

World plant and ecophysiological diversity

Introduction

For the first lab this semester we're going to take a tour around the botanical garden. While on our walk we will explore some of the plant diversity from different parts of the world and how the forms and physiology of these plants are related to the regional climates. During the coming months in lecture and lab you will learn in some detail the many physiological traits we discuss today and how they are measured. Our goal today, while on our "botanical tour," is to introduce you to how ecophysiologicalists view the world. We will examine many different types of plants, discuss the environments in which they are found and also to point out some global patterns in physiological and morphological traits. In addition to setting the stage for the coming lectures and labs, today provides you with the opportunity to look at some species/communities that you may choose to look at in greater detail for your projects during the second half of the semester.

PART 1:

Climate Diagrams

Climate diagrams are a graphical way of summarizing *average* climate data. Climate diagrams plot precipitation and temperature on a monthly basis and note periods of drought and excessive precipitation (Figure 1). Temperature is strongly correlated with potential evaporation (PE) and therefore climate diagrams can be thought of as representing the balance between when there is enough water versus when there is a deficit of water. When monthly precipitation exceeds PE, the soil is being recharged with water or there is run-off. When monthly precipitation is less than PE, plants must use stored water or face water deficits. Since plants require both water and warm temperatures to grow, looking at climate diagrams can also tell you in what months plants are most likely to grow in a given environment and what physiological stresses they face during the growing season (Figure 2).

To think about:

1. What potentially interesting information is not included in a climate diagram?
2. At first glance, could a climate diagram tell you about which plant types inhabit a given climatic zone? Why?

During this course we will often bring up examples of physiological or morphological traits that are adaptations to a certain set of environmental conditions. These adaptations differ between environments because each climatic zone imposes functional constraints (i.e. stresses) plants in different ways. Therefore, certain physiological or morphological traits might exist in some climatic zones but not in others (e.g., succulent stems in many desert plants).

Garden Tour

The UC Botanical Garden is an excellent resource available to both the university and the general public. Plants are all collected from the field and have a known collection history. Each plant is marked by a small metal tag on which is written the collection year, the scientific name, the common name, and the family. The botanical garden is organized by world regions and is

