ES 106 Laboratory #7
WEATHER – OREGON CLIMATE

Introduction

Climate is the measure and description of average weather conditions for a place on the Earth's surface over time. Earth's climate system is very complex. The atmosphere, hydrosphere (mostly oceans), lithosphere, cryosphere (ice), and biosphere all contribute to Earth's climate. Understanding how all of these subsystems work is what helps scientists determine how subsystems respond to change. Oregon is a diverse place with regards to climate. The purpose of this lab is study the climate of Oregon and to focus on the major influences on Oregon's varied climate.

Goals and Objectives

- Interpret climatic data from maps, tables, and graphs
- Describe Oregon's climate based on climatic data
- Develop an understanding of the major factors influencing Oregon's climate

Name_____**KEY**_____
Lab Day/Time_____

Pre-lab Questions – Complete these questions before coming to lab.

1. Define the following terms:

   A. Orographic lifting **UPLIFT CREATED BY WIND FORCING AIR OVER A TOPOGRAPHIC BARRIER, SUCH AS A MOUNTAIN RANGE OR LIP OF A PLATEAU.**

   B. Rain shadow **DRY AREA ON THE LEE SIDE OF A MOUNTAIN RANGE, CREATED BY THE PRECIPITATION OF MOISTURE ON THE WINDWARD SIDE CAUSED BY THE COOLING AS THE AIR IS FORCED UPWARD, AND WARMING AS THE AIR DESCENDS THE LEEWARD SIDE.**

   C. Jet Stream **SWIFT 'RIVERS' OF AIR IN THE UPPER TROPOSPHERE CREATED AT THE POLAR FRONT AND THE BOUNDARY OF SUBTROPICAL HIGH PRESSURE AND THE WESTERLY WIND BELT.**

2. What is the effect of proximity to a major body of water on climate? How does this relate to the amount of heat that water must absorb to change its temperature?
   WATER CAN ABSORB A TREMENDOUS AMOUNT OF HEAT, BECAUSE IT HAS A HIGH SPECIFIC HEAT. IT COOLS HOT AIR BECAUSE OF THIS. WHEN THE AIR IS COLD, IT WARMS THE AIR WITH THE ENORMOUS RESERVOIR OF HEAT STORED IN WARMER TIMES. THE RESULT IS A MORE MODERATE CLIMATE NEAR LARGE WATER BODIES.
3. What happens to the temperature of an air mass as it rises? Why?
   AIR EXPANDS AS IT RISES INTO LOWER PRESSURE REGIMES HIGHER IN THE ATMOSPHERE. WHEN GASES EXPAND, THEY COOL, DUE TO ADIABATIC HEAT EXCHANGE WITH THEIR ENVIRONMENT.

4. What happens to the relative humidity of an air mass as it rises? Why?
   SINCE THE AIR HAS COOLED AS IT ROSE, IT HAS A HIGHER RELATIVE HUMIDITY, BECAUSE COOL AIR CANNOT HOLD AS MUCH MOISTURE.

Laboratory Jump Start Activity

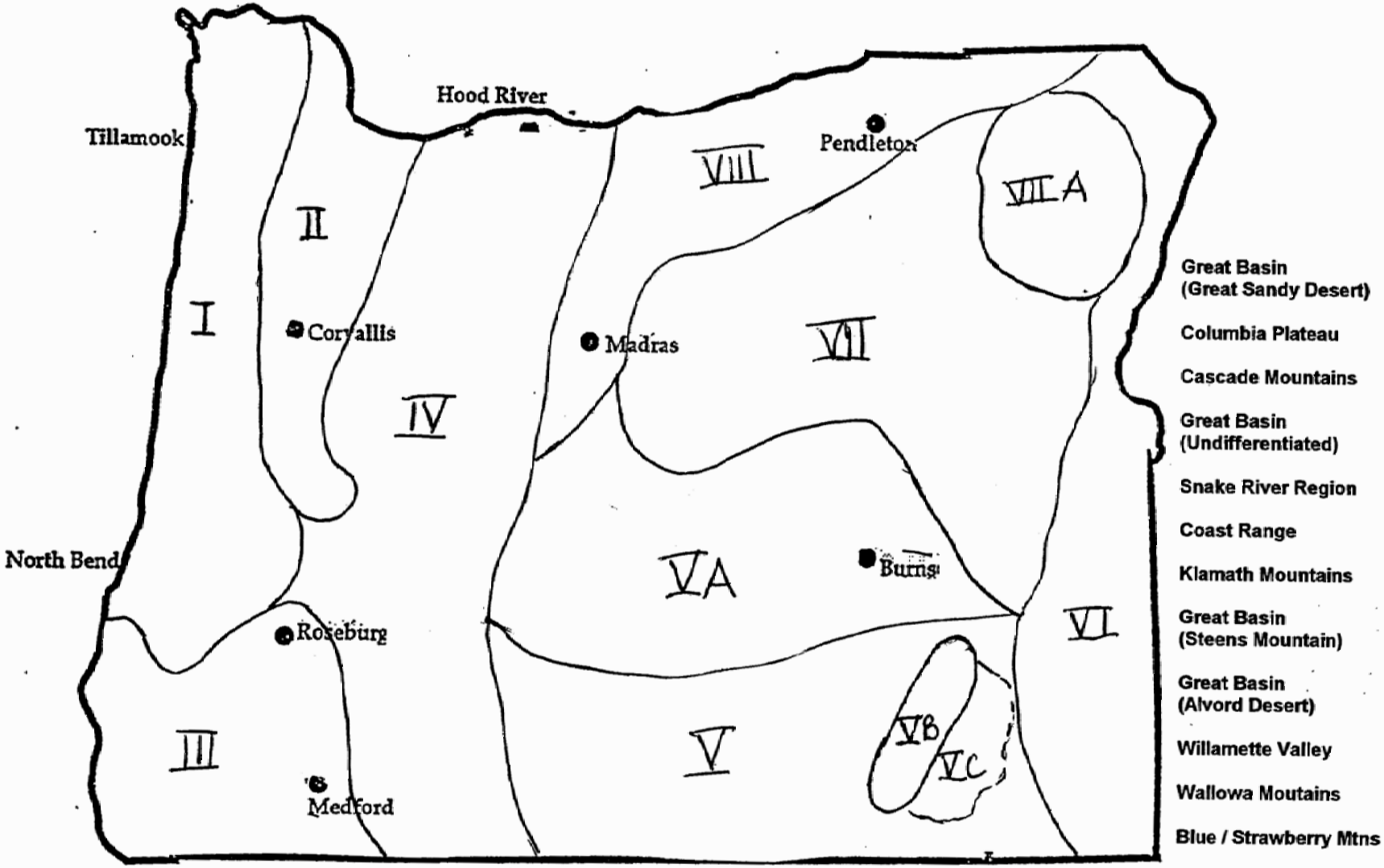
Work in groups to complete the table below by filling in the blanks. Imagine, in your minds eye, a road trip from Newport, OR to Corvallis,OR to Sweet Home,OR to Santiam Pass, OR to Bend,OR to Burns, OR to Boise, ID. Describe what type of weather and vegetation you would experience on your drive during the winter months, for example over Christmas Break. For weather descriptions, your options are: “rainy”, “snowy”, “sunny and clear”, and temperatures can be “above freezing”, or “below freezing”. For vegetation descriptions, your options are Spruce-Douglas Fir, Ponderosa Pine, agricultural fields (e.g. grass seed, wheat, etc.), Juniper-sagebrush, and sagebrush.

