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1961, pp. 63-71. https://doi.org/10.56577/FFC-12.63

in:

Albuquerque Country, Northrop, S. A.; [ed.], New Mexico Geological Society 12 th Annual Fall Field Conference Guidebook, 199 p. https://doi.org/10.56577/FFC-12

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PHYSIOGRAPHY, CLIMATE, AND VEGETATION OF THE ALBUQUERQUE REGION

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INTRODUCTION

Varied physiographic features, a 6,800-foot difference in elevation, several sources of atmospheric moisture and directions of air mass movement combine to make the climate, vegetation, and topography of the Albuquerque region interesting and complex. One can observe, first-hand, the intimate relationship between physiography, precipitation, temperature, and vegetation and use the region as a model for geomorphic and geologic interpretation.

PHYSIOGRAPHIC AREAS IN THE ALBUQUERQUE REGION

A photographic copy of the Army Map Service plastic relief maps of the Albuquerque region gives an excellent over-all view of the major physiographic features (Fig. 2). For convenience, the region is divided into a number of structural-physiographic units (Fig. 1, modified from Kelley, 1952) and specific points of interest are designated by numbers (i.e., 23). In the area covered by the photographs, elevations range from 11,389 feet at Mount Taylor Peak (39), 11,252 feet at Redondo Peak (3) in the Valles caldera, 10,685 feet at Sandia crest (17), and 10,120 feet at Manzano Peak (23) to about 4,800 feet at Belen in the southern part of the Belen-Albuquerque-Santo Domingo Basin. Elevations rise to about 6,000 feet at the northern end of this basin (8, 11, 14) and elevations of about 7,000-9,000 feet are found on some of the higher mesas and cuestas of the Colorado Plateau and San Juan Basin areas (1, 42).

CLIMATE

Temperature and precipitation in the Albuquerque region are determined largely by local topography and air mass movements from regions outside the State. The mean annual temperature ranges from 57°F at the Albuquerque Airport to 38°F at Sandia crest (17); the difference in elevation is 5,365 feet. This gradient of about 1°F for each 200-300-foot rise in elevation is the principal controlling factor in the distribution of precipitation and vegetation, and, indirectly, in the physical appearance of the landforms. The mountain tops would be even colder were it not for the increase of wind velocity with elevation which tends to displace the normally cold air with warmer air. The gradient is moderated somewhat in the deeper parts of the basins as the heavier cool air drains and settles at night after daytime convection stops. Low temperatures in the Rio Grande valley are normally 8-10 degrees cooler than for the pediments and mesas, a few hundred feet higher in elevation. The climate is decidedly continental with diurnal changes of 40°F. being common.

Air masses invade the Albuquerque region from five principal source areas as follows (Thornthwaite and others, 1942; Dorroh, 1946):

(1) Cold, dry Polar Continental from Canada and northward
(2) Cool, moist Polar Pacific from the north Pacific Ocean
(3) Hot, dry Tropical Continental from Mexico and extreme southwest United States
(4) Warm, moist Tropical Gulf from the Gulf of Mexico and the Caribbean
(5) Warm, moist Tropical Pacific from the southern Pacific Ocean.

So many directions of air movement make weather prediction in Albuquerque extremely difficult. Most of our winter and spring moisture comes from the north Pacific (type 2) although the source is so remote and so many mountain barriers intervene that only a little more than 20 percent of the annual total is from this source. These air movements (storms) result in high-level moisture that forms snow on the mountains, a little rain or snow at intermediate elevations, and blowing dust at the lower elevations, particularly in the spring. About 65-70 percent of the annual total precipitation comes in the warm season (April-September) from the Gulf of Mexico (type 4) in the form of wandering convectional thunderstorms and orographic thunderstorm buildups over the mountains. Both the North Pacific and the summer orographic storms release most of their moisture in the mountains so that there is a direct increase in precipitation with elevation, and a precipitation map (Fig. 3) of the region is very nearly a topographic map as well.

Movements of moist air from the Tropical Pacific (type 5) add little to the annual rainfall although on rare occasions some of our longest and heaviest rains have come from that source. Interpretations of Pleistocene climate and terrace formation are made difficult because of the unknown influence of this moisture source. Tropical Continental (type 3) air usually results in warm dry weather while in the winter months Polar Continental (type 1) air sweeps down the east side of the State, resulting in extended cold periods and some snow if warm moist air is displaced. Tijeras Canyon presents the Albuquerque area with a local problem as the heavy, cold air, held back by the Sandia-Manzano Mountains, finds access to the basin and literally pours through the canyon and spreads out on the "mesa" and valley below in gusts up to 50 miles per hour.

