WORKSHEET — CLIMATE

The following system of symbols (called the Trewartha Modification of the Koppen Classification System) is one that is used to classify various types of climates:

A--Tropical forest climates with no cool season; fairly constant warm temperature
- Af: constantly moist; rainfall all through the year
- Aw: distinct dry season in winter (Savanna).
- Am: monsoon rain; short, dry season, but with sufficient total rainfall to support rain forest

B--Dry climates (precipitation variable and effectiveness dependent upon the rate of evaporation, which in turn, varies directly with temperature)
- Bs: semi-arid climates (Steppe)
- Bw: desert and arid climates (Wuste)
  - h: (heiss) tropical or low-latitude--hot (**heiss** = German for "hot")
  - k: (kalt) cold or middle-latitude (**kalt** = German for "cold")

C--Mesothermal (warm temperature) forest climates with cooler but mild winters (coldest month above 32° F [0° C]; warmest month above 50° F [10° C] (**meso** = middle; **thermo** = heat)
- Cf: no distinct dry season
- Cw: dry season in winter
- Cs: dry season in summer (Mediterranean type--**medi** = middle; **terra** = earth, land)
  - a: hot summer (warmest month over 71.6° F [22° C])
  - b: cool summer (warmest month under 71.6° F [22° C])
  - c: cool, short summer; less that 4 months over 50° F [10° C]

D--Microthermal (cold, snowy) forest climates with severe winters (coldest month below 32° F [0° C]; warmest month above 50° F [10° C])
- Df: no dry season
- Dw: dry winters
  - a, b, and c same as under C

E--Polar climates with no warm season (warmest month below 50° F [10° C])
- Et: tundra climate (warmest month below 50° F [10° C], but above 32° F [0° C])
- Ef: perpetual frost (all months below 32° F [0° C]); such climates persist only over the permanent ice caps

Consider the weather data for the cities listed in Table 1. Note that "T" is the average monthly temperature in ° F and "R" is the average monthly rainfall in inches.

PROBLEM:

Classify the climatic types of these cities using the Koppen symbols (letters).

HYTHERGRAPHS

Simple graphs can be constructed for an analysis of climate and weather data. The method was originated in 1910 and first applied to a practical problem in 1916. In constructing the graph, two related variables are plotted on the graph paper. The vertical scale represents temperature and the horizontal scale represents moisture (humidity or rainfall). The monthly mean values are plotted as a series of points, one for each month and the respective points are joined by a line in order of the months. The polygon thus obtained is termed a **hythergraph** (**hy** from **hydro** = water; **ther** from **thermo** = heat; **graph** = to write) if temperature and rainfall are used, or a **climatograph** if temperature and relative humidity are correlated. "**Climograph**" is a corruption of the latter term, and has been used to mean both climatograph and hythergraph. The time unit used may be any period (hour, week, day) but is usually month or week.

PROBLEM:

Plot hythergraphs for at least Barrow, Boston, Cuyaba, Delhi, and Phoenix. Hythergraphs for Boston, Barrow, Cuyaba, and Delhi could probably be put on the same graph with different symbols, while at least Delhi and Phoenix will have to go on separate graphs because of overlapping data points. Perhaps Barrow, Boston, and Delhi could go on one graph and Cuyaba and Phoenix on another. Suggested scales are -20 to 100° F for temperature and 0 to 10 inches for precipitation. As time and interest allow, hythergraphs for the other cities could also be constructed.