FIGURE 1: CLIMATE DIAGRAMS

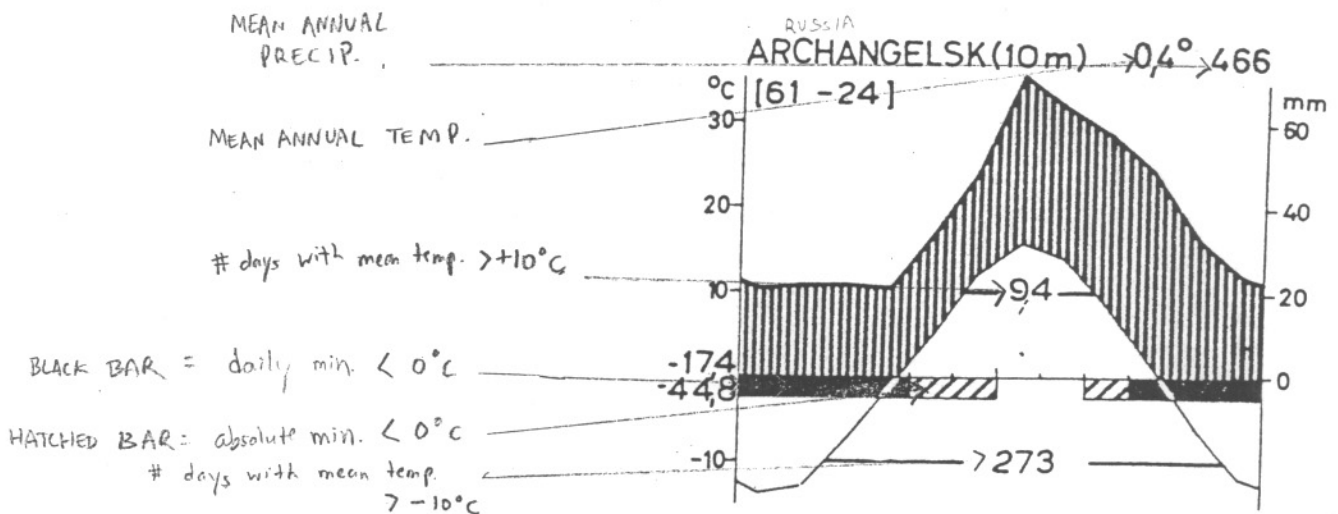
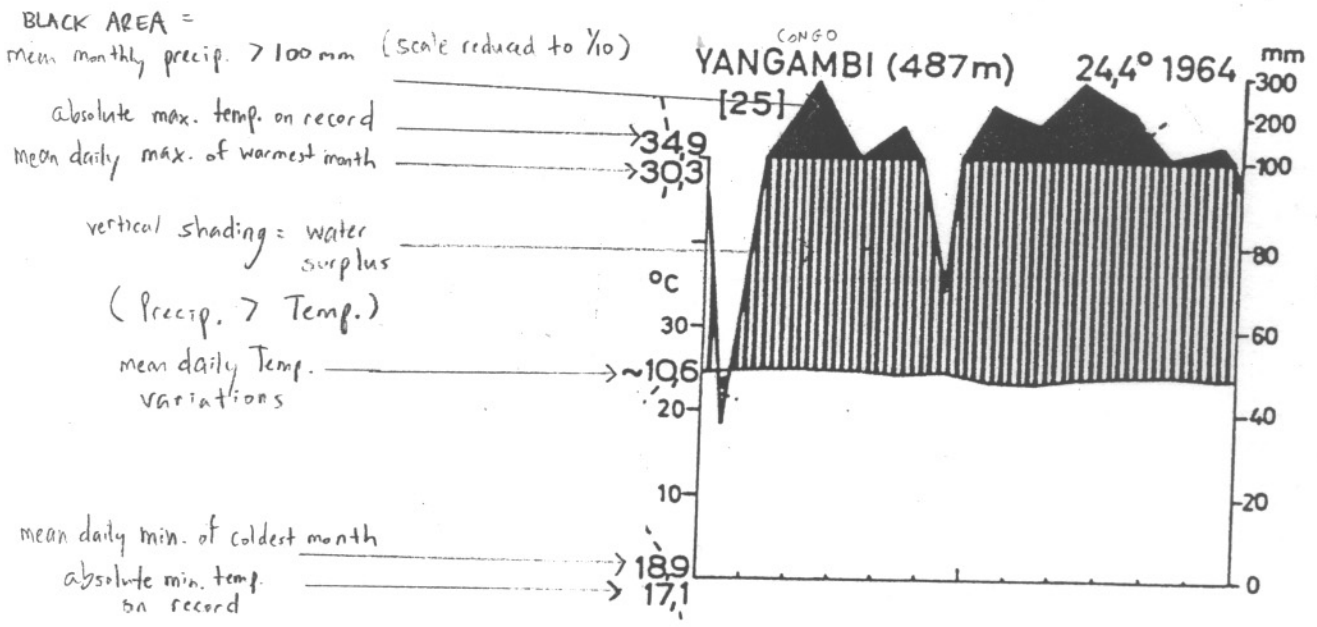
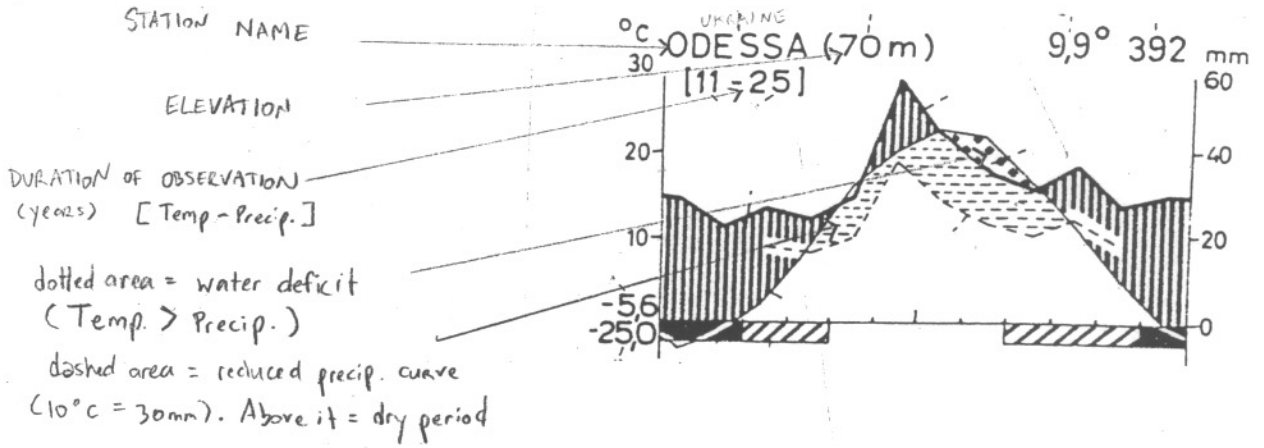


