Chapter 12

FIRE CLIMATE REGIONS

The fire weather occurring on a particular day is a dominant factor in the fire potential on that day. Fire climate, which may be thought of as the synthesis of daily fire weather over a long period of time, is a dominant factor in fire-control planning. Climatic differences create important variations in the nature of fire problems among localities and among regions. In a broad sense, climate is the major factor in determining the amount and kind of vegetation growing in an area, and this vegetation makes up the fuels available for wild-land fires. Climate sets the pattern of variation in the fire-protection job—seasonally and between one year and another. It establishes the framework within which current weather influences fire-control operations.

Knowledge of the similarities, differences, and interrelationships between regional weather patterns becomes a useful daily fire-control management device. A weather pattern that is significant to fire behavior in one region may be unimportant in another. What is unusual in one region may be commonplace in another. On the other hand, many large-scale weather patterns ignore regional boundaries, and one originating in or penetrating a region may then be a forewarning of what is soon likely to happen in neighboring regions. Fire-control personnel in line and staff positions who are transferred, either temporarily or permanently, to a new region will find this knowledge helpful in adapting to the changed environment. Understanding of regional fire climatology is critically essential to effective information exchange up to the international level, and it is vital to the continuing development of fire-control lore.

FIRE CLIMATE REGIONS

The fire climate of a region is the composite or integration over a period of time of the weather elements which affect fire behavior. Because of the nature of the effects of various weather elements on fire behavior, simple averages of the weather elements are of little control value. Two areas may have the same annual mean temperature, let us say 50°F., but one of the areas may have monthly mean temperatures ranging from 20 to 80°F., while the other may have monthly means ranging only from 40 to 60°F. The first area may have a serious fire problem during the warm months; the other may not. The extremes of temperatures within months may also be an important consideration.

In a similar situation, two areas may have the same annual precipitation. But the amount may be evenly distributed throughout the year in one area, and concentrated during one portion of the year in the other area. The seasonal distribution, the extremes, the frequency, and the duration must all be considered in describing precipitation in the fire climate of a region.

Fire climate cannot be described by considering the weather elements individually. Fire potential responds to the combined effects of all of the fire-weather elements. In the precipitation example given above, it makes considerable difference in fire climate whether or not the precipitation is concentrated in the warm season or the cold season of the year. If it is concentrated in the cold season, and the warm season is dry, the fire potential during the warm season may be extreme. Where the reverse is true, the warm season may have little fire potential, while the most critical periods may be in spring and fall. Strong winds are very important in fire behavior, providing they occur in dry weather. A region may often have strong winds, but if they occur with precipitation, they are of much less importance to the fire climate.

Fire-danger rating is an integration of weather elements and other factors affecting fire potential. In many systems, only the weather elements are considered, because they are the most variable. The principal elements incorporated are wind speed, temperature, and estimates of dead-fuel moisture, which may be obtained from the atmospheric humidity or dew point, from precipitation measurements, from fuel-moisture indicator sticks, or combinations of these or other integrating systems. Green-fuel moistures may be included by estimating the curing stage of lesser vegetation or the matureness of brush foliage. Daily fire-danger rating is dependent on current fire weather, while seasonal and average fire-danger ratings are dependent on the fire climate.

In studying fire climate, it is necessary to keep in mind that one of the most important behavior characteristics of weather is its variation with time. Thus, we need to know much more than the computed averages of past weather measurements. Normal rainfall, for example, may be an interesting bit of information, but this tells us little about the fire potential unless we know when the rain falls, the kind of weather accompanying it, the weather between rains, the frequency of drought and wet periods, and similar details.

The areas of North America in which wildland fires are a problem have a wide variety of fire climates. Latitude alone accounts for major changes from south to north. These latitudes range from about 20°N. to nearly 70°N. The shape of the continent, its topography, its location with respect to adjacent oceans, and the hemispheric air circulation patterns also contribute to the diversity of climatic types.

We will consider first, in a general way, the geographical features of North America, the pressure and general circulation affecting this continent, and the temperature and precipitation patterns. Then we will discuss the fire climate in each of 15 regions of North America.

GEOGRAPHICAL FEATURES OF NORTH AMERICA

The Interior

The extent of the North American Continent in both its north-south and east-west dimensions permits the full development of continental air masses over much of the land area. The continent is also surrounded by water and is invaded by various maritime air masses. How both types combine to influence the North American climate is largely determined by the surface configuration of the land mass.

It is particularly important that only about a quarter of North America is covered by significant mountain topography. Furthermore, all the mountains lie on the far western side of the continent except two mountain chains along the Atlantic and Gulf of Mexico seaboards. These two chains are the **Appalachian Mountains** in the United States and the **Sierra Madre Oriental** in Mexico. It is also important that, with the exception of the Brooks and associated ranges enclosing interior Alaska and adjoining Canada, all of the major mountain systems have a north-south orientation.

The entire west coast is rimmed by a series of coastal ranges extending, with only infrequent interruptions, from southern Lower California to southern Alaska. A narrow coastal plain separates the mountains from the sea over most of this coastline from Mexico to southern British Columbia. From there northward, the Coast Mountains more commonly rise abruptly from near the water. Glaciers are common along the Canadian and Alaskan coasts, increasing in number north-ward.

Two disconnected interior ranges in the Far West have additional influences on climate. The **Sierra Madre Occidental** in Mexico, east of the Gulf of California, is a secondary range largely shielded from direct Pacific influence by the mountains of Lower California. South of the tip of Lower California, it becomes the mainland western coast range of Mexico. The **Sierra-Cascade Range**, beginning in the north portion of southern California, parallels the Coast Range up to the Fraser River in southern British Columbia. This range bounds the east side of California's Central Valley and a succession of coastal valley systems through Oregon and Washington. It is somewhat higher than the Coast Range, including several peaks in excess of 14,000 feet in elevation.

The **Rocky Mountain system** forms the backbone of that portion of the continent lying in Canada and the United States. It is the continent's most massive mountain expanse and forms the **Continental Divide**, separating water that flows to the Pacific from that flowing to all other surrounding waters. The mountains extend from the Arctic Ocean west of the Mackenzie River to northern New Mexico. The Sierra Madre Occidental plays a similar role in Northern Mexico.

The vast intermountain region west of the Rocky Mountains and northern Sierra Madre is known as the **Cordilleran Highlands**. From a narrow beginning in northern British Columbia, it extends southward in a generally broadening belt to Northern Mexico, where it becomes the Mexican Plateau, and diminishes in width farther south. In the United States a large part is called the Great Basin. The region, as its name implies, is upland country. Because of both topographic and latitudinal differences, however, there are some sub-regional characteristics that are also important to the climatology of the region as a whole. We will note them in some detail later in this chapter.

East of the Rocky Mountains, all of Canada and parts of the Northern United States were scraped and gouged by the prehistoric Polar Ice Cap. This left a land of many lakes and low relief covered mostly by glacial till and numerous moraines. This glaciated region extends into, and connects with, the broad Mississippi Valley system and the adjoining Great Plains—which slope upward to the foot of the Rocky Mountains from Southern Canada to Texas.

East of the Rocky Mountains, therefore, the Appalachian Mountains represent the only topographic barrier on the continent that has a significant influence on general air circulation. It is particularly noteworthy that there is no such barrier between the Arctic and the Gulf of Mexico.

The interiors of Canada and Alaska are source regions for continental polar air and are protected from maritime influence by the western mountain chains. Upon leaving the source regions, this cP air can penetrate far to the south because of the absence of any major east-west mountain ranges across the continent. The southflowing cold air is channeled between the Rocky Mountain system and the less formidable Appalachian Mountains. It often reaches and sometimes crosses the Gulf of Mexico. The lack of mountain barriers also allows warm, moist air from the Gulf of Mexico to flow northward. This warm air constitutes a somewhat deeper layer than the continental air and is less influenced by the mountain systems.

Because of its generally high elevation, the interior of Northern Mexico is little affected by polar continental air. Maritime influence is also restricted. The Sierra Madre Occidental in the west limits the surface effects of Pacific maritime air to the coastal strip. The Sierra Madre Oriental limits the surface effects of Gulf air to the coastal plan. As Mexico’s land mass narrows toward the south between the adjacent warm Pacific and Gulf waters, the climate becomes warm and humid.

Influences of the Oceans

The Pacific Ocean has a strong maritime influence on the whole length of the western shore of North America. However, this influence extends inland near the surface for only relatively short distances because of the barriers provided by the Coast, Sierra-Cascade, and the Rocky Mountain ranges in the United States and Canada, and by the Sierra Madre Occidental and Baja California Mountains in Mexico.

The ocean current known as the North Pacific Drift approaches the west coast at the latitudes of Puget Sound, where it divides. The northern branch becomes the **Alaska Current** and flows northward and then westward along the Alaska coast. The southern branch becomes the **California Current** flowing southward along the west coast. Prevailing westerly winds off the temperate waters of the Pacific have a strong moderating influence along the coast in both summer and winter. The relatively warm waters of the North Pacific are the source of moisture for winter precipitation.

The Bering Sea also contributes some moisture for winter precipitation, while the Arctic Ocean, being largely frozen, is a principal source region for dry polar continental air. The same is true of Hudson Bay during the winter months.

The Atlantic Ocean influences the climate of the east coast, but the effects do not extend far inland because the prevailing air movement is offshore. The icy waters of Baffin Bay have a strong cooling influence on temperatures in Labrador and as far south as Nova Scotia. The Southwest Atlantic, Caribbean Sea, and Gulf of Mexico are important sources of warm, moist air affecting both summer and winter climates of much of the eastern part of the continent. Influences of the warm **Gulf Stream**, which flows northward near the southeast coast, do not ordinarily extend far inland because of the prevailing westerly winds. The wintertime temperature contrasts between the Gulf Stream and the continent create suitable conditions for the development of storms.

The Great Lakes form the only interior water system of sufficient size to have any appreciable effect on regional climate. They have a moderating effect in both winter and summer and contribute some moisture for precipitation in adjacent areas.

PRESSURE AND GENERAL CIRCULATION

The general features of the hemispheric pressure zones and wind circulation patterns were discussed in chapter 5. We will review them briefly here as they affect the North American Continent. Over the oceans the pressure is usually low near the Equator, **high** around 30°N. along the Horse Latitudes (equivalent to Northern Mexico), **low** in the Polar Front zone around 55° or 60°N. (the latitude of the northern portion of the Canadian provinces), and high in the polar regions.

These pressure zones give rise to: (1) The typical northeast trade winds blowing onshore from the Atlantic and Gulf between the Tropics and 30°N., (2) prevailing westerlies off the Pacific between 30°N. and the Polar Front zone, and (3) polar easterlies north of the Polar Front zone. As seasonal heating and cooling change, these pressure and wind systems move somewhat north in summer, and south again in winter.

Over the North American Continent the pressure zones are not as persistent as over the adjacent oceans. High-pressure centers tend to develop over land during the winter, and low-pressure centers tend to develop there during the summer. In between summer and winter there are wide variations in circulation over the continent.

The wintertime continental high pressure gives rise to migratory high-pressure centers. These centers move southward at intervals as waves or surges of cold north wind, extending as far south as the Southern States where they meet warmer air along the South Atlantic and Gulf coasts. During the transition from winter to summer, these high-pressure systems gradually weaken, and the cold north winds do not penetrate far south. By full summer, they are prevalent only in Northern Canada. The Brooks Range in northern Alaska is a local barrier against them in that area.

The Pacific and Azores—Bermuda high-pressure systems, with their clockwise airflow, dominate the summertime wind pattern over large portions of the continent. With the northward movement of the Pacific High during the spring, prevailing winds along the west coast gradually shift from generally southwesterly to northwest and north. The circulation around the Bermuda High is the dominant feature along the Mexican Gulf coast and the Central and Eastern United States.

An intense heat Low in summer in the Southwest influences the general weather pattern in most of the Southwestern United States and Northern Mexico.

