# INTRODUCTION

> Fair is foul, and foul is fair:
> Hover through the fog and filthy air.
>
> Shakespeare, *Macbeth* 1.1

Begin with the most distinctive aspect of the Bay Region climate—the diverse forms of fog. Traditionally, fog of any kind is a grim nuisance that seems to come from nowhere, hides the sun, obscures the terrain, and casts a damp pall over the land. Familiar with the murk that in their times darkened the streets of London, Shakespeare, Dickens, and many another writer associated fog with lurking evil. Combined with smoke, it creates the noxious urban miasma of smog. Dictionaries also identify "foggy" with vagueness, confusion, and other negative qualities.

In the San Francisco Bay Region, however, the characteristic summer fog is widely regarded as a boon and a blessing, bringing the clean, salty aroma of the Pacific, keeping the days refreshingly cool, advancing from the ocean in fantastic flowing forms that from day to day are unique and unpredictable. Shaped by the slant of the California coastline and the oceanic currents of wind and water, by the presence of a strait and estuary penetrating the coastal mountain ranges, by the hill-and-valley contours of San Francisco and the region around the bay, the advance of the summer fog inland from the Pacific is one of the planet's most awesome natural spectacles.

My own first experience with Bay Region fog occurred when I was a teenager traveling with my family from southern California to San Francisco. We were on the old Skyline Highway along the spine of the Santa Cruz Mountains when the road emerged from forests into an open meadow, affording a panorama that made us stop in amazement. Below us, moving in from the ocean, was a sea of billowing vapors, dazzling white in the late afternoon sun.

My father pulled the car off the road to an area where other travelers had stopped to gaze at the spectacle. Rising into the clear, dry air above the vapory sea were separate peaks and ridges, islands in the white flood. Waves of fog were moving eastward below us like ocean breakers lapping on the shores of an archipelago. We watched until the sun was at the horizon, throwing into sharp relief the shadowed troughs of the waves below their gleaming white crests.

Following the highway northward, we descended into that sea of fog and for several miles could scarcely see beyond the hood of the car. When we arrived in San Francisco, the fog was overhead, and it seemed as if we were in a city at the bottom of the ocean.

In later years, living in the city, I observed an endless variety of fog phenomena that had never been scientifically catalogued. On summer afternoons, emerging from work at the Chronicle building on Mission Street in downtown San Francisco, I could look west and see a white cascade of oceanic vapor pouring over Twin Peaks and flowing down the near slope like some slow-motion Niagara. My way home was in that direction, and en route I encountered advancing fog masses several hundred feet high, moving not only over Twin Peaks but through the low gaps in the city's hilly terrain, particularly the valley of Golden Gate Park. By the time I reached home near Buena Vista Park, I was surrounded by the thick rolling vapors, although downtown was still in bright sunshine. Wherever I have lived in San Francisco—the Presidio, Buena Vista, Pacific Heights, Telegraph Hill, Cole Valley, Sunset Heights—I have observed that the weather in my neighbor-

hood, particularly in the summer, was often drastically different from the atmospheric conditions a few blocks away, owing to the city's hill-and-valley topography. As the fog advances with the breeze from the ocean, it envelops streets and houses on the windward slopes and leaves the sheltered leeward valleys warm and sunny. If the white tide from the Pacific continues to advance, it will surmount the hills, flow down the leeward slopes, fill the valleys, and advance to the next hill, and perhaps beyond to the next valley or to the bay.

The picture is similar on a larger scale throughout the nine-county Bay Area. Fishermen along the fog-shrouded coast of Marin County on a summer day may be shivering in the low fifties while people in San Rafael, ten miles east, bask in comfortable 70-degree weather and residents of ranches at the edge of the Sacramento Valley, another forty miles east, mop their brows as the thermometer hits 100—a temperature difference of 50 degrees in fifty miles.

During the winter there are similar differences. Ben Lomond, in the Santa Cruz Mountains, averages 42 inches of rain a year, while just over the hills, in the Santa Clara Valley, the annual total is only 13 inches.

We have not yet fulfilled the age-old dream of controlling the weather, but in the Bay Region we come close; we can change the weather around us by moving a short distance. Probably no comparable area on earth displays as many varieties of weather simultaneously as the region around San Francisco Bay.

## THE WEATHER FUNNEL

The reasons for this unique situation lie in California's extraordinary geography. In general, the state has a Mediterranean climate, with mild, wet winters and dry summers. But that general type is locally modified by special features of the landscape. The prime movers in setting up the geography were two mountain ranges, a river system, and a big thaw.

The Sierra Nevada, a granite barrier rising from 10,000 to

14,000 feet into the sky some two hundred miles inland from the shore of the Pacific, intercepts the clouds and moisture-laden winds moving eastward from the ocean and forces them to drop their burdens on the mountain slopes in the form of rain and snow.

