Ecologies Teaching Guide

How to implement standards-based learning for all student levels.

Specific standards referenced are from Middle School and High School NGSS standards.

Ecologies allows students of all levels to model the flow of energy through ecosystems, as well as experiment with the resilience or fragility of ecosystems depending on their biodiversity and abiotic/biotic factors.

Through hands-on learning, as well as constant dialogue and negotiation throughout the game, students are more likely to understand and internalize ecological concepts, vocabulary, and underlying system mechanics.

What's included:

This guide includes:

- specific standards and how they are applicable
- recommendations for structuring gameplay
- a classroom worksheet with answer key
- rulebook with included concepts and vocabulary

Standards:

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Students explain how producers are able to capture the sun's energy and transfer that energy via sugars, first to primary consumers, and then to other trophic levels.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Students explain how ecosystems in each biome follow similar patterns of predator and prey interactions, and predict how ecosystems will be affected by changes in these relationships.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Students model a food web with cards, complete with explanations of the physical terrain and abiotic/biotic factors that might affect the biome and food webs within.

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Students propose and evaluate strategies for building and maintaining healthy ecosystems, using biodiversity as the main indicator of ecosystem health.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Students model with cards the concept of sunlight being the ultimate energy source for life on Earth and how light energy is transformed through each trophic level, and even recycled through the actions of decomposers and detritivores.

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

The point system in the game rewards players for maintaining higher trophic levels, as this becomes harder and harder as energy is lost at each level. The inverse relationship of available energy in the web and game points drives home the concept of higher trophic levels being more precarious and needing support from below.

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Students evaluate different game strategies based on the reasoning that changes to their food webs have knock-on effects that can destabilize their point total in the game and change the type of ecosystem the build.

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Various abiotic/biotic factor cards simulate human impacts on biodiversity and students must both try to solve this problem in the game with cards but also think of possible ways to revise the game in ways that would better reflect challenges and solutions to biodiversity loss.

Gameplay Recommendations:

Time:

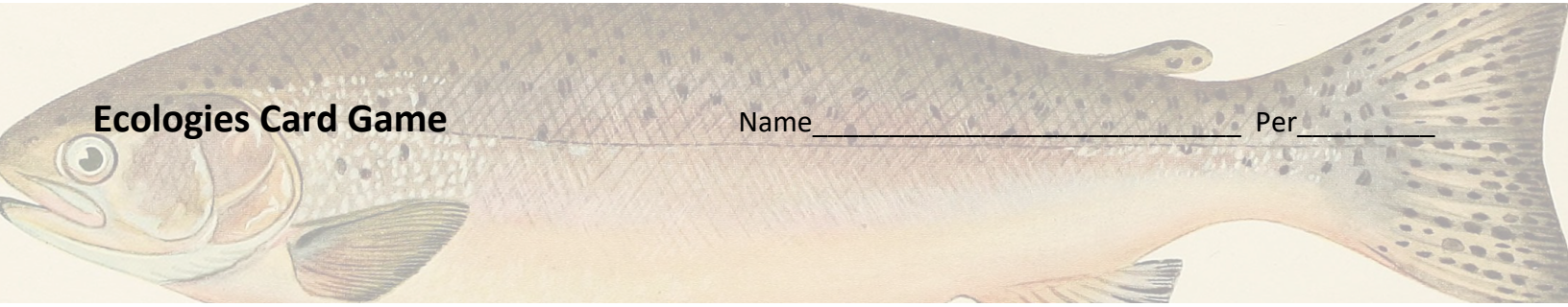
Most games take 60-90 minutes to play with around 4 players. Fewer players usually means a quicker game and more players translates to a longer game. The simplified version that makes every card worth one point and does not recycle the discard pile usually results in a game 30-50 minutes long. With set class times you can also announce that the winner is the person with the most points when time runs out. The included worksheet can also take students 60-90 minutes depending on student age and whether or not they work on it while playing the game, or do it afterwards.