TABLE 1. WEATHER IN SELECTED CITIES

STATION	T/R	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TYPE?
1 Athens, Greece	T	50	50	52	60	66	74	81	80	73	67	67	52	
	R	2.2	1.5	1.4	0.9	0.8	0.6	0.3	0.4	0.6	1.7	2.8	2.5	
2 Aukland, New Zealand	T	67	67	66	61	57	54	52	52	55	57	60	64	
	R	2.7	3.1	3.0	3.4	4.6	4.9	5.0	4.2	3.6	3.7	3.3	2.9	
3 Barrow, Alaska, USA	T	−17	−14	−14	0	21	36	40	39	31	16	9	−15	
	R	0.2	0.2	0.1	0.1	0.2	0.3	0.9	0.7	0.5	0.6	0.3	0.3	
4 Boston, Mass., USA	T	27	28	35	45	57	68	71	69	63	52	41	32	
	R	3.4	3.1	3.6	3.7	2.9	3.2	3.3	3.3	3.5	2.8	2.9	3.4	
5 Cincinnati, Ohio, USA	T	28	32	43	53	63	71	75	74	67	55	44	34	
	R	2.6	2.7	4.2	3.8	4.3	3.8	4.2	3.4	2.9	2.9	3.5	3.2	
6 Cuyaba, Brazil	T	81	81	81	81	79	77	76	78	80	82	82	81	
	R	9.8	8.3	8.3	4.0	2.1	0.3	0.2	1.1	2.0	4.5	5.9	8.1	
7 Delhi, India	T	58	62	74	86	90	90	86	85	84	79	68	60	
	R	0.8	0.7	0.5	0.4	0.6	3.1	8.1	7.9	4.4	0.3	0.1	0.5	
8 Georgetown, Guyana	T	79	79	80	80	81	80	80	82	83	82	82	81	
	R	8.5	6.0	6.8	6.4	10.0	9.9	10.0	6.5	3.1	2.9	5.9	10.0	
9 Monterrey, Mexico	T	58	62	68	74	79	82	82	83	78	72	64	57	
	R	0.8	0.7	0.8	1.3	1.3	3.0	2.3	2.4	5.2	3.0	1.5	0.8	
10 Moscow, USSR	T	14	17	25	39	55	61	66	62	49	40	28	19	
	R	1.3	1.2	1.4	1.4	1.8	2.7	3.2	3.1	2.2	2.1	1.7	1.6	
11 Odessa, USSR	T	26	29	37	47	60	68	73	70	62	52	40	32	
	R	1.2	0.9	1.1	0.9	1.1	2.2	1.7	1.4	1.2	1.5	1.1	1.2	
12 Phoenix, Ariz, USA	T	51	55	61	67	75	85	87	89	83	71	60	52	
	R	0.8	0.9	0.6	0.4	0.1	0.1	1.0	0.9	0.7	0.4	0.6	0.9	

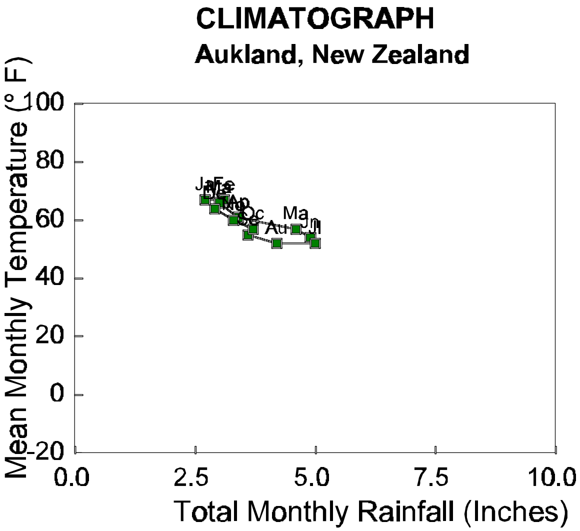


Figure 1. Climatograph for Aukland, N. Z.

For example, for city #9, Aukland, N.Z., the climatograph would look like Figure 1.

Hythergraphs also furnish a convenient means of comparing one season with another. They are convenient and useful for giving a comparison of the climate in a series of localities or to determine the probability limits for the distribution of a particular species of organism. For, example, a composite climatograph can be constructed for a locality or year in which there were large numbers of a given species of insect and compared to a climatograph for another locality or year in which no or few of that species occurred. The index thus obtained is valuable in an analysis of the influence of climatic variations upon the population size of that species.

The data in Table 2 give mean temperature and monthly total precipitation for two different years in an area of southern Illinois. The first year was particularly favorable for a species of moth called the codling moth (a fruit pest) and there were large numbers of these moths in that year. The second year, there were few moths and they were not a problem.

TABLE 2. Monthly Temperature and Total Precipitation for Two Years in a Southern Illinois Codling Moth Area