FIGURE 2

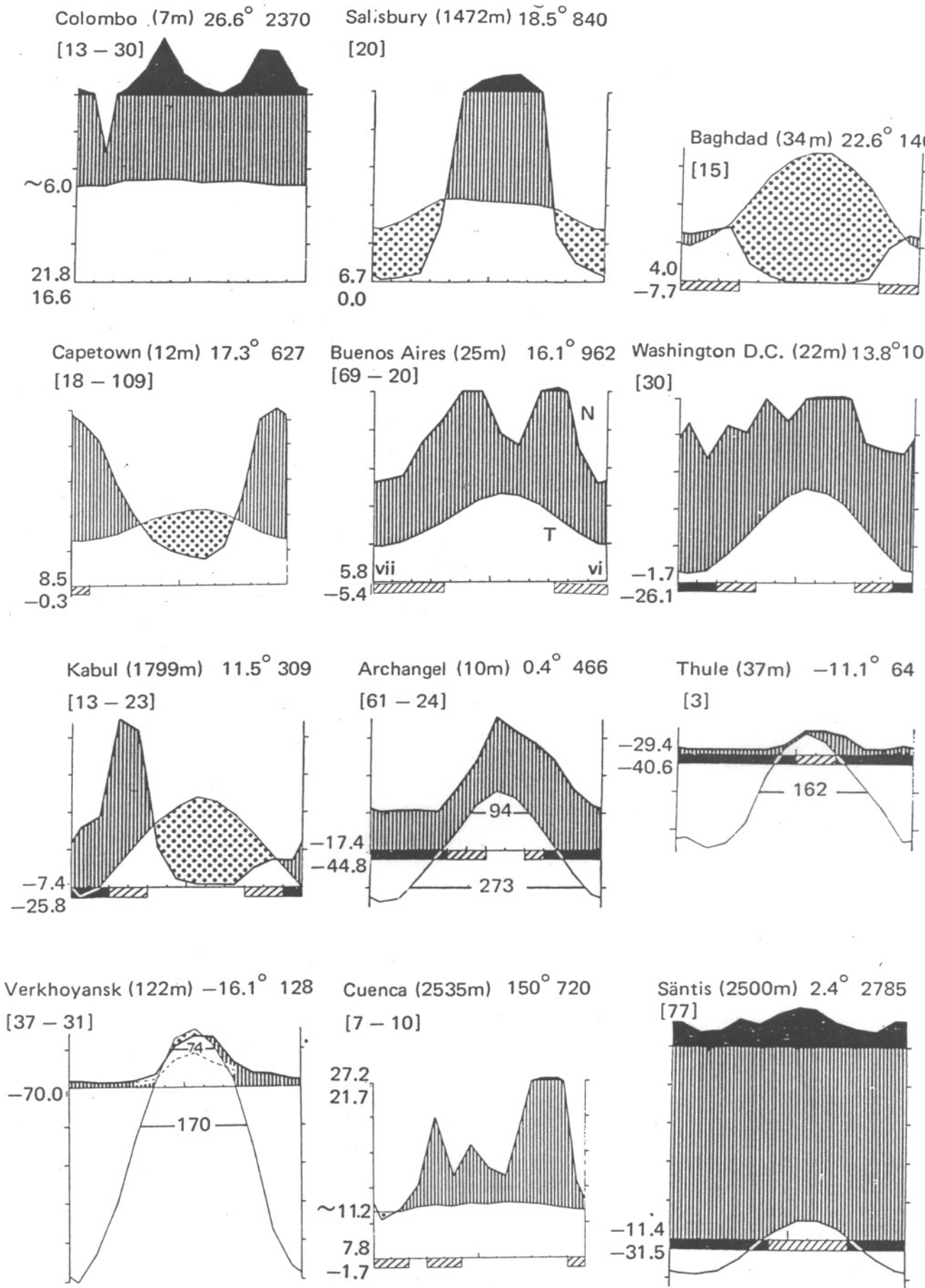


Fig. 8. Typical climatic diagrams for the climatic zones I—X. I Colombo, II Salisbury, III Baghdad, IV Cape Town, V Buenos Aires, VI Washington (see also Fig. 7 Hohenheim near Stuttgart), VII Kabul (see also Fig. 7, Ankara and Odessa), VIII Archangel, IX Thule (Iceland), VIII dry (IX) Verchojansk (Siberia), X (I—II) Cuenca in Ecuador, X (V) Säntis (Alps).

