 textbooks, making them easy to integrate into your instructional program.

- backed by first-rate training and professional development services that help maximize the value of your investment.

(exploreelearning.com, 2009)

All of these descriptions match what we are trying to accomplish and offer with our Eco Sim game. The research this organization refers to includes current findings on the benefits of teaching science and mathematics with simulations, and other multimedia tools. The existing curriculum referred to includes textbook correlations with common names such as Houghton Mifflin and Prentice Hall. In regards to the specific simulation we found, it is important to note that this is not a game, in that it does not provide "a system in which players engage in an artificial conflict, defined by rules, that result in a quantifiable outcome" (Salen and Zimmerman, need page number). Instead of Rules of Play it includes a "Student Exploration Guide" that provides great curricular guidelines for the use of the simulation including prior knowledge factors, a warm up exercise, and a final assessment. The assessment feature is interesting in that it asks the kinds of questions that require the use of the simulation to answer as well as higher order thinking skills. Overall, this simulation features four controllable elements: Trees, Deer, Bears, and Mushrooms. These four elements act as the producer (trees), consumers (deer and bears), and decomposer (mushroom). The play itself includes adding elements to an existing environment, not building one from scratch as in our Eco Sim. This simulation does include a turn-based function that also represents a year of time passing. The elements do not change very dynamically and its difficult to visualize the changes adding or subtracting elements will create, however, one interesting experience was that when we removed all of the trees from the system, it was virtually impossible to recreate the functioning system that once was.

Build a Prairie
http://www.bellmuseum.org/distancelearning/prairie/build/index.html

Build a Prairie is an interactive website using fairly simple programming and images, however, providing a basic level of understanding in how ecosystems exist. What drew us to this particular simulation is that you build a whole ecosystem by choosing specific elements that will either help or hurt the environment. You are given choices throughout the simulation including the plants, grasses, flowers, insects, and animals to be included. The constraint is the setting itself: you are to build a prairie, which is more or less a wide spread low grassy area. When given choices, you are prompted to read descriptions of each element to determine if its natural habitat is a match for this kind of system. The choices are sort of forced, in that if you make a poor choice the website will tell you why. It doesn't really provide a whole lot of room for exploring poor choices visually. A final graphic that does generate only simulates the correct elements in the system. It is limited in its functionality, but you do learn why specific creatures live in this specific environment over others. Our Eco Sim game differs in that it is actually a game, not just a simulation, which allows for dynamic interactivity between game elements.

Sim Life
http://en.wikipedia.org/wiki/SimLife

SimLife allows players to create and modify worlds, plants, animals (at a genetic level) and design environments and ecosystems. This sounds like the perfect match of education simulation that we have been striving for. In our quest to design an educational, but fun computer game for middle school aged children. Perhaps this review of Simulation games best sums up our fears:

> SimCity was a massive success. It blended a legitimate, applicable intellectual challenge with a fun, rewarding gaming experience. For many years, Maxis had difficulty reproducing or improving this winning formula. Throughout the early 1990's, they tried a variety of different balances between higher and lower order intellectual challenges. SimEarth was a bit pedantic and burdensome, but it had an inkling of a fun factor. SimAnt had a lot of action, and it taught you a lot about ants, but the intellectual scope was a little limited. SimLife was the concept taken in the wrong direction, in the extreme. SimLife was incredibly complex, terribly slow, aggressively educational, and boring as h-e double hockey sticks. (GameFAQs.com, 2009)
> http://www.gamefaqs.com/computer/doswin/review/R43044.html

Furthermore, about SimLife specifically:

> All the animals and plants are represented by very small, very, very crude, 16 color icons that move around the "planet" in a slow, jerky, random fashion. There's zero animation, zero representation, and zero fun. To check up on your animals, you have to click on them and go through a ream of paperwork, as menus and gauges tell you all you ever wanted to know and more about each little guy. This is very slow going. (GameFAQs.com, 2009)

I found this review to be pretty chilling in that during our presentation earlier this semester, we were presented with a similar worry from our classmates. Where is the fun? So in reviewing SimLife, this is the overriding feature I would like to extract: do not design a game that is complex, slow, aggressively educational, and boring. Instead design one that is *legitimate, applicable intellectual challenge with a fun, rewarding gaming experience*. If we can accomplish all of this, and teach about ecology, then we win.