Location (as you drive from west to east)	Weather	Vegetation
Newport	**__RAINY, ABOVE FREEZING _**	**SPRUCE-FIR_____**
Corvallis	**__RAINY, ABOVE FREEZING**	**AGRICULTURE_____**
Sweet Home	**__RAINY, ABOVE FREEZING**	**AGRICULTURE_____**
Santiam Pass	**__SNOWY, BELOW FREEZING**	**SPRUCE-FIR, OR PONDEROSA**
Bend	**_SUNNY AND CLEAR, BELOW FREEZING IN WINTER, HOT IN SUMMER**	**PONDEROSA OR SAGE-JUNIPER**
Burns	**_SUNNY AND CLEAR, BELOW FREEZING IN WINTER, HOT IN SUMMER ___**	**SAGE-JUNIPER OR SAGE**
Boise	**SUNNY AND CLEAR, ABOVE FREEZING_**	**SAGE OR AGRICULTURE**

In the space below, write a brief paragraph discussing what you think the controlling factors are on the weather and vegetation observations that you've made on your road trip.

AS YOU TRAVEL FROM THE COAST TO BOISE, THE CLIMATE IS A FUNCTION OF DISTANCE FROM THE OCEAN, ELEVATION, AND MOUNTAIN RAIN-SHADOW EFFECT. IT IS MOIST AND MODERATE ON THE COAST, DRIER AND GREATER TEMPERATURE RANGE AT CORVALLIS AND SWEETHOME, COLD AND MOIST IN THE PASS, AND DRY WITH A LARGE TEMPERATURE RANGE TO THE EAST OF THE CASCADES. THE BOISE AREA IS LOWER, AND HAS THE INFLUENCE OF THE SNAKE RIVER, GIVING IT A SOMEWHAT WARMER AND MORE MODERATE TEMPERATURE THAN THE HIGH DESERT OF EASTERN OREGON.

Activity 1: Physiographic Provinces of Oregon



Part A – Physiography and Precipitation Maps of Oregon

Activity 1: Physiographic Provinces of Oregon

Oregon is divided into several physiographic zones (I through VIII, with subzones) based on topography (landscape configuration), bedrock geology, and climate. These physiographic zones are listed (in no particular order) on the map labeled Activity 1: Physiographic Provinces of Oregon map (page 7-4). Using the map and the list, fill in the table below by matching the geography to the listed province. Work in groups.

Province Map Number	Province Name (from list on map)
I	**COAST RANGE**
II	**WILLAMETTE VALLEY**
III	**KLAMATH MOUNTAINS**
IV	**CASCADE MOUNTAINS**
V	**GREAT BASIN (undif?)**
VA	**GREAT BASIN (sandy?)**
VB	**GREAT BASIN (Steens Mtns)**
VC	**GREAT BASIN (Alvord Desert)**
VI	**SNAKE RIVER REGION**
VII	**BLUE / STRAWBERRY MTNS**
VIIA	**WALLOWA MOUNTAINS**
VIII	**COLUMBIA PLATEAU**

Part B - Classified Precipitation Map of Oregon

The map labeled Activity 2: Classified Precipitation Map of Oregon shows annual rainfall (in inches/year) for stations in Oregon. Your task is to create a classified precipitation map for Oregon by drawing lines for the precipitation classes noted on the map. Work in pencil first. When you have the divisions, color-code the data into the following annual precipitation classes:

Precipitation Classes	**Map Color**
<10 in/yr	Yellow
10-30 in/yr	Red
30-60 in/yr	Green
60-100 in/yr	Blue
>100 in/yr	Purple

Here's how you do it:

- At each station "dot", read the annual precipitation and color code the "dot" by using a colored pencil and the class categories listed above. Quickly do this for each station on the map (do not color the entire map at this point, only color code the dot)

- Now that you have the stations color-coded, use a pencil to draw map boundary lines between each color-coded interval, separating and dividing the stations by color. *NOTE: make sure you interpolate between data points and draw a boundary line for each precipitation class. For example, examine the two data points immediately southwest of Madras, OR (these are stations with precipitation of "8" and "110" respectively). "" falls within the "<10 in/yr" class (yellow) while 110 falls within the ">100 in/yr" class. So between the 8 and 110, you also need to include the "10-30 in/yr" class, the "30-60 in/yr" class, and the "60-100 in/yr" class.*

- Color in the entire map, filling in the appropriate color for your boundary lines. Do this quickly, but neatly (don't spend the rest of the period coloring...just get on with it).

Answer the following questions in the space provided:

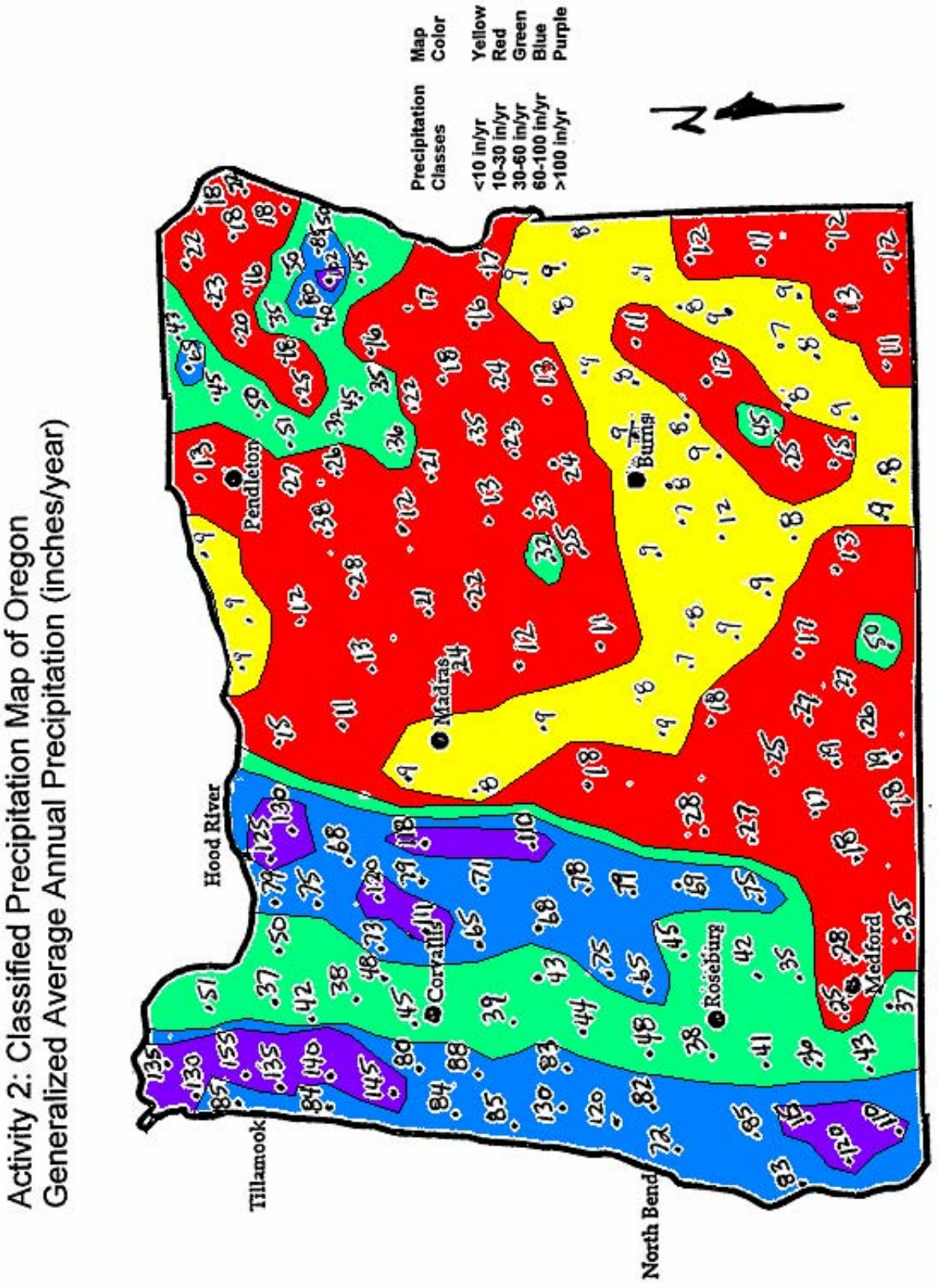
1. In comparing the Physiographic Map (Part A) to the Precipitation Map (Part B), what inferences can you make with regards to landforms and precipitation in Oregon?
   MOST RAINFALL IN OREGON IS WEST OF THE CREST OF THE CASCADE RANGE. IN LOCAL AREAS OF HIGH ELEVATION (BLUE MTNS., STRAWBERRY MTNS., WALLOWA MTNS., STEENS RIDGE), THERE IS HIGHER RAINFALL THAN THE SURROUNDING AREAS.

2. Which part of the state do you find the driest regions?
   EAST OF THE CASCADES, IN LOWER ELEVATION AREAS, OREGON HAS THE LEAST RAINFALL

3. Which part of the state do you find the wettest regions?
   THE GREATEST RAINFALL IS IN THE HIGH ELEVATIONS OF THE CASCADES AND THE COAST RANGE. GENERALLY, OREGON IS MUCH WETTER WEST OF THE CREST OF THE CASCADES.

4. Which direction do weather systems come from in Oregon: northerly, southerly, easterly, westerly?
   MOST WEATHER SYSTEMS IN OREGON COME IN FROM THE PACIFIC OCEAN, FROM THE WEST.
5. How do these weather patterns relate to the precipitation-landscape relationships that you observed above?
   THE WESTERLY ORIGIN OF WEATHER SYSTEMS LEADS TO A 'RAIN-SHADOW' EFFECT EAST OF THE CASCADES. THERE IS A RAIN-SHADOW EFFECT OF THE COAST RANGE ON THE WILLAMETTE VALLEY, AND STEENS RIDGE CREATES A SLIGHT 'RAIN-SHADOW' EFFECT ON THE ALVORD DESERT REGION OF SOUTHEASTERN OREGON.
6. What does the term "rain shadow" mean? How does it form in Oregon? Which parts of the state occupy the "rain shadow"?
   'RAIN-SHADOW' DESCRIBES THE AREA DOWNWIND FROM A TOPOGRAPHIC BARRIER, SUCH AS THE CASCADE RANGE, THAT IS DRY BECAUSE AIR IS FORCED UPWARD OVER THE BARRIER, COOLS TO ITS DEW-POINT, AND PRECIPITATES AS COOLING CONTINUES. AS THE AIR DESCENDS ON THE DOWNWIND SIDE OF THE BARRIER, IT HEATS AND DRIES THE LANDSCAPE.

REMEMBER TO INCLUDE INTERMEDIATE CLASSES BETWEEN HIGH AND LOW RAINFALL VALUES. FOR INSTANCE—BETWEEN MADRAS AND CORVALLIS: THERE NEEDS TO BE RED, GREEN AND BLUE BETWEEN YELLOW AND PURPLE



Part B - Plotting Climate Data

Activity 1 - Temperature Transect

Table 1 (page 7-10) is a summary of average annual climate data for the state of Oregon. The weather station locations are arranged by region in the state. Station name abbreviations are shown in parentheses (e.g. Corvallis station = CVO). The station locations are shown on Figure 1: Weather Station Location map for Oregon (page 7-11).

Plot a temperature transect graph from west to east across Oregon, using the following stations: Newport (ONP), Corvallis (CVO), Santiam Pass (SP), Redmond (RDM), Burns (BNO), and Ontario, (ONO). The graph paper is shown on Figure 2: Temperature Transect across Oregon (page 7-12). Using data in Table 1, plot a bar graph showing average July High Temperature (degrees F) for each of the above-listed stations. Plot a vertical bar to the temperature shown on the Y-axis at the appropriate position marked on the x-axis. Note the topographic profile for the state shown above the graph (a side-view cross-section, showing the topography from west to east across Oregon).