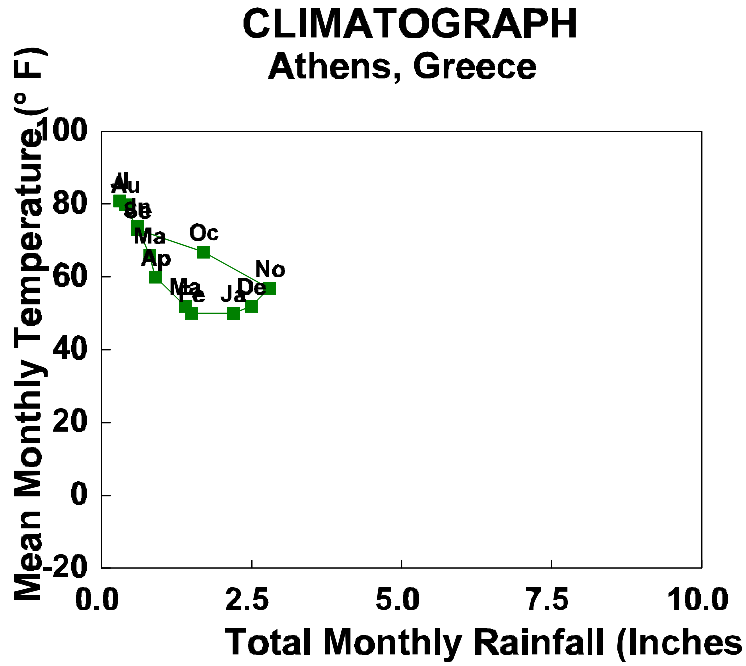
Month	(no.)	Moths Abundant		Moths Scarce	
		$\overline{X}$ Temp. (°F)	Ppt. (inches)	$\overline{X}$ Temp. (°F)	Ppt. (inches)
Jan	1	35.5	0.8	36.0	1.7
Feb	2	26.0	2.7	28.0	1.7
Mar	3	40.0	1.8	42.0	4.9
Apr	4	53.0	3.1	53.5	5.3
May--1st half	5A	59.0	2.6	N/A	N/A
May--2nd half	5B	68.0	1.6	63.5	5.1
Jun	6	77.5	1.4	73.5	3.6
Jul	7	81.5	2.3	78.0	3.6
Aug	8	74.5	3.3	74.0	5.7
Sep	9	68.0	3.7	68.0	1.2
Oct	10	57.5	5.3	57.0	1.7
Nov	11	46.5	4.2	43.0	1.8
Dec	12	35.5	0.8	36.0	1.7

Draw hythergraphs from the data in Table 2 (can be on same graph). Based on the hythergraphs:

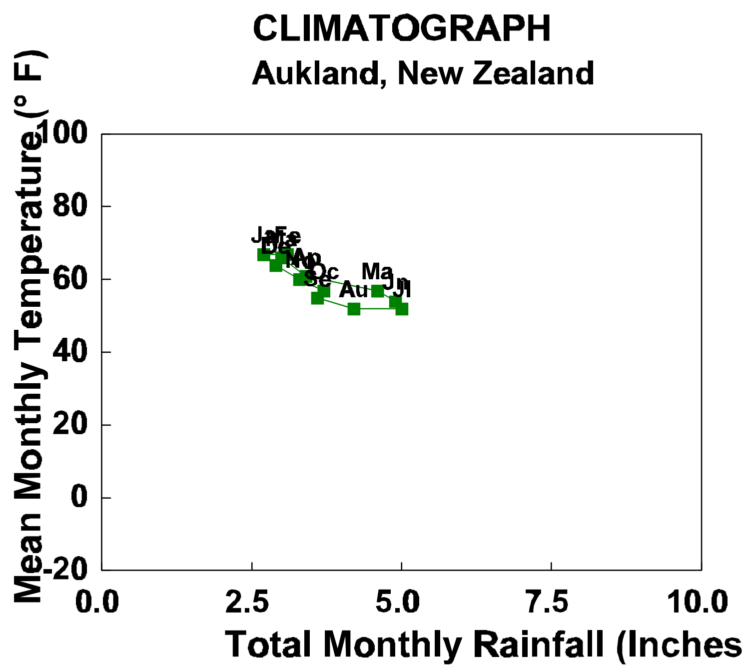
1. How does the precipitation for the period of September through November compare for the two years? Make a similar comparison for the period from March through July.
2. How do the temperatures for the period of May through July compare for the two years?
3. Do you think any of these differences are significant (in terms of the moth population)?