Players:

The game accommodates 1-6 players, but plays best with about 4 people per group. Teachers have had success pairing students into 2-person teams that share a hand of cards, meaning 8 students play a 4 person game of Ecologies. This is the best way to stretch the amount of decks used in a classroom. On the other side of the spectrum, 2-player games are still vary effective and included solo play rules allow one person to practice the concepts.

Class Prep

It is helpful but not necessary to review ecological vocabulary words like producer, consumer, biotic factor, abiotic factor, trophic level, etc. with students before the game. Students can read the rules as a group before starting, but there are also 5-minute youtube videos available to quickly go over the rules of the game before starting. Ask students to pay attention during the game to how their actions and food webs accurately or inaccurately reflect nature in the real world. This encourages critical thinking and evaluation of a model that is fun and informative, but also necessarily simplistic and incomplete, as nature is far more complicated than a card game.



Ecologies Card Game

Name_____ Per_____

1. According to the game, what are some examples of biotic and abiotic factors that affect ecosystems?

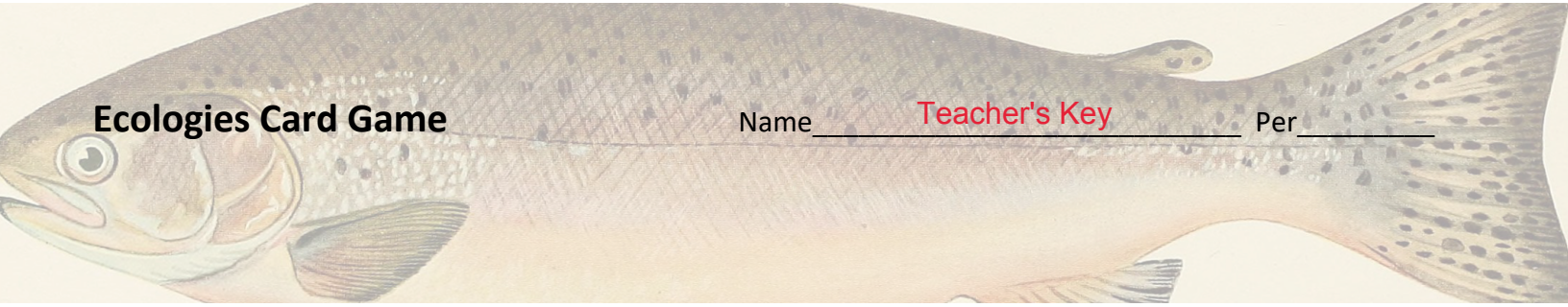
2. Why is it that when your food web loses all of its producers (autotrophs), you have to discard all the other cards, but when you lose consumers (heterotrophs), you can usually move cards around and make the web work again?

3. Did you end up with a lot of tertiary and/or quaternary consumers in your food webs? Why do you think it turned out this way?

4. Why do you think different biomes have different food webs? What was realistic about the organisms in each biome? What was unrealistic about the game?

5. Which is more stable and which is more fragile in the game, a large food web with different organisms or a small food web with just a few organisms? What does this say about biodiversity in real life?

6. Did you change any rules to make the game play better or act more realistic? If you were to redesign this game, what would you change and how would your changes affect the scientific accuracy of the game?



Ecologies Card Game

Name Teacher's Key Per

1. According to the game, what are some examples of biotic and abiotic factors that affect ecosystems?

   Students should be able to locate biotic and abiotic factor cards in the deck and explain how they affect ecosystems.

2. Why is it that when your food web loses all of its producers (autotrophs), you have to discard all the other cards, but when you lose consumers (heterotrophs), you can usually move cards around and make the web work again?

   Students should identify producers as unique in their ability to transfer the energy of the the sun into usable energy for higher trophic levels. They are foundational and food webs cannot exist without them. Many consumers, on the other hand, are easily replaced by organisms feeding at higher or lower trophic levels to fill the vacuum created by their loss.

3. Did you end up with a lot of tertiary and/or quaternary consumers in your food webs? Why do you think it turned out this way?

   Students should identify that higher trophic level organisms are more rare, as it takes a lot of organisms below to support their existence. This is because energy is lost at each feeding event and there is less overall energy available at higher trophic levels.