Questions: Answer the following questions:

1. What do you observe about the July temperature patterns when comparing the coastal area to central and eastern areas of Oregon? Hypothesize as to what physical mechanisms in the atmosphere account for this relationship.
   THE COASTAL AREA IS COOLER THAN INTERIOR REGIONS OF OREGON IN JULY. THE PACIFIC OCEAN ADDS MOISTURE TO THE ATMOSPHERE, AND MODERATES THE COASTAL TEMPERATURE

2. What do you observe about the July temperature patterns when comparing the high Cascades to central and eastern areas of Oregon? Hypothesize as to what physical mechanisms in the atmosphere account for this relationship.
   THE HIGHER THE ELEVATION, THE LOWER THE JULY TEMPERATURE. ONCE YOU CROSS THE CASCADES, THE AIR HAS BEEN DRIED BY THE ADIABATIC COOLING TO THE CONDENSATION POINT (DEW POINT) AND HAS LOST MOISTURE. IT WARMS WITH DECREASE IN ELEVATION, DUE ADIABATIC COMPRESSION, AS SHOWN BY THE HIGHEST TEMPERATURE EXISTING AT THE LOWEST ELEVATION CONSIDERED TO THE EAST OF THE CASCADES, ONTARIO.

Table 1: Mean Annual Climate Summary for Oregon

OREGON CLIMATE				Mean Annual					
	elev.	Jul Hi	Jan Lo	Temp	Precip	Snow	% Precip		
Location	feet	deg F	deg F	deg F	in.	in.	Nov-Apr	Koeppen's Climate Classification	
Coast									
Astoria (AST)	10	68	36	51	66	5	75%	Csb	*1st Letter*
Tillamook	10	67	36	50	89	3	75%	Cfb	A: Humid tropical
Newport (ONP)	140	65	37	50	72	2	76%	Csb	B: Dry
North Bend (OTH)	10	66	39	53	63	2	81%	Csb	C: Moist with mild winters
Brookings (4BK)	50	68	41	54	75	-	79%	Csb	D: Moist with cold winters
Coast Range									E: Polar climates
Laurel Mountain	3590	64	30	44	112	110	75%	Csb	
Willamette Valley									*2nd Letter*
Portland (PDX)	30	80	34	54	36	5	73%	Csb	S: Semi-arid
Hillsboro (HIO)	160	80	33	52	38	5	76%	Csb	W: Arid
McMinnville (MMV)	150	82	34	52	42	5	78%	Csb	w: dry winters
Salem (SLE)	200	82	33	52	39	6	77%	Csb	s: dry summers
Corvallis (CVO)	190	80	33	52	43	6	78%	Csb	f: Wet all seasons
Eugene (EUG)	360	82	34	53	49	6	79%	Csb	
Southwestern Valleys									*3rd Letter*
Roseburg (RBG)	510	84	35	54	32	4	78%	Csb	h: Hot and dry
Grants Pass	920	90	33	55	31	5	81%	Csa	k: Cool and dry
Medford (MFR)	1300	91	30	54	19	8	75%	Csa	a: Summers long and hot
Klamath Mountains									b: Summers long and cool
Sexton Summit (SXT)	3840	75	31	48	37	97	76%	Csb	c: summers short and cool
Cascades									
Government Camp	3980	68	24	42	86	278	76%	Dsb	
Detroit Dam	1220	77	33	51	87	18	76%	Csb	
Marion Forks	2480	80	26	46	68	112	77%	Csb	
Santiam Pass (SP)	4750	73	21	40	87	437	77%	Dsc	
Crater Lake	6470	68	18	38	66	495	78%	Dsc	
North Central									
Hood River	500	80	28	51	31	36	80%	Csb	
The Dalles (DLS)	100	88	30	55	14	12	79%	Csa	
Hermiston (HRI)	620	88	26	53	9	8	69%	BSk	
Pendleton (PDT)	1480	88	27	52	12	17	67%	BSk	
Milton-Freewater	970	89	28	54	14	12	64%	BSk	
South Central									
Madras	2230	87	23	49	11	12	62%	BSk	
Redmond (RDM)	3060	85	22	47	9	20	60%	BSk	
Prineville	2840	87	22	48	10	12	62%	BSk	
Bend	3660	82	22	46	12	35	67%	BSk	
Klamath Falls (LMT)	4090	85	20	48	13	35	70%	Dsb	
Burns (BNO)	4140	84	13	43	13	42	57%	Dfb	
Lakeview (LKV)	4780	84	19	46	16	65	66%	Dsb	
Northeast									
LaGrande (LGD)	2750	86	24	49	17	30	58%	Dsb	
Enterprise	3880	78	12	41	16	53	50%	Dfb	
John Day (5JO)	3060	88	21	49	13	24	54%	Dfb	
Baker City (BKE)	3370	85	17	46	11	25	57%	Dfb	
Southeast									
Ontario (ONO)	2140	96	19	52	10	18	67%	BSk	

