Page 156

Each time I hike through the Wasatch Mountains, I cannot help but be impressed by the diverse vegetation types. In particular, as I hike up Big Cottonwood Canyon in the Wasatch Mountains, beginning at the mouth of the canyon and ending up at Brighton, I notice that there are distinct elevation zones that characterize the distribution limits of most if not all tree species. There are some clear patterns regarding the lower elevation at which a tree species first occurs and upper elevation at which that tree species disappears from the vegetation.

One strange but consistent observation that I have made is that the elevation at which a tree species first occurs on the south-facing slope is not the same as where that tree species first appears on the north-facing slope. Similarly, at the upper distribution limits, the trees disappear from the vegetation at different elevations. These observations suggest that factors other than elevation alone may be important in determining plant distribution. Moreover, I noticed a general trend for the leaf area of a given tree species to be lower at the lower distribution limits than in the mid-range elevation for that tree species.

Yet one more thing continues to puzzle me. As I hike over Guardman's Pass and make my way onto the east side of the Wasatch Mountains towards my home in Wanship, I notice that the relationships between tree distribution and elevation are slightly but consistently different. I will leave it for a future date to figure out this oddity. I know that there must a good explanation, because my cousin Wilford always says that there are strong relationships between climate and plant distribution.

I recorded observations of plant distributions for a few key species in Big Cottonwood Canyon below.

Species	Lower distribution limit (m) on north-facing slope	Lower distribution limit (m) on south-facing slope	Upper distribution limit (m) on north-facing slope	Upper distribution limit (m) on south-facing slope
Abies concolor	1,685	1,875	2,220	2,450
Abies lasiocarpa	2,050	2,250	no upper limit in canyon	no upper limit in canyon
Pseudotsuga menziesii	1,870	2,130	2,195	2,460

Go to page **Exam 1 data starter (/exam-1-data.html)** **156 (/page-156.html)** **157 (/page-157.html)** **158 (/page-158.html)** **159 (/page-159.html)** **160 (/page-160.html)** **161 (/page-161.html)** **162 (/page-162.html)** **163 (/page-163.html)** **164 (/page-164.html)**

Page 157

I thought that these tree-distribution patterns might be related to precipitation and so I went to the weather station records and recorded long-term precipitation data for a number of locations in the central Wasatch Mountains (recorded below). You see, I thought that precipitation amount might possibly be related to elevation. I even found a few climate diagrams for key cities at the base of the mountains as well within the Wasatch Mountain Range. It took me a while, but now I realize that there are clear distinct precipitation patterns with elevation. Hmm, I'll bet that these data even explain why the snow is generally deeper at the Alta Ski Resort (front side) than at the Park City Ski Resort (back side).

Location	Elevation (m)	East or west side of central Wasatch Mountains	Mean annual precipitation (mm)
Park City	2,136	east	481
Salt Lake City	1,290	west	415
Park City Summit	2,810	east	677
Wanship	1,800	east	418
Red Butte #2	1,650	west	580
Red Butte #4	1,890	west	720
Red Bute #6	2,195	west	880
Brighton	2,640	west	1,108
Coalville	1,682	east	392

Given this, I went back to my lecture notes and found a possible explanation for plant distributions based on potential evapotranspiration. Wow, who would ever have thought that there was a relationship between these water and plant distribution parameters. This approach even seems to explain why the tree canopy has its lowest leaf areas at the lower distribution limit. Interesting, very interesting. In fact, this is almost as exciting as going out this weekend to pick elderberries in order to make my Thanksgiving elderberry pie.