4. Why do you think different biomes have different food webs? What was realistic about the organisms in each biome? What was unrealistic about the game?

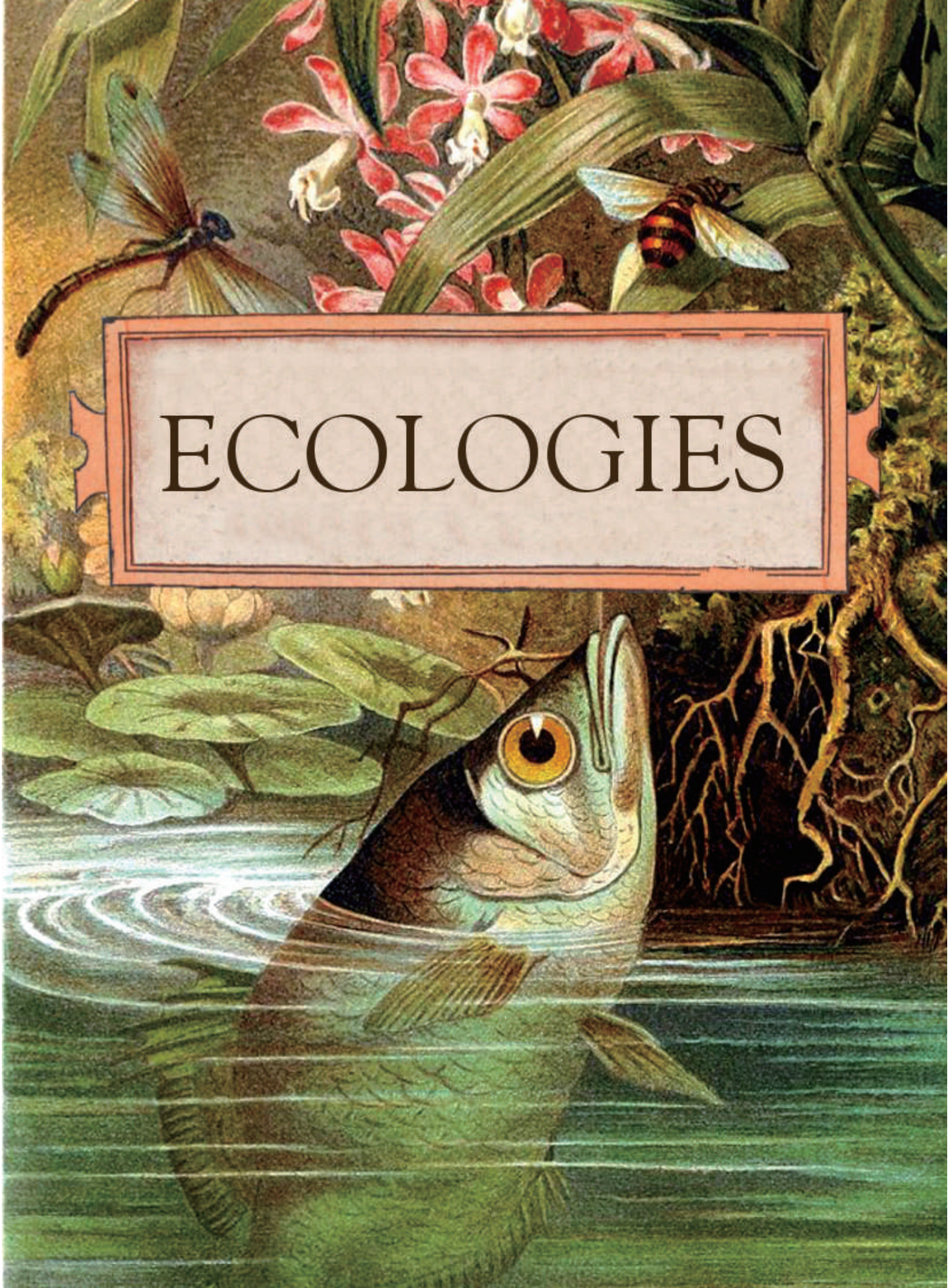
   Students should explain that different physical environments will favor organisms with different characteristics and behaviors. Realistic aspects can include any accurate modeling the game achieves. Unrealistic aspects include simplicity and gameplay choices like restricting certain animals to only one biome in order to balance the game.