Figure 1: Weather Station Location map for Oregon

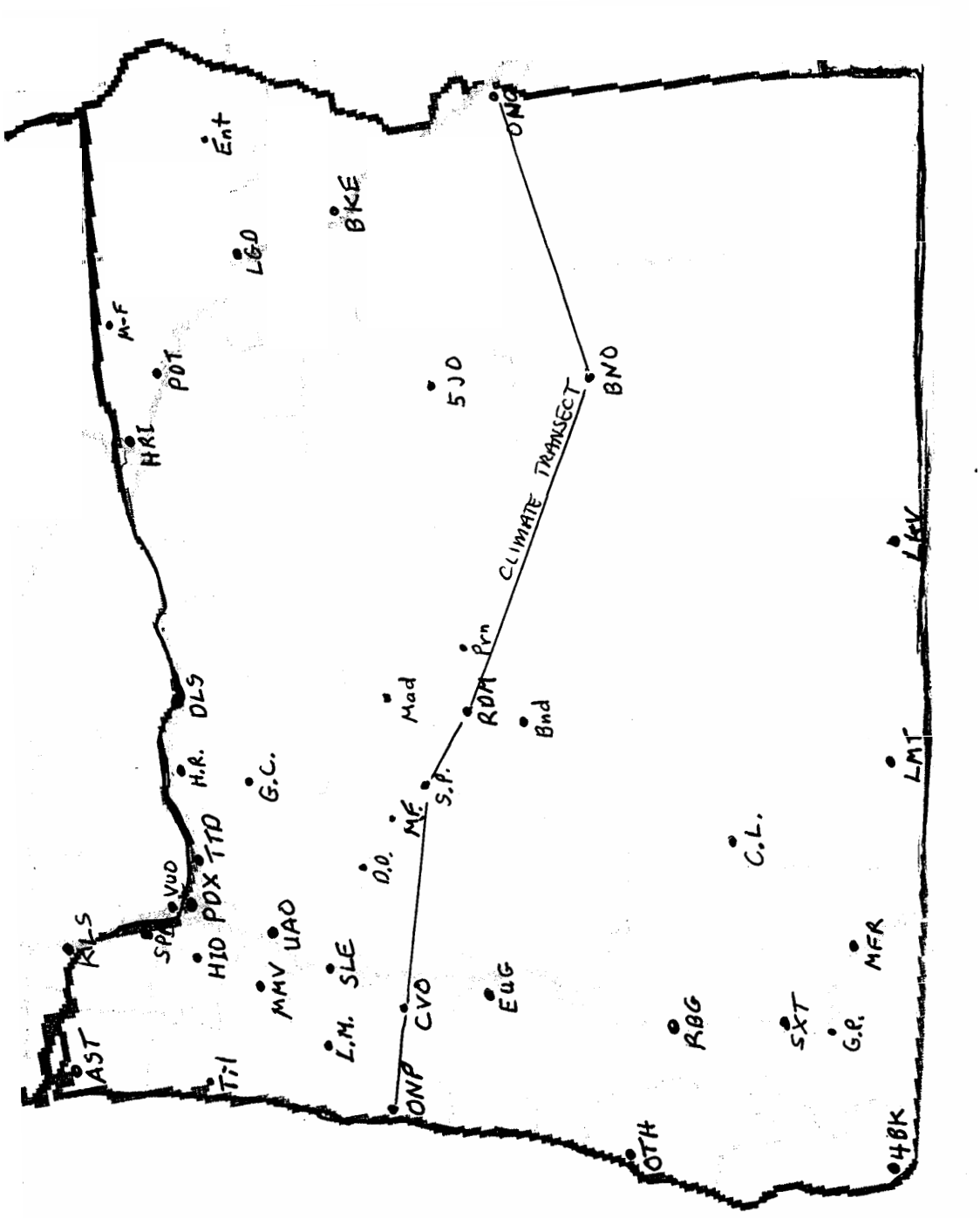
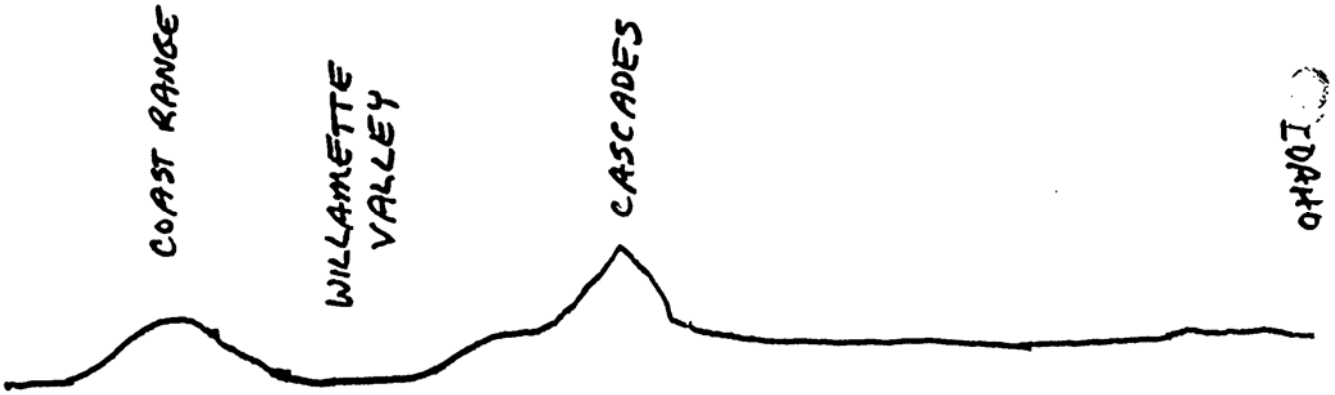
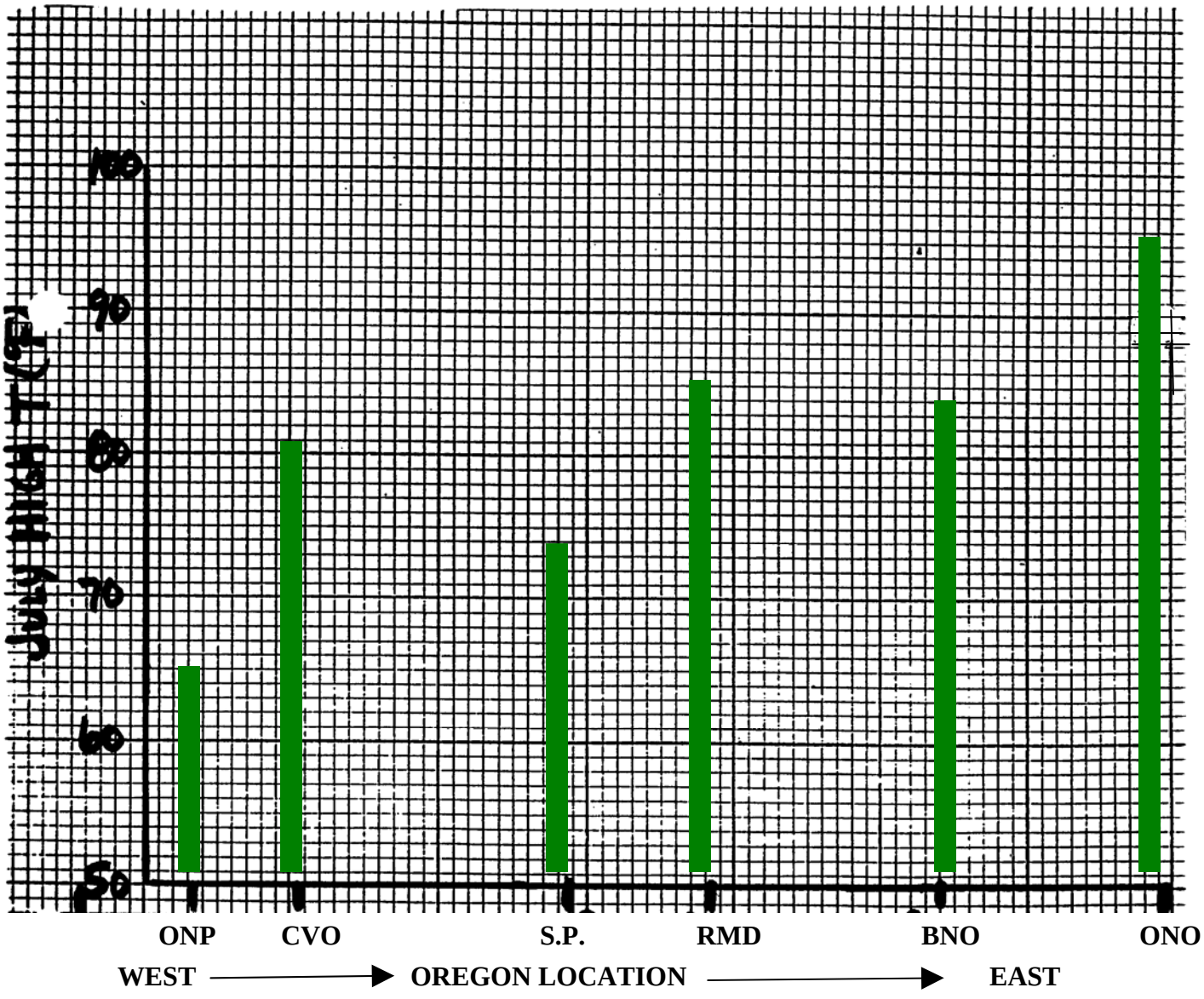