VEGETATION

Early naturalists in the Southwest soon recognized the remarkable correlation between vegetation and elevation and realized that under the influence of temperature and moisture availability the vertical changes corresponded, in an approximate way, with latitudinal changes. Each 1,000-foot increase in elevation is about equivalent to a 200-mile northward shift of latitude so that the type of plants found in Canada, such as spruce and fir, occur above 8,000 feet on mountains while plants typical of Mexico, such as mesquite and creosote bush, have extended their range up the Rio Grande valley as far north as the Rio Salado. This resulted in the formulation of the concept of **life zones** by Merriam (1890) and the naming of zones such as the Hudsonian, Canadian, and Sonoran based on the vertical distribution of plant and animal life but using geographic terms to impart the idea of a relationship to latitude. Later, ecologists found it necessary to refine the concept of life zones and classify character-

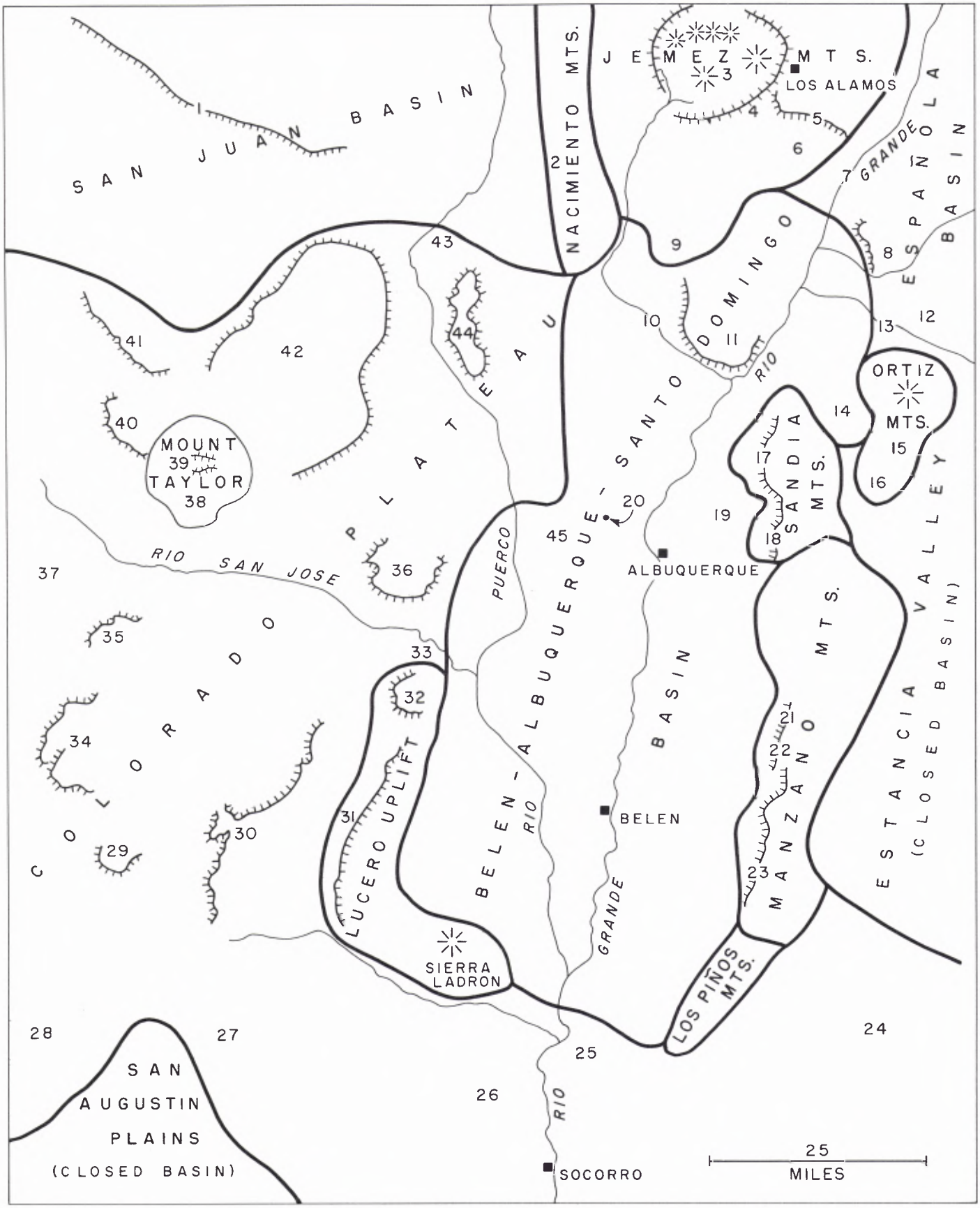

Figure 1. Structural-physiographic areas and physiographic features in the Albuquerque region, New Mexico (modified from Kelley, 1952).