5. Which is more stable and which is more fragile in the game, a large food web with different organisms or a small food web with just a few organisms? What does this say about biodiversity in real life?

   Students should identify biodiversity as the main indicator of a healthy ecosystem. This is because multiple species create redundancy and allow for one organism to take over a certain role or niche in the event that a specific species goes extinct. Simple webs are fragile because they lack diversity, and complex webs are resilient when facing challenges.

6. Did you change any rules to make the game play better or act more realistic? If you were to redesign this game, what would you change and how would your changes affect the scientific accuracy of the game?

   Students should demonstrate understanding through critical thinking about the game's design, it's accuracies, and its limitations. Changing the rules or redesigning the game's structure allows students to show deeper understanding of the underlying systems being represented and to evaluate important modeling criteria.

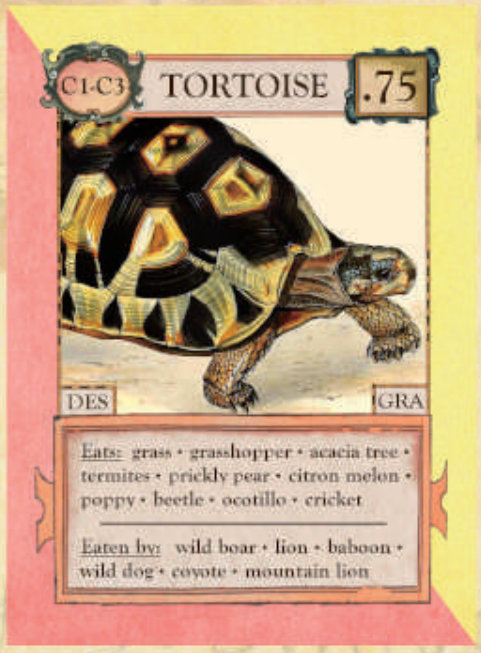

ECOLOGIES

Setup and Overview

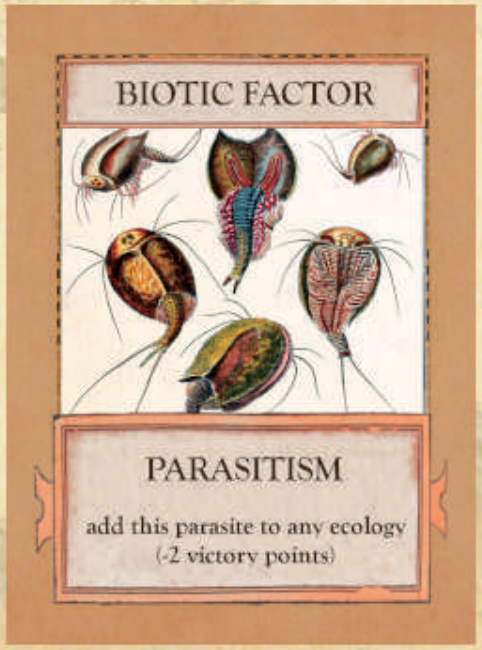
ECOLOGIES includes 108 cards. There are 77 organism cards, 21 biome cards, and 10 biotic/abiotic factor cards. Players build food webs using their cards, which are worth victory points. **The winner is the first person to reach 12 victory points, or the person with the most points after all cards have been drawn and players have completed a round without anyone playing a card.** When the main deck is depleted, shuffle the discard pile and turn it over. If both the main deck and discard pile are depleted, players keep playing until more cards are discarded or a round of turns is completed without anyone playing a card. **To start, deal each player 7 cards.**

