

Pull One Thread: Testing a Prairie Web for Its Keystone

Investigation question: When one part of a shortgrass prairie is removed or weakened, how many other populations change, and does a change to a living part or to a nonliving part send the bigger ripple? Does real survey data agree with what the model predicts?

Collaborative systems modeling

Groups of 4

1 session

Setup 5 · Activity 45 · Cleanup 5 min

MS-LS2-4 · assesses

MS-LS2-1 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Card keeper:** Lays out the cards, lifts the removed or lost card at the start of each wave, and resets the board between trials.
- ☐ **Rule reader:** Reads each tugged card's needs aloud, applies the rules card, and says which token it gets and why.
- ☐ **Token placer:** Places the red, yellow and green tokens and flips LOST cards face down, but only after the group agrees.
- ☐ **Recorder:** Fills in the trial table, counts the tokens, and checks the totals against the board before the reset.

Safety

- Yarn is a tangling and tripping hazard. Keep the strings on the desk or floor area, never around a neck, wrist or finger, and coil them before anyone stands up.
- If you build the web on the floor, keep it out of walkways and away from doors; step around the web, not over it.
- Scissors, if used for tape or tokens: cut away from fingers. No other hazards beyond ordinary classroom materials.

Procedure

1. Lay out the 15 cards about 30 to 40 cm apart: the rain and soil water card along the bottom edge, the three plant cards above it, the plant eaters and the burrows card in the middle, and the predators along the top.
2. Tape one string for every pair in the string list: green for food, brown for shelter, blue for water, orange for clipping. Tape each end to the back of a card so the cards can still slide. Count the strings: there should be 32.
3. Read the rules card together. Each person predicts which card's removal will change the most other cards (q1); write the group's predicted number of changed cards for every trial in the trial table.

4. Trial 1: remove the prairie dogs. The Card keeper slowly lifts the prairie dog card about 20 cm. Every card that slides or tugs is directly linked; those cards make up wave 1. The Rule reader applies the rules to each wave-1 card, and the Token placer puts down tokens and flips any LOST card face down.
5. Next wave: lift each card that was just LOST and apply the rules to the cards it tugs. Also follow DOWN tokens to the cards that need the DOWN card (its eaters, or the users of a shelter or of water). UP tokens stop where they are. Keep going, wave by wave, until a wave adds no new tokens.
6. Record the trial: the number of wave-1 cards, the names of LOST cards, the numbers of DOWN, UP and MIXED cards, and the total number of cards that changed. Then remove every token, flip the cards face up and put the removed card back.
7. Trial 2: remove the bison. Trial 3: remove the grasshoppers. Repeat steps 4 to 6 for each.
8. Trial 4: drought. Do not remove the water card. Put a yellow DOWN token on it, follow its blue strings, and apply the rules wave by wave as before.
9. If time allows, run trial 5 on a card your group chooses, predicting first.
10. Graph the total number of cards changed and the number LOST for each trial. Then read the field evidence, answer q3, and compare it with your model's prediction for burrowing owls.
11. Answer the analysis questions; finish at home if needed. Untape the strings, bundle them by color, and return cards and tokens to the envelope.

Record your observations

Lab 2 recording sheet: Pull one thread

This is a model of a patch of shortgrass prairie on the Great Plains. Each card is one population or one nonliving part, and each string is a link: who eats whom, who shelters where, which plants need the soil water, and which plants the prairie dogs clip. A ★ marks a **MUST HAVE**: if it is lost, the population is lost from this patch.

Prairie web cards (cut apart)

1 Rain and soil water

Nonliving. Rain that soaks into the soil. Needed by: grasses, wildflowers and shrubs. It comes from the weather, outside the model.

2 Burrows

Nonliving structure: tunnels and mounds. Needs: ★ prairie dogs, which dig and repair them; without prairie dogs, burrows cave in and fill with soil over a few years. Shelter for: prairie dogs, black-footed ferrets, burrowing owls, prairie rattlesnakes and cottontails.

3 Grasses (blue grama, buffalograss)

Producer. Needs: ★ rain and soil water. Eaten by: prairie dogs, bison, grasshoppers, cottontails and deer mice (seeds).

4 Wildflowers

Producer: broad-leaved flowering plants. Needs: ★ rain and soil water. Eaten by: prairie dogs, grasshoppers, cottontails and deer mice (seeds).

5 Shrubs (saltbush, rabbitbrush)

Producer. Needs: ★ rain and soil water. Clipped by: prairie dogs, which bite off shrub seedlings and branches near their burrows. Shelter for: cottontails.

