INTRODUCTION

Climate is a basic part of the natural environment and exerts a strong influence on many of man's activities. In the Puget Sound basin especially, effective land-use planning requires consideration of climatic influences, for the climate differs significantly in the various parts of the area. However, climatic information may not be given adequate consideration in the planning process if pertinent data are not readily available or if the importance of some climatic features is not apparent.

The purpose of this study is to review available data related to the climate of the Puget Sound basin, and to present selected climatic information along with an evaluation of its significance and general adequacy for planning purposes. This is part of continuing efforts aimed at improving the accessibility and usefulness of environmental and other data needed for land-use planning, resource development, and environmental protection.

The climate of the region is controlled largely by air movement from the Pacific Ocean and by major landforms. Winter storms from the south or southwest bring abundant moisture into the area. A shift in the general air movement during the summer results in drier air from the northwest (fig. 1). The Olympic Mountains and the mountains of Vancouver Island effectively protect the area from the full intensity of winter storms reaching the coast, whereas the Strait of Juan de Fuca and the Chehalis Valley and adjacent lowlands provide low-level passages for marine air moving inland (fig. 1). The Cascade Range usually shields western Washington from continental air masses and their greater temperature extremes. All the mountains cause uplift and "wringing out" of the moist air passing over them. Much of this moisture is stored at least temporarily in snow and ice fields on the mountains. However, the effects of the enclosing mountains are not all beneficial; they also induce stagnation of air masses over the lowlands.

Precipitation—its amount and distribution, its intensity and frequency, and its storage in snow and ice fields—along with air movement patterns and temperature data, probably are the most important climatic considerations for land-use planning in the Puget Sound basin. Only these features of the climate are the subject of this graphic presentation. Other types of climatic information such as humidity, solar radiation, and evaporation, though important to special planning needs, are not considered here.

DATA AVAILABILITY AND ADEQUACY

Climatic data for the Puget Sound basin are available from many sources. The principal source is the National Weather Service, which operates a national network of stations that record precipitation, temperature, air movement, and other climatic data. The Weather Service also acts as a repository for some, but not all, climatic data from other sources. The adequacy of the data and interpretation should be assessed before applying these data to planning. The references below list some of the more significant sources.

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PRECIPITATION

Among the basin's climatic features, precipitation has the greatest importance for the widest range of planning needs