TEMPERATURE VARIATIONS

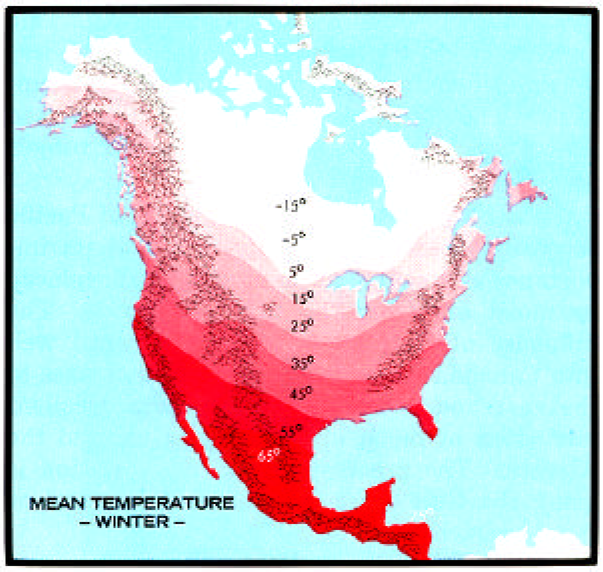
Temperatures vary with the intensity of solar radiation at the earth's surface, among other factors. Because of this, there is a close relationship between average temperatures and latitude. Another major influence on temperature patterns is the distribution of land and water surfaces. At any given latitude, mean temperatures are higher in summer and cooler in winter over land than over water. The annual range of temperature between winter and summer is greater in the interior of the continent than over the adjacent oceans. The blocking effect of the high western mountain ranges also influences the mean temperature pattern.

A third major influence on temperature is elevation because, as we learned in chapter 1, the temperature through the troposphere usually decreases with height. Thus, an area a few thousand feet above sea level may have average maximum temperatures comparable to a low elevation area many hundreds of miles farther north.

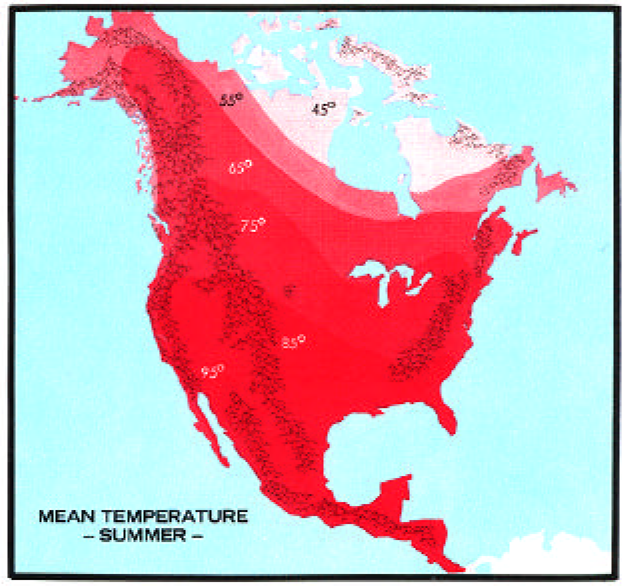
A map of the mean winter temperature shows that temperatures are higher along the east and west coasts than they are in the interior, and higher along the west coast than the east coast. These differences are more marked at higher latitudes than at lower latitudes. In the general west-to-east airflow, the west coast is more strongly influenced by the adjacent ocean than the east coast. In addition, the west coast is sheltered from the cold continental air masses by high mountain ranges.

In January, almost all of the interior of Canada and the Northern United States have mean temperatures below freezing. The coldest temperatures are found in the region between Hudson Bay and northern Alaska. The Great Lakes have a slight moderating effect on the temperature pattern; this area shows slightly higher mean temperatures than points to the east or west.

In the summer, differences in temperatures between the northern and southern sections of the continent are much less than in winter. The effect of the lesser angle of the sun's rays in the northern latitudes is partially offset by the longer days there. The sharp temperature gradient across the Pacific coastline is largely



Mean winter temperatures reflect the ocean influence, with higher temperature along the coast than in the interior. The decrease in temperature from south to north is due to latitudinal differences in the sun's inclination and the length of daylight.



Mean summer temperatures also show the ocean influence with temperatures lower along the coast than in the interior. The effect of latitude is much less pronounced in summer than in winter. Highest temperatures are found in the desert regions of the Southwest.

due to the cool California Current off the coast and the intense daytime heating which is felt, not only in the American Southwest, but also to some extent up through British Columbia and into interior Alaska.

The highest temperatures in summer are found in the lowlands of the Southwest; the lowest temperatures are found in Northeastern Canada.

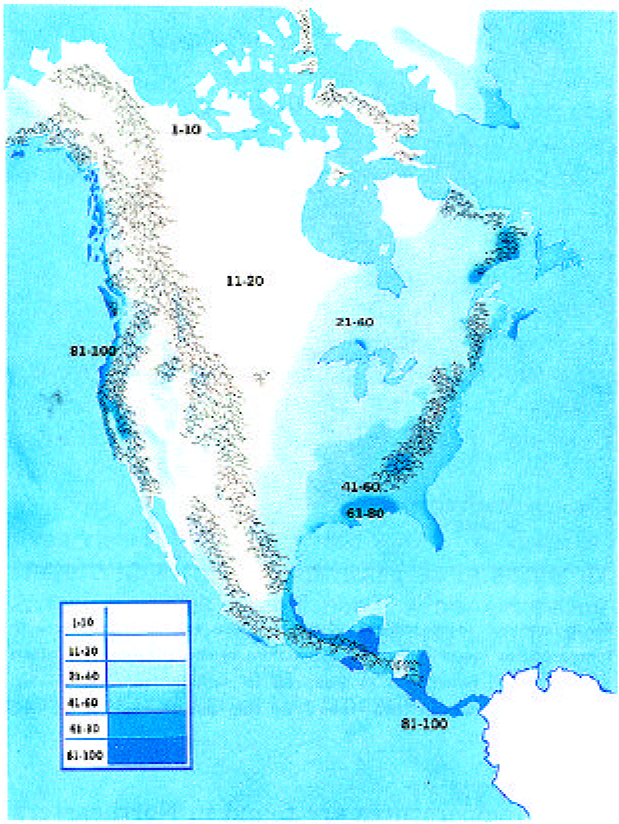
In general, autumn temperatures are higher than spring temperatures in North America. There are some exceptions; in Texas and the interior of British Columbia, temperatures are higher in April than in October.

PRECIPITATION PATTERNS

Both annual precipitation and seasonal distribution of precipitation depend on: (1) The moisture content of the air and vertical motions associated with surface heating and cooling, (2) major pressure systems, and (3) frontal and orographic lifting. This lifting has its greatest effect when the prevailing moist wind currents blow across major mountain systems.

In North America, the greatest precipitation is on the Northern Pacific coastal plains and the western slopes of the mountains, due to the influx of moist air from the Pacific Ocean. Maximum fall is on the Pacific Northwest coast of the United States, with amounts decreasing both north and south of this region. The inland valleys receive less precipitation than the coastal plains and coastal mountains. Along the western slopes of the next major ranges, such as the Sierra-Cascades, further lifting of the moist air again causes an increase in the total precipitation. A third, and final, lifting of these westerlies occurs on the western slopes of the Rocky Mountains, which extract most of the remaining precipitable moisture.

In each of these cases of orographic lifting, there is a decrease in precipitation activity as the air flows across the crests. Previous precipitation has left the air less moist. The lifting force has ceased, and often there is subsidence on the leeward side, which further reduces the



Annual precipitation varies widely over North America. Maximum precipitation is along the Pacific Northwest coast and the Gulf coast. Lowest amounts occur in the Great Basin, the Southwest semidesert and desert regions, and the Arctic region.

degree of saturation. Such a leeward area is said to lie in a rain shadow, a term derived from its similarity to the shadows cast by the western mountains as the sun goes down. This explains why the inland valleys receive less precipitation than the coastal plains and mountains. The Great Basin area in the United States lies in such a rain shadow, and ranges from semidesert to desert.

East of the Rocky Mountains, air of Pacific origin has become relatively dry, and its importance as a source of precipitation is replaced by moist air from the Gulf of Mexico. The influence of Gulf air extends northward well into Canada. Annual precipitation increases to the east and south under the more frequent intrusions of moist air from the Gulf and the Atlantic. The greatest annual precipitation is along the Gulf coast and the southern end of the Appalachians.

In most areas of the continent, there is considerable variation in annual rainfall. Wet and dry years may occur irregularly in poorly defined patterns, or as wet and dry fluctuations of variable duration. Within any one climatic region, a characteristic variation can usually be identified. Common ones are: Normally moist but with occasional critically dry years; typically dry with only infrequent relief; or longer period fluctuations of alternating wet years and dry years.

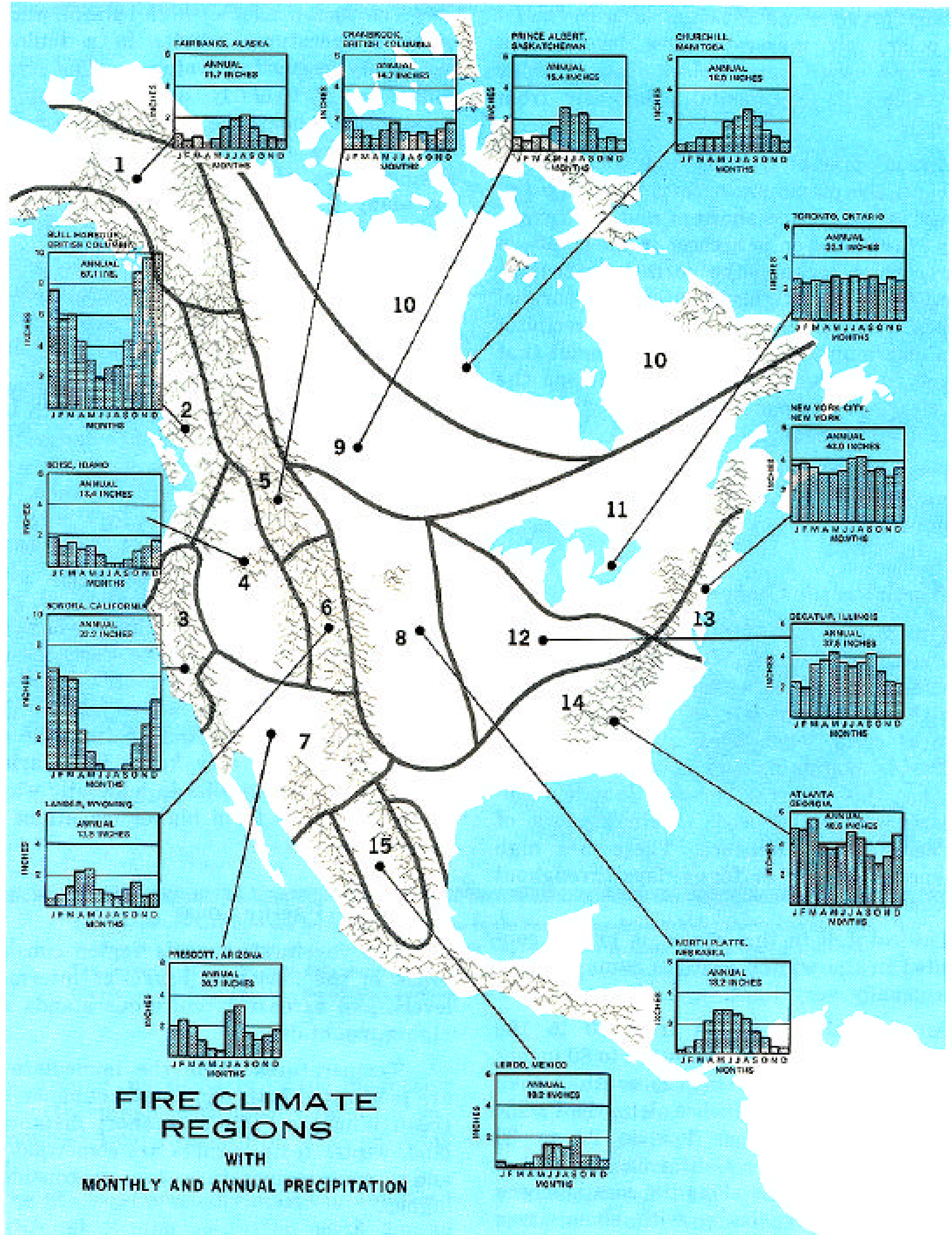
The seasonal distribution of precipitation varies widely over the continent and is often as important in fire weather as the total annual amount. We will discuss some of these characteristics region by region in the following section.