ANSWERS

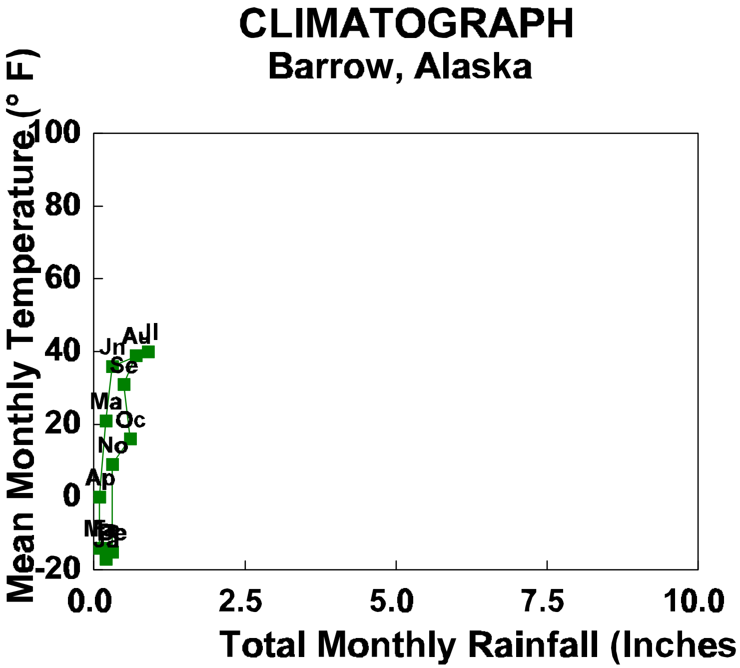
Cs



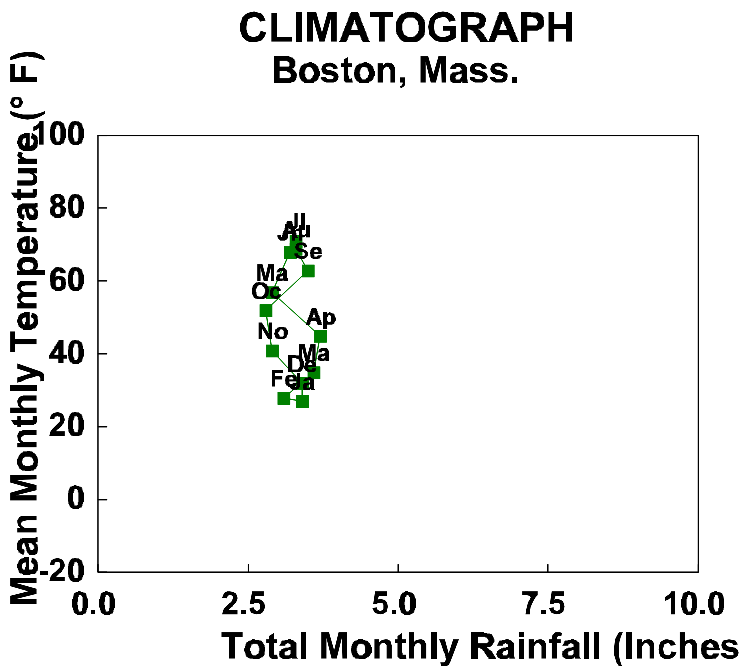
Cf



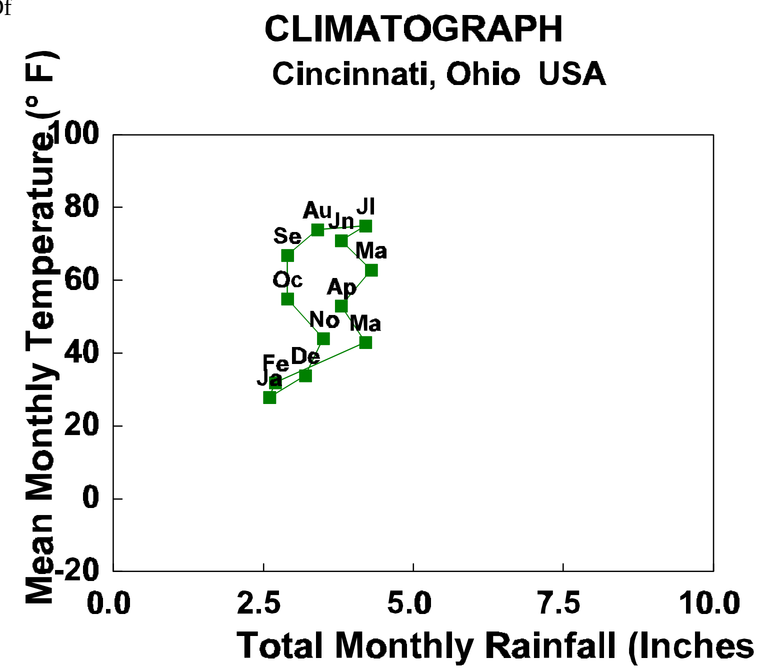
ET


CLIMATOGRAPH
Barrow, Alaska
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Jn
Jl
Se
Ma
Oc
No
Ap