→ actually Greenland

therefore ideal for examining general vegetation patterns in different climates. Today we only have time to visit a small section of the gardens, but encourage you to return here on your own to look at plants from additional climatic zones.

To think about:

As we walk around the garden keep the following questions in mind:

1. Based on climate diagrams, what climatic factors might be most important in driving plant physiological characteristics in each climate?
2. What physiological traits are most important to plant success in each climate?
3. Is morphological convergence indicative of physiological convergence?

Stop 1: Chaparral (California)

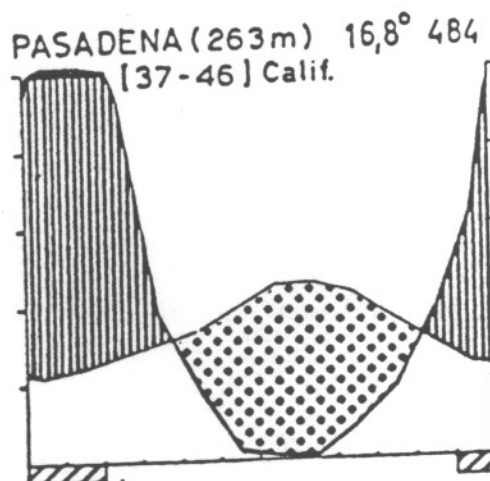
California's chaparral is a classic Mediterranean ecosystem. A Mediterranean climate is defined by hot, dry summers and mild, wet winters (Fig. 4). Much of California falls within this climatic zone and although rainfall and temperature vary across the state the climate diagrams are very similar (Fig. 3). Plants are most photosynthetically active in late winter and spring when days are longer, temperatures are warmer and there is still sufficient moisture available. During the summers plants either become dormant, die, reduce radiation at the leaf surface via varied adaptations, and/or must be able to photosynthesize when little water is available. Adaptations that allow a plant to continue photosynthesis in the hot, dry summer environment include small leaves, leaf hairs to reflect excess radiation, thick leaves to reduce the surface area to volume ratio, and vertical leaf orientation. Fire is a frequent disturbance in the chaparral, and many species have evolved to benefit from fire. Closed-cone pine trees (e.g. *Pinus radiata*) have cones that are glued shut with resins that melt in the fire. Other species have wood with explosive resins, to promote fire. The seeds of these species then germinate in a guaranteed high light environment.

Common species: *Salvia* spp. (sage), *Ceanothus* spp., *Arctoptaphylos* spp. (manzanita), *Rhus* spp., *Simmondsia* (jojoba)

To think about:

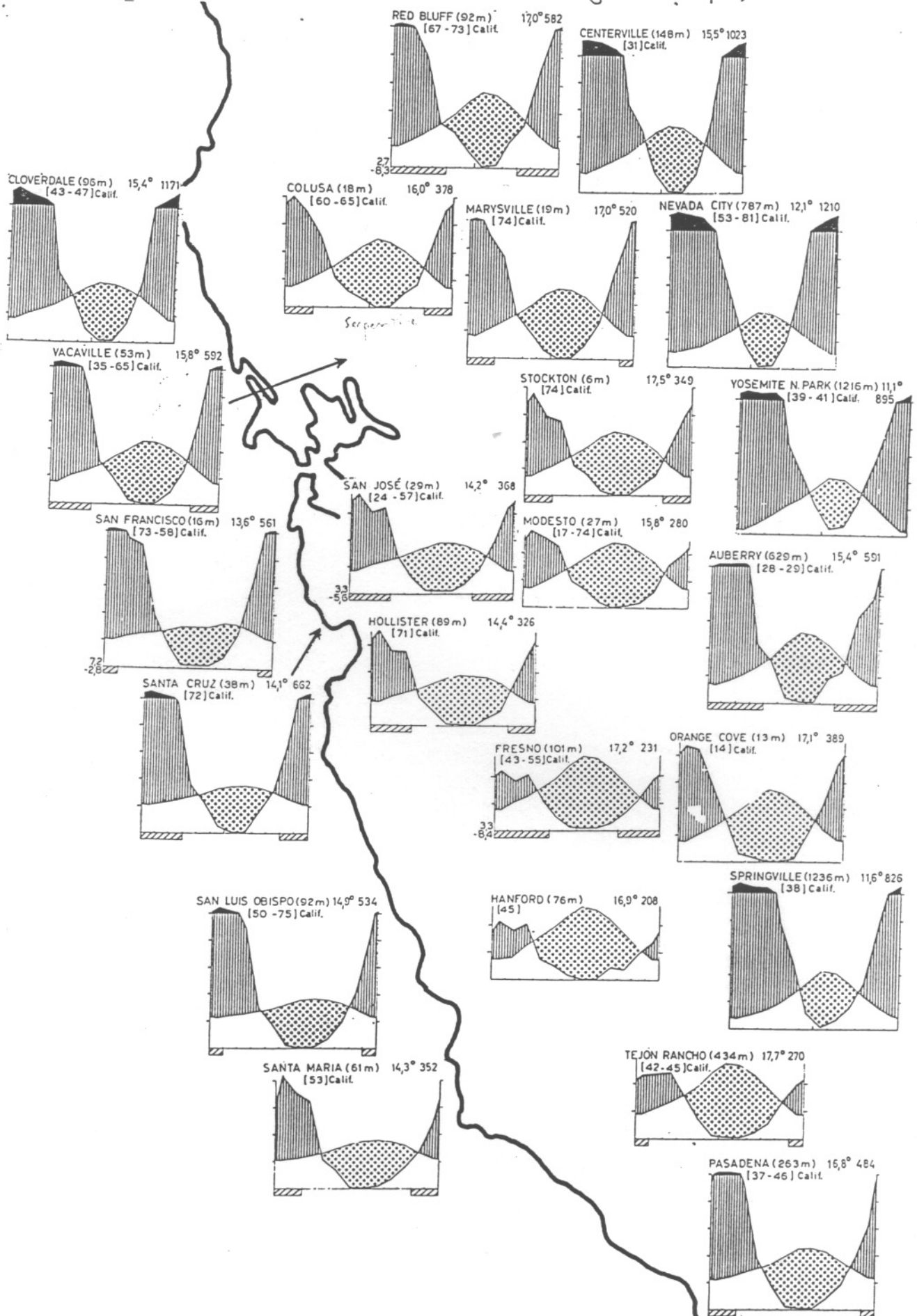
1. What sorts of stresses do you expect chaparral species to experience?
2. Do you expect variation in stress response between life forms (e.g. herbs, shrubs, trees etc.)? Why? What would you guess these differences are?
3. Based on Figure 3, how do the climate diagrams vary from east to west and north to south in California? What do these changes indicate? How would these changes affect plants growing in these ecosystems?

Fig. A



Thornthwaite and Mather Climate Diagrams (California Climate Diagrams)

FIGURE 3:



PART 2:

For the next section of the lab we will break up into three groups and explore habitats intensively. Each group will be given 5 - 10 minutes to walk around the habitat to which they are assigned and note down as many of the potential adaptations to the environment they can come up with. We suggest you wander through the area (on the paths) to first note similarities between the plants and then note specific examples of adaptations you think may be important.

Following this exploratory period, the groups will come together each group will teach the others about their assigned ecosystem and the approached plants take in dealing with the adverse environment. Below is a list of potential characters that plants can alter as adaptations to their environments. Peruse the list before setting out to look at the plants.

leaf size
leaf shape
cuticle thickness
leaf hairiness
leaf angle
leaf thickness
leaf color
deciduousness
life form
rooting depth
water storage
density of wood
vessel size
sunken stomata
stature
surface of leaf with stomata
hyperaccumulation of metals
root to shoot ratio
water use efficiency
leaf area
which part of the plant is photosynthetic
photosynthetic pathway (CAM, C3, C4)

Stop 2: Serpentine (California)

