TEACHING TEAM DIRECTIONS FOR PART 2 of BCP PROJECT

NOTE: Prior to starting the discussion in the directions below, your groups should have done the following:

- ❑ (1) plotted a skeleton plot of their own core,
- ❑ (2) pattern-matched their plots with others in the group to make the group composite,
- ❑ (3) matched the group composite up with your site's SKELETON PLOT MASTER.
- ❑ (4) assigned dates to each student's own skeleton plot.

ALSO -- At some point you should **match up your 2 group composites with the SKELETON PLOT MASTER into one combined composite of both the early part of the record and the later part of the record.** Show the students how it all fits together.

Once you've done the above, proceed with the steps outlined below as you lead the discussion with your 2 combined groups (i.e., your MEGAGROUP):

IMPORTANT: When you get your 2 groups into a combined MegaGroup it is strongly suggested that you ask everyone to get up and rearrange themselves or move to another location (outside in the hall, front or back of the classroom, etc.) where they can sit in a circle so everyone can participate. (The 2 groups with a student in a wheelchair are located in the front of the classroom , so you can rearrange yourself right there.)

PART A: SITE DESCRIPTION TABLE (p 136) *(The 1st five rows of the OBSERVATION Table on the worksheet (p 136 in Class Notes) should already be filled out based on Dr H's lecture at the start of class)* - if these rows are not filled out by all students, tell the students who are lacking info that they can go to the LINK for the I-3 Assignment BCP Project in D2L under Assignments which contains Dr. H's presentation slides on the 5 sites. The info they need to fill in the top rows can be found there.

PART B: ANALYZING YOUR SITE (p 137)

- ❑ **Get your two groups together into the megagroup** and show them how the early & late parts of the record match up if you haven't already done so. – This is your **SITE COMPOSITE.**
- ❑ After this is done – once you are sure **everyone has DATES assigned to their skeleton plot**, **carefully untape the combined plots and have the students leave it in their folder**
- ❑ Now begin leading them through **PART B of the worksheet (p 137). Be sure everyone knows what site they are working on.** (Almagre, Sheep, etc.) It's **written on the Master**.
- ❑ At the start of class, you will be given 2 manila folders (one for each half of your megagroup) which contain:
  - **(1) the skeleton plot masters for all 5 sites**
  - **(2)** the **ring width indices for all 5 sites**
  - **(3) a list of major volcanic eruptions.**
- ❑ First, show them (again) the **SKELETON PLOT MASTER for your SITE only** (ignore the other 4 sites for now). You can give out the 2 copies of the skeleton plot to the students and ask them to pass them around the circle so everyone has a chance to see it.
- ❑ Then guide them through each of the **3 BOXES they need to fill in on the top half of p 137 under the heading "Data Collection & Observations from your site's SKELETON PLOT MASTER**
- ❑ Next show them the **RING WIDTH INDICES PLOT for your SITE.** Tell them this is a plot of the ACTUAL ring widths (not a skeleton plot) of your site. **Explain what ring width indices are:**

> ***Ring width indices represent departures of growth for any one year compared to average growth for the whole record. Average (normal) growth is defined as an index = 1.00. For example, an index of 0.75 for a given year indicates growth was below normal (with narrower rings) that year.***

- ❑ Point out that the indices plot covers the *entire* 1750 - present record. Then get the site group going on a discussion of what they see in the **INDICES PLOT** (trends, weird periods, narrow ring years match up to the SKELETON PLOT, etc. should be things that the students point out). **Tell them to write these observations down on the bottom half of p 137 in the section under Data Collection & Observations for your site's RING WIDTH INDICES PLOT.**
- ❑ Finally**, close out the discussion on YOUR SITE** by summarizing what the group has noticed and discovered about the site, esp. with respect to **frequency of frost rings, trends, and variations over time**.

You can also go around the group and ask them to share what they wrote in the **SITE DESCRIPTION TABLE (p 136)** so that everyone has good notes on the presentation. After this sharing, have one or two of the students who seem to be taking good notes summarize the key points for the site for the entire group -- or do it yourself.

PART C: ANALYZING SITE-TO-SITE COMPARISONS (p 138)

- **The GOAL for this section is for the students to be able to complete the last 4 rows in the TABLE on p 136 for the other 4 sites.** (These rows should already be filled out for YOUR SITE based on Part B above).
- **In your megagroup, place the ring width indices plots for the other 4 sites + the plot for your site in the center of the circle (or have students around the circle hold them up) so everyone can see all the plots at once.** (If it works better for you, since you have 2 copies of the plots, you can also organize the megagroup into 2 smaller groups.) **Compare the patterns and trends with your site. Ask the students: What are the similarities, what are the differences. What's the trend of tree growth in the 1900s?**
- Then get out the **skeleton plots for the other sites** and compare the **frequency of frost rings** at other sites with your site. Ask the students**: Do frost rings get more frequent over time or less frequent -- or is there no strong pattern at all?**

PART D: DEVELOPING & TESTING HYPOTHESES (bottom of p 138-140)

- **Please be sure you are quite familiar with PART D (Developing and Testing Hypotheses)** so you have a good feeling for how to facilitate this discussion and guide your classmates to the key points.