Go to page **Exam 1 data starter (/exam-1-data.html)** **156 (/page-156.html)** **157 (/page-157.html)** **158 (/page-158.html)** **159 (/page-159.html)** **160 (/page-160.html)** **161 (/page-161.html)** **162 (/page-162.html)** **163 (/page-163.html)** **164 (/page-164.html)**

Page 158

My grandson (Reisende) was recently stranded back in the eastern United States and decided to make his way back to Utah by car. That kid loves to drive and most of all to enjoy the great vegetation that the United States has to offer (The great ecologist Forrest Shreve (http://people.wku.edu/charles.smith/chronob/SHRE1878.htm) is one of his academic heroes). Reisende is so darn interested in the relationships between climate and plant distribution that he stopped along the way to record the vegetation type. When stopped (remembering safety first), Reisende used his cell phone to describe everything to me. I recorded a few of these notes below, but he talked so fast that I am not sure that I recorded everything that he said. Not only that, but the darn kid then took the time to log onto the internet and obtain a climate diagram for each of these locations. He e-mailed me some of those graphics which I have now pasted into my notebook on page 159 (/page-159.html). But the poor kid is so scatter-brained that he forgot to tell me which climate diagram is associated with which vegetation type. When will he send me the remaining climate diagrams? Well, I do know that Reisende saw the eastern deciduous forest of Tennessee, the savannas of Texas and eastern Oklahoma, the tall grass prairie of eastern Kansas, the short grass prairie of western Colorado, the coniferous forests of the Rocky Mountains in Colorado and Wyoming, and the deserts of southern Utah. Wow, what a trip.

Telephone notes

(1) Eastern deciduous forest of Tenessee: beautiful closed-canopy forests; dicotyledonous trees about 25-30 m tall; well developed understory of herbs and small shrubs; much of this area is young forest (maybe 100-200 years old)

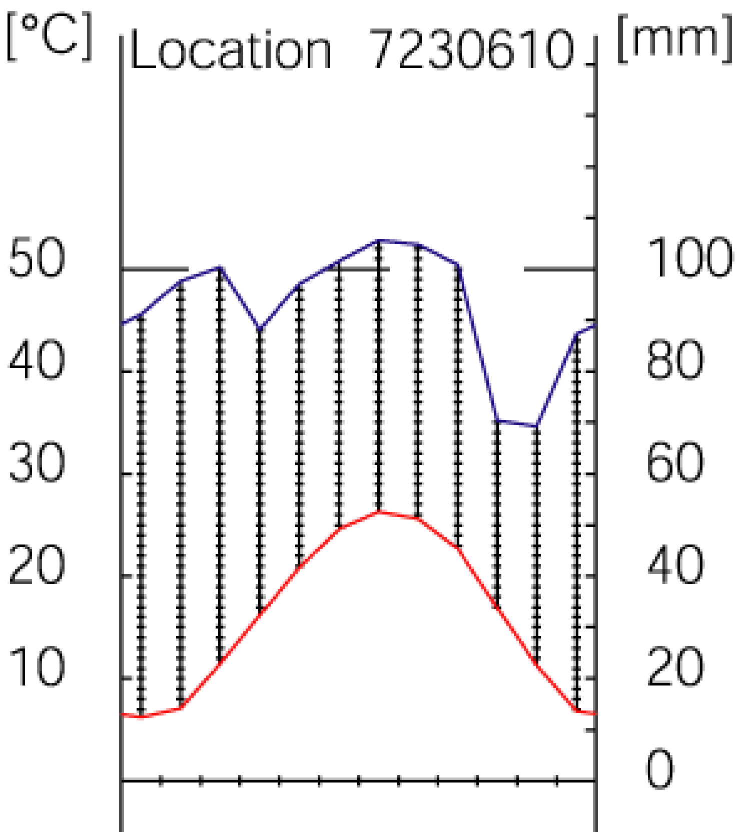
(2) Savannas of Texas: open tree landscape with grass interspersed; not the same as the typical tropical savannas such as I saw in southern Brazil last week; this area is mostly natural, but heavily grazed in some regions