FIRE CLIMATE REGIONS

Considering geographic and climatic factors together, it is possible to delineate 15 broad climatic regions over the continent. Most of these differ in one or more aspects, giving each a distinctive character affecting the wildland fire problem. In considering the climatic characteristics of a particular region, we should remember that generalities must be made and that there are many local exceptions.

1. Interior Alaska and the Yukon

The vegetation in this regain is predominantly spruce and aspen, with some tundra and other lesser vegetation in the north. The Yukon Basin has a warm, short summer. Continental heating has produced summertime temperatures of 100°F., but temperatures as low as 29°F. also have occurred in July. Winters are extremely cold. The high coastal mountains



Fire climate regions of North America, based on geographic and climatic factors, are as follows: (1) Interior Alaska and the Yukon, (2) North Pacific Coast, (3) South Pacific Coast, (4) Great Basin, (5) Northern Rocky Mountains, (6) Southern Rocky Mountains, (7) Southwest (including adjacent Mexico), (8) Great Plains, (9) Central and Northwest Canada, (10) Sub-Arctic and Tundra, (11) Great Lakes, (12) Central States, (13) North Atlantic, (14) Southern States, and (15) Mexican Central Plateau. The bargraphs show the monthly and annual precipitation in inches for a representative station in each of the fire climate regions.

generally prevent the invasion of mP (maritime polar) air masses at low levels. The Brooks and other ranges block the inflow of even colder cP (continental polar) air from the north.

Annual precipitation is only about 10 to 15 inches, the maximum occurring during the summer in convective showers and with weak fronts. Precipitation is highest in the southern portion, which includes the northern extension of the Cordilleran Highlands and their parallel chains of lesser mountains. Although precipitation is maximum in summer, it is so scant that wildland fuels dry out considerably during the long, clear, dry summer days. Dry thunderstorms are not infrequent.

The usual fire season starts in May after melting of the winter snows and lasts until September.

2. North Pacific Coast

This is a region of rain-forest types with heavy coniferous stands. Because of the maritime influence, coastal areas are comparatively warm throughout the winter. The lowest temperatures occur when a cP air mass crosses the coastal mountains and covers the Pacific coast, but this is a rare event. Summer temperatures are rather cool, again because of the Pacific Ocean influence. There is a high frequency of cloudy or foggy days throughout the year.

The rainfall in this region is mostly concentrated in the winter months; summer rainfall is usually very light.

Annual rainfall varies from 60 to 150 inches along the coast, averaging 60 to 80 inches along British Columbia and the south Alaska coastal plains, 80 to 100 inches along the Pacific Northwest coast, and as low as 20 to 30 inches in some northern California coastal sections. Many local areas along the coastal slopes have much greater totals, with some areas receiving over 150 inches; in the Olympic Mountains, annual precipitation ranges up to 240 inches. The valley systems to the east of the Coast Ranges receive 12 to 20 inches in British Columbia, 30 to 50 inches in Washington and Oregon, and 15 to 20 inches in northern California.

The combination of high rainfall and moderate temperatures results in a buildup of **extremely heavy fuel volumes.** The maritime influence, particularly along the immediate coast, usually holds the fire danger to moderate levels during most seasons. However, some summers are very dry and warm with high fire danger. During these periods, fires are characterized by high intensities, firewhirls, and long-distance spotting.

The fire season usually runs from June through September. Lightning fires increase in number and severity from the coast inland.

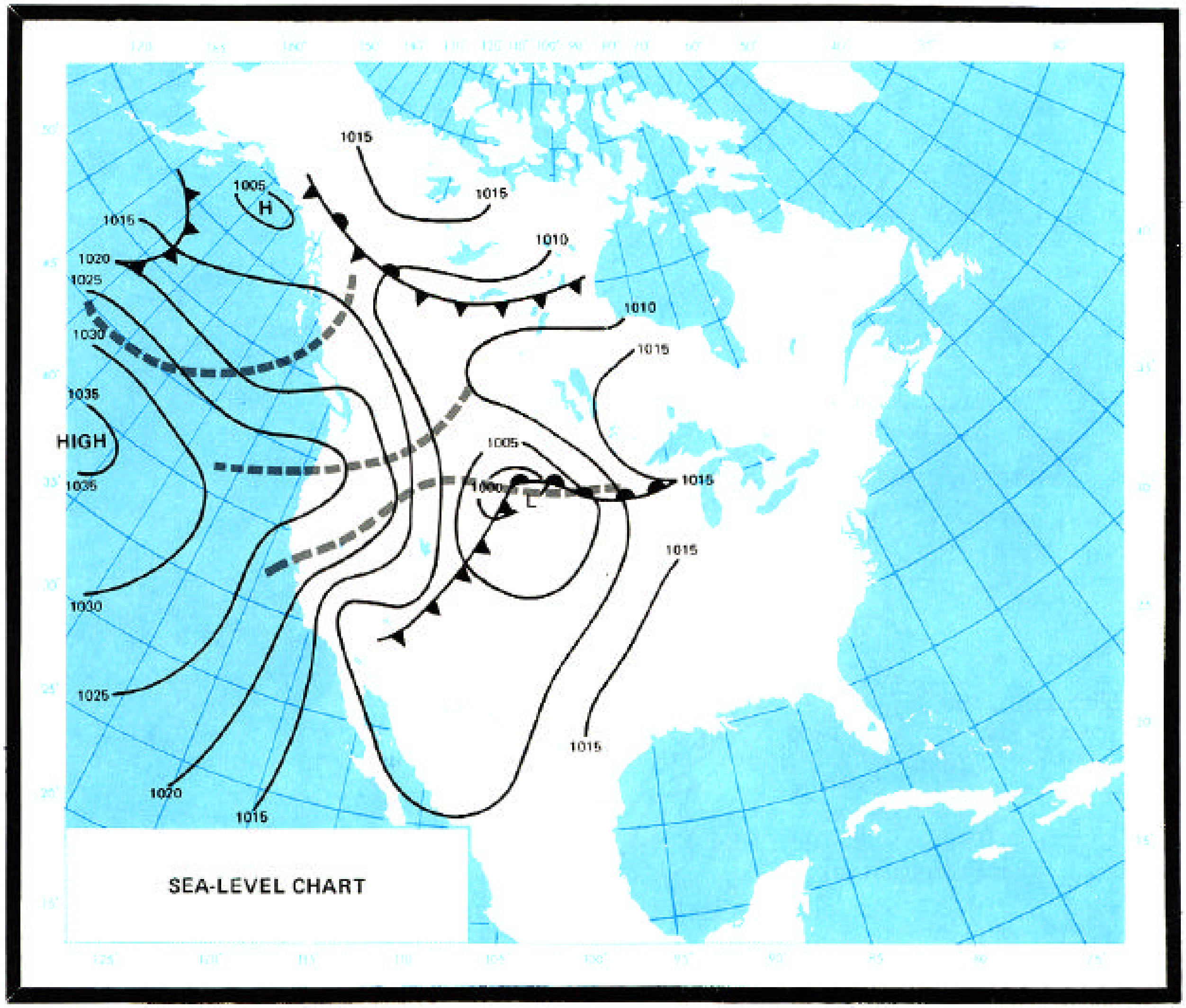
In northern California and in western Oregon and Washington, **strong, dry north to east winds may produce extreme fire danger in late summer and early fall.** Two synoptic weather types produce this critical fire weather. One is a cold-front passage followed by a bulge of the Pacific High extending inland over the coast. The attendant northeasterly winds blowing downslope produce a warming and drying foehn effect. The second type follows when higher pressure develops east of the Cascades at the time a trough lies along the coast. The resulting dry easterly winds will cause high fire danger west of the Cascades. Airflow from the northeast quadrant not only keeps the marine air offshore, but also results in adiabatic warming as the air flows from higher elevations down to sea level.

3. South Pacific Coast

The vegetation in this region consists of grass in the lowlands, brush at intermediate levels, and extensive coniferous stands in the higher mountains.

Temperatures along the immediate coast are moderated both winter and summer by the ocean influence. But only short distances inland, winter temperatures are somewhat lower and summer temperatures average considerably higher.

The annual precipitation is generally light, around 10 to 20 inches at lower elevations. Precipitation in the mountains ranges up to 60 inches or more locally. Summers are usually rainless, with persistent droughts common in southernmost sections. Widespread summer thunderstorms, with little precipitation reaching

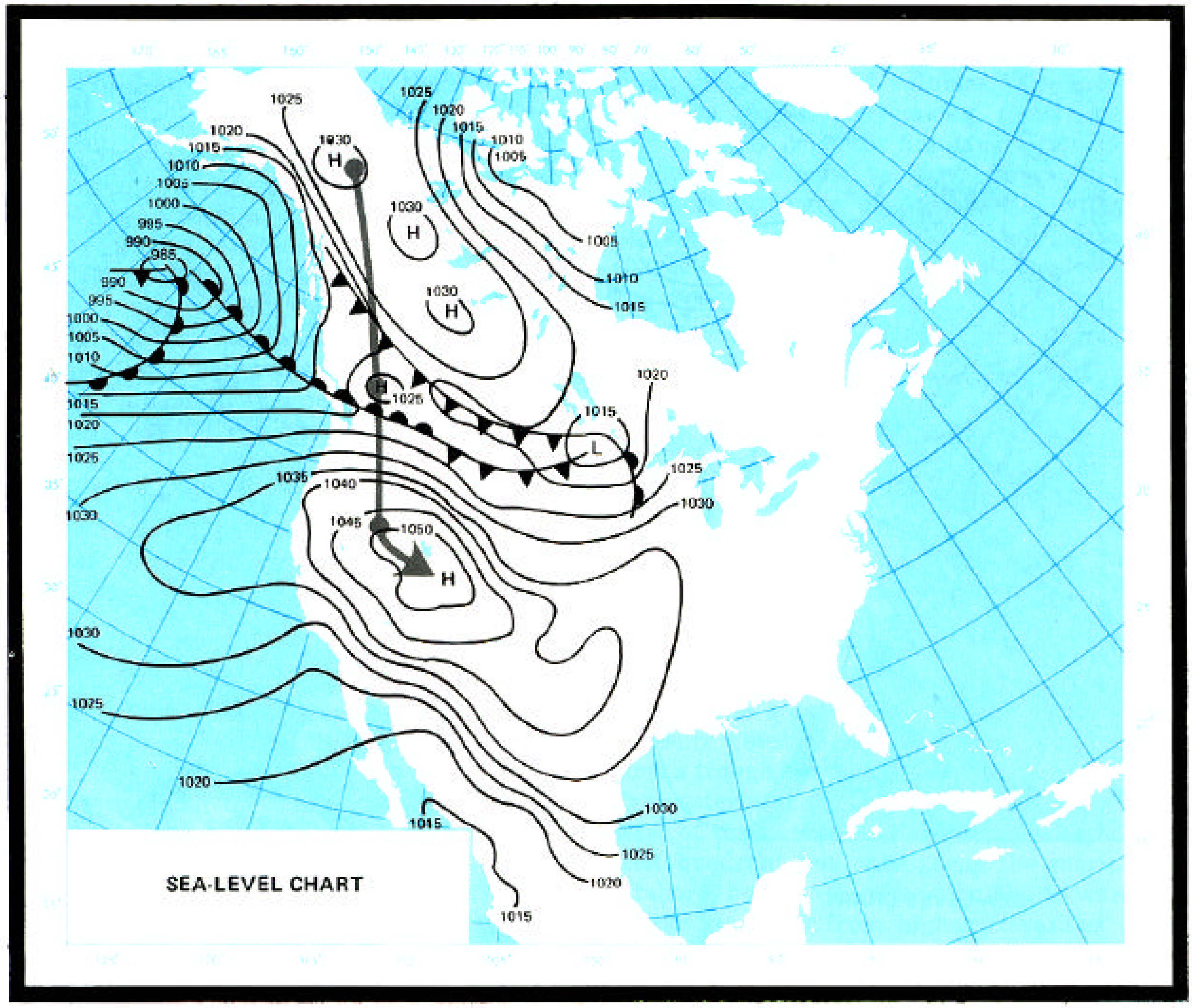


Post-frontal offshore flow can bring high fire danger to the Pacific coast from British Columbia to southern California. The area affected by the pattern on this sea-level chart is northern and central California. The dashed lines are the past daily positions of the front. The bulge of the Pacific High moving inland to the rear of the front produces the offshore northeasterly winds.

the ground, particularly in the mountains of the northern half, occasionally result in several hundred local fires within a 2- or 3-day period.