PHYSIOGRAPHIC FEATURES IN THE ALBUQUERQUE REGION

1. Chacra Mesa (elev. circa 7,000 feet)
2. Pajarito Peak in Nacimiento Mts. (elev. circa 9,000 feet)
3. Redondo Peak in Valles caldera (elev. 11,252 feet)
4. Sierra de Los Valles (elev. circa 10,000 feet)
5. Pajarito Plateau or Jemez shield, cut here by Frijoles Canyon—1,000 feet deep
6. San Miguel Mts. (elev. circa 8,000 feet)
7. White Rock Canyon, about 1,000 feet deep below rim at circa 6,500 feet
8. La Bajada Mesa (elev. circa 6,200 feet)
9. Borrego Mesa (elev. circa 7,500 feet)
10. Jemez River, breaching the Valles caldera and flowing southward through Canon de San Diego, 1,800 feet deep
11. Santa Ana Mesa—basalt capped (elev. circa 6,000 feet)
12. Los Cerrillos—mainly stock-like intrusions (elev. circa 7,000 feet)
13. Galisteo Creek
14. Hagan structural embayment (elev. circa 6,000 feet)
15. San Pedro Mts. (elev. 8,240 feet)
16. South Mtn. (elev. 7,985 feet)
17. Sandia crest (elev. 10,685 feet)
18. South Sandia Mtn. (elev. 9,765 feet)
19. Sandia (East) Mesa, opposite Bear Canyon (elev. circa 6,000 feet)
20. Albuquerque volcanoes, mainly on Segundo Alto terrace (elev. of volcanoes, 6,033 feet; elev. of terrace circa 5,600-5,800 feet)
21. Mosca Peak (elev. 9,490 feet)
22. Bosque Peak (elev. 9,630 feet)
23. Manzano Peak (elev. 10,120 feet)
24. Chupadera structural platform (elev. circa 6,500 feet)
25. San Acacia structural constriction (elev. of Rio Grande is circa 4,600 feet in this area)
26. Socorro structural uplift
27. Gallinas Mts. (elev. 8,730 feet)
28. Datil Mts. (elev. 9,585 feet)
29. Cachow Mesa (elev. circa 8,300 feet)
30. Mesa del Oro (elev. circa 7,500 feet)
31. Gallina Mesa (elev. 7,840 feet)
32. Lucero Mesa (elev. circa 6,500 feet)
33. Mesa Redonda (elev. 5,420 feet)
34. Cebolleta Mesa (elev. circa 8,500 feet)
35. Putney Mesa (elev. 8,165 feet)
36. Mesa Gigante (elev. circa 6,500 feet)
37. Lava beds (elev. circa 7,000 feet)
38. San Mateo Mts. (elev. circa 9,000 feet)
39. Mount Taylor Peak (elev. 11,389 feet—highest point in Fig. 2)
40. La Jara Mesa (elev. 8,560 feet)
41. San Mateo Mesa (elev. circa 8,100 feet)
42. Mesa Chivato (elev. circa 8,500-9,000 feet)
43. Cabezon Peak—volcanic neck (elev. circa 7,500 feet)
44. Mesa Prieta (elev. circa 7,200 feet)
45. Llano de Albuquerque—Ortiz surface (elev. circa 6,000 feet)

Explanation for Figure 1.

istic plant and animal associations into biotic communities. The elevation tolerances for these **biomes** are as restrictive as those of life zones. Hoff (1959) has suggested elevation ranges for the plant and animal associations in New Mexico and has related them to life zones (Fig. 5).

The Arctic zone or Alpine Tundra association does not occur on Mount Taylor, the Jemez Mountains, or the Sandia-Manzano Range although it does cap the highest peaks in the Sangre de Cristos. The Desert Plains association or Lower Sonoran life zone barely extends into the southern part of the Albuquerque-Belen basin.

The three main types of vegetative cover are grassland, shrub, and forest. Grass is of the short semi-desert type in the lowlands and of the taller mountain grass and meadow type when associated with forest cover at the higher elevations. Shrubs are mainly sagebrush, salt-bush, grease-wood, catclaw, rabbit-brush, and creosote-bush. The pinyon-juniper forest association is the most extensive vegetative cover in the region (5,470,000 acres in the upper Rio Grande basin, as compared to 2,883,000 acres for semi-arid grassland and 2,163,000 acres for ponderosa pine; Dortignac, 1956). Other forest types are ponderosa pine, spruce, fir, and aspen. A map of these vegetative types (Fig. 4) approximates a topographic map and a precipitation map.

The extreme dryness, occasional summer thunderstorm, little runoff, and sparse vegetation of the lowlands are in sharp contrast to the wetness, periodic rainfall and snowfall, high spring runoff, and thick vegetative cover of the uplands. Also, it is now known that moisture and temperature changes were considerable in the Pleistocene. Life zones were lowered several thousand feet, the lowlands were covered with woodland, and the closed basins contained large lakes. In some way, these complex factors are responsible for the typically "arid" aspect of the topography expressed in steep canyons, the break in slope at mountain bases, the steep retreating slopes of the mesas and terraces, and the lingering closed basins.

CHARACTER OF STRUCTURAL-PHYSIOGRAPHIC AREAS IN THE ALBUQUERQUE REGION

Nacimiento Mountains and San Juan Basin

Structurally, these are the oldest features in the region, with the initial folding and faulting beginning near the end of the Cretaceous and continuing intermittently through the Tertiary. Cuestas (1) dip into the basin along the southern margin and outcrops of the Mesozoic formations swing sharply to the north and become hogbacks along the eastern side of the basin adjacent to the Nacimiento uplift. The Nacimiento Mountains are an asymmetrical domal anticline about 50 miles long with a core of gneissic granite flanked by patches of upper Paleozoic sediments except along the steep west side where the granite is exposed.