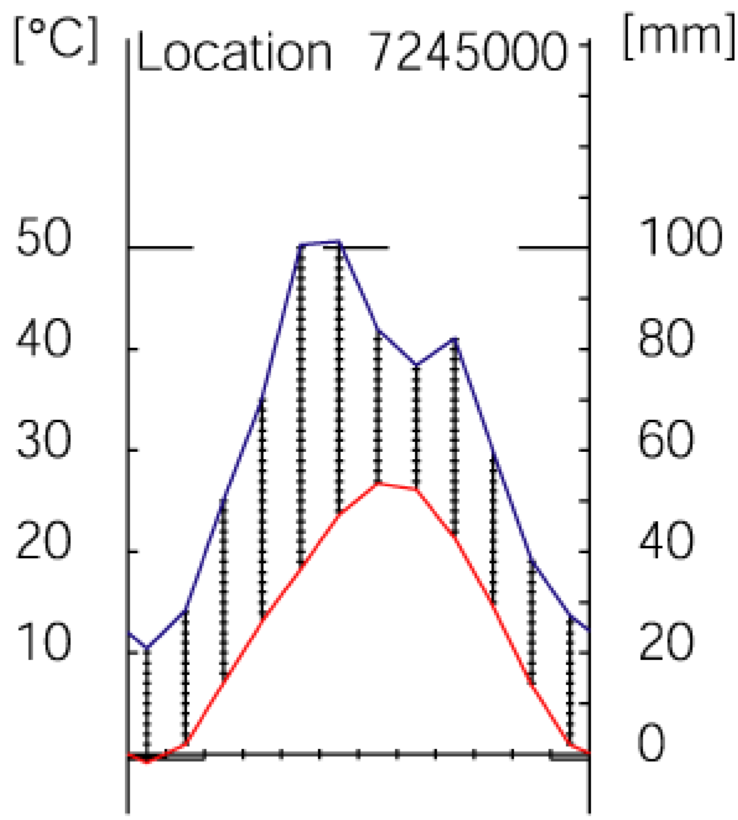
(3) Tall-grass prairie: absolutely beautiful; grassland with few dicot herbs; grasses typically 1.5 m tall; this vegetation is uncommon though because most of the region has been converted to agriculture

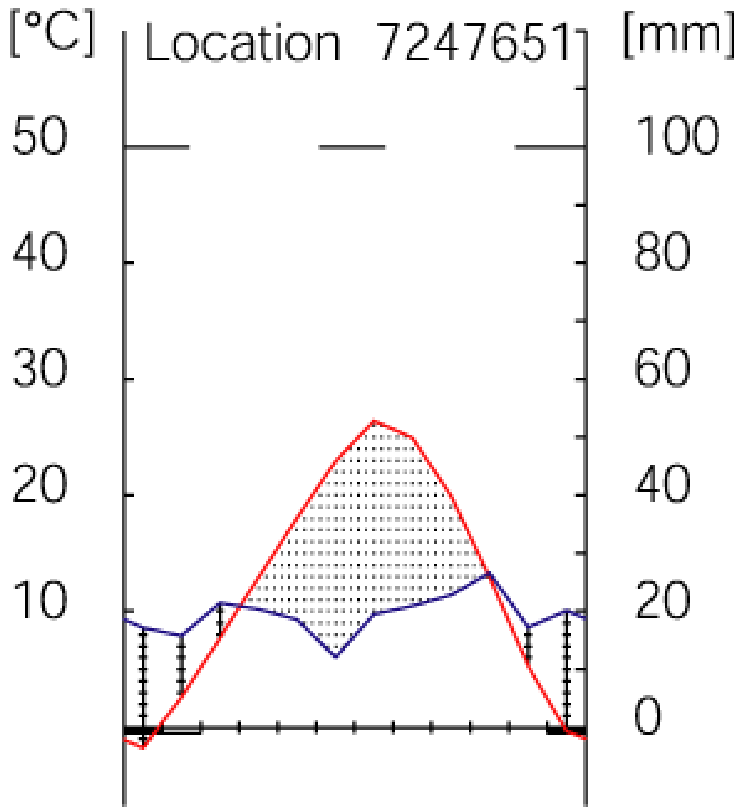
(4) Shortgrass prairie: grass dominated landscape with few dicot herbs and no shrubs visible; grasses are typically 10-30 cm tall; most of this grassland are is ocassionally grazed by cattle

