FIGURE SET HEADER for Set #1

Figure Set 1: Changes in cottonwood and willow abundance in the 20th century.

Purpose: To practice interpreting graphical data; to use the data to generate hypotheses about what could have caused a decline in cottonwood and willow recruitment.
Teaching Approach: Pairs share and hypothesis development
Cognitive Skills: (see Bloom's Taxonomy) knowledge, comprehension, interpretation, analysis
Student Assessment: generate hypotheses

BACKGROUND for Set #1 (back1.html)

Background

Where have the cottonwoods and willows gone?

Biologists and managers in Yellowstone National Park have noticed changes in the abundance of cottonwood and willows along streams and rivers in the Park, especially in valleys where elk congregate in the winter. Beschta (2003) and Ripple and Beschta (2004) collected data on cottonwood size classes (trunk diameter in cm) and willow height, respectively, and placed the data into time series. Summary figures from these two papers are presented here, but note that cottonwood diameter has been converted to approximate tree age (establishment date) based on linear regression models not included here (see Beschta 2003). Cottonwood data are divided between floodplain sites (i.e. sites in the valley bottom likely to be inundated in years of high spring run-off) and meander sites (i.e. the insides of river bends adjacent to the channel, where sediments are deposited after spring floodwaters recede), because cottonwood seedling establishment and growth rate are influenced strongly by landform/position. Seedlings are most likely to become established on exposed sediments after substantial spring snowmelt floods, and growth rate after establishment differs for meander vs. floodplain sites (Beschta 2003).

The data lead us to ask, what has happened to the woody riparian vegetation in these valleys?

FIGURES for Set #1 – there are 2 of them (figure1.html)

Figure Set

Figure
Figure 1-1 Cottonwoods

Legend
Figure 1-1. The number of narrowleaf cottonwood trees established during 20-year intervals in a 9.5 km^2 area of the Lamar Valley, northern Yellowstone National Park. Ages were derived from size class data collected in 2001. Open bars represent numbers of cottonwoods on floodplain sites; closed bars are cottonwood numbers on meander sites (S d I c information). The floodplain and meander tree populations were kept separate, because trees grow at different rates in these locations, requiring different age estimates based on tree

diameter. The black bar represents an estimate of cottonwood seedling density on the entire study site in 2001, and is on a different scale (thousands vs. 50-60). The shaded area indicates expected numbers of cottonwoods in each age class under conditions of frequent/regular recruitment. From Beschta (2003).

Figure

Figure 1-2 Tall willows

Caption

Figure 1-2. Twentieth century time series of the status of riparian willow communities on the Gallatin River, within and adjacent to northern Yellowstone National Park. Willow height and abundance were estimated from historical photographs as well as historical records and field measurements; a a ≥ 100 cm (but note that the shrub willows in this region may reach heights of 3 m or more under good conditions). The shaded region between dashed lines reflects the range of variability/uncertainty in the data, since they are based mainly on qualitative assessments as opposed to absolute measurements. After Ripple and Beschta (2004a).

STUDENT INSTRUCTIONS for Set #1 (students1.html)

Student Instructions

In 2001 Robert Beschta sampled the cottonwood population in a 9.5 km^2 study area in the Lamar Valley of Yellowstone National Park. He was interested in measuring first hand a phenomenon that informal observers had noted for several decades: that there had been little to no cottonwood c a (c a d c o trees ≥ 5 cm in diameter). Dr. Beschta was also very interested in trying to explain this lack of recruitment by looking for links between the cottonwoods and a variety of environmental factors.