Bryan and McCann (1936) and Church and Hack (1939) believed that the flat summit of San Pedro Mountain (just north of Fig. 1) in the Nacimientos represented an old erosion surface, possibly of early-middle Tertiary age. Bryan and McCann also believed that they could trace remnants of the younger Ortiz surface into the area and recognized four other surfaces in the upper Rio Puerco drainage (Fig. 5).

Spruce, fir, and aspen are found on San Pedro Mountain and ponderosa pine covers most of the range. Most of the San Juan Basin is covered with the pinyon-juniper association and large patches of sagebrush (**Artemesia tridentata**) are found east of Cuba. Salt-bush and greasewood are found along the Rio Puerco.

Jemez Mountains

The Jemez Mountains consist of a high central caldera (reported to be the largest in the world) flanked by a broad shield of volcanic flows and pyroclastics. Several high peaks such as Redondo Peak (3, elev. 11,252 feet) occupy the crater. The bordering Valles Mountains (4) on the southeast attain elevations of over 10,000 feet and even higher elevations are found on the northern rim, north of Figure 1. Many large streams have dissected the shield or plateau around the caldera forming a radial pattern of steep-walled canyons more than 1,000 feet deep. Jemez River (10), flowing through one of these (Canon de San Diego), has breached the caldera rim on its southwest side.

The history of the volcanic center can be summarized from Ross (1931) as follows:

1. Even-bedded and chaotic flows of andesite, latite, and some basalt and rhyolite, from a center not far removed from the present caldera, accumulated on a mid-Tertiary erosion surface sloping upward to San Pedro Mountain.
2. Profound erosion, and then a series of basalt eruptions from local centers.
3. Erosion, followed by explosive rhyolitic eruptions on a tremendous scale during which the great caldera was blasted out of the older volcanics and extensive tuff beds were deposited on the flanks.
4. Some erosion, followed by more rhyolitic volcanic activity and the building up of secondary cones 2,000-3,000 feet above the floor of the caldera.
5. Erosion, and caldera-filling with alluvial and lacustrine deposits (the lake persisted long enough to allow wave-cut terraces to form on the sides of the peaks). Finally, deep erosion of the flanks and breaching of the rim. Many hot-spring deposits were formed during this last phase.

None of the high peaks in the Jemez Mountains reaches timberline but the trees are dwarfed on northeast slopes and a few Hudsonian plants are found. Spruce, fir, and aspen represent the Canadian life zone and the large park-like valleys of the caldera (e.g., Valle Grande) are grass covered. Ponderosa pine and Gambel oak mark the Transition zone with pinyon pine, juniper, and live oak in the Upper Sonoran zone at the lower elevations. In 1913, Bailey stated that elk and mountain sheep had disappeared and few if any grizzlies remained. Black bear, mule deer, mountain lions, bobcats, coyotes, foxes, badgers, porcupines, prairie dogs, squirrels, and chipmunks remain.

Sandia-Manzano and Ortiz Mountains

The Sandia-Manzano Ranges are easterly tilted fault blocks with a western slope and core of Precambrian granitic and metamorphic rocks and a crest and east flank of Pennsylvanian limestone. Sandia Mesa (19) and the east mesa of the Manzanos are treeless pediment slopes merging with the alluvium of the basin at some unknown distance from the break in slope at the base of the mountains. The dip slope, if projected to the probable area of greatest faulting 2-5 miles from the crest would suggest a hypothetical elevation for the Precambrian surface

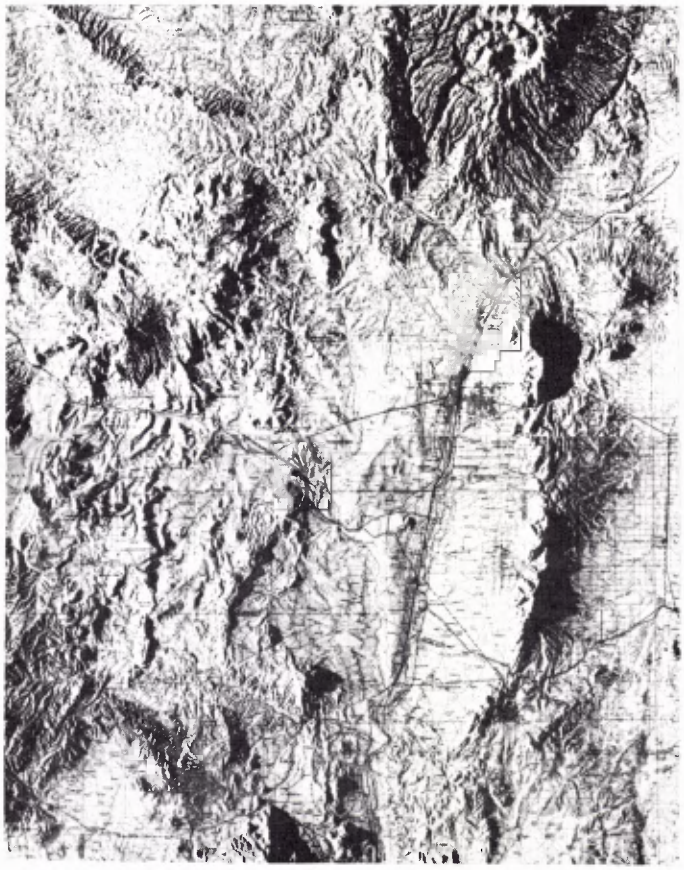

Figure 2. Physiography of the Albuquerque region, New Mexico.