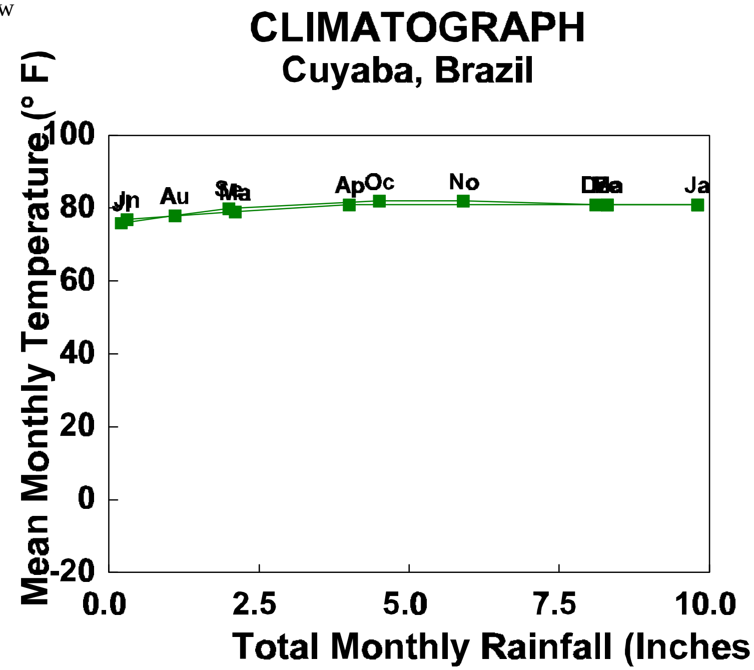
Df


CLIMATOGRAPH
Boston, Mass.
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Jl
Se
Ma
Oc
Ap
No
Ma
De

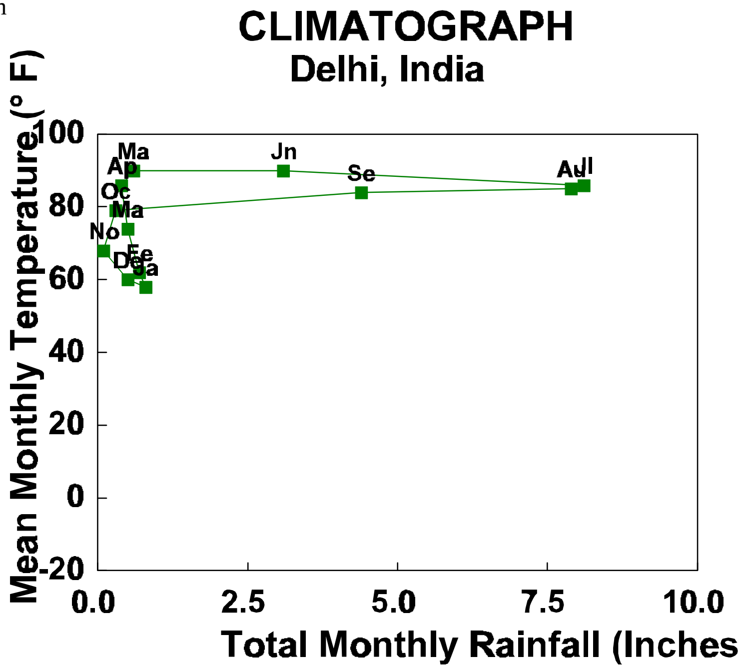
Df


CLIMATOGRAPH
Cincinnati, Ohio USA
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Au
Jn
Jl
Se
Ma
Oc
Ap
No
Ma
Fe
De
Ja