Figure 2: Temperature Transect across Oregon





Based on your precipitation data (Part A) and temperature data (Part B), *intuitively decide*, which parts of the state would you classify as "Maritime" and which parts would you classify as "Continental". Based on your observations and intuitive answer, describe the terms maritime and continental in terms of seasonal temperature and precipitation. Fill in the table below (use Table 1 to augment your observations)

Intuitive Answer Here:
WEST OF THE CASCADES IS A MARITIME REGION.
EAST OF THE CASCADES IS A CONTINENTAL REGION

	Maritime	Continental
Summer Temperatures (Hot or Cool?)	**_COOL____**	**__HOT___**
Winter Temperatures (Moderate or Extreme)	**MODERATE**	**_EXTREME_**
Summer Precipitation (Dry or Wet?)	**WET____**	**__DRY____**
Winter Precipitation (Dry or Wet?)	**_WET_____**	**__DRY____**

Activity 2 - Focus on South-Central Oregon.

Examine the annual climate data (Table 1) for the South Central Oregon section (stations include Madras, Redmond, Prineville, Bend, Klamath Falls, Burns, and Lakeview). Use the data for the listed weather stations to make plots on the graphs provided for:

- Figure 3a: Mean Annual Precipitation vs. Elevation
- Figure 3b: Mean Annual Temperature vs. Elevation
- Figure 3c: Mean Annual Temperature vs. Mean Annual Precipitation

The graphs have already been scaled for you. All you need to do is the plot and label the seven points on each graph (i.e. plot a point for each south-central weather station on each graph). **Do not draw a "best-fit" line if the data points are scattered in a "shot-gun" pattern.** (The shotgun pattern indicates little relationship between the two parameters).