of about 11,000 feet (Kelley, 1959). Kelley also believes that as much as 15,000 feet of Tertiary deposits may occupy the deeper parts of the Albuquerque-Belen basin. This would mean a total vertical displacement in excess of 20,000 feet. If the thickness of the Paleozoic and Mesozoic section is added (probably present prior to faulting), a displacement of more than five miles is likely. Fossils from the associated deposits in the basin indicate that most of the tilting and faulting took place in late Miocene and Pliocene time, perhaps coincident with the early volcanic activity at Mount Taylor and in the Jemez Mountains.

The Ortiz Mountains, San Pedro Mountains (15), South Mountain (16), and Los Cerrillos (12) are a complex cluster of sills and stock-like and laccolithic intrusions of monzonite and latite-andesite into volcanics and early Tertiary sediments. Intrusive activity pre-dates the faulting and tilting of the Sandia-Manzano Mountains (late Eocene, Stearns, 1953; McRae, 1958). Equivalents of the pediment surface (Ortiz surface) surrounding the Ortiz Mountains (Ogilvie's conoplain) have been traced over the entire region and beyond.

The Sandia and Manzano Mountains have narrow crests of the Canadian life zone extending down to about 8,000 feet on the colder slopes. Elements of this forest include white fir, blue spruce, Douglas fir, limber pine, and Rocky Mountain maple, with ash, alders, and willows along the streams (Bailey, 1913). The Canadian patches are surrounded by a continuous Transition zone (7,000-8,000 feet on cold slopes and 8,000-9,000 feet on warm slopes) of ponderosa pine forest and scattered oaks. The

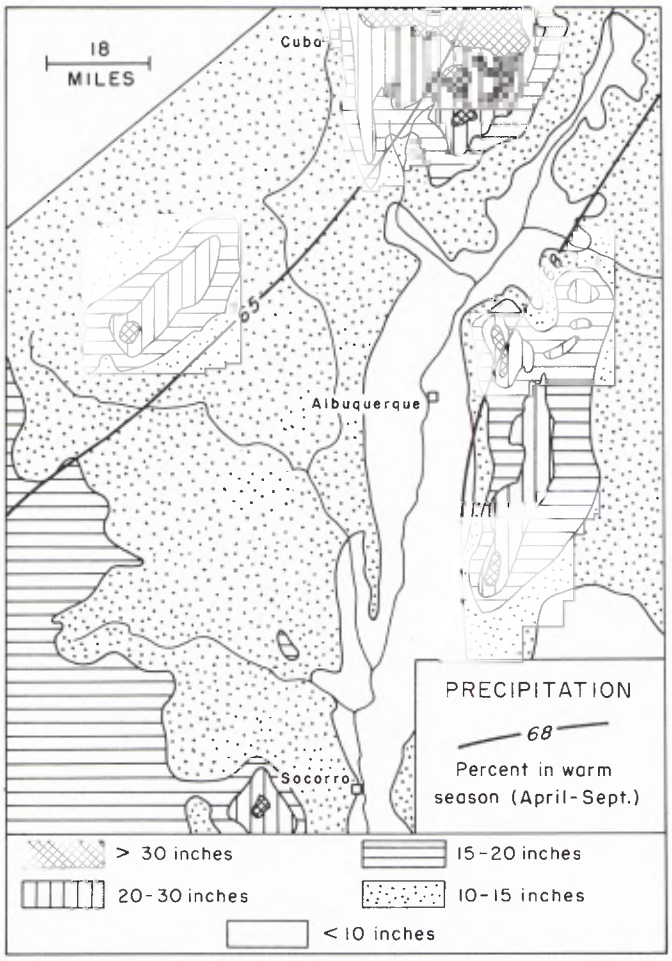

Figure 3. Mean annual precipitation in the Albuquerque region, New Mexico (from Dortignac, 1956).