In order to address these issues, he identified and measured the diameter of all the cottonwood trees (≥ 5 cm diameter) within the study area (700 trees!). About half of the cottonwoods were a d ca d ba d a b d (a d) Lamar River. The other half grew in small, open groves spread across the river floodplain. Because cottonwoods are both obligate riparian and early successional species, they rely on the dynamic nature of river systems to insure their survival and reproductive success. Seedlings usually become established in the early summer or late spring after high spring run-off waters have receded, leaving behind freshly scoured surfaces and fresh sediment on meander point bars and in the floodplain where seeds germinate best (Beschta 2003). By measuring the diameter of trees, and correlating size with tree age, Dr. Beschta was able to reconstruct approximate establishment dates for cottonwoods, to address whether there had in fact been a gap in tree recruitment.

If there *was* a gap in tree recruitment, he needed to know when it was occurring were seedlings becoming established, or not? So during the 2001 field season, Beschta also measured seedling density in 5 sub-plots (2 x 30 m). Seedlings ranged from 10-60 cm tall, and were 1-5 years old. Density ranged from ~4,000-70,000 seedlings per hectare.

Robert Beschta and his colleague William Ripple have looked for similar trends among other riparian tree and shrub species in the Greater Yellowstone Ecosystem. Willows are the other major streamside woody plant species in this region, and they grow on similar sites and under similar conditions to those preferred by cottonwoods. But unlike cottonwood trees, whose size can be used to infer age, willows are shrubs with multiple side branches and growing shoots (ad) a ca -sprout from the root stock over and over again. Because of this difference, willow recruitment could not be measured as it was for the cottonwoods, but willow abundance and relative vigor could be assessed by making density and height measurements in the field. These measurements were then compared with qualitative evidence of willow abundance from historical photographs, records and field measurements. The authors were able to use these estimates to re-construct a general model of the history of willow growth and decline in the Yellowstone region during the 20th century.

Based on the data presented here, what was the pattern of growth and recruitment in woody riparian vegetation for stream valleys in the Greater Yellowstone region during the 20th century? With a partner, use the Step One-Step Two approach, described below, to interpret the results shown from the studies of Beschta (2003) and Ripple and Beschta (2004a)

- **Step One:** Describe the graphs and what they show. Make sure you understand how the figures are set up, what the axes show, and what information is depicted. Carefully describe the overall patterns in the data, and make comparisons between the two figures.

- **Step Two:** Try to interpret the data. What do they tell you about the history of woody vegetation establishment in the Yellowstone region? Do both figures tell a similar story? What information is missing from these figures? Why is the expected distribution of cottonwood trees in Fig. 1-1 shown as a swathe as opposed to a single line? How do you suppose the researchers were able to predict the expected number of trees (Fig. 1-1) and tall willows (Fig. 1-2)?

Be prepared to explain the graphs and your conclusions from them to the class.

Once the class has agreed on a general interpretation of the figures, return to your partner and work together to generate (and write down) at least two testable hypotheses that could explain the patterns shown in the figures. Be prepared to share your hypotheses with the rest of the class. You may also be instructed to turn in your hypotheses along with a brief explanation of why each one presents a viable explanation for the observed patterns.

NOTES TO FACULTY for Set #1 (faculty1.html)

Faculty Notes

This exercise is appropriate for sophomore to junior-level biology or environmental studies students with at least introductory knowledge of ecological principles such as food webs, predator-prey interactions and population dynamics, and with some experience interpreting graphs.

The "Step One-Step Two" approach is explained in the "Interpreting Figures and Tables" essay. As the essay explains, students often have difficulty interpreting figures because they do not realize that understanding figures takes time. This approach slows them down and requires them to pay attention to axes and other aspects of a figure.

Students should either read the background material, b a - c a the setting and background for the issue, and then work in pairs to interpret the figures. They should be able to recognize that the graphs show a significant decline in woody vegetation recruitment (for cottonwoods) and growth (for willows), starting as early as 1930 , d by a release of seedlings and an increase in willow height around 2001. (*Note:* In Figure 1-1 you might need to point out the black bar on the right hand side that indicates seedling abundance, and make sure students realize it is on a different scale.) They should also note that the observed distribution of cottonwood age classes is quite different than the expected distribution. The data on willow height are more qualitative (why?), but show a similar pattern. This should get the students thinking about what could have happened during the decades since 1930 to prevent the establishment and/or survival and growth of cottonwood seedlings and willows, and what happened in (or before) 2001 to allow for the establishment of so many seedlings and the increase in average height of willows.