Design

Overall game idea, including game genre, levels

We are designing a simulation game. It is interesting to think about what constitutes the game-like qualities in a simulation. "Sim City is a toy that players make more puzzle like by setting their own goals" (need citation). Is a simulation like a puzzle? I think that there are puzzle like elements to a simulation that has more of a narrative behind it. Therefore the player utilizes forms of strategy and We based all of the elements the player can create on the Fire Island ecosystem from Long Island, NY.

Therefore, all of the characteristics and issues that ecosystem faces, we wanted to put into the game's system. The player would begin by adding all of the elements into a blank land canvas. The player would also complete missions to create the system. Once the system is designed, the player would have to it through a series of missions/levels including issues such as pollution, invasive species and weather events.

<u>Platform</u>
We are designing a PC game. This kind of platform is accessible in both home and school settings and also reflects our current capabilities as game designers.

<u>Game Rules</u>
Operational Rules:
The implicit rules are defined by our Rules of Play:

Eco Sim is a simulation game that allows you to control the animals and plants in an ecosystem. You will chose which plants and animals to put in the system, where to place them, and how many to include. Your setting is a northeastern island that includes a wide variety of plant and animal species. These species will live, consume, reproduce and die, and you must be prepared to keep the system healthy. You will also have to complete missions that will occur as the game progresses. These missions will threaten your ecosystem and it is up to you to solve the problems and keep everything alive.

The game begins with a blank land map that already has the body of water, sand, and grasses on the land. The land map is ready for a population.

In order to place plants and animals in your system, you will need to spend "DNA points." These points are earned through the successful survival and reproduction of plants and animals in the system. You also earn points through game missions.

Once the ecosystem is in place you will be able to see the different processes the occur like energy flows (sunlight, photosynthesis, consumption, decomposition, etc.) This will help you see how the system is functioning and if there are any problems with your plants or animals getting enough food or reproducing.

(We have been discussing how exactly to save the game in the middle of game play. We are still deciding if the player is only able to save missions once they have been completed, or if the player could save a game mid mission. For instance, if a player quit the game in the middle of the mission, would they then need to go back to the beginning of that mission? We are still considering which is the best option.

Constituative Rules:
The constituative rules are concerned with internal events (events related to the processing of a choice) and not with external events (events related to the representation of a choice). (Kalen and Zimmerman, page 147)

When the player chooses an element to place in the system, there are a number of underlying algorithms in place that determine how that element will behave. We defined game play elements as the following:

- DNA point value: This is how many DNA points the player will need to spend in order to add this element into the ecosystem. The player begins the game with a certain value of DNA points, and earns them through the survival and reproduction of their species as well as completion of game missions.
- Turn base game play: The player will hit a button after spending DNA points and completing a turn. One years time will pass which is indicated by the year listed next to the turn button
- Completing a turn constitutes of the player deciding how to complete the current game mission. This usually includes manipulating the environment in some way and spending DNA points.
- Animals within the system (mammals, marine mammals, rodents, birds, fish, amphibians) are defined as having a hunger value, a life expectancy, reproductive rate, and diet.
- Hunger value is defined as a numerical value that indicates how much of a certain food resource that animal is likely to consume on a turn (a year). The actual amount of food consumed depends on the availability. If the hunger value is not met over a year by a certain percentage, that animal's life expectancy is decreased by a certain percentage. (See list of animals for specific values)
- Life expectancy is defined as the number of years that animal or plant will live, based on real life characteristics of the plants and animals featured in this game. This value is affected by the animal's actual age, their hunger value being met regularly, as well as environmental factors such as air quality.
- Air quality is defined as the level of carbon dioxide and other greenhouse gases in the atmosphere. Level is indicated on the player's menu as a good, moderate, or poor. Poor air quality negatively affects flora and fauna health by 20%. Moderate air quality negatively affects the flora and fauna health by 10%. Good air quality does not affect flora and fauna health.
- Reproductive rate is defined as the number of offspring at least two animals will reproduce in one year.
- Diet is defined as what the animal will consume within the system. Some food items are pre-existing in that they will exist without the player's intervention (grass, insects), while others are elements the player has placed in the system (like fish, rodents, or rabbits)
- Certain species of plants and animals will also be assigned a nutritional value if another creature in the environment consumes them. Other environmental elements such as bacteria and fungi consume decayed matter or waste, which will also be assigned a nutritional value.
- For elements with a certain nutritional value, the size and quantity of supply is also accounted for (for example, the square footage of a grass spot on the map)