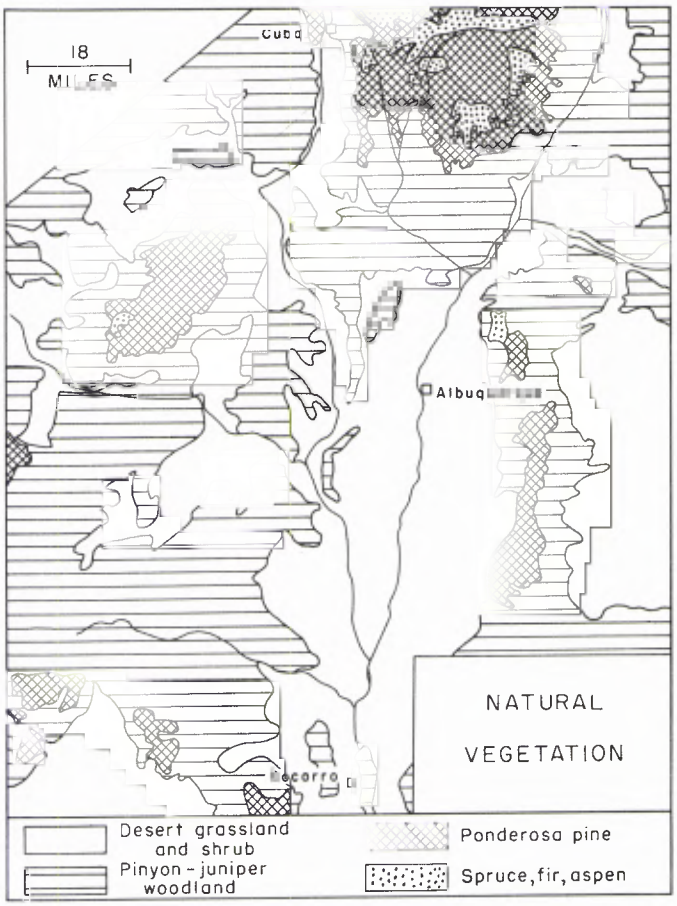

Figure 4. Vegetation in the Albuquerque region, New Mexico (after Dortignac, 1956).

Upper Sonoran zone occupies the foothills and surrounding higher valleys. A few ponderosa pine are found on top of the Ortiz Mountains. Mule deer and black bear are found in the mountains and mountain sheep have been doing well since their re-introduction (one estimate places the present total near 600 in the Sandia Mountains).

Mount Taylor and the Colorado Plateau

The group of mountains around Mount Taylor include the high lava plateaus of Mesa Chivato (42), La Jara Mesa (40), several smaller mesas, and the flanking San Mateo Mountains (38) on the south side of the peak. The main cone is the oldest volcanic feature in the area and consists of rhyolitic tuff, flows of porphyritic latite and trachyte, and porphyritic andesite, in that approximate order of formation (Hunt, 1936). At the peak of the cone is a large amphitheater-like depression surrounded by a high arcuate ridge (Mount Taylor Peak (39), 11,389 feet, is the highest point on this rim) and containing a steep secondary cone about 1,000 feet high. The high mesa country surrounding the cone and to the northeast is held up by later flows of basalt and andesite. The largest mesa (Mesa Chivato, 42) covers about 400 square miles and is about 2,000 feet above the general drainage level. The lava on Mesa Prieta (44), the large outlier to the northeast, was once part of the same series of flows. Several volcanic necks such as Cabezon Peak (43) occupy the valley between the mesas and apparently were the feeders for the flows on the mesas. The eruptions that formed Mount Taylor proper probably began in the Miocene with continuing subsidiary activity (Hunt, 1938). Some of the younger flows on the mesas overlie correlatives of the Ortiz surface which may be as young as early mid-Pleistocene (discussed later).

Structurally, the Colorado Plateau adjacent to the Albuquerque-Belen basin is divided into the Lucero uplift on the south and the Rio Puerco fault zone on the north marking the transition from the Rio Grande trough to the plateau. The Acoma structural embayment lies west of these two units and Mount Taylor is in the northwest corner along the axis of the largest structural feature, the McCartys syncline. This entire area contains remnants of an old erosion surface (probably Ortiz) that was once graded to the Albuquerque-Belen basin. The surface is preserved under the lava caps on the mesas around Mount Taylor, smaller outlying mesas, and on the higher parts of the Lucero uplift (Fitzsimmons, 1959). Present river level is 1,000 to 1,500 feet below the old surface but successively lower and younger surfaces are poorly preserved if present. Some of the isolated lava-capped mesas may have preserved younger stages in the stripping of the area but this would be difficult to demonstrate. Younger surfaces seem to persist mainly along the main drainage of the Rio Grande and Rio Puerco and up Jemez River as far as San Ysidro. Several basalt flows (37) in the Rio San Jose drainage are found at the present river level (McCartys flow near Grants) or just a few feet above the present