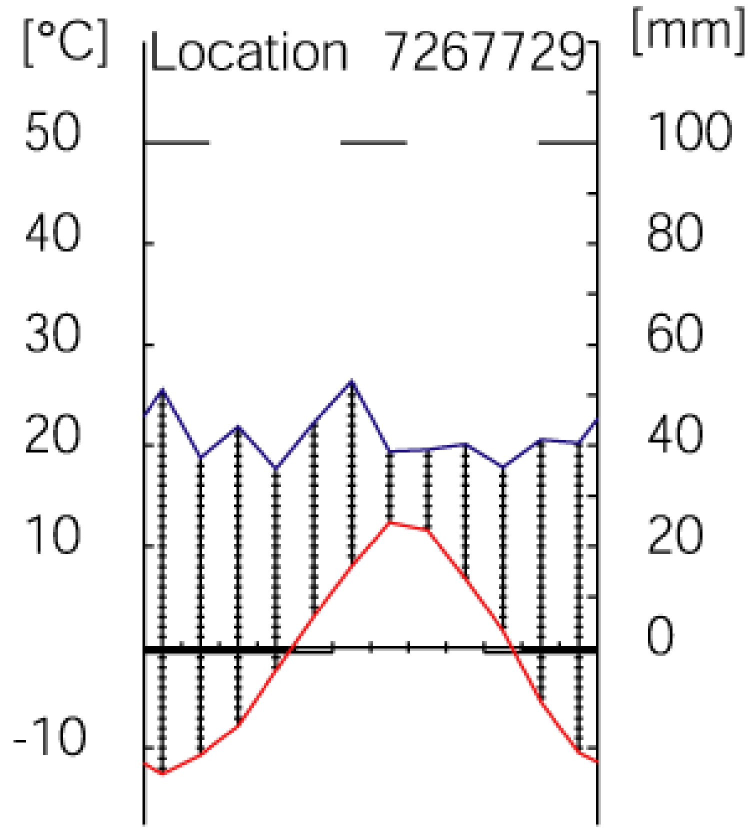
(5) Rocky Mountain coniferous forest: spectacular coniferous forest with dense, closed canopies; very limited understory vegetation development; most of this vegetation is still pristine

(6) Deserts of southern Utah: open, sparse vegetation dominated by shrubs, but with grasses interspersed; the active grasses appear to be C4 based on leaf cross section analysis using a hand lens; this regions looks like it has had limited cattle impact


[°C]
Location 7230610
[mm]
50
40
30
20
10
100
80
60
40
20
0


[°C]
Location 7245000
[mm]
50
40
30
20
10
100
80
60
40
20
0

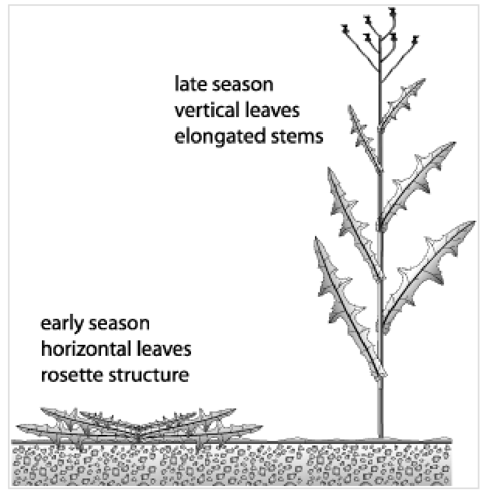




Go to page Exam 1 data starter (/exam-1-data.html) 156 (/page-156.html) 157 (/page-157.html) 158 (/page-158.html) 159 (/page-159.html) 160 (/page-160.html) 161 (/page-161.html) 162 (/page-162.html) 163 (/page-163.html) 164 (/page-164.html)