The fire season usually starts in June and lasts through September in the north, but **in the south critical fire weather can occur year round.**

Several synoptic weather types produce high fire danger. One is the cold-front passage followed by winds from the northeast quadrant —the same as was described above for the coastal region farther north. Another is similar to the east-wind type of the Pacific Northwest coast, except that the high is farther south in the Great Basin. This Great Basin High type produces the foehn-type Mono winds along the west slopes of the Sierras and Coast Ranges, and the Santa Ana winds of southern California. Peak Santa Ana occurrence is in November, and there is a secondary peak in March. A third high fire-danger type occurs when a ridge or closed High aloft persists over the western portion of the United States. At the surface, this pattern produces very high temperatures, low humidities, and air-mass instability.



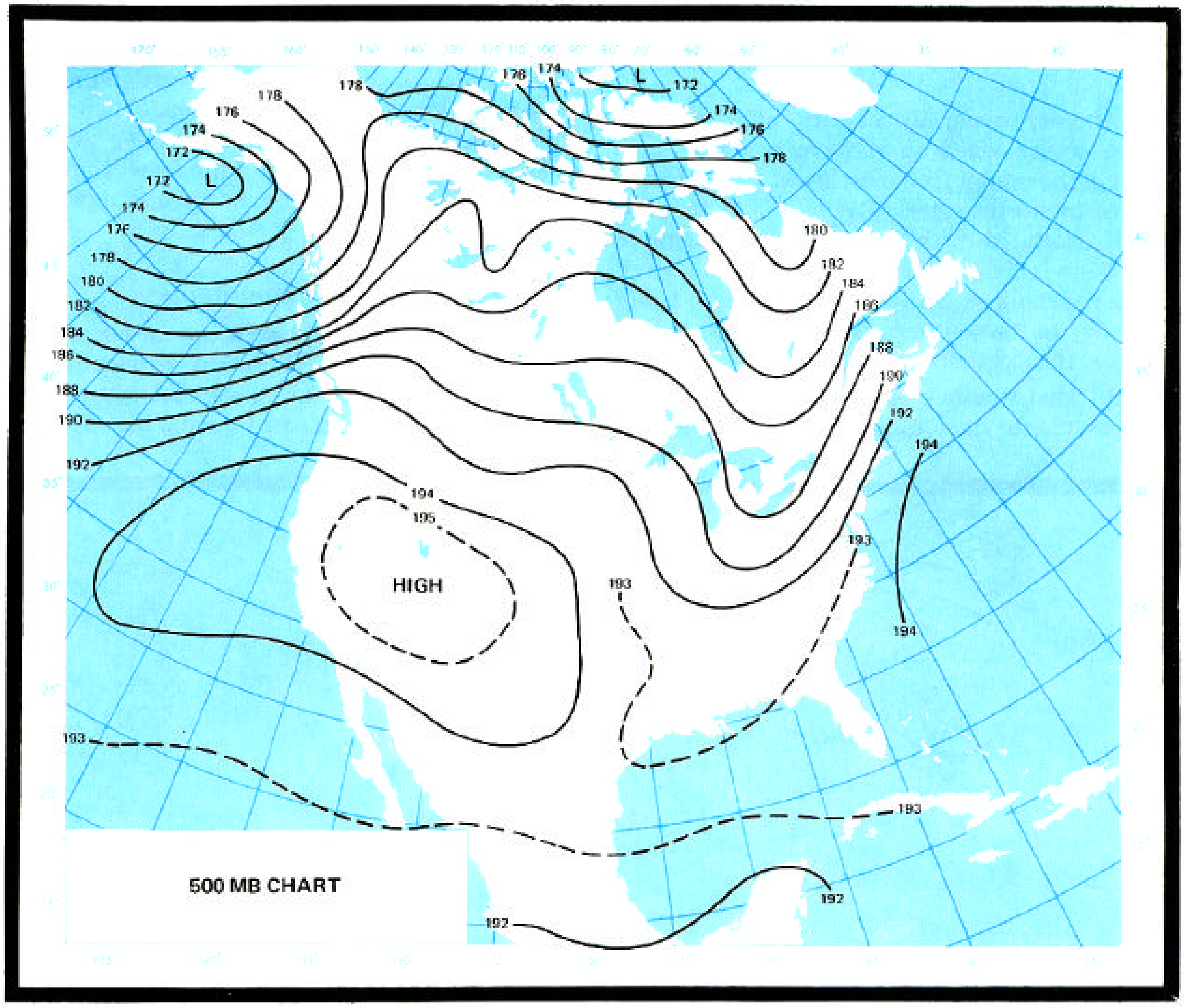
The Great Basin High type develops when a high-pressure center of either mP or cP origin moves into the Great Basin area. If a trough of low pressure lies along the coast, offshore foehn-type winds from the northeast or east are produced. This sea-level chart shows a pattern which produced strong Santa Ana winds in southern California. The track and past daily positions of the High are shown.

4. Great Basin

In the Great Basin or intermountain region the vegetation consists of generally sparse sagebrush and grass, with some pine and fir at higher elevations. This is largely a plateau region but occupies a significant portion of the Cordilleran Highlands, with their individual peaks and lesser mountain systems, between the Rocky Mountains and the Sierra-Cascades.

The Rocky Mountains generally prevent the westward movement of cold cP air masses from the Great Plains to the Great Basin, so major cold waves with high winds are rare. Winter temperatures are quite low, however, because of the high elevation and good radiational cooling. Summer heating is very effective, and summer temperatures are high.

Annual precipitation is rather low, ranging from 10 to 20 inches in eastern Washington and Oregon and western Idaho to less than 10 inches in Nevada and Utah. At higher elevations, precipitation is higher, generally 20 to 40 inches, as in the Blue Mountains in eastern Oregon and Washington and the Wasatch Range in Utah. The entire Great Basin is in



An upper-air pattern associated with high fire danger during the summer in the Western United States has the subtropical High aloft located over the Far West. This pattern, illustrated by this 500-mb. chart, produces very high temperatures, low humidities, and unstable atmospheric conditions near the surface.

a rain shadow. The mP air masses which enter the region from the west have crossed the Sierra-Cascade Ranges and have lost much of their moisture during the forced ascent.

Much of the precipitation occurs in the wintertime, although some areas have a secondary maximum in spring. Precipitation is more general and widespread in winter, while in spring it is showery and scattered. Summer precipitation is generally light. Intensive local heating produces frequent afternoon thunderstorms, but usually little precipitation reaches the ground.

The fire season normally starts in June and lasts through September and, occasionally, October. Both timber and range fires are common.

Several synoptic weather types produce high fire danger in the Great Basin. Often, the pattern aloft is more distinctive than the surface pattern. One pattern is the same as is described above for the South Pacific coast region; that is, a pattern with an upper-air ridge over the western portion of the United States. At the surface in the Great Basin the pressure pattern tends to be fiat, often with a thermal trough extending from the Southwest to the Canadian border. This pattern produces hot, dry days with considerable low-level, air-mass instability during the summer.

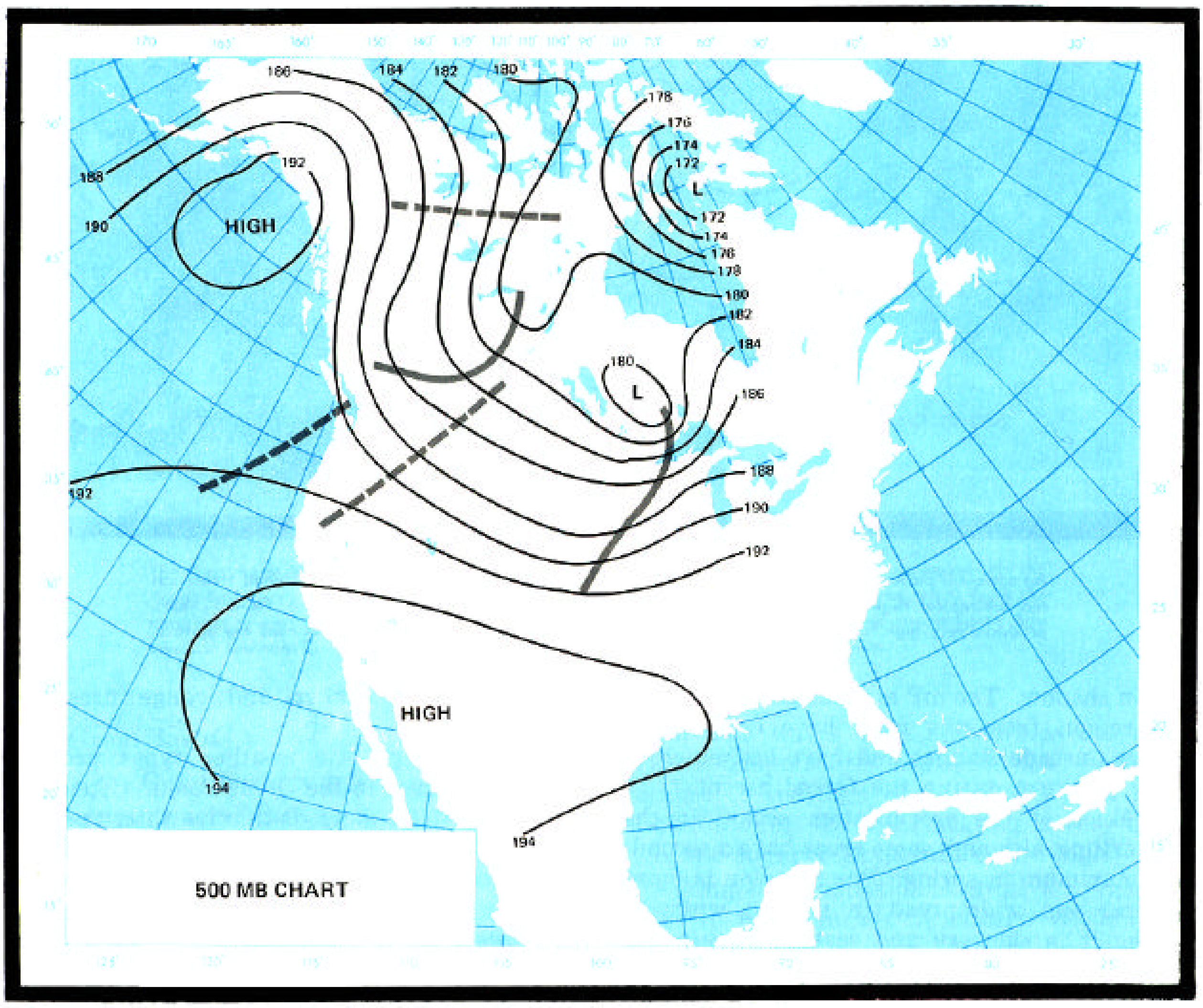
Subsidence beneath the ridge may result in very low humidities that sometimes reach the surface.

Another upper-air pattern affecting this region occurs when short-wave troughs move through the region from northwest to southeast, steered by northwesterly flow aloft. If the cold front associated with a short-wave trough is dry, the windiness with it will produce a peak in the fire danger. These fronts are more likely to be dry in the southern portion of this region than in the northern portion.