I suggest letting students grapple with the figures on their own for several minutes before coming back to a question and answer session with the whole group. If the instructor circulates among pairs of students, s/he will probably get a feel for what the major sticking points are for students and can then address these via discussion with the whole class. Good discussion questions the c ca c a d c , a d d m in correct and careful interpretation of the figures include the following, which address some common points of confusion for students:

- What are tree age classes, and how would you go about gathering the information to construct a figure such as this one (Figure 1-1)?
- The author did not core every tree and count its rings in order to determine tree age directly. Can you think of reasons for *not* measuring tree age directly, but doing it indirectly instead (as a function of tree diameter)?
- How did the author generate the expected distribution of tree age classes in Figure 1-1? Why is it shown as a swathe instead of a single line?
- Why would you expect numbers of trees in younger classes to increase? Why are seedlings so much more abundant than other age classes, even in the expected distribution?
- Why did Beschta keep the tree data from meander and floodplain sites separate?
- Why are the data for willows *not* based on age classes?
- Why are the willow height data qualitative instead of quantitative?
- Are qualitative data useful, or not? Should they be included in scientific research? What might be gained by using this approximate information instead of absolute, quantitative data (i.e. measurements of willow height)? (T b a a d a a way to reconstruct willow height or abundance data quantitatively for the whole 20th century as we can for cottonwood trees; but we can use other methods to draw a *general*

picture of the trends in willow abundance over this time frame, to see if it corresponds with what we know about trees in the region.)

Each instructor will have to read their class to determine how much, if any, of this large group discussion and de-briefing is needed before students are ready to move on to the next step, which is generating hypotheses to explain the trends shown in the two figures.

Students usually suggest two general categories of hypotheses (though other ideas may surface as well, and can be good fodder for discussion if time allows):

1. **climate-related** hypotheses in some form (drought, low river flows, lack of spring
   d ...), d d d d a a a
   dynamics, or how much background information you choose to give them beforehand; and

2. **browsing-related** hypotheses, given the title of this exercise, information in the *Background* section, and also the fact that the Yellowstone wolf-elk interaction has been in the news quite a bit in recent years.

You should call on some of the student pairs to write one or more of their hypotheses on the board for class discussion. The next figure set will allow them to address the two general categories of hypotheses listed above, so try to guide the class towards grouping similar hypotheses together, and possibly re-phrasing them as necessary. Each student pair should also turn in written versions of their hypotheses, to be assessed against a simple rubric such as the one included here. When the hypothesis papers are returned in the next class period, it would be a good idea to go over this rubric in detail with the students so they can learn from their mistakes and work towards writing cleaner hypotheses in the future.

<u>**Hypothesis Scoring Rubric**</u>

The Hypothesis:	focuses on one manipulated variable; is very specific, simply stated and easily testable; clearly addresses the problem; is written using a clear and consistent format (. . I T B ca).	focuses on one manipulated variable; is specific, but not crystallized into a simple statement and might not be easily tested; contains a prediction demonstrating some connection to the knowledge of the student but it is not communicated fully; is clearly (. . I T B ca).	focuses on one variable but does not provide an explanation as to why the prediction was made; addresses the problem indirectly; is expressed in confusing or unclear language (i.e. does not use I T B ca format).	does not focus on or identify a specific variable; does not address the problem or does so very indirectly; is expressed in confusing and unclear language (i.e. does not use I T B ca format).
Score:	**4**	**3**	**2**	**1**

(Adapted from http://www.eastmont206.com/ejhs/html/profile/staff/thibault/rubrics/hypothesis%20rubric.htm)