PRECIPITATION AMOUNT AND DISTRIBUTION

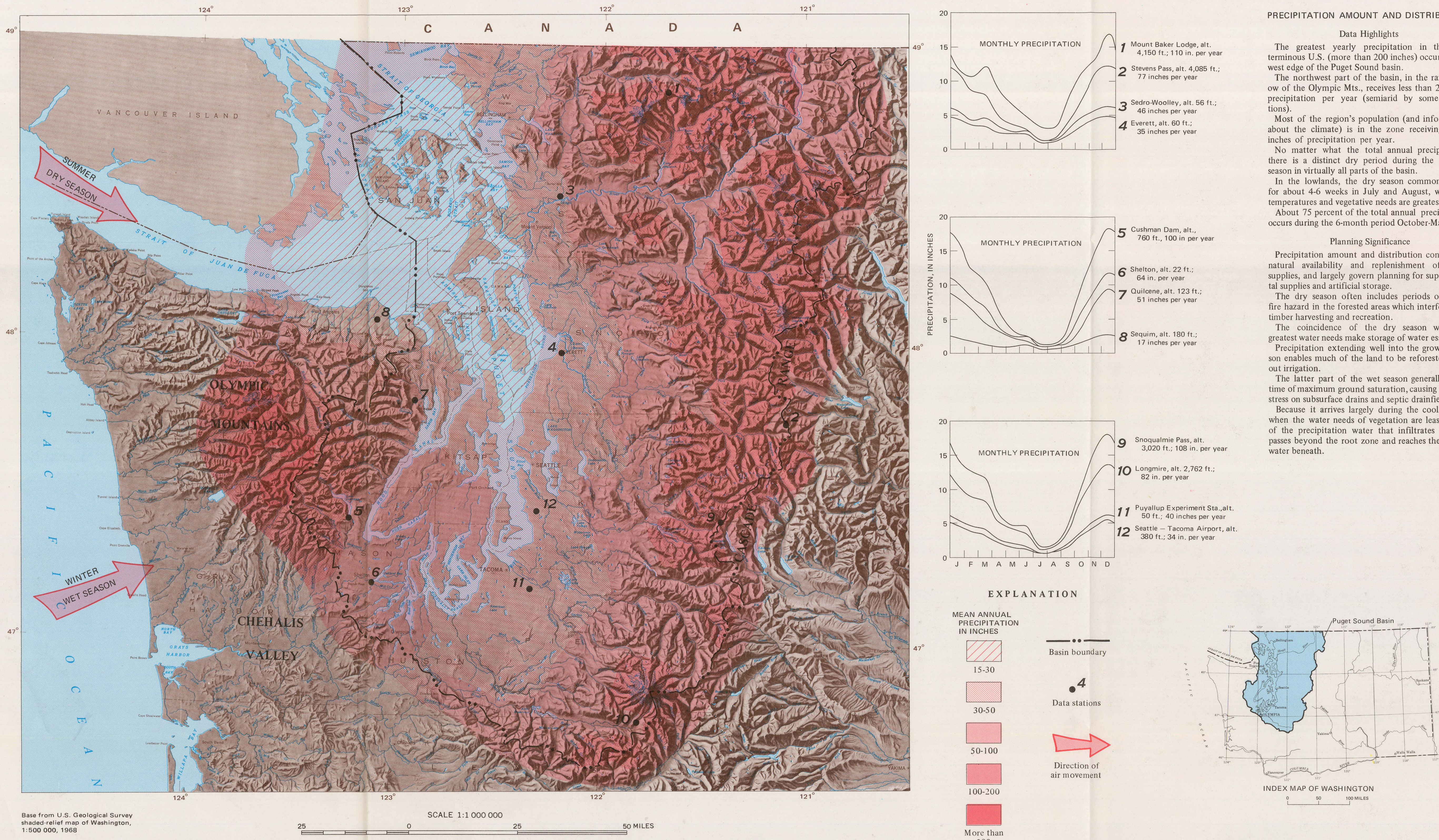


FIGURE 1.—THE AMOUNT OF PRECIPITATION RANGES WIDELY, VARYING MAINLY WITH ALTITUDE AND WITH DISTANCE AND DIRECTION FROM THE MOUNTAINS. (Data from Phillips, 1968; U.S. Soil Conservation Service, 1965, U.S. Weather Bureau, 1961.)

PRECIPITATION AMOUNT AND DISTRIBUTION

Data Highlights

The greatest yearly precipitation in the conterminous U.S. (more than 200 inches) occurs at the west edge of the Puget Sound basin.

The northwest part of the basin, in the rain shadow of the Olympic Mts., receives less than 20 in. of precipitation per year (semiarid by some definitions).

Most of the region's population (and information about the climate) is in the zone receiving 30-50 inches of precipitation per year.

No matter what the total annual precipitation, there is a distinct dry period during the growing season in virtually all parts of the basin.

In the lowlands, the dry season commonly lasts for about 4-6 weeks in July and August, when air temperatures and vegetative needs are greatest.

About 75 percent of the total annual precipitation occurs during the 6-month period October-March.

Planning Significance

Precipitation amount and distribution control the natural availability and replenishment of water supplies, and largely govern planning for supplemental supplies and artificial storage.

The dry season often includes periods of severe fire hazard in the forested areas which interfere with timber harvesting and recreation.

The coincidence of the dry season with the greatest water needs make storage of water essential.

Precipitation extending well into the growing season enables much of the land to be reforested without irrigation.