- For this part you will continue to use the **master skeleton plots and ring-width indices for ALL 5 SITES**. Tell the students they will also need to **refer to the Site Description Table on p 140** so they can compare the different sites in terms of location, elevation, upper forest border vs. lower forest border, vegetation density, soil depth, etc.

- **HYPOTHESIS #1 -- Answer the questions for Hypothesis #1: Trees in sites that are closer together will pattern-match and crossdate better than sits that are far apart.**

Before you start comparing, ask the students if they think the hypothesis will be supported by the data. The students should compare the California (CA) site **MASTER SKELETON PLOTS** with each other and the Colorado (CO) **MASTER SKELETON PLOTS** with each other and then compare the CA with the CO plots. They should discover that the hypothesis IS supported: the CA sites pattern match and crossdate with each other *(even Methuselah – although not quite as well),* and the CO sites pattern match and crossdate with each other **but the CA sites don't match and crossdate with the CO sites.**

Then the students are asked to **speculate on what factors** (local climate, similar species, etc.) might influence whether sites crossdate or not. Since all the sites are bristlecone pine, the reason they close sites crossdate is not because the tree species are the same. The discussion should come up with the key idea that close sites **experiencing the same local (or regional) climate will crossdate** -- but that CA and CO are so far away from each other that the climate variations are different in these two regions and hence the trees in CA won't crossdate with the trees in CO.

SOME ADDITIONAL THINGS TO DISCUSS RE: THE INDICES PLOTS:

- **You should ask them this question: Will trees in sites that are closer together -- and which crossdate -- exhibit similar variation and trends in their ring-widths (the INDICES) over time (i.e. throughout the entire length of the record.)**

Point out the **INDICES** plots for all the sites (not the skeleton plot masters) because this question is about **ring width variations over time.** ← NOTE this means "co-varying" throughout the entire length of the record, i.e. going up and down at the same time. *Before you start comparing, ask the students what they think the answer might be .* They should say **YES --** if the sites crossdate in their skeleton plots, it seems logical that the ring width trends should vary together over the entire period of the record.

Now have them **compare the indices for the 3 CA sites that crossdated** and **the 2 CO sites that crossdated**. They should notice that in the early part of the record, the CA indices vary together at the 3 sites, but that in the later part of the record, Methuselah doesn't increase in growth while Campito and Sheep do. The two CO sites vary together fairly well throughout the record, but not perfectly.

Hence the question about ring widths varying together throughout the whole period of record is **NOT supported by the CA data.** Now start a discussion on why: **Why does growth at Methuselah behave differently than Campito and Sheep?** They should eventually come up with these reasons: lower elevation of Methuselah compared to other two is influencing it's tree-growth, the upper forest border sites are more sensitive to temperature and the lower forest border (Methuselah) to precipitation, etc. Just try to get them thinking critically about the problem and help them summarize a few key points.

Now on to **HYPOTHESIS #2** -- NOTE: At the beginning of class I will have given a short overview of the goals of the BCP Project. To prepare students for the discussion of Hypothesis #2, in that overview I will:

(1) show a slide of the **Global Temperature curve** which shows warming beginning in the mid 1800s, and escalating in the late 1900s. You can see graphs showing this warming on pp 27 -29 in Class Notes and in Fig 1-4 in SGC-Kump. You should also have the students look at the graphs on p 78 in Class Notes which go way back in time.

(2) explain the concept of **CO_2 fertilization** (def*) "an increase in the growth rate of plants by the addition of CO_2 to the atmosphere".* To make this connection, I will remind the students about the process of **photosynthesis** (def) "*the process by which an organism such as a green plant uses sunlight, carbon dioxide, and water to produce organic matter and oxygen."* $CO_2 + H_2O$ + solar energy $\rightarrow$ $C_6H_{12}O_6 + O_2$ (see p 46 in SGC-Hobson; if necessary, you can refer students to p 104 in Class Notes)

- **HYPOTHESIS #2** -- Next the worksheet presents a hypothesis that scientists have proposed to explain the prominent increasing trend in tree growth in the 1900s that shows up at most (but not all) of the sites: **Hypothesis #2: The increasing growth trend in the 1900s is evidence of a local (at a site) or a regional (throughout the American West) temperature response to the Northern Hemisphere (N.H.) / Global warming trend. (NOTE: the N.H. / Global trend is observed when temperature records around the globe are averaged together).** <= this states Hypothesis #2 a tad better than what's written on p 139 – It may help to clarify what's meant by local vs regional and where the N.H. temperature graph comes from.– so read this version to the students.