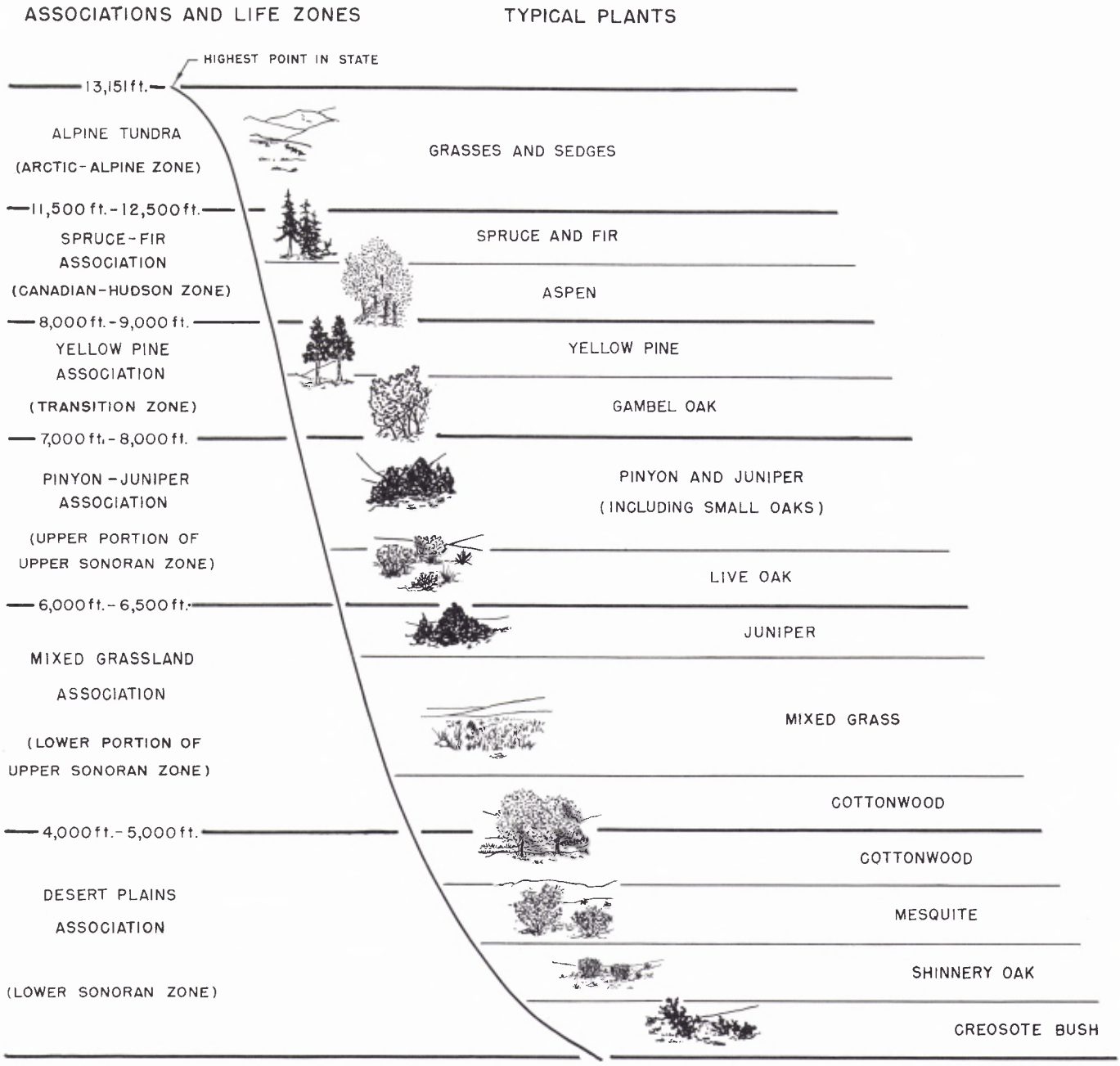

Figure 5. The altitudinal distribution of community types (designated as "associations" and the conspicuous plants at various elevations. The chart pertains chiefly to the central and north-central parts of New Mexico. (Drawing by Bettie Brockman. Reprinted from **The ecology and distribution of the pseudoscorpions of north-central New Mexico** [Univ. New Mexico Pub. in Biology No. 8], by C. Clayton Hoff, Albuquerque, 1959, by permission of the University of New Mexico Press.)

level where recent arroyo cutting has taken place.

The upper part of the crater of Mount Taylor is forested with spruce, fir, and aspen and the lower inner part with mountain grassland. The Canadian zone, however, lacks many of the typical members of the spruce-fir association (Bailey, 1913), perhaps because of the small size of the high mountain mass. The outer slopes and high mesa tops of the plateaus have scattered stands of ponderosa pine and Gambel oak. Semi-desert grassland and shrub consisting mainly of salt-bush and grease-wood occupy most of the river bottoms of the Rio Puerco and Rio San Jose and virtually all the mesas are covered with juniper and pinyon-juniper woodland.

The Canadian zone on Mount Taylor has black bear, mule deer, porcupines, meadow mice, and shrews. The outer slopes and mesa tops have gray squirrels, chipmunks, Colorado wood rats, pocket gophers, Rocky Mountain cottontails, and raccoons.

Belen-Albuquerque-Santo Domingo Basin

This basin is one of the largest in a series of north-trending basins in the Rio Grande trough. It is widest in the vicinity of Albuquerque and constricted to the south by the San Acacia channel and to the north by a structural narrowing formed by the continuation of the Cerrillos (12)

trend (La Bajada constriction, Kelley, 1952). Coincident with the large-scale faulting, deepening of the basin, and tilting of the adjacent mountain blocks in late Miocene time, detritus from the highlands was washed into the basin and now comprises a complex sequence of gravel, sand, silt, clay, and caliche deposits collectively known as the Santa Fe formation. At first, deposition must have been in a series of isolated closed basins but by mid-Pleistocene time the Rio Grande had established itself and begun the stripping that is now so evident. Nothing is known of the sediments under the deeper parts of the basin; presumably they are Cretaceous and older although some early Tertiary deposits may also be present. Where the basin narrows and shallows in the Santo Domingo area, the early Tertiary Galisteo formation and Espinaso volcanics are exposed.