The latter part of the wet season generally is the time of maximum ground saturation, causing greatest stress on subsurface drains and septic drainfields.

Because it arrives largely during the cool season, when the water needs of vegetation are least, much of the precipitation water that infiltrates the soil passes beyond the root zone and reaches the ground water beneath.

PRECIPITATION INTENSITY AND FREQUENCY

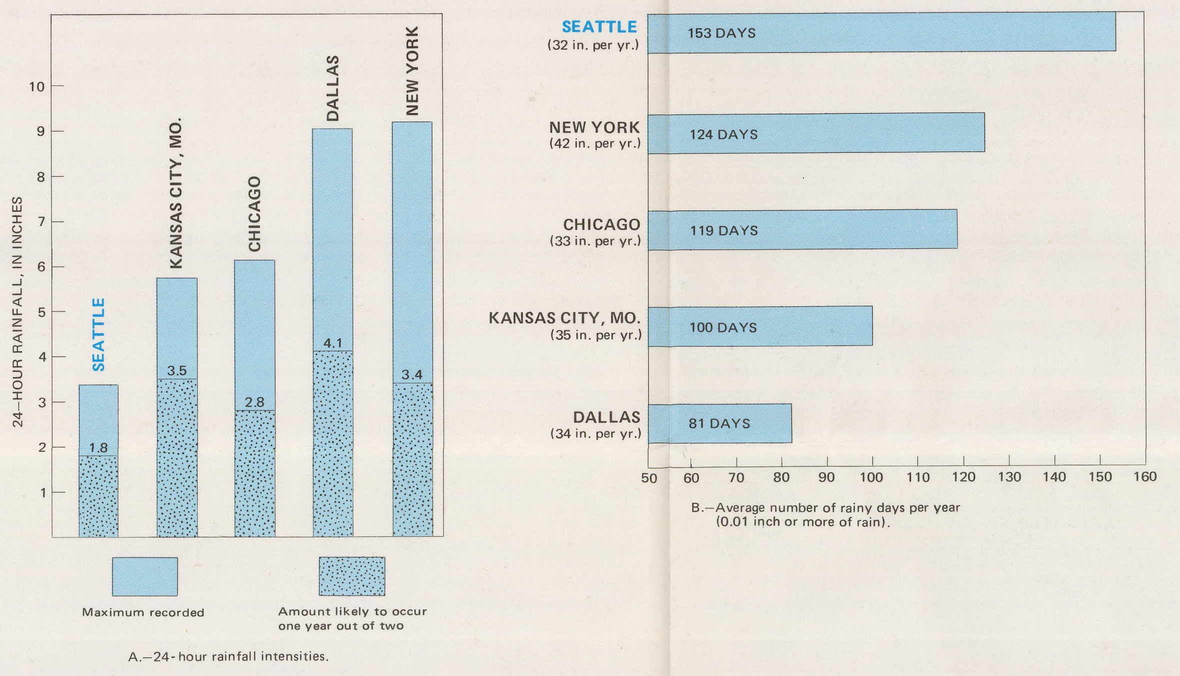


FIGURE 2.—RAINFALL IN THE PUGET SOUND LOWLAND IS CONSIDERABLY LESS INTENSE BUT MORE FREQUENT THAN IN OTHER AREAS RECEIVING ABOUT THE SAME YEARLY AMOUNT.—(Data from Hershfield, 1961, and U.S. Weather Bureau, 1961.)

PRECIPITATION INTENSITY AND FREQUENCY

Data Highlights

Intense rains occur, on the average, less frequently in the Puget Sound lowland than in most other U.S. areas, but the lower intensity is balanced by a greater frequency of precipitation.

The precipitation intensity in the basin increases with altitude, but is comparatively low even in foothill areas.

Planning Significance

Problems related to erosion and local runoff are noticeably less in the Puget Sound lowland than in the adjacent mountains and in other regions where rainfall is more intense.