The water, cascading down the western slope of the Sierra in an intricate network of creeks, waterfalls, streams, and rivers, merges in the Central Valley to form the greatest river system within the boundaries of any single state. This tremendous volume of water, slicing through the Coast Range to the sea, carved the Carquinez Strait and the Golden Gate long before San Francisco Bay was formed.

At the end of the last Ice Age, the great glaciers melted in such volume that the oceans overflowed. Over a period of thousands of years, rising seas flooded through the river-carved gorge at the Golden Gate and occupied an inland valley to create San Francisco Bay. The river no longer flowed to the sea but emptied into the bay at the Carquinez Strait.

Thus the successive action of the river and the ocean created the only complete breach in the Coast Range, which borders the Pacific for most of California's length. As a result, the Bay Region is the meeting place of continental and oceanic air masses. Through the funnel of the Golden Gate and San Francisco Bay, the immense aerial forces of sea and land wage a continual war, and the tide of battle often flows back and forth with regularity. The line between the two types of air masses, particularly in summer, may zigzag through the streets of San Francisco and extend in similar erratic fashion across the entire region.

## THE SUBDIVIDED RANGE

The reason for the zigzags—the highly variable weather patterns within the region—is the complex topography of the Coast Range, which modifies the basic struggle between air masses of land and sea in intricate ways. (Although the Coast Range is actually a series of ranges, it is more convenient to

refer to it here in the singular.) The weather of any mountain range, with its ridges and canyons and valleys, is complex enough, but the section of the Coast Range comprising the Bay Region divides and subdivides into various subranges, each with its own hill-and-valley contours, creating its own modifications of the basic weather and climate patterns.

In general, the Coast Range in this region is a double chain of mountains running north and south (or, more precisely, north-northwest and south-southeast). Between the two chains lies the basin of San Francisco Bay, including the valleys at the ends of the bay: Petaluma on the north and Santa Clara on the south (see fig. 1, facing p. 1).

The western range consists of the Santa Cruz Mountains, south of the Golden Gate, and the Marin hills, including Mount Tamalpais, to the north. As if to complicate matters further, the eastern part of the Coast Range in this vicinity is itself divided into two main chains. Immediately to the east of the bay are the Berkeley Hills, paralleled, beyond the San Ramon and Livermore valleys, by the higher Diablo Range. North of the bay, this double aspect of the range continues, but it is further subdivided into subsidiary chains, including the Sonoma, the Mayacmas, and the Vaca mountains, which separate the legendary wine-grape valleys of Napa and Sonoma.

## MICROCLIMATES

Eastward from the ocean, over the several ranges, each successive valley has less of a damp, seacoast climate and more of a dry, continental climate—hotter in summer and colder in winter. But this basic pattern is further modified and complicated by a number of gaps and passes in the ranges—the most important of which is the Golden Gate—that allow the easy penetration of seacoast weather inland.

The pattern is also modified by large bodies of water, which tend to cool their shores in the summer and warm them in the winter. The most important of these is, of course, San Francisco Bay itself and its various subdivisions and tributaries,

including San Pablo Bay, Suisun Bay, and the Sacramento–San Joaquin Delta, where the major rivers of the Sierra and the Central Valley converge in a complex network of watercourses and low islands.

Because the land takes these varied forms, there is actually no such thing as a Bay Region climate. There are only innumerable microclimates within the region, varying widely from mountain to mountain, from valley to valley, and from point to point within the mountains and valleys.

The results are manifold: the great flowing fogs that move through the Golden Gate and over the coastal hills from the ocean in summer; the warm, dry winds that sometimes whip down through the canyons to the bay in spring and fall, scuffing the bay surface into whitecaps; cumulus clouds, which drift eastward across the sky in winter, throwing moving patterns of light and shade across land and water; massive cumulonimbus clouds, which may build up to heights of 50,000 feet or more above the rim of mountains around the bay; rains that deluge one valley while scarcely dampening the next; snows that occasionally dust the tops of the highest peaks; and the rare frosts that whiten the lowlands.

All these phenomena are of minor concern to the average city dweller, who merely has to decide whether to take a coat or umbrella to the office in the morning. But they are of great interest to those who are directly affected by the weather, including pilots of ships and small boats, who must learn to navigate in the fog and cope with churning seas stirred up by winds; crews who repair power lines and telephone wires damaged by storms; road workers who keep the streets and highways clear of debris in heavy rains and winds; the passengers and crews of the hundreds of planes whose schedules may be upset by blinding fog; carpenters and construction workers, who cannot operate in storms; dairymen, who must spend extra money for hay if not enough rain falls to raise a good crop of grass; painters on the bay's great bridges; grape growers in Napa and Sonoma and Livermore, who fear late frosts and early rains; and farmers in the interior valleys, who must

reckon when to prune and irrigate and plow by observing signs in the sky.