The following plant and animal characteristics have been assigned specific values that may change. Once our game prototype is up and running, we will reevaluate if the values we assigned allow for a balanced yet challenging play experience:

Mammals:
- White Tailed Deer:
    - DNA Point Value: 10,000
    - Per Turn Hunger: 5000
    - Life expectancy: 8 to 14 years
    - Reproductive Rate: 1 per year
    - Diet: 50% Grass, 50% leaves (from shrubs, grasses, and trees)

- Cottontail Rabbit:
    - DNA Point Value: 25
    - Per Turn Hunger: 10
    - Life expectancy: average of 1 to 2 years
    - Reproductive Rate: average of 12 to 16 per year, per female.
    - Diet: 50% Grass, 50% leaves (from shrubs and other grasses)
    - Nutritional Value: (consumed by Foxes)

- Common Raccoon:
    - DNA Point Value: 100
    - Per Turn Hunger: 50
    - Life expectancy: 3 years
    - Reproductive Rate: 2 – 5 per year
    - Diet: 40% Seeds (from trees like acorns), 40% fish and frogs, 30% rodents.

- Red Foxes:
    - DNA Point Value: 200
    - Per Turn Hunger: 100
    - Life expectancy: 3 years
    - Reproductive Rate: 5- 8 per year
    - Diet: 10% insects, 10% seeds, 10% berries, 20% rodents, 20%frogs, 15%rabbits, 10%fish, 5% deer fawns

- Harbor Seals:
    - DNA Point Value: 10,000
    - Per Turn Hunger: (10 – 18 pounds of food per day) 5000
    - Life Expectancy: 25 – 30 years
    - Reproductive Rate: 1 per year
    - Diet: 100% Fish

(These are just some of the examples of the underlying mechanics driving the interaction among elements in the game.)

Other constituative rules pertain to in-game missions, in which external, irregular elements will be introduced into the system affecting the existing elements health, life expectancy, etc. These missions are described in the narrative section and will include a portion here in regards to the algorithmic effects they have on the game elements.

Incentives

In "Unlocking Achievements: Rewarding Skill with Player Incentives," Mary Jane Irwin proclaims:

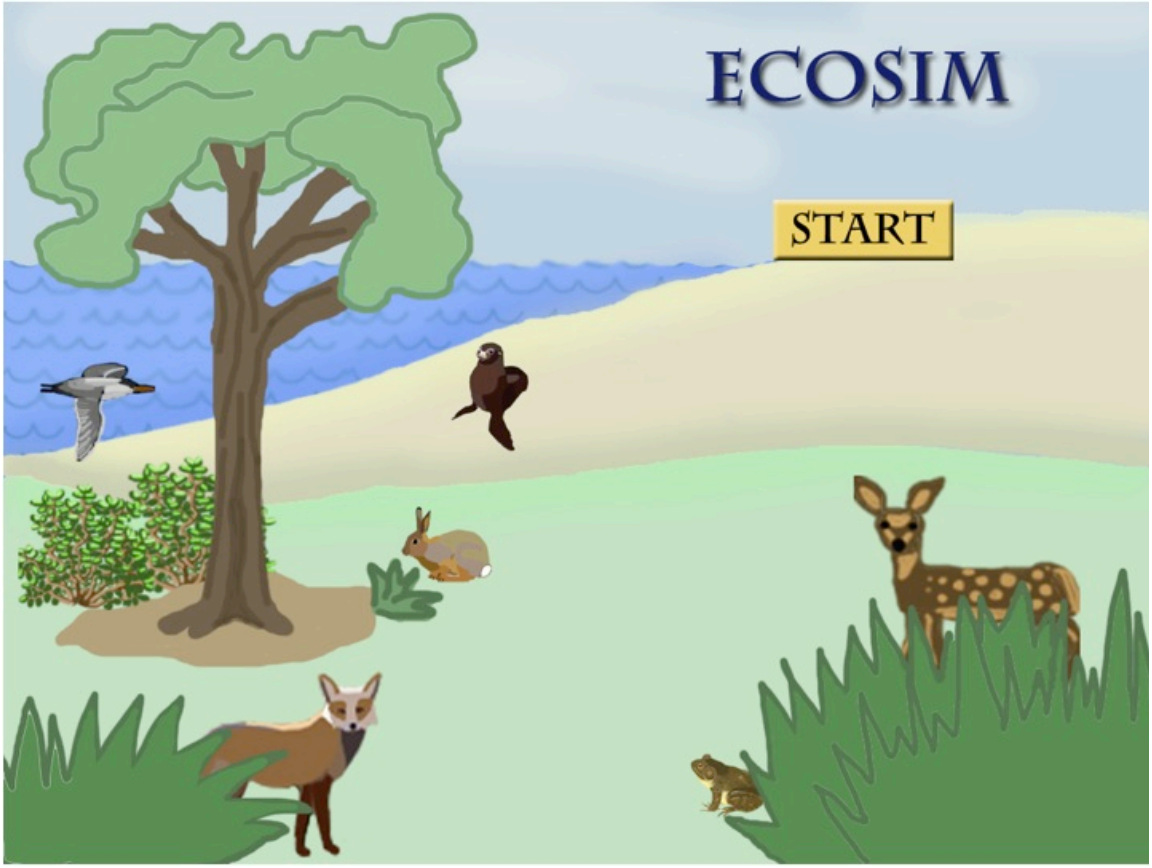
"When deployed skillfully, achievements keep players engaged. They foster community. They are a reason to play new games. They're a new metric to prove game mastery. Hell, achievements are the new high score." (Irwin, Gamasutra, 2009)

With a game like ours, with seemingly unlimited animals and plants to chose from, we could include achievements on a regular basis. In this, the final phase of our design and deployment of our game, we are developing portions of the narrative that will include unlocking new animals to place in the system, and mission based achievements. This is an important design consideration because, as we mentioned earlier, the risk of extracting the fun out of a game is a real threat. We are looking at ways to implement engaging, fun game events in order to make this educational game not explicitly educational and pedantic. Again, incentives will include mission based achievements related to the complexity of the ecological system developed, as well as unlocking more game elements to place in the system. Within the scope of our capabilities as game designers, we could foresee adding more human interaction with missions, as well as visual perspective changes like images and narrative enhancers. These are also considered in the section on emotional design.