Flooding in lowland valleys generally is triggered by persistent, relatively intense rainfall in the mountains, often accompanied by rapid melting of accumulated snow.

The slow, steady rainfall commonly does not exceed the infiltration capacity of the soil, and much of it soaks into the ground, resulting in more recharge to the ground-water system than would be the case if rainfall were more intense.

Some engineering guidelines developed in other areas with more intense rainfall may be inappropriate for the Puget Sound lowland. These may include effects of urbanization on storm runoff, storm sewer design, and sediment yield from areas of logging or construction.

SNOW AND ICE

SNOW AND ICE

Data Highlights

Annual snowfall ranges from less than 10 inches in the lower valleys to 50 inches at altitudes of 500-800 feet, and hundreds of inches in the higher mountains.

Accumulation and persistence of snow in the Puget Sound lowland varies with distance from the Sound and with slight differences in altitude. Snow generally melts quickly in the lowland, where depths seldom exeed 15 inches.

Snowfall usually begins in September at highest altitudes, gradually spreading downward to reach a snowline of 1,500 to 2,000 feet above sea level by midwinter.

Snoqualmie Pass, a popular winter recreation area in the Cascade Range, receives an average annual snowfall of more than 400 inches, the water content of which probably is more than 43 inches (fig. 3B).

Maximum snow depth in the mountains is usually reached during March at moderately high altitudes and April or May in the higher parts of the Cascades.

Abundance and rapid accumulation of snow create avalanche hazards in the mountains.

Glaciers (figs.3A and 4), formed where long-term snowfall exceeds melting rate, occupy about 120 square miles in the mountains and yield about 300 billion gallons of meltwater per year in the basin.

Planning Significance

In major streams that are not fed by glaciers, the winter snowfall largely determines the flow during the following spring and early summer.

Periodic "inventories" of mountain snow guide predictions of flooding potential and hydropower capacity.

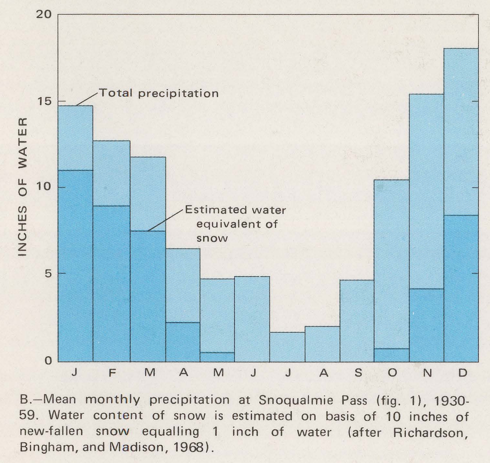
Glaciers provide a long-term as well as a seasonal regulation of streamflow; they generally melt faster following winters of light snowfall.

Streams that are fed by glaciers have comparatively greater, more dependable dry-season flows than other streams in the basin. However, these streams have a higher suspended sediment load, which may limit their use for some purposes.

Nearly continuous snow plowing and sanding are necessary during winter periods to keep cross-Cascade highways readily passable; even in the lowlands, snow and ice conditions commonly impede transportation once or more per winter.

Avalanche hazards in mountains require use of snowsheds along transportation routes, avalanche control in winter recreation areas, and zoning against dwellings in avalanche-prone areas.

A.—Glaciers, shown in blue on figure 4, provide streamflow after the annual snowpack has melted, when needs for water are greatest.



B.—Mean monthly precipitation at Snoqualmie Pass (fig. 1), 1930-59. Water content of snow is estimated on basis of 10 inches of new-fallen snow equalling 1 inch of water (after Richardson, Bingham, and Madison, 1968).

FIGURE 3.—MOUNTAIN SNOW AND GLACIERS PROVIDE STORAGE OF PRECIOUS WATER.

AIR MOVEMENT

Air-movement data are deficient for many planning needs

AIR MOVEMENT

Data Highlights

The prevailing direction of wind over the lowlands is from the south or southwest during the wet season and from the northwest during the dry season. Average velocity is less than 10 miles per hour.