For the seven million people who live and work in the San Francisco Bay Area, the weather is the lowest common denominator, consistently the most recurrent topic of conversation on street corners, in corridors and elevators, in taverns, on buses and trains, and wherever people gather to talk. Although weather talk is common worldwide, here it achieves a particular flavor and intensity unknown elsewhere.

Residents of other parts of the country are likely to open a conversation with a remark such as: "Some weather we're having lately, isn't it?" But in the Bay Region no one—except tourists and newcomers—assumes that the listener has been experiencing the same kind of weather as the speaker, and the opening gambit is likely to be: "What's the weather like where you live?" Commuters to San Francisco compare notes on their respective communities, and no one is greatly surprised if Berkeley has fog while Alameda is in bright sun, or if Mill Valley has rain while Palo Alto is dry.

## THE OCEAN OF AIR

Before getting into the detailed peculiarities of the Bay Region's microclimates, we should review some general facts about the atmosphere that apply to all weather and climate everywhere on earth.

1. The ocean of atmosphere that surrounds the earth bears down on the earth's surface with an average "weight," or pressure, of 14.7 pounds per square inch at sea level. The exact pressure depends, however, on the altitude, air temperature, and other variables.
2. Warm air is light and tends to rise; cold air is heavy and descends. Because the cold air presses down more heavily on the earth's surface than warm air, cold air causes high pressure; warm air, low pressure. (Temperature is not the only determinant

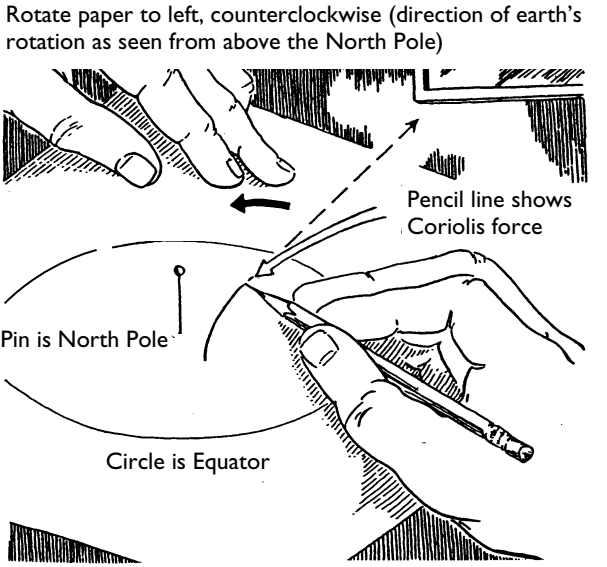


Figure 2. The Coriolis force

of high and low pressure, but it is a key to the formation of San Francisco's distinctive fogs.)

3. Just as water tends to seek its own level, so air tends to equalize its pressure. Thus, air moves horizontally from a high-pressure area to a low-pressure area; winds blow from a cool to a warm zone, just as cold air will move through a door or window into a warm room, creating a draft. (There are exceptions to this, too.)
4. When dry air rises, in general it expands and cools at the rate of about 5.5 degrees Fahrenheit per thousand feet of elevation.
5. When air descends, it compresses and grows warmer at about the same rate.
6. Warm air is able to hold more moisture (in the form of vapor, which is invisible) than cool air. If warm,

damp air begins to cool off, it will reach a point where it can no longer contain its vapory load (the dew point), and the moisture will condense into drops of visible fog or cloud. A familiar example is the condensation that occurs when air is cooled by contact with a glass of cold water and the condensed moisture is deposited on the outside of the glass.

7. Air moving freely across the surface of the earth tends to curve to the right, clockwise, in the Northern Hemisphere, and to the left in the Southern Hemisphere. This tendency is a result of the Coriolis force, or Coriolis effect—named for the French scientist who formulated the principle.

To illustrate the Coriolis force, draw a large circle with a dot in the center on a piece of paper (see fig. 2). The circle represents the earth as seen from above the North Pole, and the dot is the pole itself. Rotate the paper slowly counterclockwise, representing the rotation of the earth. As the paper rotates, draw a short line inside the circle from any point toward some fixed point off the page, such as the wall of the room. You will find that the line on the paper curves to the right.

In the same fashion, anything moving freely over the surface of the Northern Hemisphere tends to curve to the right because of the rotation of the earth beneath it. (In the Southern Hemisphere, the curve is to the left.) This is true not only of winds but of ocean currents, rockets, and artillery projectiles. Even rifles must be compensated to counteract the drift of the bullet. This clockwise motion of winds and ocean currents is particularly important to understanding the Bay Region weather.