Point out that *it is possible* that either **a local or a regional growth response** (i.e., . a "growth spurt") *might* be evidence of a **global warming temperature trend**, but that **the students can't test this hypothesis without having additional data.** Then ask them to speculate on what data they would need to properly test the hypotheses. They should come up with ideas like:

-- Get some local temperature data near the sites with the growth spurt and see if the local temperature increases at the same time as the ring widths; then see if the local temperature data has the same trend as the Northern Hemisphere global warming trend. NOTE: even if the growth spurt, the local temperature, and the global temperature **all co-vary (vary together and show the same trend)**, the only thing that has been demonstrated is a **correlation** (an *association* between the variables of global warming, local warming, and a site-specific growth spurt), but **NOT** a **cause-and-effect relationship** that proves global warming caused the growth spurt.

-- Another suggestion would be to probe why the Methuselah site does NOT show the growth spurt: Get some local temperature data near the site without the growth spurt and see if the temperature increases or decreases, even though the ring-widths do not. If the temperature increases, but the ring widths do not, then this may say something about the lack of influence of global temperature.

-- To probe the reasons for growth trends further, ask what other kinds of data could be collected: some possibilities: **precipitation, solar radiation, cloudiness, evaporation, winds, etc**.

– If no one comes up with it, suggest that we could even measure the **amount of CO_2 in the local environment** where the trees are growing. Remind them of **CO_2 fertilization** and that CO_2 levels have increased dramatically in recent decade – could this be the direct cause of the recent growth spurt? If so, why is the growth spurt observed at some sites and not others? More complexity!

To warp this section up, emphasize that there **are many variables** that could explain a growth spurt – or the lack of one – and that only a really intensive field experiment could begin to answer the question of what might be causing this recent increase in growth at some of the sites. **Although students will want to know what the "right" answer is -- tell them that these are difficult research challenges that scientists are still in the process of analyzing -- i.e., cutting edge research.** BUT also tell them that **the convergence of evidence** from many local and regional field studies combined with theoretical and model results is the best way scientists will be able to get closer to defining cause and effect in local and regional responses to observed global warming.

- **HYPOTHESIS #3** The last part of PART D is for the students to develop their own hypothesis (Hypothesis #3) about **frost rings** in the trees at the study sites and how the frost ring frequency might be expected to change under warmer conditions. *(Remember, the frost rings are plotted on the **master skeleton plots,** so use these in your hypothesis testing.)*

- **Answer the question for Hypothesis #3 (your own hypothesis)**

Here they should be able to come up with some sort of simple hypothesis statement that can actually be tested with the data at hand. (**Tell them to look at Hypothesis #1 as a "model" for how to express a simple and testable hypothesis is words.)**

They should be able to come up with something like:

> *Hypothesis #3: More frost rings will occur at higher elevation sites where temperatures are colder & the growing season is shorter than at lower elevation sites where temperatures are warmer and he growing season is longer.*
>
> This one is easily testable with the data at hand and they should discover that it's true -- the lowest elevation site, Methuselah has fewer frost rings than the higher elevation site.
>
> Have them test it and discuss reasons why it might be true or not true.

Another possible hypothesis:

> *If the warmer temperatures are causing the post-1900 growth spurt at the high elevation sites, then the frequency of frost rings should be less after 1900 than before.*
> (Note that to be valid, they should compare a pre-1900 period of the same length as the post-1900period)
>
> They will be able to test this to see that the frequency of frost rings does decrease in the 1900s at the high elevation sites. However, since this hypothesis also assumes a dependence on temperature, to REALLY test it, some additional temperature data would be needed. Have them test this and discuss reasons why it might be true or not true.
>
> At some point hopefully someone will bring up the volcano-frost ring connection and suggest that maybe the frequency of climatically effective volcanic eruptions has decreased over time. You could then point out that there are no frost rings after the 2 most recent big eruptions (El Chichon in 1982 and Pinatubo in 1991). Why might this be? We're not sure, but one explanation might be because that due to recent regional or global warming, the cooling effect of the eruptions was not as effective as in the past and didn't result in frost rings.

As long as the students are thinking critically and drawing logical conclusions about the basic information that's been given to them, they should be ok. **Keep reminding them that the only data they have to test their hypothesis are: (1) skeleton plot masters w/ dates of frost rings on them and (2) ring with indices – NO temperature data! They also have a list of major eruptions with dates. Be sure you have them write something in the box on the bottom of p 139 and the very important box about "Explanations" on p 140.**

Once you get through Hypothesis #3, you are DONE!

The explanation of what needs to be done for I-3 (20 pts) is posted online under ASSIGNMENTS.