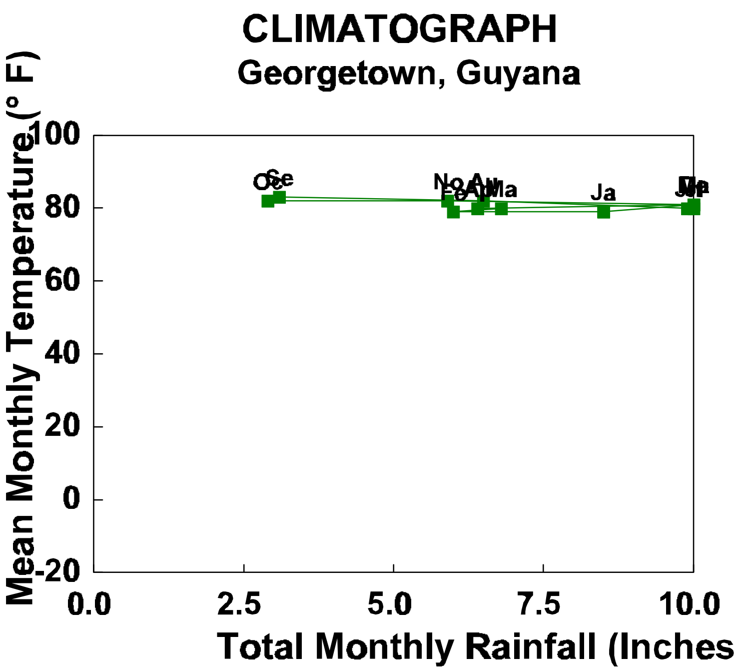
Aw


CLIMATOGRAPH
Cuyaba, Brazil
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Jn
Au
Ap
Oc
No
Ja

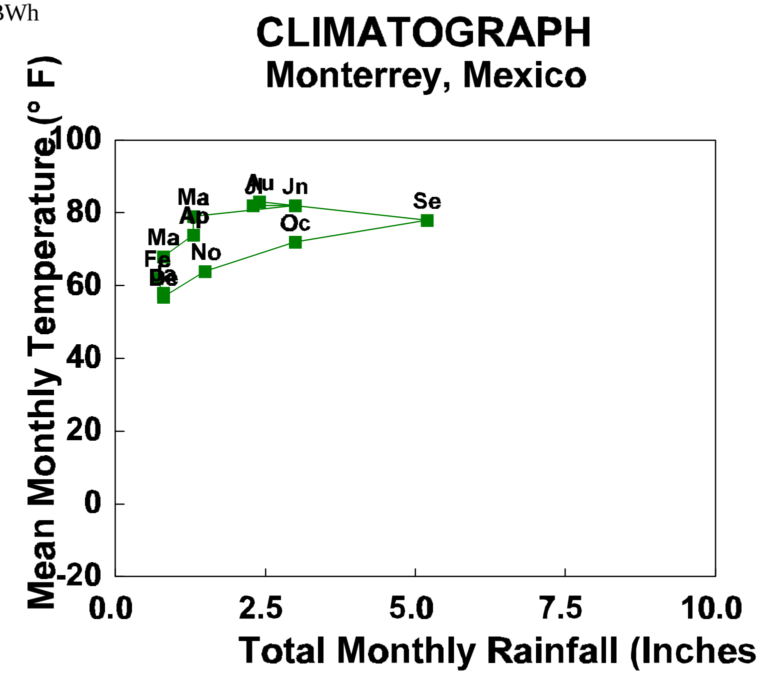
Am


CLIMATOGRAPH
Delhi, India
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Ma
Jn
Ap
Se
Oc
Ma
No
Fe

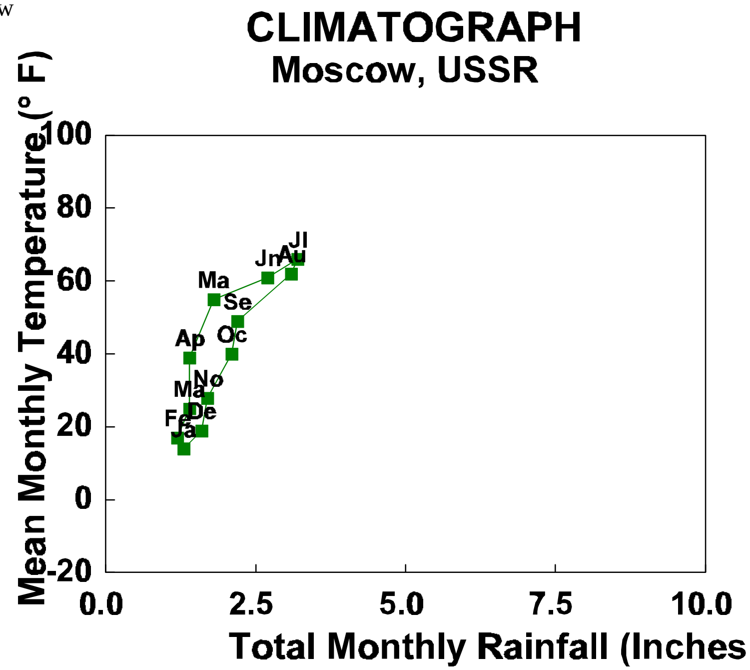
Af


CLIMATOGRAPH
Georgetown, Guyana
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Se
Ma
Ja