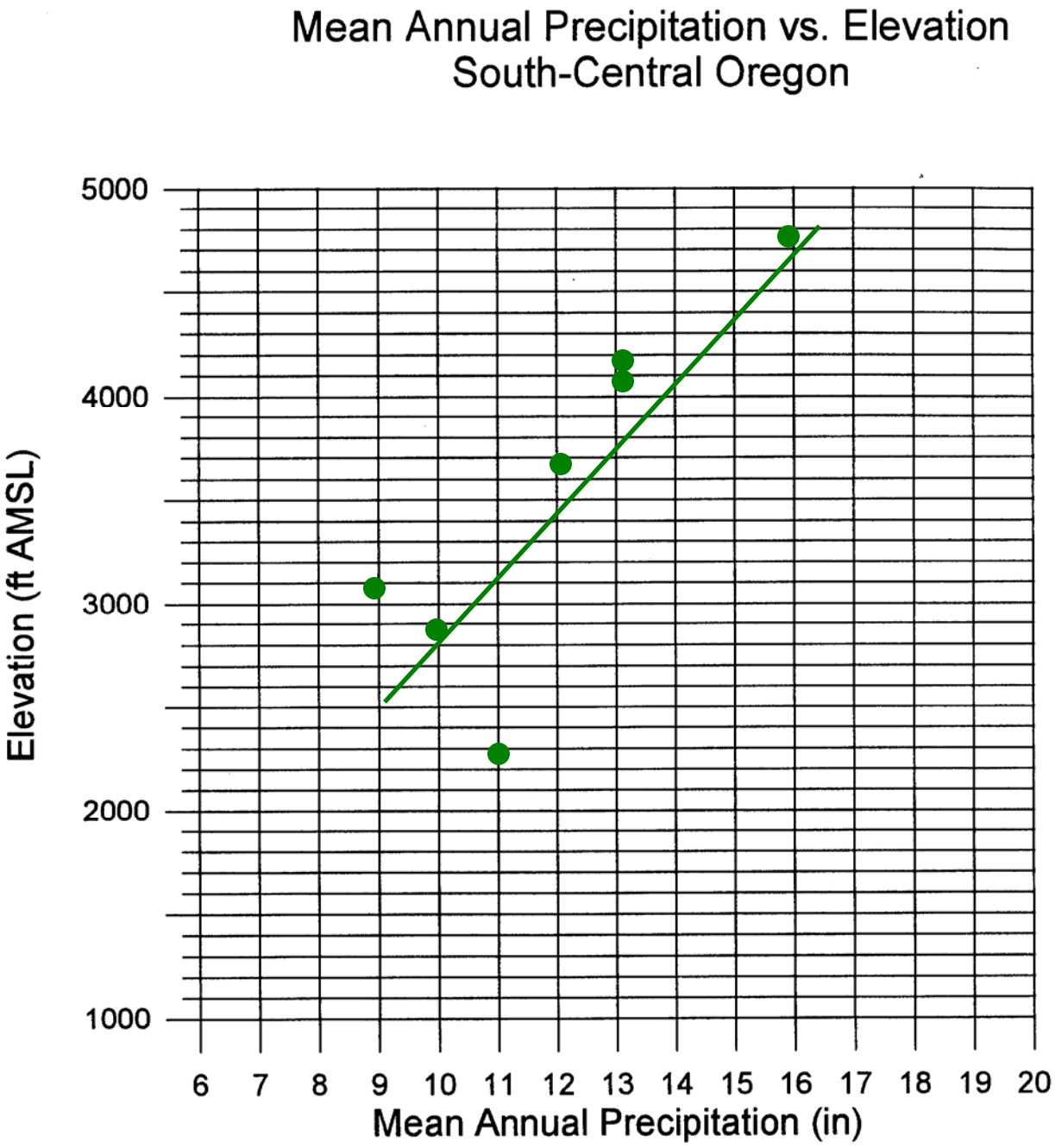


Figure 3a: Plot of Precipitation vs. Elevation—South-Central Oregon

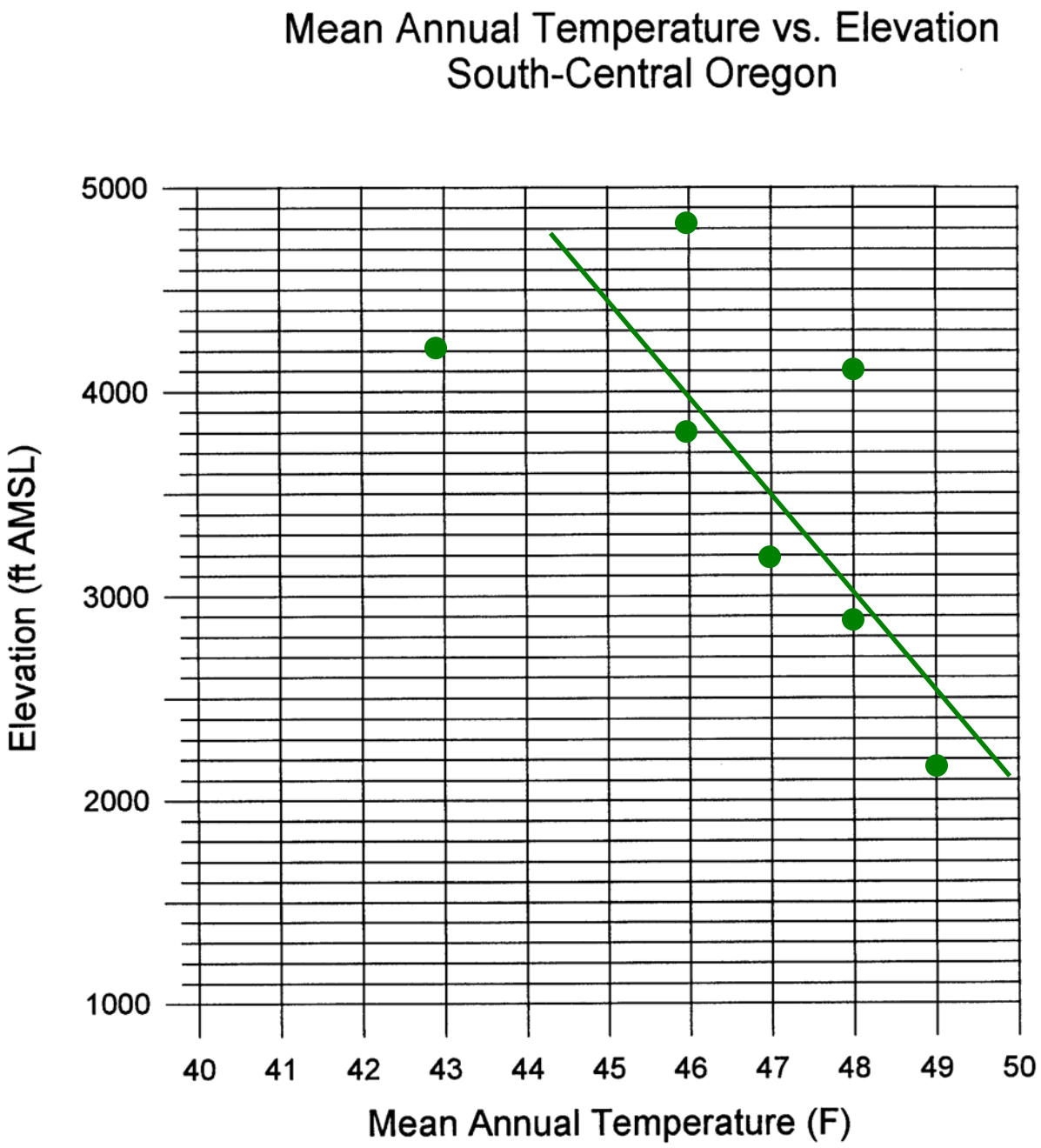


Figure 3b: Plot of Mean annual Temperature vs. Elevation—South-Central Oregon

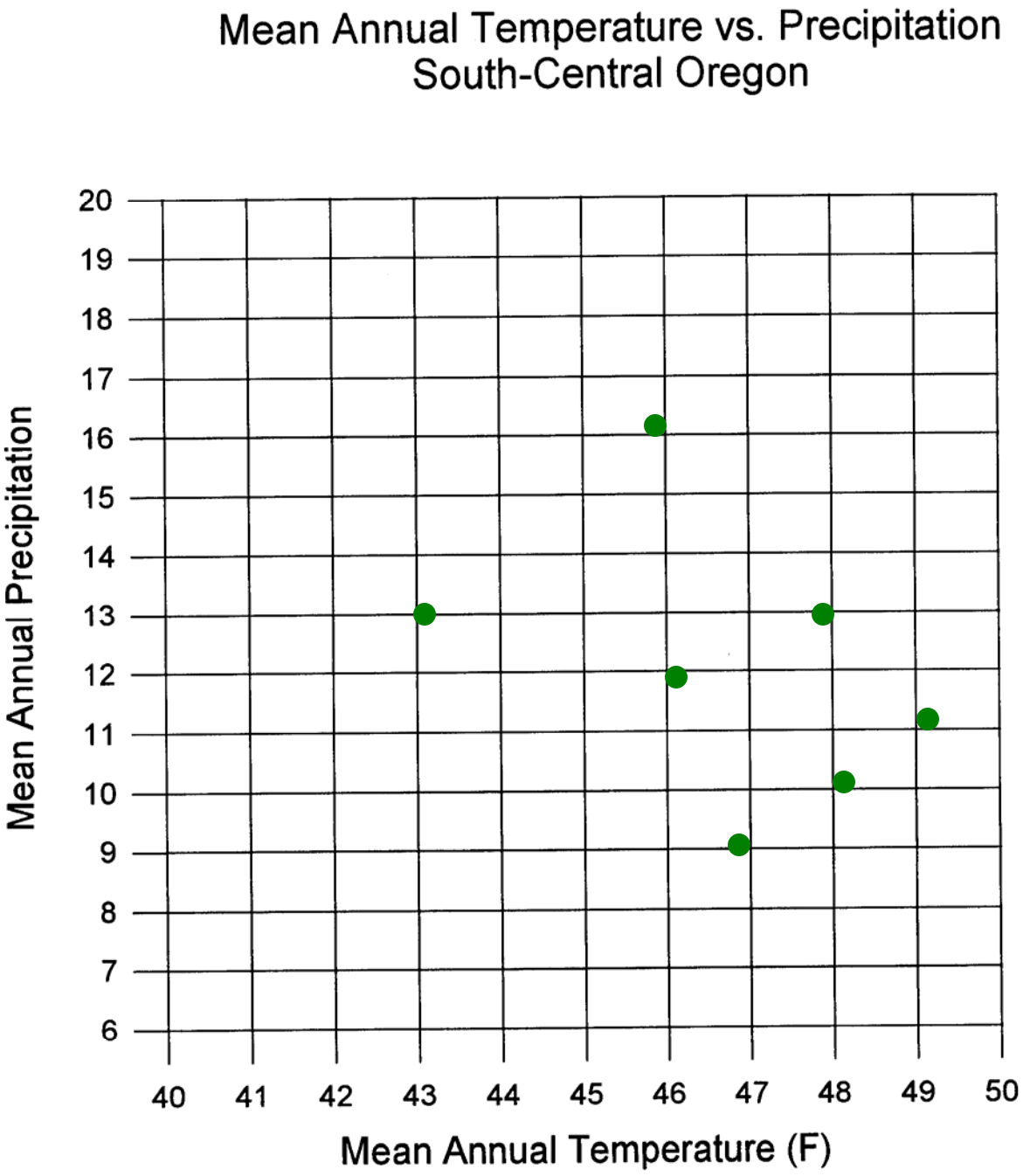


Figure 3c: Plot of Mean Annual Temperatrue vs. Percipitation—South-Central Oregon

Questions

1. How does precipitation relate to elevation in south-central Oregon? How consistent is the relationship given your data set (good fit, moderate fit, or poor fit)?
   THERE IS MORE PRECIPITATION AT HIGHER ELEVATIONS IN SOUTH-CENTRAL OREGON. THE DATA HAS A GOOD 'BEST FIT' LINE.

2. How does mean annual temperature relate to elevation in south-central Oregon? How consistent is the relationship given your data set (good fit, moderate fit, or poor fit)? Is the data relationship as convincing as the Precipitation-Elevation data?
   AT HIGHER ELEVATIONS IN SOUTH-CENTRAL OREGON, THE MEAN ANNUAL TEMPERATURE IS LOWER. THE DATA HAS A MODERATE CORRELATION TO THE 'BEST FIT' LINE.

3. How does mean annual precipitation relate to temperature in south-central Oregon? How consistent is the relationship given your data set (good fit, moderate fit, or poor fit)?
   THERE SEEMS TO BE VERY LITTLE CORRELATION BETWEEN THE AMOUNT OF RAINFALL AND THE MEAN ANNUAL TEMPERATURE IN SOUTH-CENTRAL OREGON.

4. Given the lecture concepts of evaporation, forceful lifting, atmospheric elevation, dew point, relative humidity, and precipitation, write a summary paragraph explaining your graph observations in terms of atmospheric physics.
   AS AIR RISES, IT EXPANDS AND COOLS (ADIABATIC PROCESS OF GAS TEMPERATURE). THIS COOLING ALLOWS THE AIR TO REACH MOISTURE SATURATION, AND PRODUCE PRECIPITATION. THE ANNUAL TEMPERATURE MAY AT HIGHER ELEVATIONS MAY BE PARTLY DUE TO ADIABATIC PROCESSES, BUT RECALL THAT THE TROPOSPHERE IS HEATED FROM BELOW, BY THE RE-RADIATION OF SUN ENERGY ABSORBED BY EARTH AND RADIATED AT INFRA-RED (HEAT) WAVELENGTHS. THIS PHENOMENON RESULTS IN LOWER TEMPERATURES AT HIGHER ELEVATIONS, BECAUSE THE AIR AT THAT LEVEL IS NOT AS WARM AS AT SEA LEVEL.