Aesthetic design (2D, 3D, cartoon, avatar, etc.) with storyboards

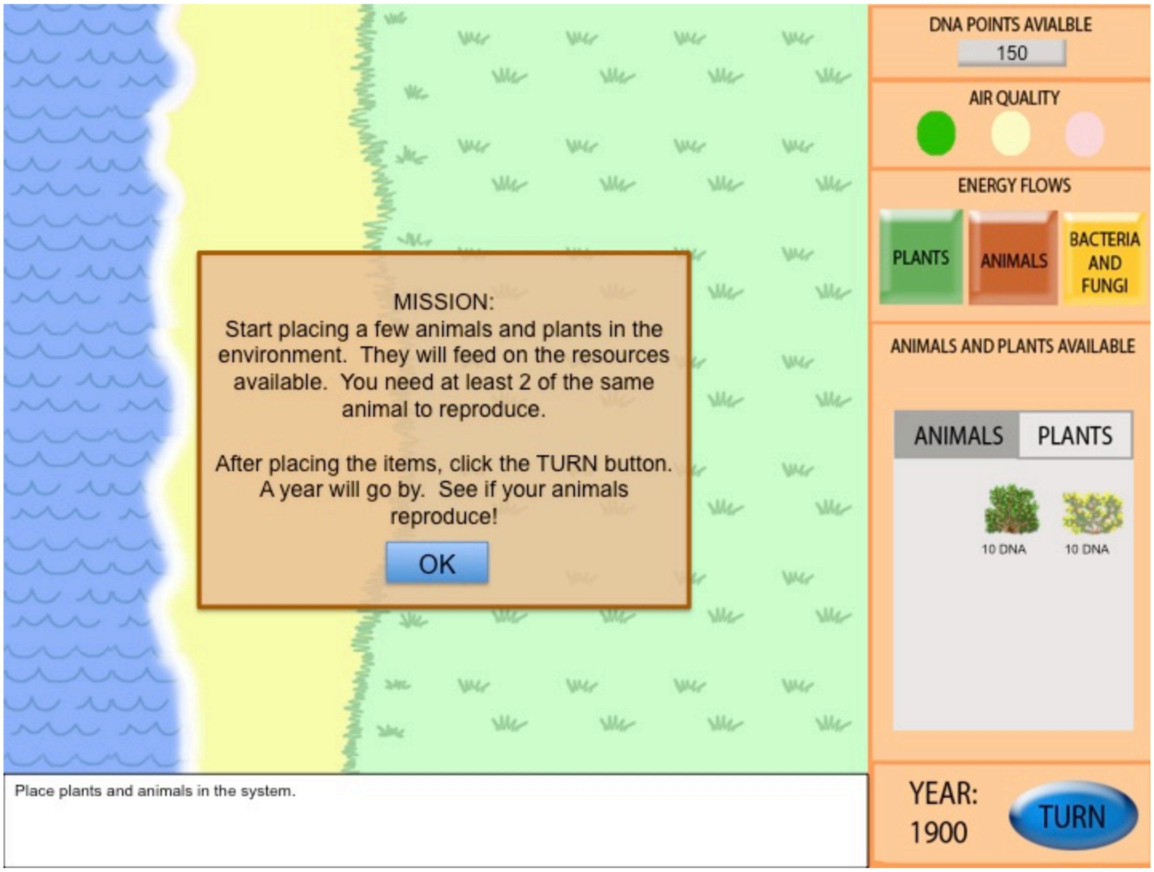
This game is largely two-dimension in its aesthetic design, similar to other simulation and strategy games.

Main Menu Image.