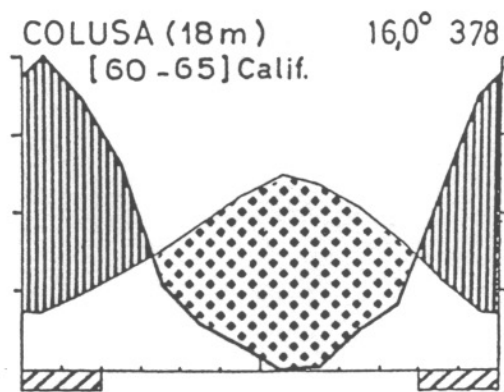
This serpentine community is a specialized subset of the chaparral community (Figure 5). Serpentine rock occurs throughout the world, including large outcrops in California. This ultramafic rock presents a unique and stressful environment for plants. Serpentine has high concentrations of toxic metals, a low Ca:Mg ratio, and forms a shallow, coarse soil. This soil texture results in the rapid drainage of water producing extremely dry soils in upland areas and moist seeps in valleys. This set of conditions has resulted in many endemic species (e.g. *Cupressus sargentii* and *Quercus durata*). Other species, termed serpentine indicator species, occur both on and off serpentine, but are usually indicative of poor soil quality. (e.g. *Pinus jeffreyi* and *Callocedrus decurrens*)

Common species: Eriogonum sps., *Streptanthus* sps., *Arctostaphylos* sps., *Cupressus sargentii*, *Quercus durata*

To think about:

1. What plant physiological and morphological traits do you expect to be similar and dissimilar to the chaparral?
2. Do you expect serpentine species worldwide to look like California serpentine species?
3. Do you expect competition for water to be higher or lower than in the chaparral?

figure 5.



Stop 3: Alpine (California)

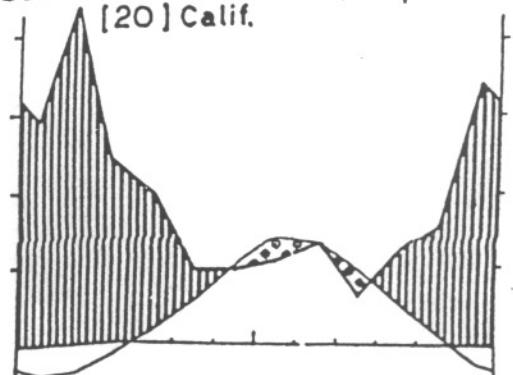
Defined by its lack of trees, the alpine zone is generally characterized by low growing perennial herbs and shrubs. The California alpine zone has a modified Mediterranean climate (Figure 6, but note that this is for a montane, not alpine, environment). The Sierra Nevada, in eastern California, still experiences wet winters and hot, dry summers, but the precipitation falls primarily as snow. The growing season is short, especially where snowbanks can linger into July. In most alpine zones temperatures are low during the growing season and moisture is not limiting. This generalization does not fit for the Sierra Nevada. Surface temperatures can exceed 80°F on a warm summer afternoon, there is little cloud cover, and plants can receive no rain for over a month in mid-summer. In addition the plants are subjected to desiccating winds.

Common species: Eriogonum sps., *Ivesia* sps., *Phlox* sps., Asteraceae

To think about:

1. What morphological and physiological features do you expect to find in all alpine plants?
2. What unique morphological and physiological features do you expect Sierran alpine plants to display?
3. How does the alpine growing season differ from that in other parts of California?

Figure 6.
SOUTH LAKE (2940m) 4,3° 454
[20] Calif.



Stop 4A: Deserts (New World)

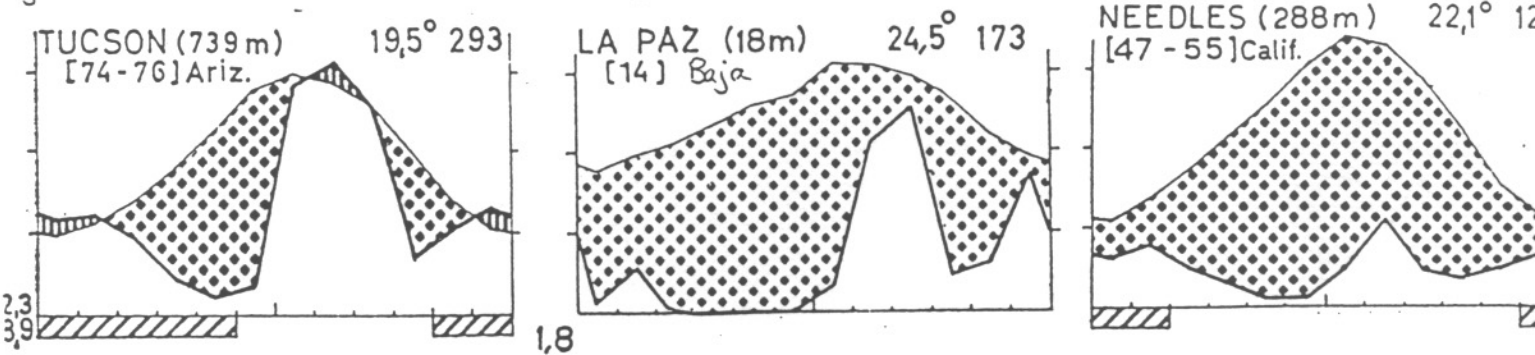
Desert environments experience nearly constant water deficit (Figures 7, 8) and most deserts are also characterized by hot temperatures. Water tables, soil water present all year round, are often the only source of water during the long dry season. However the water table is often very deep. Plants are not only confronted with dry soils but very strong leaf to air humidity gradients (known as vapor pressure deficits). Thus leaves must strain to prevent water loss through stomata as well as through the cuticle. Nights, however, provide a reprieve from the intense gradient of leaf to air humidity. Deserts in the Southwest of the United States are found in the monsoon belt and thus often receive huge amounts of precipitation in the summer which can result in flash flooding (see Fig. 7 Tucson). Additionally, light levels are often very high, forcing plants to protect themselves from leaf damage through intense leaf temperatures and high UV loads.