Very light winds (up to 3 miles per hour) and calm air are common over the Puget Sound lowlands, particularly at locations south of Everett, which are least affected by air movement through the Strait of Juan de Fuca. During most summer afternoons, a light northerly or westerly breeze develops after a morning calm over the Sound and adjacent lowlands.

The strongest winds are generally from the south or southwest during late fall and winter. Winds can be expected to reach 75-90 miles per hour on the average of once in 50 years in the lowlands, much oftener in the high mountains.

Topography and other local conditions strongly affect air movement, especially winds near the ground and movement during periods of calm or very light winds.

Planning Significance

Wind direction determines where air pollutants go; wind speeds and vertical air movement control rate of dispersion of the pollutants.

Knowledge of winds and vertical air circulation is just as necessary for efficient disposal of air-borne wastes as knowledge of streamflow is for waste-water disposal.

Future local effects of air pollution can be lessened by restricting smog-producing activities (automobiles and certain industries) in areas of frequent calm air or very light winds.

Data on frequency, strength, duration, and prevailing direction of high winds are needed for many planning and design purposes, such as design of above-ground power transmission lines, design and location of suspension and pontoon bridges, forest-management planning, (including selection of areas for reforestation), planning and design of port facilities, and selection of recreation sites.

EXPLANATION

Wind diagrams show the average frequency of winds at various speeds and from various directions. The width of the direction arrow shaft indicates the range of wind speed (see scale below). The length of each segment of the arrow shows the percentage of time wind was from that direction for that wind speed. The percentage of time when winds are 3 miles per hour or less is shown by the encircled number.