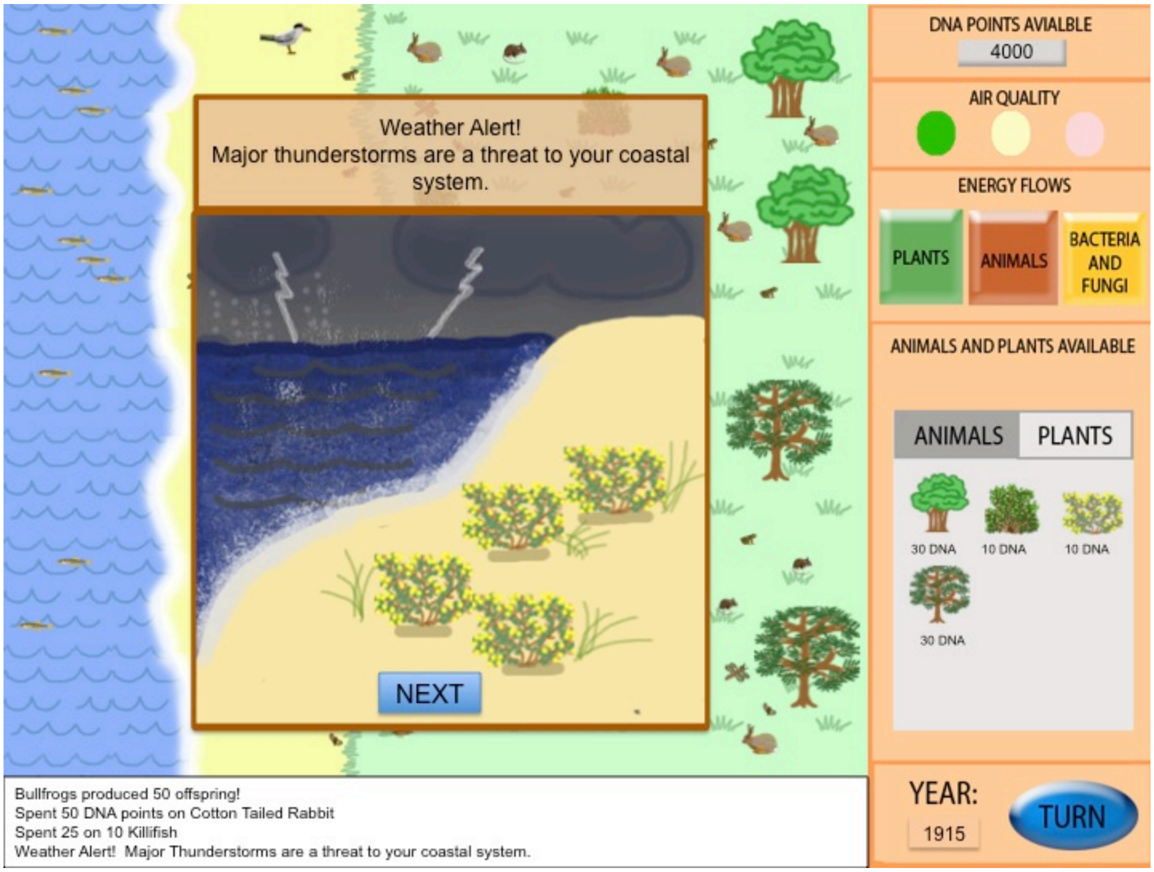
Storyboard images:

Storyboard 1:



In the above illustration, the player would have just started the game, with a blank land map. The selection of options in the menu includes the limited number of flora and fauna to begin populating the map with, the DNA points available, as well as the energy flow views. It also illustrates the beginning of a game mission. When the player starts a mission an activity box pops up on the screen, giving the instructions.

Storyboard 2:



In this illustration, a complex screenshot of the game is presented with multiple interacting elements, numerous animals and plants available to add into the system, and a numeric list of the number of animals and plants in the system. The current game mission is being set up through a narrative.