Common species: Cactaceae, Agave sps., Yucca sps

To think about:

1. In leafless desert plants, what part of the plant now carries out the function leaves have in “typical” plants?
2. What morphological and physiological changes do you think accompany the loss of leaves in many desert plants?
3. What other life history strategies might be common in desert plants?

Figure 7.



Stop 4B: Deserts (Old World)

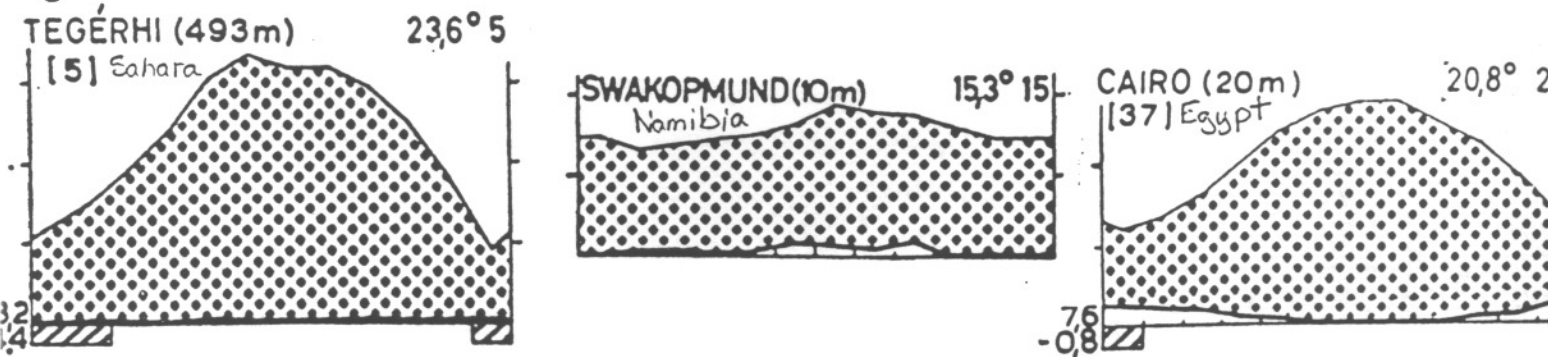
Environments are similar in Old World and New World deserts with high light loads and high leaf temperatures coupled with extreme water deficit. In fact, some areas in the Sahara never receive precipitation as rain. Rather they receive all their water input as dew in the morning (see Fig. 8, Tegérhi). Due to the similarity of the environments, you may expect the adaptations the plants adopt may be rather similar (and they are). Pay close attention to similarities you find between the plants in the two areas but in particular make sure to note down the family the plants are from.

Common species: Euphorbiaceae, *Aloe* sps., *Mesembryanthemum* sps.

To think about:

1. Why do you expect to see functional convergence?
2. Aloes (and *Agave* and *Yucca* species) have stomates at their leaf bases. Why is this an advantage?
3. Are their climatic differences between the new world and old world deserts?

figure 8.