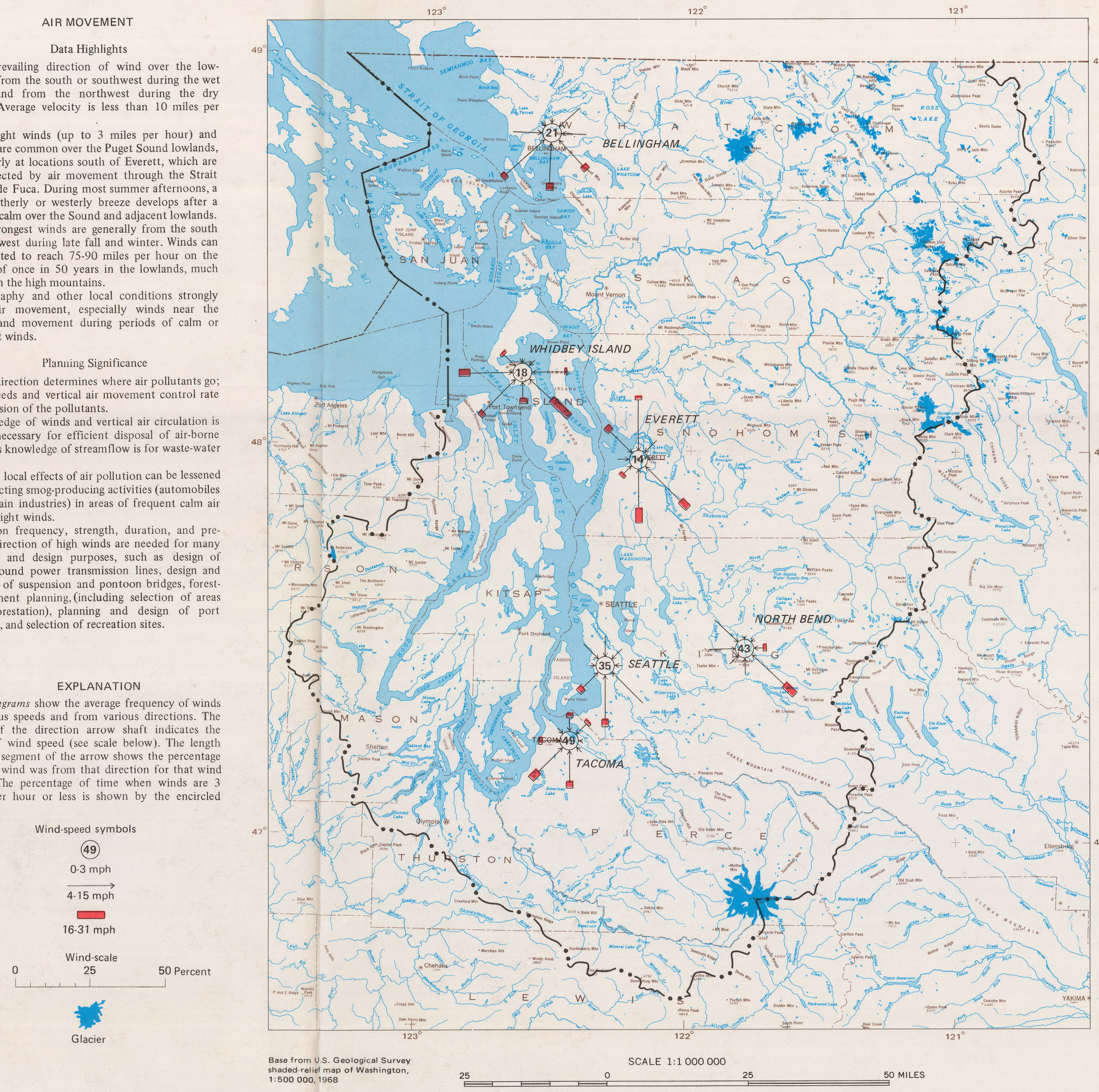


FIGURE 4.—AVERAGE WIND SPEED OVER THE LOWLANDS IS LESS THAN 10 MILES PER HOUR, AND STAGNANT AIR IS COMMON. (Data from Bonneville Power Administration, 1965.)

TEMPERATURE

Air-temperature data most useful for planning are the high and low temperatures and changes with altitude

HIGH AND LOW TEMPERATURE

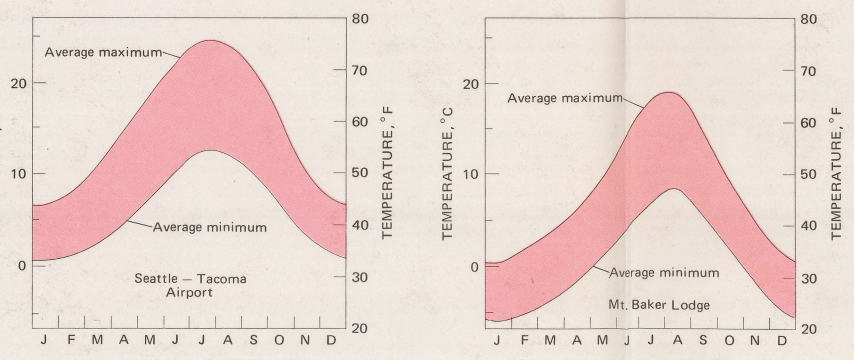


FIGURE 5.—AIR TEMPERATURES ARE GENERALLY MILD IN THE LOWLANDS, BUT VARY CONSIDERABLY WITH ALTITUDE. SHOWN HERE ARE RANGES BETWEEN AVERAGE DAILY HIGH AND DAILY LOW TEMPERATURES FOR TWO SELECTED LOCATIONS FOR EACH MONTH. DAILY TEMPERATURE EXTREMES ARE NOT SHOWN.—(Data from National Weather Service.)

HIGH AND LOW TEMPERATURES

Data Highlights

Air temperatures are milder and less extreme in the Puget Sound lowland than at similar latitudes in other regions of the U.S. Temperatures below zero (°F) and above 100 are rare near the Sound.