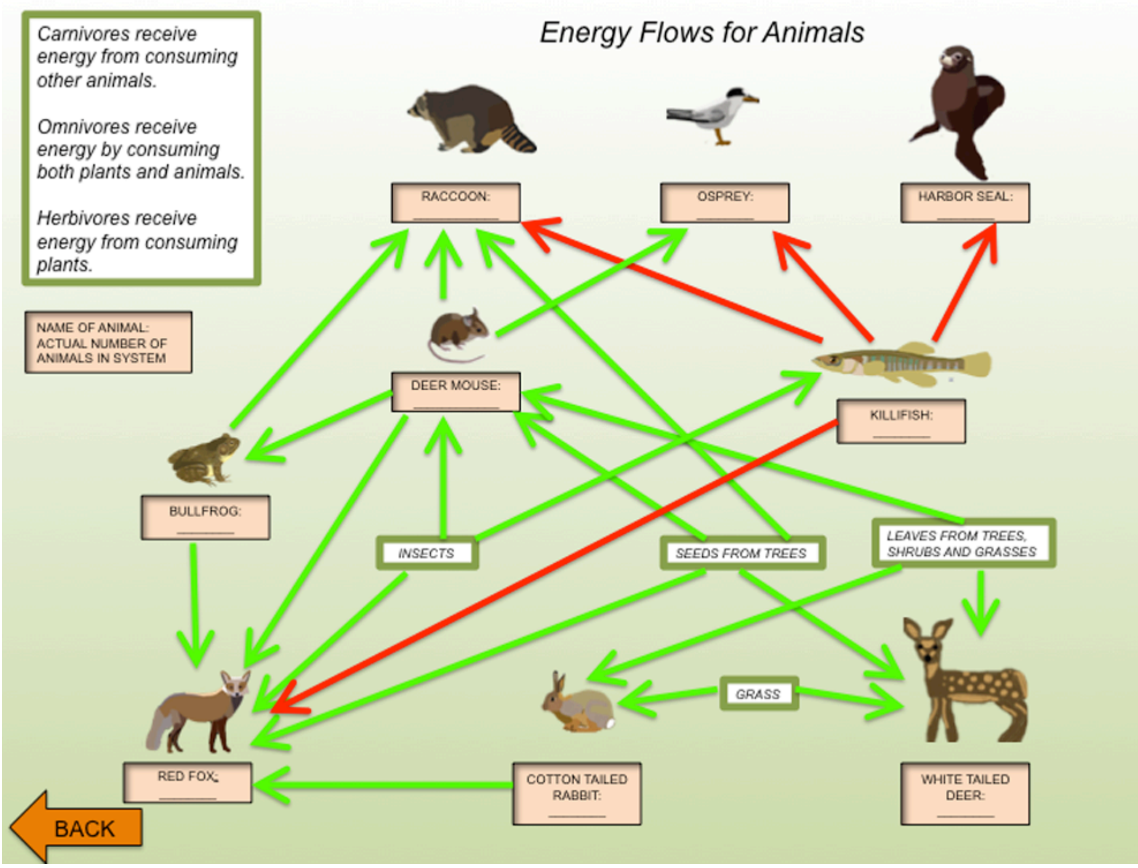
Storyboard 3:

The above image depicts another game mission, in which the player uses additional resources to complete game tasks. Content relevant to the mission is included in the dialogue box, and the landscape has changed to reflect the mission state as well.

Storyboard 4:

This is an example of a win state after a player successfully completes a mission. This indicates why they were successful, and provides a number of rewards.

Storyboard 5:



At any point during game play, the player will be able to view the energy flow of animals, plants, or bacteria. Furthermore, a very deliberate abstraction of the food web will be standardized whenever the player looks at it, which may aid in comprehension and understanding of the systems problems. As opposed to trying to figure out what the arrows indicate every time you look at one of the systems views.

<u>Game mechanics (user interactions) with wireframes</u>

The storyboard images presented in the previous section illustrate the user interaction with the game. The player interacts with the game through the selection of animals and plants, the spending and earning of DNA points, and the analysis of imbalances in the system through the energy flow charts.

<u>Description of player experience (walk-through)</u>

The game begins with a short narrative, introducing the game and the story behind it. It is explained to the player that they are the creator of an ecosystem. The screen layout is explained as well as the mission based increments. Tutorials as to how to interact with the game menu are embedded into the game play at key moments, as opposed to lumped all together at the very beginning. When the game prompts the player to make a choice, a useful tutorial for whatever features that choice includes, will be presented. The game will include missions that require the player to simply add new elements (plants and animals) into the system. These beginning missions will more contextualizing and tutorial based. The main game missions that we have determined thus far will include:

- A drought occurs – this will affect the plants and animals in the system mainly.
- Pollution – will affect air quality, animal health, and will require outside human intervention. This kind of mission will include elements that will be utilized simply for this specific mission, and not for the rest of the game as a whole.
- Build a salt-marsh – the player will need to build a salt marsh using the appropriate vegetation, in order to sustain the fish and wildlife that depend on it for their survival. The wildlife that rely on the salt marsh may likely be available as an achievement of this mission.
- A bug infestation – we would like to incorporate missions like this, in which a large amount of bugs suddenly appear in the system, and the player will need to most likely add a ton of rodents and frogs into the system in order to eat up all of the insects.

These are just a few of the game mission ideas we have developed.