6 Black-tailed prairie dogs

Herbivore: a ground squirrel that lives in large colonies. Food: grasses or wildflowers. Needs: ★ burrows. Eaten by: black-footed ferrets, prairie rattlesnakes, coyotes and ferruginous hawks. Also digs and repairs the burrows and clips shrubs.

7 Bison

Herbivore, the largest animal in the model. Food: grasses (its only food here). Eaten by: nothing in this model.

8 Grasshoppers

Herbivore (insect). Food: grasses or wildflowers. Eaten by: burrowing owls and deer mice.

9 Cottontails

Herbivore (a rabbit). Food: grasses or wildflowers. Shelter: burrows or shrubs. Eaten by: prairie rattlesnakes, coyotes and ferruginous hawks.

10 Deer mice

Omnivore. Food: grass seeds, wildflower seeds or grasshoppers. Eaten by: burrowing owls, prairie rattlesnakes, coyotes and ferruginous hawks.

11 Black-footed ferrets

Predator. Food: ★ prairie dogs (almost its only food). Needs: ★ burrows (it lives in prairie dog burrows). Eaten by: nothing in this model.

12 Burrowing owls

Predator. Food: grasshoppers or deer mice. Needs: ★ burrows (on the Great Plains it nests in old prairie dog burrows and seldom digs its own).

13 Prairie rattlesnakes

Predator. Food: prairie dogs, cottontails or deer mice. Shelter: burrows, or rock crevices (not in the model).

14 Coyotes

Predator. Food: prairie dogs, cottontails or deer mice.

15 Ferruginous hawks

Predator: a large hawk of open plains. Food: prairie dogs, cottontails or deer mice.

String list (32 strings)

Color	Link	Tape one string between
Blue	Water	Rain and soil water and each of: grasses, wildflowers, shrubs (3 strings)
Brown	Shelter	Burrows and each of: prairie dogs, black-footed ferrets, burrowing owls, prairie rattlesnakes, cottontails; also shrubs and cottontails (6 strings)
Orange	Clipping	Prairie dogs and shrubs (1 string)
Green	Food	Grasses and each of: prairie dogs, bison, grasshoppers, cottontails, deer mice (5 strings)
Green	Food	Wildflowers and each of: prairie dogs, grasshoppers, cottontails, deer mice (4 strings)
Green	Food	Grasshoppers and each of: burrowing owls, deer mice (2 strings)
Green	Food	Prairie dogs and each of: black-footed ferrets, prairie rattlesnakes, coyotes, ferruginous hawks (4 strings)
Green	Food	Cottontails and each of: prairie rattlesnakes, coyotes, ferruginous hawks (3 strings)
Green	Food	Deer mice and each of: burrowing owls, prairie rattlesnakes, coyotes, ferruginous hawks (4 strings)

Rules for every wave — LOST (red token, flip the card face down): you lose every option for one of your needs (all of your foods, or all of your shelters), or anything marked ★. **DOWN** (yellow): you lose one of several foods or shelters, or something you need is DOWN. **UP** (green): something that eats you or clips you is LOST. **MIXED**: you collect both a yellow and a green token. LOST beats everything. **Travel**: a LOST card is lifted in the next wave and tugs all its strings; a DOWN card passes DOWN only to the cards that need it; UP tokens stop where they are. Stop when a wave adds no new tokens.