Card Types

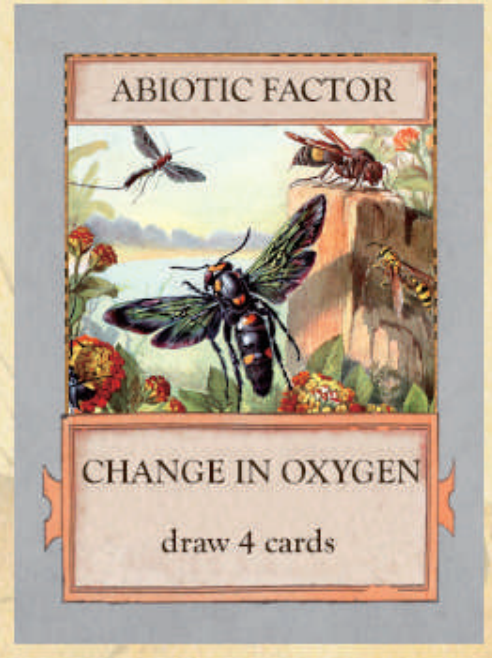
BIOME



ORGANISM



BIOTIC FACTOR



ABIOTIC FACTOR

Turns and Gameplay

Turns follow the same pattern: **draw 2 → trade → play 2 → purchase.** To start, draw 2 cards. Next, trade cards with your opponents if you'd like. **There are no restrictions on the number or types of cards to be traded with others, so long as they are unplayed cards in hand and not active cards on the table.** After trading is complete, you may play up to 2 cards. Playing any type of card counts as one of the two plays. Finally, before ending a turn, players can purchase 1 new card for every 4 unplayed cards they would like to discard. This option is desirable when a player has many unwanted cards, but is not necessary each turn. A similar purchase can be made by destroying one's own ecology that is no longer wanted.

In this case the trade is 3 for 1, rounding down (ex. destroying an ecology with 10 cards would net 3 new cards). This is rarely desirable but still an option.

DRAW 2

TRADE

PLAY 2

PURCHASE

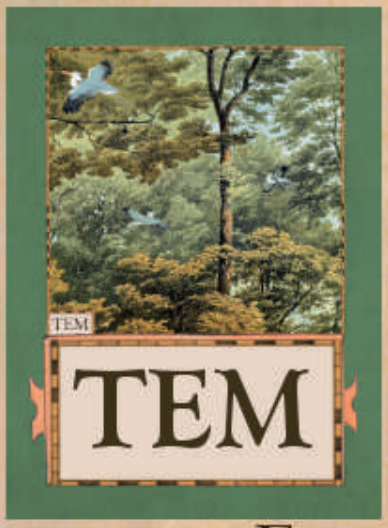
Biome Cards

The first card each player plays will be a biome card. This is because every ecology needs a biome before it can be populated with organisms. Only one biome card is needed per ecology. Multiple biome cards may be played, but each one is the start of its own ecology. Each biome has its own color and abbreviation. Organisms played in a biome must have a matching background color / abbreviation. Some organisms survive in two biomes. Biomes give **"healthy ecology bonuses"** when players fulfill 5 specific roles in the food web: (P), (C1), (C2), (C3), and (SD). Organisms can switch roles within a biome or move to different biomes during a player's turn, but can only have one role in one biome at a time.

Biomes:

Coniferous Forest

Tundra



Temperate Forest

Grassland

Desert

Tropical Forest

Marine

Organism Cards

Trophic levels are shown in the upper left corner and victory points in the upper right. The background colors and 3-letter abbreviations indicate which biome(s) the organism can survive in. The text box shows what it eats and what it is eaten by. Cards are placed in rows above what they eat, as energy comes from the foundation of the food web and moves up. The only exceptions to this rule are scavenger, decomposer, and detritivore cards (SD), which eat everything but are always placed on the same level as primary consumers (C1) in the food web. Many cards have multiple trophic levels, and can be moved around the food web to function in different roles, as long as each organism has food available to it. The bottom row of cards is for biome cards and producers (P). **A biome card must be played first, and a producer card** (P) **played second.**

Together these two cards become the foundation for all other cards above. The second row is reserved for organisms acting as primary consumers (C1) or scavengers/decomposers/detritivores (SD). The third row is reserved for secondary consumers (C2), the fourth row is reserved for tertiary consumers (C3), and any rows above this are reserved for organisms acting as quaternary and above consumers (C4). Cards do not have to be placed directly over what they are eating and multiple types of animals can feed off of one type of prey animal. For example, the (C1) zooplankton card can support multiple (C2) organisms above it, as the one card represents an entire population of zooplankton being eaten by multiple types of predators.