As with other simulation games it is difficult to establish a win-state. There usually isn't one. However, we feel that the mission based challenges will add a layer of complexity to the system once the player has built it up. If we have a finite number of missions, then the game would end with the successful completion of all of the missions.

Theory

Cognitive Design (what cognitive design principles will be implemented)

Through the act of constructing an ecosystem, we aim to encourage the development of higher order thinking skills. This is in line with the constructionist learning principles that arrive out of the constructivist learning environments.
First of all some of the foundations of constructivism are that knowledge is constructed from experience. Learning results from a personal interpretation of knowledge, and learning is an active process in which meaning is developed on the basis of experience. The players construct their knowledge of an ecosystem through building it, and controlling the elements involved within, instead of merely observing an existing system.

In *Epistemology and the Design of Learning Environments*, Hannafin and Hill refer to constructionism as "constructional design practices." An underlying assumption in constructional design practices is that the learner is an *active, changing entity. As such, there is a need for layers of negotiation among the teacher, learner, and/or designer of the learning space* (Cennamo et al, 1996). In such environments, knowledge building tools and the means to create and manipulate artifacts of understanding are provided. It is not an environment in which concepts are explicitly taught. Nothing in the environment is fixed or limited, the meaning of knowledge is fluid and subjective, as well as the skills to acquire the knowledge. Rather, as beliefs and understandings emerge or questions and uncertainties surface, both the meaning of the learning resources and the environment's support features evolve. (Hannafin, Hill, 2007)

Constructional design involves four learning by design principles (Papert, 1980):

- *Individuals are active learners and control their own learning process.* Within the scope of this game, the players are in control of the ecosystem they have built, from start to finish. Therefore, the knowledge they extract from this process is also largely dependent on what they create and how they create it.

- *Individuals create concrete, tangible evidence (artifacts) that reflect their understanding.* The player is constructing a tangible, working simulation of an ecosystem.
- *Artifacts are shared collectively as well as reflectively on individually to extend one's understanding.* This is the only element that is not directly apparent in the game play. As mentioned in the Game Implementation Recommendation, if the game is played within a school environment, the students may be able to share their personal experiences through a "student exploration guide," that will prompt them to think about and reflect on their experiences.
- *The learning problems and context are authentic, that is, they focus on solving a practical problem.* Environmental concerns are ever present, and the problem solving methods learned through sustaining an ecosystem are practical and authentic.

<u>Emotional Design (how will learners' emotions be manipulated)</u>

Will Wright has said: "By enabling the player to create the content of the game, this in turn creates empathy within the player." (Will Wright's TED talk) Player's emotions are not overtly involved in this kind of simulation game, yet the idea of empathy being created is an important design factor. Empathy entails feeling ownership over the problem, and can in a sense, bond the player to the game. The player is creating an ecosystem with living animals that will essentially reproduce, eat, and die. These are factors that are inevitable. However, the game missions aim to introduce dramatic situations into the seemingly halcyon ecosystem, not only in order to challenge the player, but to also engage them emotionally.

<u>Narrative Design (narrative idea, opening, cutscenes)</u>

Our overall narrative begins in the year 1900, with the blank land map. The player is told that this is the year 1900, and is given a brief explanation of the development of civilization that will affect ecosystems. This contextual element is mainly used to explain the air quality issues that will affect the animals and plants throughout the game. Ideally, a number of cut scenes would be included to introduce the game, to introduce game missions, as well as reward the player when missions are completed.

<u>**Evaluation**</u>

<u>Description of how learning will be measured</u>

As we discussed with Jody Underwood, embedding assessments into game learning environments is a tricky thing to do. First, establishing clear learning goals is imperative, and to arrive at proper evaluation methods based on these goals and objectives. Our main idea for how to evaluate the learning through this game would be externally, in a traditional classroom setting where students can discuss and reflect on their experience with their teacher. As mentioned in previous sections, a "student exploration guide" could be designed to match a class's specific curriculum. With such a guide, the students responses to prompts about specific game elements could be evaluated by their teacher. We will continue to develop evaluation methods over the next few weeks.