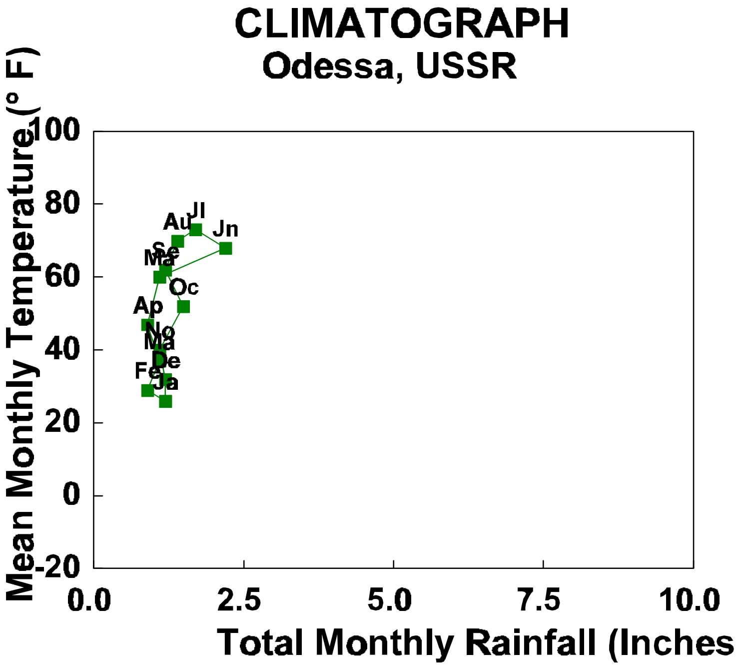
BWh


CLIMATOGRAPH
Monterrey, Mexico
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Jn
Se
Ma
Ap
Oc
Ma
No
Fe