Biotic/Abiotic Factor Cards

Powerful biotic and abiotic factor cards are mixed into the deck. Some give victory points. Others hurt your opponents' ecologies or help your own. Biotic factors are derived from the living parts of an ecosystem and abiotic factors come from the non-living parts. These 10 cards have a huge impact on the game so play them at the right moment! For example, there is a card that forces everyone to discard down to 5 cards. This is best used when opponents have large hands but the player has a small hand. Some cards are added to ecologies. Some are permanent player buffs placed on the table. One-off action cards are discarded after use but can come back when the discard pile is recycled later in the game.

BIOTIC

ABIOTIC

Food Webs

Food webs, and their interactions with the environment, are what make ecologies. They are dynamic relationships that often change. **Non-producer organisms may be moved around and between food webs during a player's turn, but producers (P) cannot leave the web they are placed in.** For example, a badger can act as a scavenger (SD) on the second row, but move later to the fourth row to act as a tertiary consumer (C3). Organisms only fulfill one role at a time. **The only time players can move organisms outside of their turn is when opponents destroy a card or alter their ecologies.** If a web is disturbed in this way, the player may attempt to reorder the remaining cards in a way that works.

If there are cards without a food source however, they must be discarded. For example, **if a web was based on one producer (P) and that card is destroyed, all cards above it must be discarded unless they can move to a viable biome.** This is a good reason to have multiple producers, or otherwise protect ecologies. **There are no "decaying biomass" cards.** (SD) cards use all organisms as potential food. If an organism is eating an (SD) card, it is acting as a (C2), because **(SD) cards are always placed on the (C1) row.**

Healthy Ecology Bonuses

Bonuses are listed on biome cards and activated when an ecology has at least one card acting in each of the following 5 roles: **(P), (C1), (C2), (C3), and (SD).**

Many cards can move around to different roles in different trophic levels, but they cannot fulfill multiple roles at the same time. This means **a player will need at least 5 cards in the biome before it's possible to activate the bonus.** Note that quaternary consumers (C4) are not necessary for a biome to be considered healthy. **Bonuses are only active when an ecology is healthy and disappear if the ecology is no longer healthy.** A healthy temperate forest ecology lets a player redraw each card they get one time, meaning if they don't like a card they draw, they can place it at the bottom of the deck and draw again. The replacement card must be accepted. A healthy tundra biome results in a better purchase rate for cards. Unwanted cards in hand can be traded in 2 for 1

and destroyed biomes can be traded in 1 for 1. Purchases can never be cheaper than 1 for 1. See remaining biome cards for other healthy ecology bonuses. **Bonuses can stack** (ex. if a player has 2 healthy tropical forest ecologies they can steal a card each turn, instead of every other turn).

Healthy ecologies include one biome card and at least one organism for each of the following roles:

PRODUCER	**(P)**
PRIMARY CONSUMER	**(C1)**
SECONDARY CONSUMER	**(C2)**
TERTIARY CONSUMER	**(C3)**
SCAVENGER/DECOMPOSER	**(SD)**

*** Quaternary consumer (C4) not necessary**

Single Player Game

Single player games start with 7 cards. Single player turns follow the pattern of **draw 4 → discard 3 → play 2 → purchase.** Draw 4 cards at the beginning of each turn. Next, discard 3 cards of your choice. Then play up to 2 cards and purchase new cards if you wish before ending your turn. Keep playing until the deck runs out. **Do not recycle the discard pile.** Play your remaining cards if possible. The game is now over. Total your final points and keep records of your high scores. **Note:** some interactive cards will be impossible to use in the single player game and should be among those you discard or use to purchase new cards (4 unplayed for 1 new card, 3 active for 1 new when destroying ecologies).