Name_____**KEY**_____
Lab Day/Time_____

POST-LAB ASSESSMENT

1. Using what you have learned in lab today, look at the South American continent on a map and explain the existence of the Atacama Desert east of the Andes.

IN LIGHT OF THE FACT THAT THE ATACAMA DESERT IS ACTUALLY WEST OF THE ANDES, RECALL THAT ITS LATITUDE (15^{o} S) IS WITHIN THE TRADE WIND BELT. THESE CONSISTENT EAST-TO-WEST WINDS ACROSS THE CREST OF THE ANDES CREATE A RAIN SHADOW TO THE WEST OF THE RIDGE IN THIS LATITUDE. THE AIR COOLS AS IT IS FORCED UPWARD OVER THE MOUNTAINS, AND DESCENDS AND WARMS, EVAPORATING ANY AVAILABLE MOISTURE. SOME AREAS OF THE ATACAMA DESERT HAVE HAD NO RECORDED RAINFALL (SINCE EUROPEAN RECORDS BEGAN SOME 400 YEARS AGO!).

2. Given the location of St. Paul, Minnesota, predict what the general climate conditions should be like for that city. What will the summers be like? What will the winters be like? Justify your answer based on concepts from today's lab.

ST. PAUL, MINNESOTA IS CONTINENTAL, ISOLATED FROM THE MODERATING INFLUENCE OF THE OCEAN. IN SUMMER, MARITIME TROPICAL AIR MASSES TRAVEL ACROSS NORTH AMERICA, HEATING AS THEY GO, MAKING ST. PAUL VERY HOT AND MUGGY. IN WINTER, CONTINENTAL POLAR AIR MASSES COME IN ACROSS THE NORTHERN CONTINENT, RESULTING IN VERY COLD AND SOMEWHAT DRY WEATHER.

3. Sometimes on a partly cloudy day in the Willamette Valley, you will see thick clouds to the west over the coast range. The clouds then seem to thin and break up in the Willamette Valley and then thicken to the east over the Cascades. What effect accounts for this pattern in cloud cover? Explain.

THE AIR IS FORCED UPWARD OVER THE COAST RANGE, SO IT EXPANDS AND COOLS (DUE TO ADIABATIC COOLING OF EXPANDING GASES). THE COOL AIR REACHES ITS DEW-POINT, AND CONDENSATION (CLOUD FORMATION) OCCURS. AS IT GETS OVER THE COAST RANGE, IT DESCENDS, AND WARMS ABOVE ITS DEW-POINT, AND THE CLOUDS VAPORIZE (LITERALLY). THE SAME CONDENSATION PROCESS OCCURS AS THE AIR IS FORCED UPWARD OVER THE CASCADE RANGE, FORMING CLOUDS AGAIN.