Page 160

The prickly lettuce (*Lactuca serriola*) is a common annual weed throughout most of the United States. This plant is unusual in that it has two leaf types shown below. Early in its life cyle (April-May), the plant has rossette leaves that are horizontal in their orientation. Just before flowering (June-July), the meristem bolts and the new leaves are all vertically oriented with the leaf surfaces facing in an east-west direction.



This past year several students in my class became involved in a project measuring aspects of the leaf energy balance and water loss for this plant. The students measured the leaf conductances to water vapor at midday (between 11:45 am and 12:15 pm) on clear days. To my surprise, the measured leaf conductance values were identical for both horizontal leaves early in their life cycle and even later in vertical leaves just before flowering. Well, this does intrigue me.

I have heard that this change in leaf orientation during development has an adaptive value. Well, it is indeed now clear to me why this change in orientation is useful in extending the plant's activity longer into the summer drought. This year we conducted an experiment in which we modified leaf orientation and then followed water loss, growth, and reproduction by the plant.

A detailed description of the methods we used is presented on the following page (page 161) (/page-161.html). The results of our experiments are presented on the pages following the methods description (page 162). (/page-162.html)

Page 161

Methods and Materials

To determine the effect of leaf orientation on growth and reproduction, plants of both *L. serriola serriola* and *L. serriola integrifolia* were grown outdoors in pots. The pots were constructed of 15 cm diameter PVC pipe and were 75 cm deep. The depth of the pots was sufficient to allow the plants to root naturally. Two treatments were used. Plants in the control group were allowed to grow and orient their leaves naturally. Plants in the experimental group were manipulated so that the cauline leaves were prevented from orienting vertically, east-west; emerging cauline leaves were restrained with fine wires attached to an adjacent rod. Once the leaves were fully expanded the restraints were removed since leaves would not reorient. In general the leaves of the experimental plants were forced to orient in all directions with angles of 0 - 45° from horizontal. The wires did not damage the leaves, covered an extremely small surface area of the leaves, and had no effect on leaf shape or area.

The plants were watered periodically during the course of the growing season. Each plant received the same amount of water. Water loss was monitored by weighing entire pots. To avoid damage to the plants and pots due to excessive handling, only a subset of plants (N = 7) in each of the treatments was used for these measurements.

All plants were harvested at the same time. Flower production, above-ground dry weight, and below-ground dry weight were determined. During the weeks preceding the harvest, matured seeds were harvested from flowers to determine average number of viable seeds per flower and average seed weight. Above-ground biomass included stems, leaves, and flower stems. Below-ground biomass included all root material recovered by washing roots over a 0.5 cm mesh screen. Plant material was oven dried at 60° C for 48 hours.

Go to page **Exam 1 data starter (/exam-1-data.html) 156 (/page-156.html) 157 (/page-157.html) 158 (/page-158.html) 159 (/page-159.html) 160 (/page-160.html) 161 (/page-161.html) 162 (/page-162.html) 163 (/page-163.html) 164 (/page-164.html)**