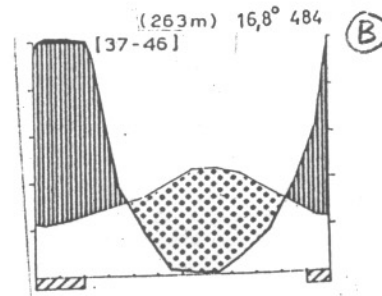
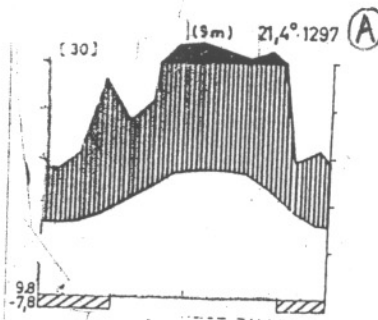
Lab 1: Exercise
Due Tuesday 1/28/03, 1 pm

The purpose of this exercise is to increase your familiarity with climate diagrams. Please refer to the handout for Lab 1 for help understanding climate diagrams. Your task is to determine which of the pair of climate diagrams corresponds to which of the two cities listed for each pair. The climate diagrams are paired by city name.

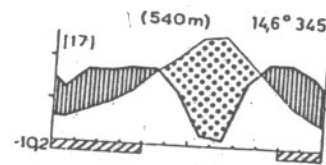
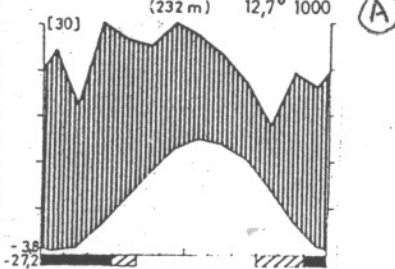
For each of **FOUR OUT OF SIX** pairs, provide **FOUR** reasons why you decided A was City X and B was City Y. You should try to provide quantitative and descriptive responses. For example, the response "Diagram A is in France and B in Texas as diagram B has an absolute minimum temperature of -10.2 versus -27.2 for diagram A" is a far preferable to "diagram B is hotter." Over all your responses, try to make use of as much of the information included in the diagrams as possible.

1. Hollywood, California & Hollywood, Florida?
2. Toledo, Spain & Toledo, Ohio?
3. Portland, Oregon & Portland, Maine?
4. San José, Costa Rica & San José, California?
5. Kingston, Jamaica & Kingston, Rhode Island?
6. Paris, Texas & Paris, France?

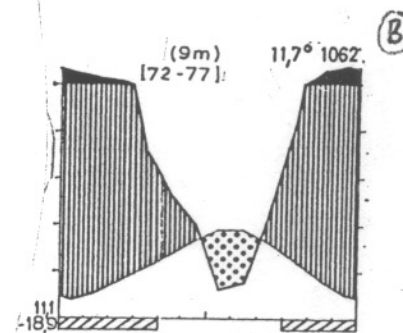
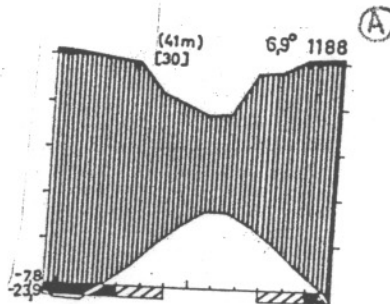
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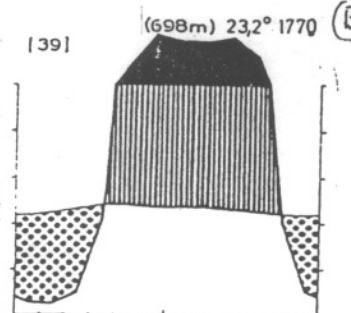
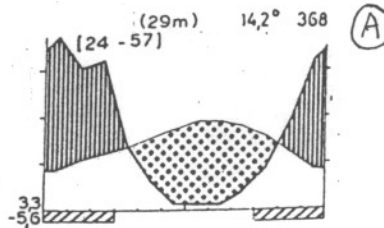
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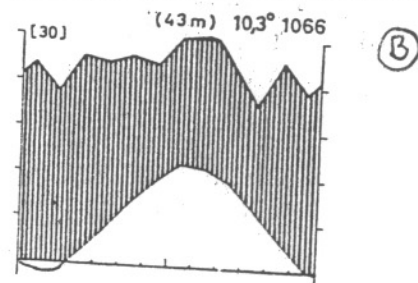
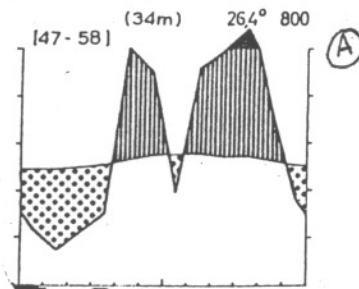
3.



4.



5.



6.