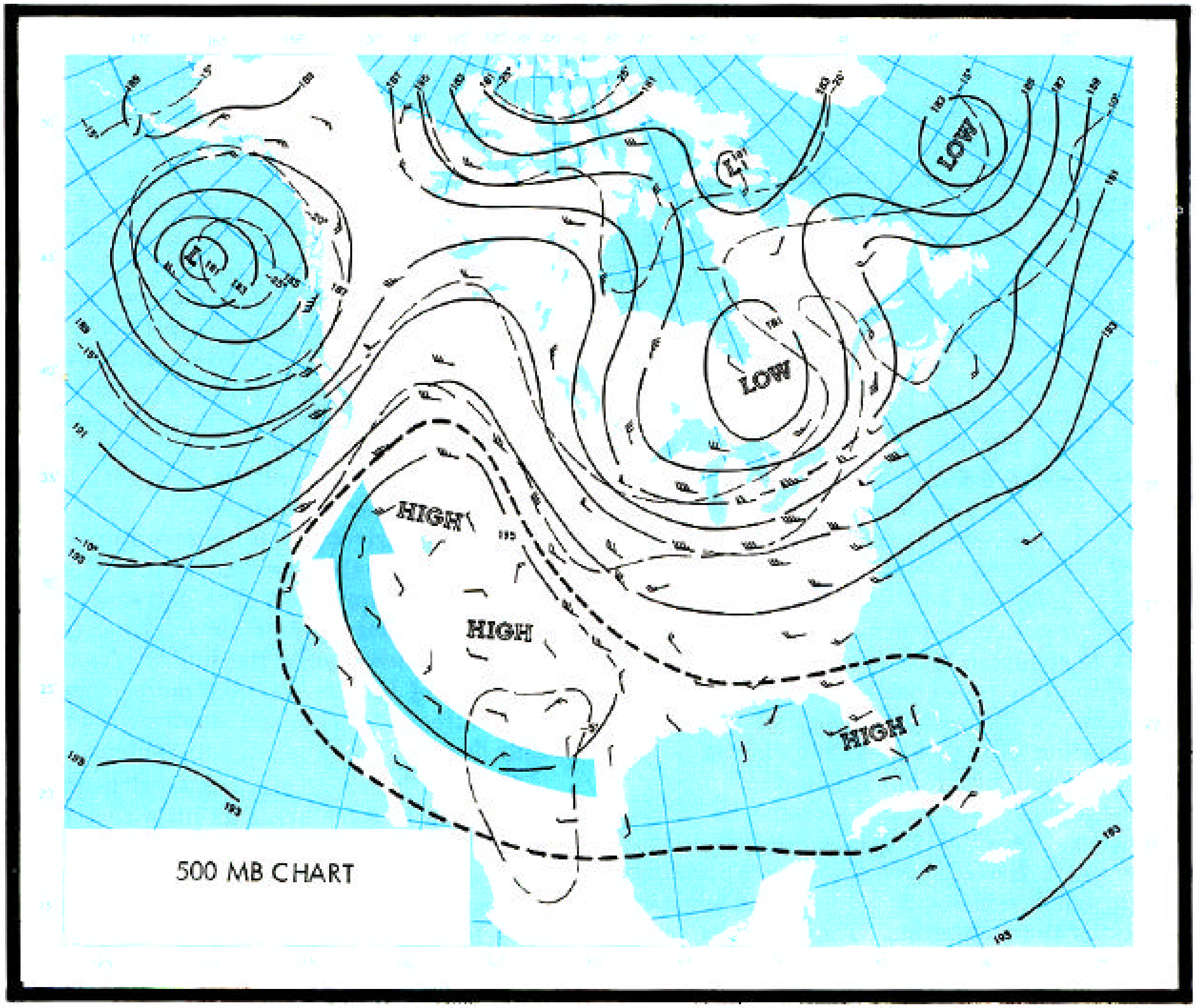
A third weather pattern, which is important as a fire starter, develops whenever the anticyclonic circulation around a closed High aloft has transported moist air from over the Gulf of Mexico across the Southwest and northward into the Great Basin region. Then, daytime heating and orographic lifting of the moist air produces many high-level thunderstorms, which may cause numerous lightning fires.

5. Northern Rocky Mountains

Heavy pine, fir, and spruce stands dominate the Northern Rocky Mountain region. Many mountain peaks extend above timberline. The portion of this region in Canada includes the



Short-wove troughs aloft, when accompanied by dry surface cold fronts, can cause high fire danger in the Great Basin and Rocky Mountain regions from late spring to early fall. This 500-mb. chart shows short-wave troughs moving eastward and southeastward in a northwesterly flow pattern. Past daily positions of the short-wave troughs are shown by heavy dashed lines.



Moisture from the Gulf of Mexico is transported to the Southwest and the Western States at mid-tropospheric levels when a close High aloft moves into the position shown on this 500-mb. chart. Daytime heating and orographic lifting of the moist air combine to produce many high-level thunderstorms.

Cordilleran Highlands with numerous mountain ranges and dissecting river courses, in addition to the Rocky Mountains. Winter temperatures are quite low, and summer temperatures are moderate.

Annual precipitation ranges from 10 to 20 inches in the valleys to 40 to 60 inches locally in the mountains. Most of the precipitation falls in the winter and spring in the southern portion of this region, while in the northern portion it is fairly well distributed throughout the year, in most years. Winter precipitation is in the form of snow. In the southern portion, there often is widespread rainfall until June, followed by generally light precipitation during the summer.

There is a gradual drying out of forest fuels during July and August with increasing fire danger. Frequent thunderstorms may occur then but little or no precipitation reaches the surface, so that frequent and severe lightning fires occur in both the Canadian and United States portions of the region. Also, extremely low humidities can result from large-scale subsidence of air from very high levels in the atmosphere. Occasional chinook winds on the east slope of the Rockies produce moderate temperatures and are effective in bringing subsiding air to the surface.

The fire season usually extends from June or July through September.

The synoptic weather types producing high fire danger are similar to those described for the Great Basin region. Particularly important are the ridge-aloft pattern which produces warm, dry weather and the patterns producing high-level thunderstorms.

6. Southern Rocky Mountains

The vegetation in the Southern Rocky Mountain region consists of brush and scattered pine at lower elevations, and fir and spruce on higher ridges and plateaus. Many peaks extend above timberline. As in the Northern Rockies, winter temperatures are quite low, and summer temperatures are moderate for the latitude because of the elevation influence.

Precipitation is generally around 10 to 20 inches annually in the valleys and on eastern slopes, and 30 to 40 inches locally at higher elevations on the western slopes. The heavier precipitation at higher elevations is caused by the additional orographic lifting of mP air masses as they are forced across the Rocky Mountains. Most of the precipitation in the winter is in the form of snow. Precipitation is light but not infrequent during the summer, mostly as thunderstorms. These storms cause wildland fires, but ordinarily the burned acreage is small.

There are strong chinook winds with associated warm and dry conditions in the spring and fall on the eastern slopes of the mountains. These winds sometimes bring subsiding air from high levels in the atmosphere down to the surface and produce extremely low humidities.

The fire season normally extends from June or July through September, but earlier or later periods of critical fire weather may be caused by the chinook winds.

The synoptic patterns which produce high fire danger are the ridge aloft and dry cold-front passages. In addition, the pattern producing chinook winds is important on the eastern slopes. In this pattern, the airflow aloft is usually at right angles to the mountain range, while at the surface, a High is located in the Great Basin and a front is found east of the Rockies. In the area between the front and the Rockies the air flows downslope, winds are strong, temperatures are high, and humidities are acutely low.

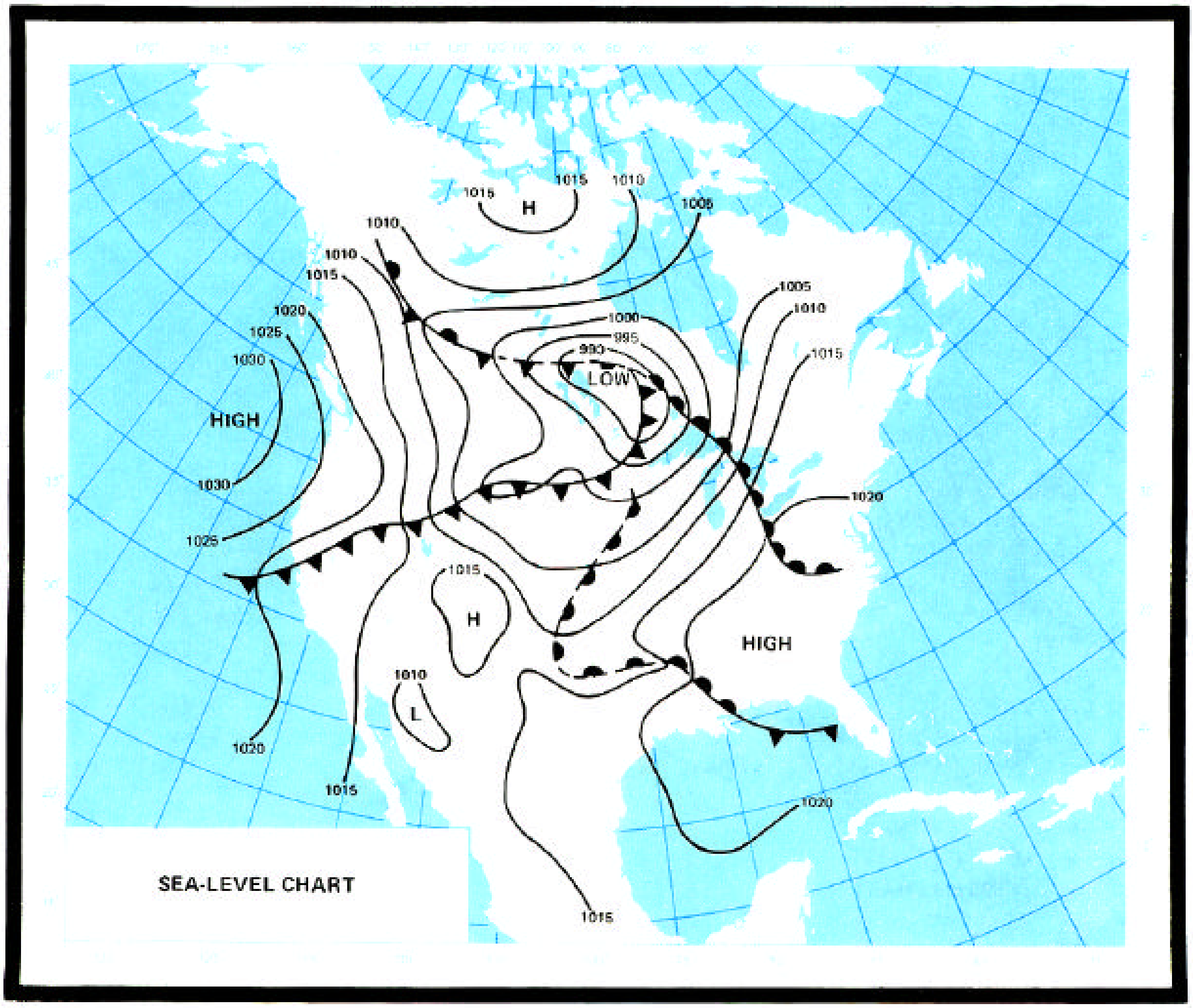
7. Southwest

The vegetation in the Southwest (including Sonora, Mexico) is mostly grass, sage, chaparral, and ponderosa pine. The region in which wildfire is a problem is essentially a plateau, but it also includes the southern portion of the Cordilleran Highlands. The low-elevation areas of the Southwest have a large annual range and a large diurnal range of temperatures, the latter being larger in the summer than in the winter. The higher elevations have both lower mean and lower maximum temperatures. Spring and early-summer temperatures are very high during the daytime because of clear skies and low humidities. The extreme southwest low-elevation portions have extremely hot and dry summers, while the higher elevations of the rest of the region have more moderate temperatures, and frequent summer thunderstorms during July, August, and September.

The Southwest is quite dry, with annual precipitation in some areas as little as 5 to 10 inches. This occurs as winter rain or snow, and as rains accompanying the frequent summer thunderstorms. In the first scattered storms in the late spring and early summer, little precipitation reaches the ground. Later in the summer, thunderstorms are usually wet.

The Southwest is characterized by an annual minimum of fire danger in the winter months and a secondary minimum in August. The most dangerous fire season is generally May and June when the problem of dry thunderstorms is combined with drought. Rainfall with thunderstorms accounts for the lower fire danger during the summer season. Fires started by lightning during this time of the year are usually not difficult to handle.