Number of days between killing frosts is characteristically about 180 or more in the lowlands, and decreases to less than 150 in valleys in the foothills. At altitudes above 4,000 feet, below-freezing temperatures may occur even in mid-summer.

The highest temperatures in summer and the lowest in winter usually occur during infrequent periods of easterly winds; the lowest often are associated with movement of cold air masses from interior Canada.

In general, the temperature decreases about 3°F for each 1,000-foot increase in altitude; even so, wintertime temperatures in all but the highest mountains generally are mild in comparison to many other parts of the U.S.

"Hard" freezes, with frost penetrating more than a few inches into the ground are rare in the lowlands but common in the mountains. They generally are followed by small earth slumps and rockfalls as the ground thaws.

Planning Significance

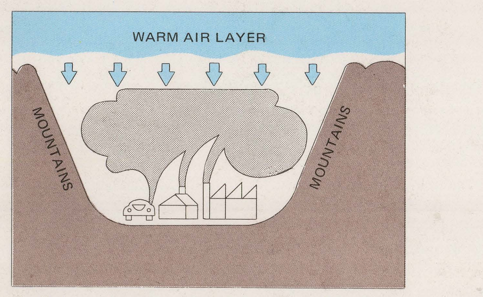
In most parts of the basin where slopes and soils are suitable for farming there is more than an ample growing season for crops normally grown at this latitude.

Temperature-related problems such as energy shortages in winter and water shortages in summer are compounded during persistent cold or hot weather.

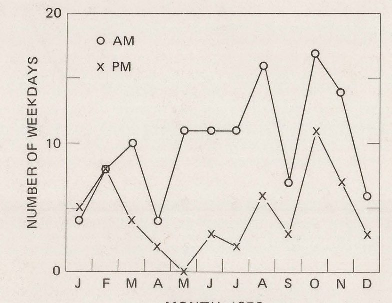
Periods of alternate freezing and thawing are times of rockfall and landslide hazards, especially along mountain transportation routes.

Recreational opportunities are varied, largely because of the wide range in temperatures occurring within a narrow geographical area. Various recreational activities, such as fishing and skiing, are prolonged by following the seasonal shift of temperatures between the different altitude zones.

TEMPERATURE INVERSIONS



A.—During temperature inversions, cool surface air is trapped under a layer of warmer air and pollutants cannot disperse upward.



B.—Numbers of weekdays per month with temperature inversions between surface and 2,000-foot altitude, Seattle, 1972. (Data from Puget Sound Air Pollution Control Agency, based on weekday measurements at Portage Bay, Seattle.

FIGURE 6.—AIR TEMPERATURE INVERSIONS, COMMON OVER THE PUGET SOUND LOWLAND, DRAMATICALLY INTENSIFY AIR POLLUTION PROBLEMS

TEMPERATURE INVERSIONS

Data Highlights

Air-temperature inversions, which intensify air-pollution problems (fig. 6A), are prevalent in the Puget Sound basin, largely because of the mountain-basin setting.

Temperature inversions and associated air pollution are most frequent in the basin during early spring and again in late summer and early fall.

Temperature inversions were recorded at Seattle during each month of 1972 (fig. 6B); they were most frequent in October.

Temperature inversions seldom prevail more than a few days before they are displaced by a new weather system moving into the region.

Planning Significance

Air pollution is usually more noticeable under conditions of intense temperature inversions, clear or hazy skies, and light winds or calm air.

Information on the occurrence and persistence of temperature inversions in different parts of the basin allows prediction of areas of relative susceptibility to air pollution.

Control of air pollution requires information on persistence of temperature inversions and source and timing of pollutants, such as those from automobiles and industry.

Effective planning for disposal of air-borne industrial wastes and control of open burning depends upon data on air movement and temperature variations.

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CLIMATIC FACTORS RELATED TO LAND-USE PLANNING IN THE PUGET SOUND BASIN, WASHINGTON

By
B. L. Foxworthy and Donald Richardson
1973

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