Page 162

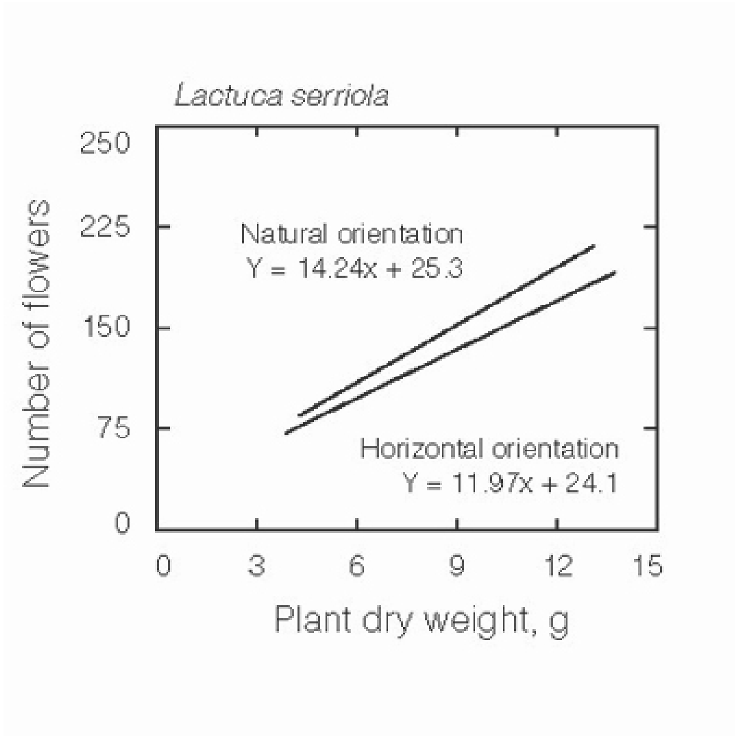
Results from the *Lactuca serriola* leaf re-orientation growth experiment are shown below. Each of the experimental measures were significantly different from the control measurements.

Parameter	**Natural cauline-leaf orientation (control plant)**	**Horizontal cauline-leaf orientation (experimental plant)**
Water loss measures		
Total daily transpiration from June 15 - July 19; units are grams of water l oss per plant per day	36.8	42.4
Total daily transpiration fromJuly 20 - July 27; units are grams of water loss per plant per day	23.4	28.9
Reproductive measures		
Number of viable seeds produced per flower	19.0	15.0
Average seed weight (mg)	0.5	0.5
Total number of flowers per plant	132.0	67.0

Go to page **Exam 1 data starter (/exam-1-data.html)** **156 (/page-156.html)** **157 (/page-157.html)** **158 (/page-158.html)** **159 (/page-159.html)** **160 (/page-160.html)** **161 (/page-161.html)** **162 (/page-162.html)** **163 (/page-163.html)** **164 (/page-164.html)**

Page 163

Now, in the *Lactuca serriola* growth and leaf re-orientation experiments, not all plants were of equal size at the end of the experiment. This may indicate that there were some genetic differences in the plants we randomly chose for these experiments. However, when we measured the relationships between reproductive output (number of flowers produced) and plant size, there were quite interesting results (see below). The "natural orientation" is our control group and the "horizontal orientation" is our experimental group. the two regression slopes are significantly different from each other.



Go to page Exam 1 data starter (/exam-1-data.html) 156 (/page-156.html) 157 (/page-157.html) 158 (/page-158.html) 159 (/page-159.html) 160 (/page-160.html) 161 (/page-161.html) 162 (/page-162.html) 163 (/page-163.html) 164 (/page-164.html)

Page 164

I just found some of the life form data that Reisende sent to me during his travels. It is amazing that the data are so clear, linking environment and life form. I am impressed that Reisende remember to use the Raunkaier classification system when describing the different life forms he observed as he traveled.

Location	Phanerophyte	Chamaephyte	Hemicryptophyte	Geophyte	Therophyte
Location 1	2%	28%	29%	10%	31%
Location 2	70%	21%	7%	1%	1%
Location 3	48%	21%	18%	9%	4%

Go to page **Exam 1 data starter (/exam-1-data.html)** **156 (/page-156.html)** **157 (/page-157.html)** **158 (/page-158.html)** **159 (/page-159.html)** **160 (/page-160.html)** **161 (/page-161.html)** **162 (/page-162.html)** **163 (/page-163.html)** **164 (/page-164.html)**