Since the Southwest has a generally high level of fire danger in spring and again in fall, the important synoptic patterns are those which cause peaks in fire danger or those which cause dry thunderstorms. The most critical fire weather occurs with a broadscale pattern aloft showing a ridge to the east and a trough to the west of the region, and southwesterly flow over the region. The fire danger peaks as

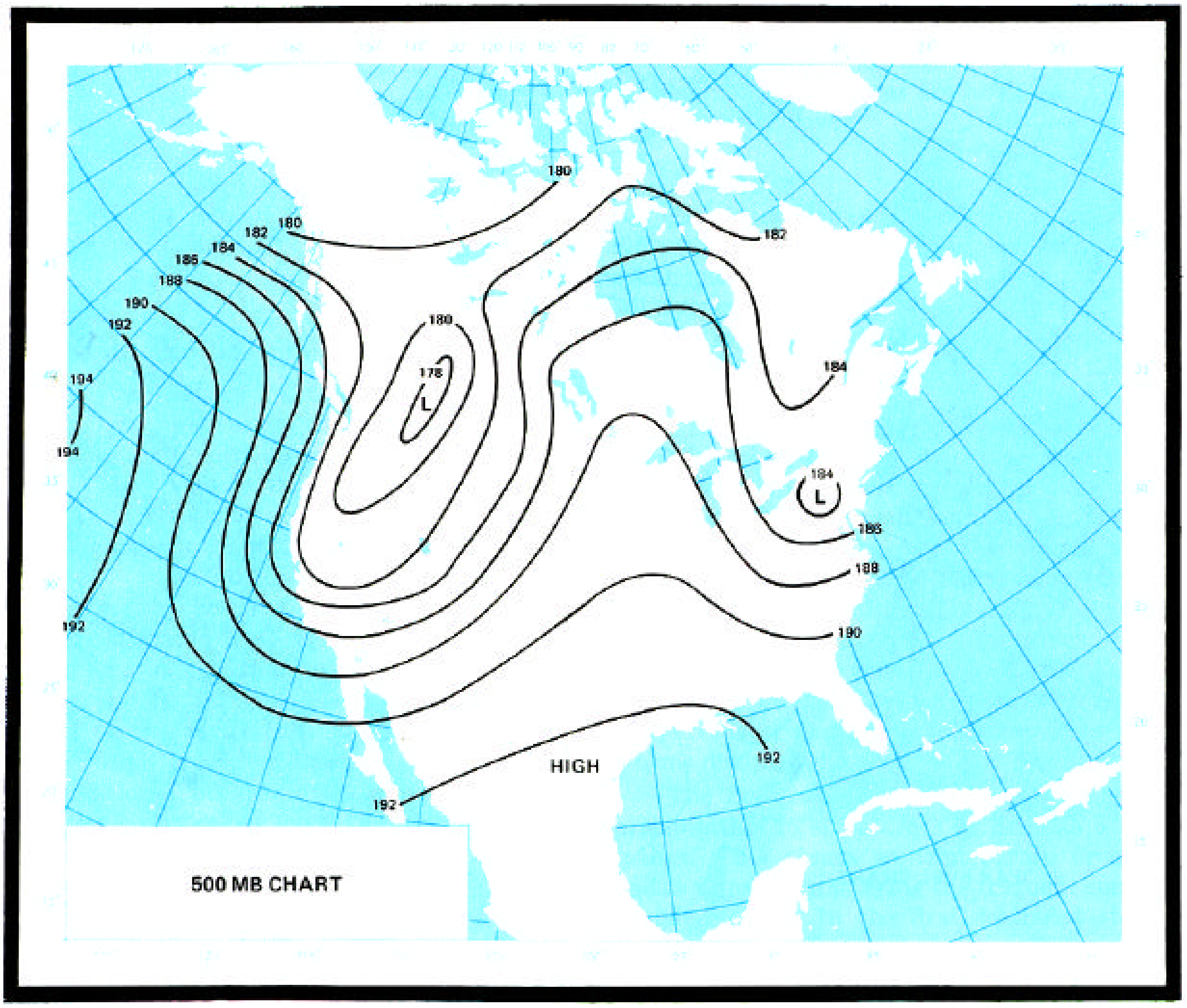


This winter sea-level chart illustrates the synoptic type producing chinook winds along the east slope of the Rockies. A High is located in the Great Basin and a front is in the Plains. In the area between the front and the Rockies, strong winds blow downslope, producing high temperatures and acutely low humidities. Airflow aloft is perpendicular to the mountain range. In this case, during 3 November days chinook winds progressed southward from Montana and Wyoming to Colorado, New Mexico, and Texas.

short-wave troughs move through this pattern and cause a temporary increase in wind speed. The pattern favorable for thunderstorms has the subtropical High aloft to the north of the region, and southeasterly flow bringing moist air from over the Gulf of Mexico to the Southwest region. When this pattern becomes established, the first moisture brought in is usually in a shallow layer aloft. The resulting thunderstorms tend to be of the dry, fire-starting type and appear when the fuels are dry and the fire potential is high. Then, as the pattern persists, moisture is brought from the Gulf of Mexico in a deep layer, and the thunderstorms produce rain which reaches the ground and reduces the fire danger.

8. Great Plains

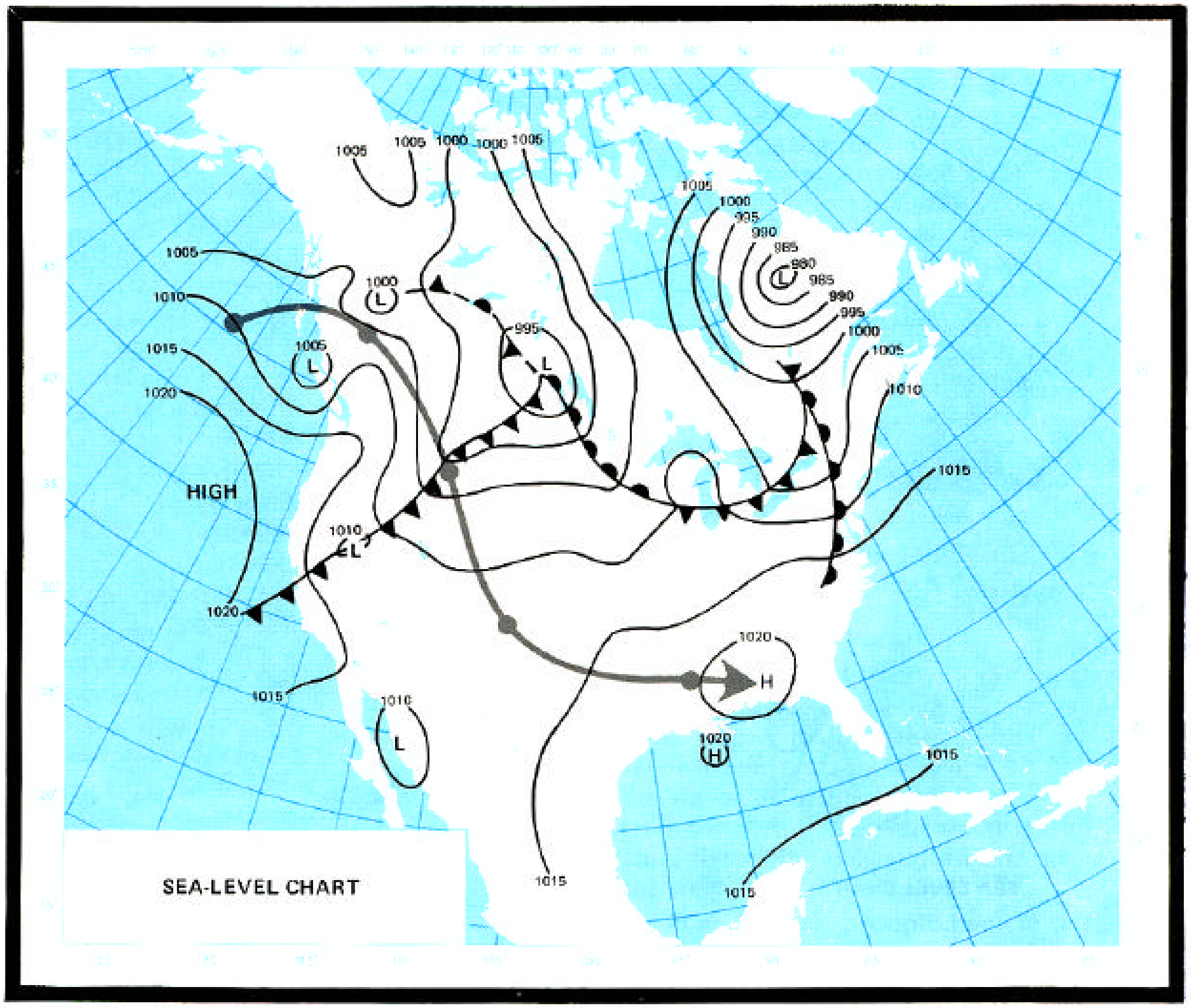
Vegetation in the Great Plains consists of grasses, cultivated lands, and timber in isolated regions. Fuels are generally too light and sparse to create a serious fire hazard except in the timbered areas. Temperatures in the Great Plains vary drastically from winter to summer—due to the frequent presence of cP air masses



Southwesterly flow aloft often brings high fire danger to the Southwest, southern Great Basin, and southern Rocky Mountain regions. In this spring example, the ridge at 500 mb. is to the east and the trough to the west of the affected regions. Peaks in fire danger occur with the passage of short-wave troughs aloft and their associated dry surface cold fronts.

in the winter, and the occasional presence of cT and mT air masses in summer, particularly in the southern portions. The Plains are open to intrusions of winter cP air from Northern Canada, since no mountain barrier exists, and these air masses sometimes penetrate to the Southern Plains and even to the Gulf of Mexico. In the summer, cP air masses often influence the Northern Plains. At the same time, cT or mT air may persist in the Southern Plains and thus account for a wide latitudinal range in summer temperature. Maritime air from the Pacific must cross the western mountains to reach the Plains, and arrives as a relatively dry air mass.

Precipitation in the Great Plains is generally light to moderate, increasing both from north to south and from west to east. Amounts range from 10 to 20 inches in the northwest to 20 to 40 inches in the southeast. The western portion of the Plains is in the Rocky Mountain rain shadow. This, in part, accounts for the low precipitation. Also, mT air is less frequent in the western than eastern portions, and fronts are more intense in the eastern portion. Winter precipitation is usually in the form of snow in the north and, frequently, also in the south. Maximum precipitation occurs in the early summertime, mainly in the form of convective showers and frequent thunderstorms. Thunder-



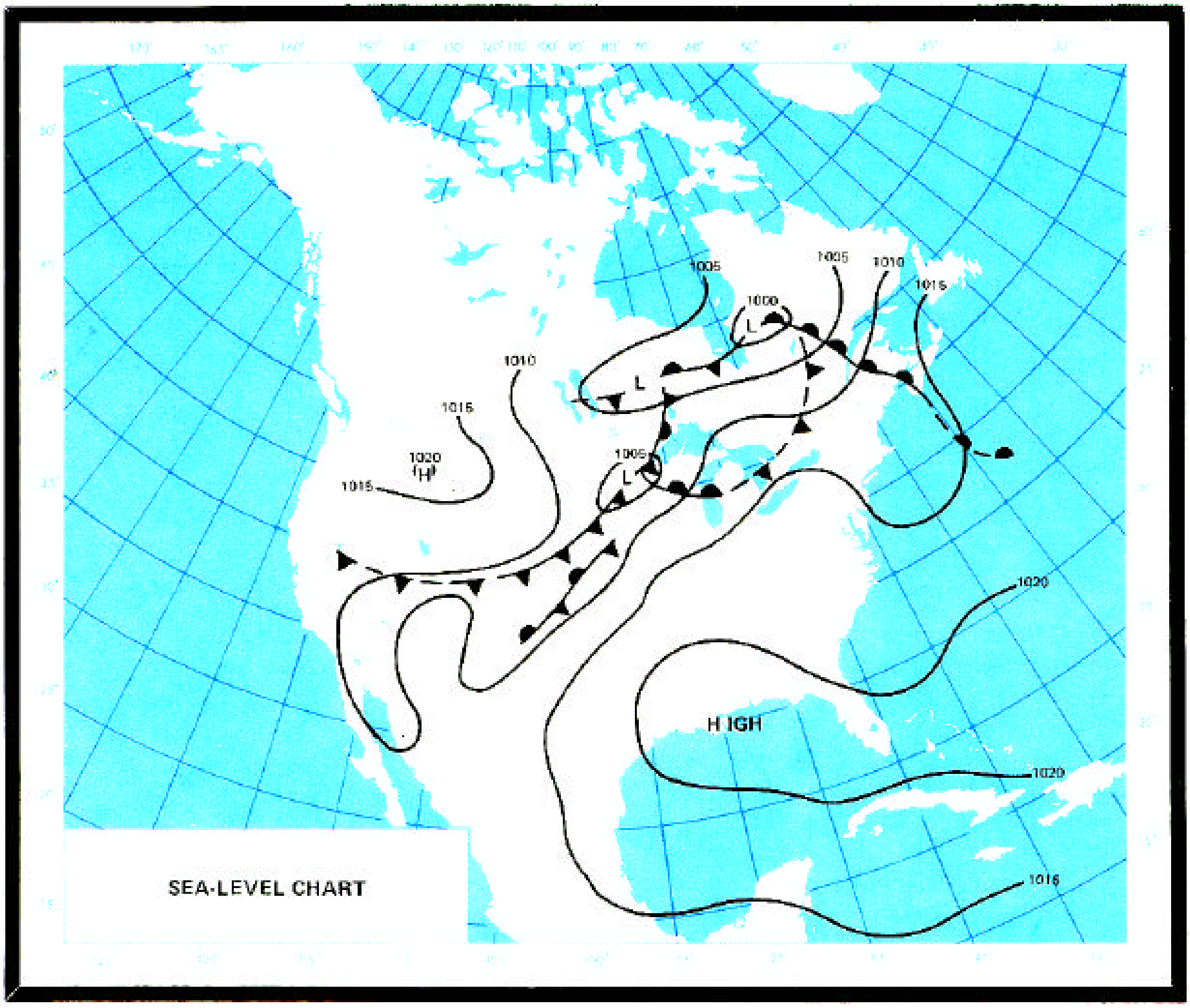
The Pacific High synoptic type is very common and can bring high fire danger to all regions east of the Rockies. An mP air mass enters the continent, usually in the Pacific Northwest or British Columbia, as a high-pressure area, loses much of its moisture as it moves across the mountains, and reaches the region east of the Rockies about as dry as cP air masses, The regions affected depend upon the track taken by the High. In this example, the flow aloft was meridional and the High plunged southward along the Rockies and then moved eastward. In other cases, the flow aloft may be zonal and the High will take a predominantly easterly course. Usually, the western or northwestern portion of the High is the most critical firs-danger area.

storms are usually wet and cause fewer fires than in the West.