Simplified Game

Younger players and adults wanting a streamlined version can play the simplified game. In the simplified version, there are no fractional points. Every organism is worth exactly 1 victory point. The winner is the first person to reach 12 victory points. If the deck is depleted before anyone achieves 12 victory points, the player with the most points wins the game.

The Science

This game was developed by a biology teacher to simulate ecological concepts. While necessarily simplified, the systems introduced underpin all life on Earth. Ecology is the study of interactions between living and nonliving parts of an ecosystem. Different environments and ecosystems will have different plants, animals, physical features, and weather. When looked at on a large scale, these unique collections of habitats and ecosystems are referred to as biomes.

Earth has many different biomes, each with their own ecology, or set of interactions. For example, a desert biome has an ecology very different from a temperate forest biome because the

relationships and interactions between organisms and their environment differs greatly in these two areas. One of the easiest ways to judge the health of an ecology is to look at food webs, which are representations of what eats what and how energy flows through the living parts of a biome. With few exceptions, all biomes ultimately derive their energy from the sun. However, only producers (P) like plants and algae can harness the sun's power in order to produce sugars. Herbivores are called primary consumers (C1) because they are the first to consume these sugars. Carnivores get the energy by consuming herbivores, so they are called secondary consumers (C2). Predators higher up the food chain include tertiary consumers (C3) and quaternary consumers (C4). A food web

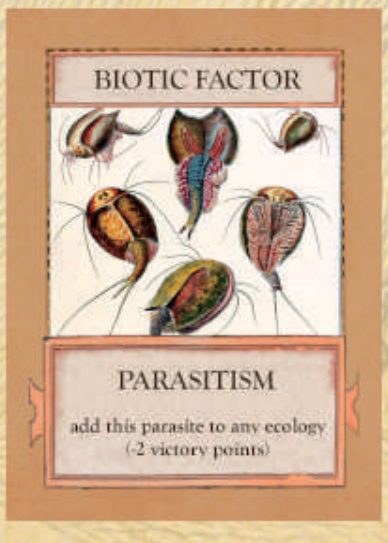
is a tangle of many food chains and also includes scavengers, decomposers, and detritivores (SD). Scavengers, decomposers, and detritivores are the organisms that break down decaying biomass, either mechanically or chemically, in order to recycle nutrients back into the system. A healthy ecology will have a mix of all these organisms.

In this game, healthy ecology bonuses are given when a biome's food web contains at least 5 organisms doing the following 5 jobs: **(P), (C1), (C2), (C3), and (SD).** Healthy ecology bonuses are different for each biome and are listed on biome cards. Biomes are color-coordinated. Food webs in this game might seem strange, as the likelihood of eating an item is not shown, so even though many

animals eat one preferred food, all possible foods are listed. For example, herbivores eat small insects in the wild even though the vast majority of their diet comes from plants, and some organisms are only preyed upon when young and weak, or during a unique stage of their life history. To balance gameplay, organisms are restricted to certain biomes. For example, earthworms are found everywhere on Earth, but in this game they are restricted to temperate forests. Food webs are purposefully incomplete here, as real webs contain thousands of species, far too many for a card game. These food webs are meant to pique your interest and encourage research. They are not definitive.

Example Food Webs

Note: the jaeger is feeding on arctic hares, not polar bears. Cards do not have to be directly over what they eat. The polar bear is acting as a scavenger.



Questions and Comments

If you have any questions or comments please visit us at **montrosebiology.com** and click "contact us." We value your feedback and would love to hear from you!

There are multiple expansions/sequels planned for the future. They will introduce new biomes, factor cards, organisms, and healthy ecology bonuses. Players will be able to play them as stand-alone games or combine new and old decks for novel interactions, choosing which cards to include or exclude.

The rules written here are guidelines. Players should also have a say in how a game is played. If you find that altering the game in any way helps your family or friends enjoy the cards more, please do so!