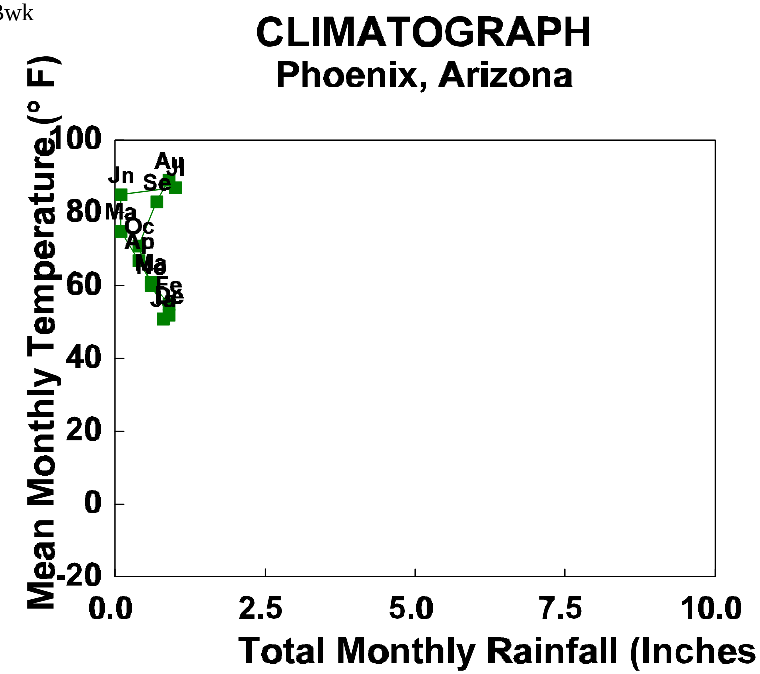
Dw

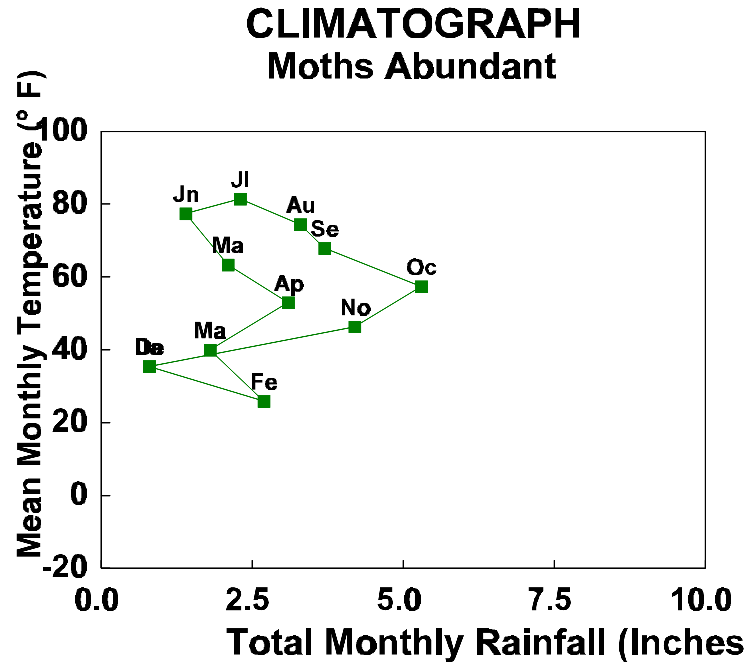

CLIMATOGRAPH
Moscow, USSR
Mean Monthly Temperature (° F)
100
80
60
40
20
0
-20
0.0
2.5
5.0
7.5
10.0
Total Monthly Rainfall (Inches
Jl
Jn
Au
Ma
Se
Ap
Oc
No
Ma
De
Fe
Ja

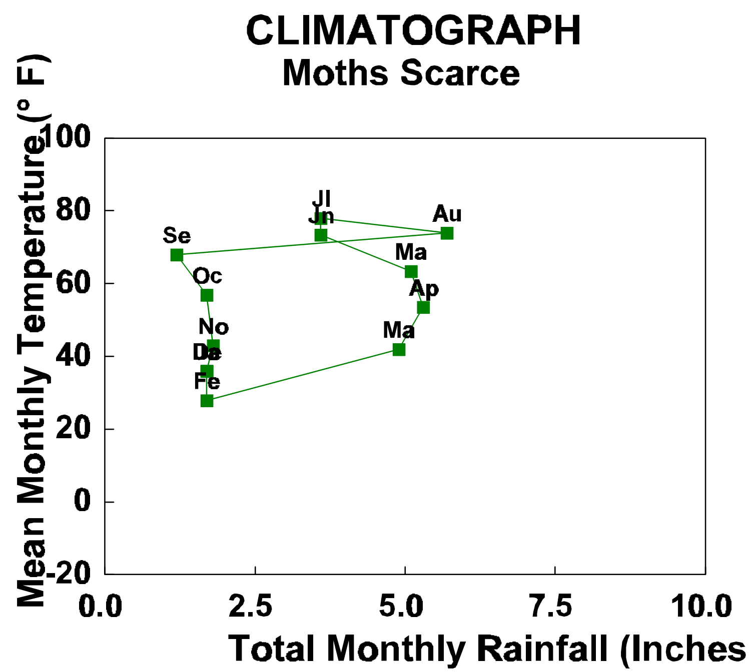
BS


CLIMATOGRAPH
Odessa, USSR
Mean Monthly Temperature (° F)
Total Monthly Rainfall (Inches
100 80 60 40 20 0 -20
0.0 2.5 5.0 7.5 10.0
Au Jl Jn Se Ma Oc Ap No Ma De Fe Ja

Bwk


CLIMATOGRAPH
Phoenix, Arizona
Mean Monthly Temperature (° F)
Total Monthly Rainfall (Inches
100 80 60 40 20 0 -20
0.0 2.5 5.0 7.5 10.0
Au Jl Jn Se Ma Oc Ap Ma No Fe De Ja


CLIMATOGRAPH
Moths Abundant
Mean Monthly Temperature (° F)
Total Monthly Rainfall (Inches
100 80 60 40 20 0 -20
0.0 2.5 5.0 7.5 10.0
Jl Jn Au Se Ma Oc Ap No Ma De Fe


CLIMATOGRAPH
Moths Scarce
Mean Monthly Temperature (° F)
Total Monthly Rainfall (Inches
100 80 60 40 20 0 -20
0.0 2.5 5.0 7.5 10.0
Jl Jn Au Se Ma Oc Ap No Ma De Fe