The western portion of the Great Plains is subject to chinook winds which blow down the east slopes of the Rockies and extend some distance into the Plains. The combination of extremely low humidities and mild temperatures can create short periods of extreme fire danger in spring and fall, although chinook occurrence in the winter may be more frequent.

The fire season usually lasts from April through October, although the summer season, because of higher humidities, is less severe than spring or fall (except in the Black Hills).

Most critical fire-weather periods in this region are associated with the Pacific High synoptic type, the Bermuda High type, or the chinook type. Some periods occur with Highs from Hudson Bay or Northwest Canada, but these are more important to the regions farther



The Bermuda High type, shown on this sea-level chart, is most important in the Southern States but can produce high fire danger in any region east of the Rockies. It is most frequent in spring, summer, and early fall and may persist for long periods of time. A westward extension of the semipermanent Bermuda High, often well into Texas, cuts off Gulf moisture. This is the typical drought pattern for the eastern regions. Subsidence and clear skies produce low humidities and usually high temperatures.

east. The chinook type has been described above. The Pacific high type occurs when an mP air mass breaks off of the Pacific high-pressure cell and moves eastward across the mountains into the Great Plains following a Pacific cold front. The mP air loses much of its moisture in crossing the mountains, and arrives in the Plains as a comparatively dry and mild air mass. Highest fire danger is found on either the fore or rear sides of the High.

The Bermuda High type is most important in the southern portion of this region. In this type, the semipermanent Bermuda High extends far westward across the Gulf States and into Texas. A ridge aloft is located over the middle of the continent. Warm, dry air from Mexico flows northward into the Plains, often causing a heat wave. The Bermuda High is a persistent summer pattern and sometimes causes long periods of drought. Nonforest types account for most of the area burned.

9. Central and Northwest Canada

With the exception of the southern prairies, vegetation in this part of Canada consists predominantly of spruce, pine, poplar, and aspen forest with various mixtures of other species. In spite of the short growing season in the far northwest, comparatively good tree growth results from the long daylight hours. Much of the vegetation in the region reflects an extensive past fire history.

This region is glaciated with mostly low relief, except for the more broken topography of the mountain foothills along the western boundary. A common characteristic is very low winter temperatures. The region serves as both a source region and southward pathway for cold cP air masses. The large north-south and east-west geographical extent of the region results in significantly different summer temperature and moisture regimes from one part of the region to another.

The far northwest portion of the region has long, predominantly clear, sunny days contributing to rapid and extensive drying of forest fuels. Even though the summer season is short, drying is only occasionally and temporarily alleviated by summer showers. Proceeding southward and eastward, the summer days are not as long, although the season is longer. On clear days, maximum temperatures may be considerably higher here than in the northwest portion of the region, but cloudy days with shower activity are frequent.

Precipitation distribution is an important part of the regional climatology. The average annual amounts vary from 8 to 10 inches in the far northwest, to 20 inches in southern portions of the Prairie provinces, and up to 30 inches at the eastern extremity. Winter snows are generally light because the cold air holds little moisture, so it is usual for at least half of the total precipitation to come in the form of summer rains. These rains often are thunderstorms with accompanying lightning fires, and they occur with varying frequencies in virtually all parts of the region. The principal cyclone tracks during the summer run through the central part of the region.

The geographic extent of this region is so great that it is not practical to designate any particular fire season for the area as a whole. For example, locally there may be both a spring and fall fire season, a summer fire season, or any combination of these.

10. Sub-Arctic and Tundra

This region, extending from the Mackenzie Delta to the Atlantic, supports scattered patches of scrub spruce forest in the south merging with open tundra in the north. It is all low glaciated terrain. Annual precipitation is about 10 to 15 inches in the northwest and up to 20 to 25 inches in the east. More precipitation falls in the summer than in winter.

The fire season is principally during mid-summer. Strong winds and low humidities are common. The average number of fires is small, with apparently half or more caused by lightning. There is considerable evidence of severe past fire history.

11. Great Lakes

The vegetation in the Great Lakes region consists mainly of aspen, fir, and spruce in the north and some additional hardwoods in the south. There are several upland areas, including the western slopes of the Appalachians, but most of the region has been heavily glaciated. Winter temperatures are quite cold, and summer temperatures are variable. In summer, the region is subjected to cool cP air masses from the north, warm and moist mT air masses from the south, and mild mP air masses from the west.

The annual precipitation in the Great Lakes region is moderate, generally over 30 inches. It is fairly well distributed throughout the year, but most areas have somewhat larger amounts in summer. Winter precipitation is mostly in the form of snow, and the greatest amounts occur with intense cyclones involving mT air masses. Summer precipitation is largely in the form of showers and thunderstorms. Lightning fires are common on both sides of the St. Lawrence and in the northern Great Lakes area.

Strong winds are common with intense storms in fall, winter, and spring, and with squall lines and strong cold fronts in the summer. Humidities are normally moderate to high except during brief periods when cP and mP air masses are warmed by heating and subsidence before much moisture can be added to them.

The Great Lakes are sufficiently large to influence the climate of portions of the region.

Near the shores, when the gradient winds are weak, lake breezes can be expected on summer days. The lake breeze is cool and humid and moderates the summer climate along the lake shores.

On a larger scale, the Great Lakes modify air masses that pass over them. Cold air masses passing over the warmer lakes in the fall and winter are warmed and pick up considerable moisture, resulting in heavier precipitation to the lee of the lakes. The amount of moisture picked up depends to a large extent upon the length of the overwater fetch. In spring and summer, warm air masses are cooled as they pass over the cooler waters of the lakes. If the air mass is moist, fog and low clouds form and drift over the leeward shores.

The Great Lakes also affect the synoptic-scale pressure pattern. In spring and early summer when the lakes are relatively cool, they tend to intensify high-pressure areas that pass over them. In fall and winter when the lakes are relatively warm, they tend to deepen Lows that pass over them. On occasion, they will cause a trough of low pressure to hang back as the Low center moves on toward the east. This tends to prolong the cloudiness and precipitation.

The fire season generally lasts from April through October with peaks in the spring and fall. In hardwood areas, the leafless trees in spring expose the surface litter to considerable drying, which increases fire danger. After the lesser vegetation becomes green and hardwoods leaf out, the fire danger decreases. In fall, the lesser vegetation is killed by frost, the hardwoods drop their leaves, and the fire danger again increases.

The synoptic weather patterns producing high fire danger in the Great Lakes region are usually those involving Highs moving into the region from Hudson Bay, Northwest Canada, or the Pacific. Occasionally the region is affected by a Bermuda High type, but this is infrequent and usually occurs during the period when the vegetation is green. The Pacific High type, which was discussed with the Great Plains region, causes more high fire-danger days than any other type.

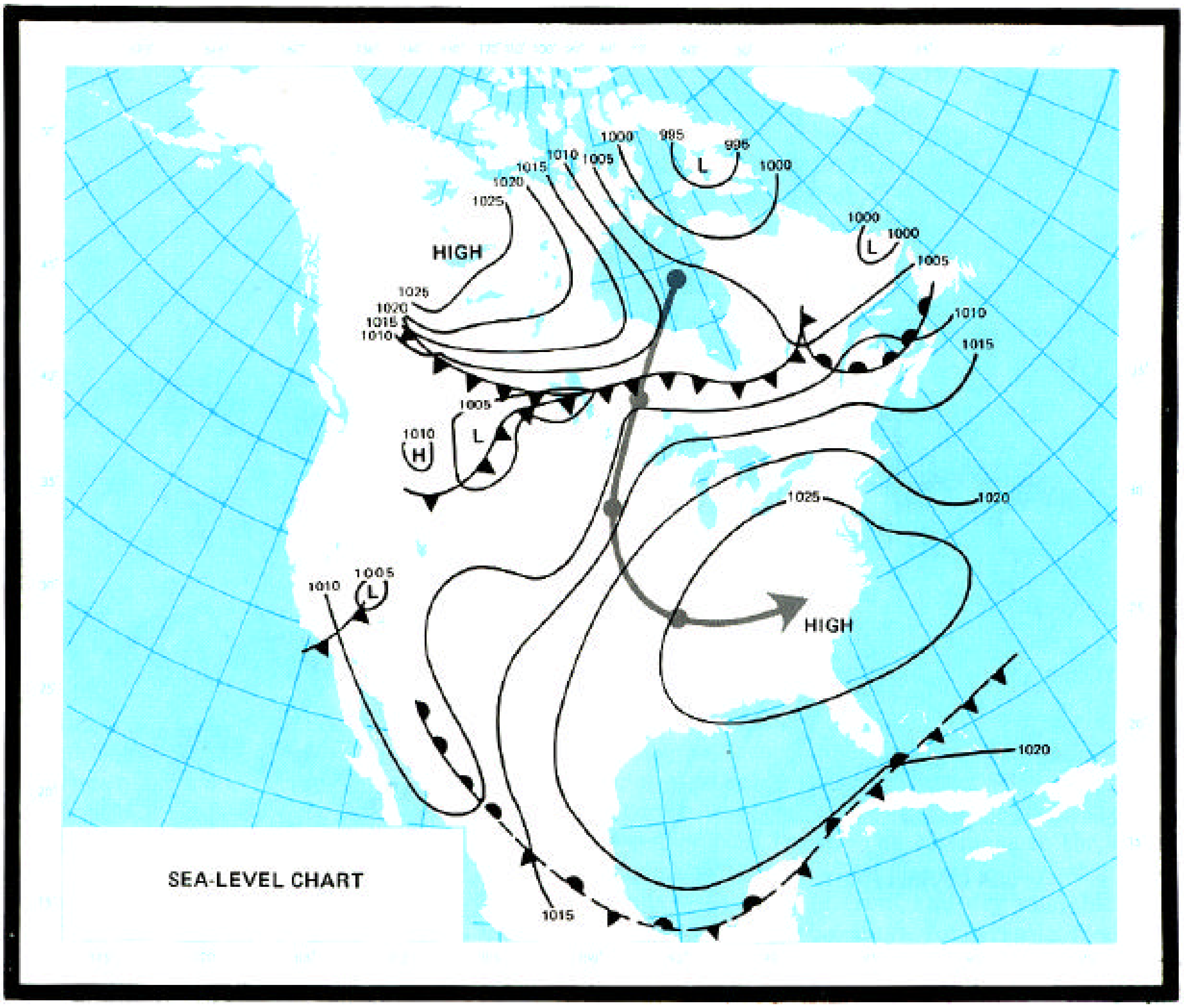
The Hudson Bay High and Northwest Canadian High types involve cP air masses that move southward or southeastward from their source regions in Canada and on through the Great Lakes region under the influence of a meridional pattern aloft. These air masses are warmed by surface heating and subsidence as they move to lower latitudes. High fire danger is occasionally found in the forward portion of the air mass, if the front preceding it is dry. But the most critical area is usually the western or northwestern portion of the High. By the time this portion of the High reaches a locality, the air mass has been warmed by heating and subsidence, and the humidity becomes low and remains low until either Gulf moisture is brought into the system or the next cold front passes.