Trial table

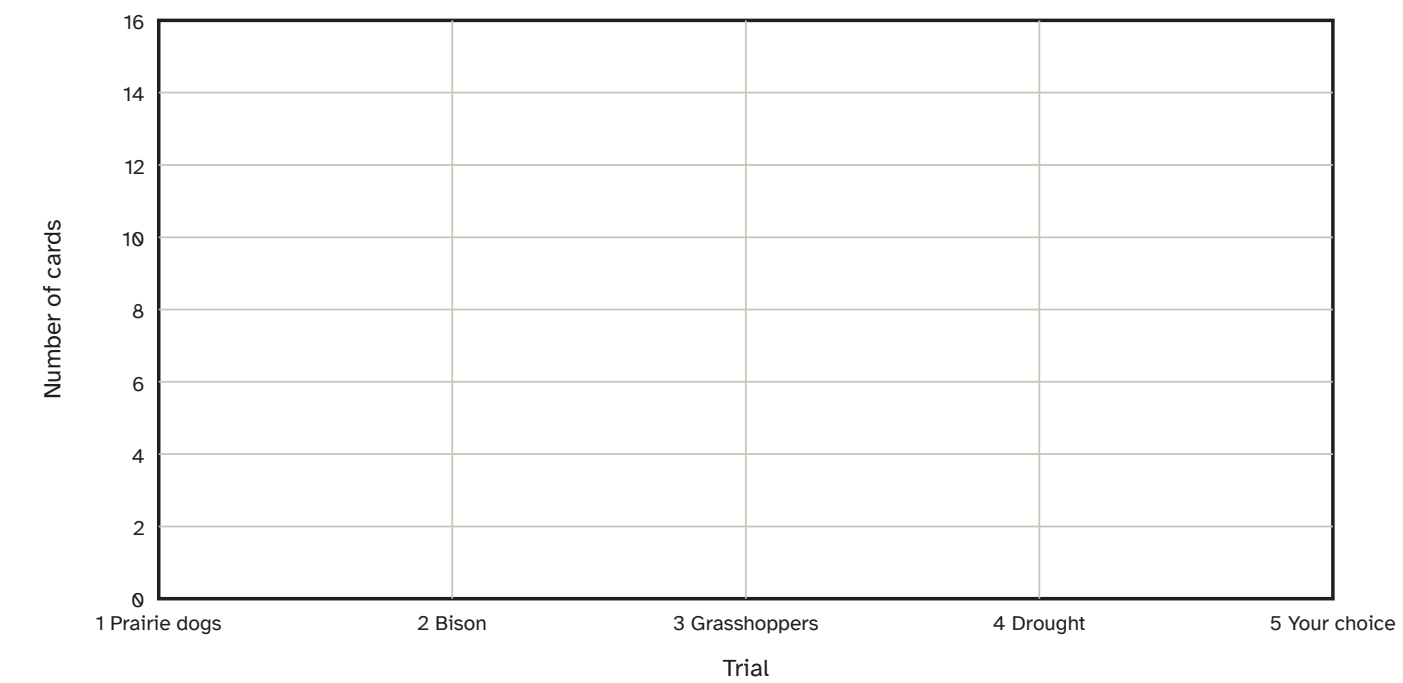
Trial	Change made	Predicted number of cards that change	Wave-1 cards (number)	LOST cards (names)	DOWN / UP / MIXED (numbers)	Total cards changed (not counting the one you changed)
1	Remove prairie dogs					
2	Remove bison					
3	Remove grasshoppers					
4	Drought: soil water DOWN					
5	Your choice: remove _____					

1.

Before trial 1: predict which single card's removal will change the most other cards, and explain your reasoning.
2.

In trial 3, the ferruginous hawks went DOWN even though hawks do not eat grasshoppers. Trace the chain, link by link, that reached the hawks.

Cards changed in each trial (draw two bars per trial: total changed and number LO



Check the model against the field

Burrowing owls on prairie dog colonies, Great Plains National Grasslands, spring and summer 1998

Kind of colony	Colonies surveyed	Colonies where burrowing owls were found
Active (prairie dogs present)	444	307
Inactive (prairie dogs gone because of plague, shooting or poisoning)	138	15

Two more field findings. **1.** Black-footed ferrets get almost all of their food from prairie dogs and live in prairie dog burrows. By 1987 the last 18 known wild ferrets had been captured for captive breeding, and the ferrets living in the wild today come from captive-bred animals released onto prairie dog colonies. **2.** In a five-year experiment in a desert grassland, mesquite shrubs became three to five times more abundant in plots where prairie dogs had been removed than in plots where prairie dogs remained.

- 3.** (a) Use the owl table to calculate the percent of active colonies and the percent of inactive colonies where burrowing owls were found. (b) Your model predicted burrowing owls are LOST when prairie dogs disappear. Does the field evidence agree completely, partly or not at all? Explain.

Analysis questions

- 4.** Rank trials 1 to 4 from the most cards changed to the fewest, giving each total. How many times as many cards changed when prairie dogs were removed as when bison were removed?

- 5.** Bison are by far the biggest animals in this model. Use your trial totals and the number of strings attached to each card to explain why prairie dogs, not bison, act as the **keystone species** here.

- 6.** In trial 1, how many cards changed in wave 1, and how many changed only in later waves? Name the later-wave cards and write the chain that reached one of them, link by link.

7. Trial 4 changed a nonliving part. Compare it with trial 1: which changed more cards, and which caused cards to be LOST? Use both results to argue whether a change to a physical component can affect populations as much as a change to a biological one.

8. Find two places where the model and the real world probably disagree. (a) Compare the model's prediction for burrowing owls with the survey table. (b) In trial 1 the model says wildflowers go UP when prairie dogs are removed, but field surveys often find more wildflowers on prairie dog colonies, where digging and clipping open up space for them. For each, say what the model leaves out and how you would change a card or a rule.

9. Write a short argument using only the real survey data, not the model: does losing the prairie dogs from a colony affect the burrowing owls there? Give a claim, the numbers as evidence, the reasoning (a mechanism), and one limit of this evidence.