12. Central States

The vegetation in the Central States region is mostly hardwoods, and mixed pine and hardwoods, interspersed with agricultural lands. The topography is mostly flat to gently sloping. The principal exceptions are the Missouri and Arkansas Ozarks and the western portions of the Appalachians. Summer temperatures tend to be high in the southern portion of the region, but relative humidities are usually high also. The northern portion experiences brief periods of high temperatures and brief periods of moderate temperatures as mT air masses alternate with either mP or cP air masses. Winters can be extremely cold in the north.

Annual precipitation is moderate, generally 20 to 45 inches, with snow and rain in the winter, and showers and thunderstorms in the summer. Usually, there is sufficient rain with thunderstorm activity to minimize lightning fire occurrence. The maximum precipitation usually falls in early summer in the north, but there is a fair distribution throughout the year in the southern portion. There are occasional dry summers, but the green tree canopies and green lesser vegetation are usually sufficiently effective in the summer to keep fires from being aggressive.

As in the Great Lakes region, the principal fire season is in spring and fall when the hardwoods are not in leaf and the lesser vegetation is dead. In the southern portion of the region the spring season is somewhat earlier and the fall season somewhat later than in the northern portion.

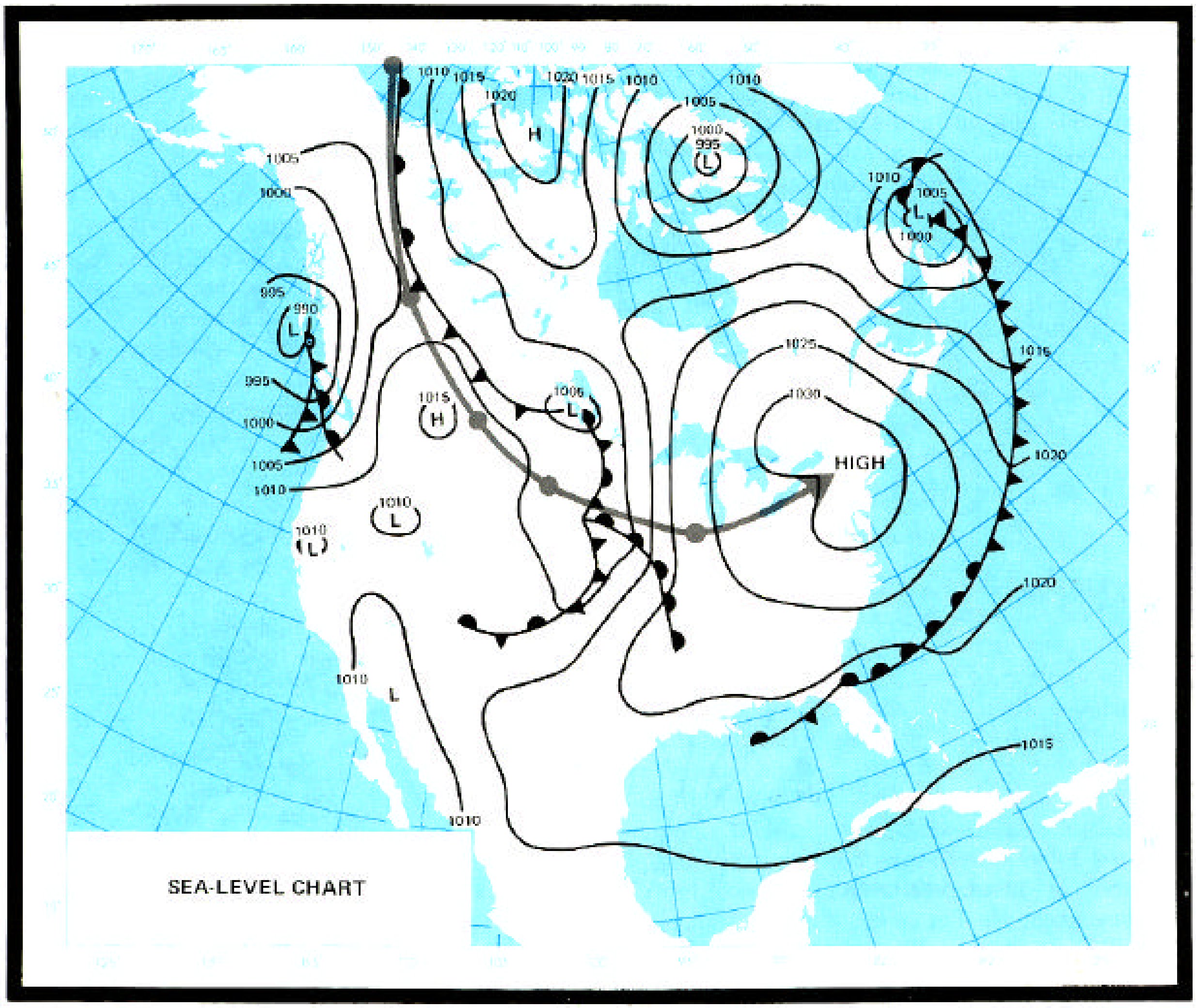


The Hudson Bay High type can bring high fire danger to any of the regions east of the Rockies. As shown on this sea-level chart, a cP air mass from the vicinity of Hudson Bay moves southward or southeastward, warming and subsiding as it moves to lower latitudes. The highest fire danger is usually found on the northwest side of the High, This type is most frequent in spring and fall, with spring being the most critical season.

The synoptic weather patterns producing high fire danger in the Central States are similar to those affecting the Great Lakes region, except that the Bermuda High type influences the southern portion of the Central States region more frequently. Nevertheless, the Bermuda High is the least important of the types, both from the standpoint of frequency and from the fact that it occurs mainly during the summer months when vegetation is green. The Pacific High, Hudson Bay High, and Northwestern Canadian High types, in that order, cause nearly all of the high fire danger in spring and fall. These types have been described above for adjoining fire climate regions.

13. North Atlantic

The forests in the North Atlantic region vary from extensive spruce stands in the north to predominantly hardwoods in the southern portions. The region is bounded on the west by the crest of the Appalachians and on the east by the sea. The coastal plain is wider than that facing the Pacific and increases in width



The Northwest Canadian High synoptic type is least frequent in summer and most frequent in winter. In winter the air mass is so cold, however, that fire danger is low. The highest fire danger is produced in spring and fall. As shown on this sea-level chart, a dry cP air mass from Northwest Canada moves southeastward under meridional flow aloft, and warms by subsidence and passage over warmer land as it moves to lower latitudes. It can affect all regions east of the Rockies. The north and northwest sides are most critical, but high fire danger can occur on any side of the High.

from north to south. The immediate coast is influenced by the Atlantic Ocean and often is cool and foggy. But because the general movement of weather systems is from west to east, the maritime influence usually does not extend far inland. For this reason, temperatures can be quite low in whiter and quite high in summer. On occasion, mP air from the Atlantic moves sufficiently southwestward to influence this region.

The annual precipitation is moderate to heavy, with totals of 40 to 50 inches, and is fairly well distributed throughout the year. There is a slight maximum during the summer and a slight minimum during the spring. Storms moving into the region from the west do not produce as much precipitation on the east side of the mountains as storms which move northeastward along the coast. In the first case, the descending flow on the east side of the mountains diminishes the precipitation. In the second case, the cyclonic circulation around a Low moving along the coast brings in moist air from over the ocean, and the mountains provide additional lift to increase the precipitation. Wet thunderstorms are common, and lightning fires are few.

Heavy snows in the northern coniferous forests persist well into spring. The leafless hardwoods in the areas of lesser snow cover expose the surface litter to drying influences of the sun and strong winds during the spring months. Both the conifers and hardwoods are susceptible to cumulative drying during the fall.

The fire season usually lasts from April through October with peaks in the spring and fall. Drought years are infrequent but may be severe.

The synoptic weather types associated with high fire danger in this region are the Pacific High, Hudson Bay High, Northwest Canadian High, and Bermuda High. All of these types have been described above.

14. Southern States

The vegetation in the Southern States consists mainly of pines along the coastal plains, hardwoods in bays and bottomlands along stream courses, and mixed conifers and hardwoods in the uplands. **Flash fuels, flammable even very shortly after rain, predominate in this region.** The topography along the Gulf and Atlantic is low and flat. Inland from the Atlantic Coast it merges with an intermediate Piedmont area. The southern Appalachians are included in this region, and the central portion includes the lower Mississippi Valley.

Summers are warm and generally humid, because the region is almost continuously under the influence of an mT air mass. Winters have fluctuating temperatures. When mT air moves over the region, high temperatures prevail. Following the passage of a cold front, cP air may bring very cold temperatures—well below freezing—throughout the Southern States.

Annual precipitation varies from 40 to 60 inches over most of the region, except for about 70 inches in the southern Appalachians and over 60 inches in the Mississippi Delta area, and falls mostly as rain. The influence of the moist mT air from the Gulf of Mexico causes abundant rainfall in all seasons, with slightly higher amounts in August and September due to the presence of hurricanes in some years. Spring and fall have less precipitation than summer or winter, with spring being wetter than fall. Winter precipitation is usually associated with frontal lifting or with Lows that develop over the Southern States or the Gulf of Mexico and move through the region. Summertime precipitation is mostly in the form of showers and thunderstorms. During the colder months, much fog and low stratus are formed by the cooling of mT air as it moves northward.

The fire season in the Southern States is mainly spring and fall, although fires may occur during any month.

The four synoptic types that bring high fire danger to the other regions east of the Rockies also bring high fire danger to the Southern States. The Hudson Bay High and Northwest Canadian High types affect this region less often than the regions to the north. The airflow pattern aloft must have considerable amplitude for Highs from Canada to reach the Southern States.

The Pacific High type causes more days of high fire danger than any other type. Pacific Highs may reach this region with either meridional or zonal flow aloft. **Very often, the most critical fire weather occurs with the passage of a dry cold front.** The air mass to the rear may be mP or cP. The strong, gusty, shifting winds with the cold front and dry unstable air to the rear set the stage for erratic fire behavior.

The Bermuda High type is second to the Pacific High in causing high fire danger in this region. This type is rather stagnant and persists over the region for long periods of time, mostly in spring, summer, and fall. The **cutting off of Gulf moisture** by the Bermuda High, when it extends westward across the Southern States to Texas, is **the typical drought pattern** for this region. Aloft, a long-wave ridge is located over the central part of the continent and the belt of westerlies is far to the north, near the Canadian border.

Subsidence and clear skies produce low **humidities and high temperatures.** These factors, plus the extended drought, **set the stage for high fire danger.** Peaks in fire danger occur as winds increase with short-wave trough passages and their associated surface cold fronts on the north side of the Bermuda High. Lightning accounts for only a minor number of fires.

15. Mexican Central Plateau

The vegetation in the plateau region of Mexico is largely brush and grass with ponderosa pine at higher elevations. The region is a high plateau and mountainous area, generally above 6,000 feet, lying between the two principal north-south mountain ranges. It differs from the Southwest mainly in that it is affected more directly by moist air from both the Gulf of Mexico and the Pacific, although this influence is restricted, by mountain barriers. Temperatures are comparatively cool for the latitude because of the elevation. Characteristically, the summers are warm with frequent convective showers and generally high humidities. The winters are cool and dry.

The annual precipitation is low to moderate. The maximum occurs in the summer with frequent thunderstorms due to continental heating. In spite of greater precipitation, the fire season is mostly in the summer.

SUMMARY

From this brief look at the fire climate over the North American Continent, we have seen that variations in climate, along with variations in vegetative conditions, produce differences in the fire seasons from one region to the next.

In general, the fire season in the western and northern regions of the continent occurs in the summertime. But the fire season becomes longer as one goes from north to south, becoming nearly a year-round season in the Southwest and southern California.

In the East, the fire season peaks in the spring and fall. Some fires occur during the summer months, and in the Southern States they can occur in winter also.

In Mexico, the low-lying coastal areas are tropical and have little fire danger, while the high-level central plateau has a summer fire season.