The basinal deposits are very complex although a three-fold classification has been made by Bryan and McCann (1937) and clarified by Baldwin (1956). The lower gray member includes the Abiquiu tuff to the north and the Abiquiu (?) formation overlying the Espinaso volcanics and the Galisteo formation in the Santo Domingo basin. The middle red member constitutes the main body of the Santa Fe formation and is a thick sequence of fanglomerates representing the main subsidence. Faunal evidence for the age of the formation has come from this member which is considered to be in the Miocene-Pliocene transition zone (Baldwin, 1956). Confusion enters at this point. In places there is an unconformity between the middle red and upper buff members. The upper member contains well-sorted gravels that have been referred to as the Tuerto gravel, Ancha formation, and Puye gravel in different parts of the Santo Domingo basin and northward. Apparently, these few hundred feet of sediments represent axial gravels interfingered with basalt flows and pediment material from the sides of the basin that were deposited after the Rio Grande had begun integrating its drainage.

A persistent geomorphic surface (Ortiz) is found in the Albuquerque region and beyond. The gradient when projected to the Rio Grande near the type area of the Ortiz Mountains reaches the river at about 500 feet above the floodplain. The surface is found on the conoplain around the Ortiz Mountains, under the basalt cap on Santa Ana Mesa? (11), and on the Llano de Albuquerque (45, the divide between the Rio Puerco and Rio Grande). West of the Albuquerque-Belen basin it is preserved under basalt caps in the plateau area. Southward, correlatives of the Ortiz (Jornada-La Mesa surface) can be traced to Chihuahua, Mexico. The western correlative (Zuni surface) can be traced to the Chuska Mountains and into Black Mesa, Arizona (Fitzsimmons, 1959). The truncation of pre-Tertiary units in regions outside the basin and the local truncation of deformed beds in the Santa Fe formation has led to the belief that the Ortiz surface, and correlatives, is an erosion surface (Bryan and McCann, 1938). However, a surface of such wide areal extent at such a high elevation would be easier to conceive if it were a combined erosional-depositional surface graded to playa basins rather than an integrated erosional system (assuming that a longer stable period can be maintained in a closed system). The problem of the type of surface centers around the relationship of the Ortiz to the axial gravels of the ancestral Rio Grande. Baldwin (1956) has already pointed out that the surfaces above and below the gravels were referred to indiscriminately as "Ortiz" by Bryan. A recent statistical study of the surface gravels in the Santo Domingo basin by Blagbrough (1961) has demonstrated that the Ortiz surface is entirely on pediment material whereas the next younger La Bajada surface is cut on both pediment and axial material. The La Bajada surface, then, is younger than the axial gravels and the axial-pediment-gravel relations of the Ortiz surface are still partly undemonstrated.

The recent discovery of fossil mammals under the Jornada-La Mesa surface in southern New Mexico allows a more precise determination for the probable age of the Ortiz surface. Hibbard identified a Kansan mammalian fauna indicating that the surface is no older than early mid-Pleistocene (Ruhe, 1960). Ruhe also concluded that integration did not take place until after the formation of the surface. If this is the case, the Albuquerque-Belen basin remained closed until the mid-Pleistocene and the axial gravels postdate that time.

Terraces below the Ortiz surface have been cut on both the main body of the Santa Fe formation and on the axial gravels and are a prominent feature in the Rio Grande and Rio Puerco drainage. These surfaces have been assigned many local names because correlation is difficult and complicated by basinward tilting and faulting. A compilation (Fig. 6) shows little agreement in terrace levels with the possible exception of the prominent surface about 75 feet above river level. The information in Figure 6 was taken from Bryan (1938), Bryan and McCann (1936, 1938), Cabot (1938), Denny (1941), Wright (1946), and Miller and Wendorf (1958). The elevations are the number of feet of the projected grade above the present floodplain.

The terraces are in various stages of preservation along the sides of the valley owing to local differences in drainage and dissection. For example, in the Albuquerque vicinity, the flat, level Ortiz surface can be seen on the western skyline (45), the Segundo Alto terrace is under the basalt flows associated with the Albuquerque volcanoes (20), and the two lower terraces can also be seen on the west side of the river. On the eastern Sandia Mesa (19), however, there is one long, continuous sloping plain from Bear Canyon, the large re-entrant in the Sandias, to the Rio Grande terrace near the river.

The surfaces represent successive intervals of stabilization in the downcutting and stripping of the Rio Grande and Rio Puerco drainage systems. There is little agreement on the mechanisms of stabilization and causes of downcutting, and apparently either climatic-vegetative changes or tectonic instability or both can be invoked although climatic control has gained more acceptance. Life zones in the region may have been lowered by as much as 4,000 feet during glacial intervals in the Pleistocene (Antevs, 1954), and even if half of that estimate is accepted, pinyon-juniper woodland would have covered most of the Rio Grande valley and ponderosa pine forests would have clothed the higher mesas and terraces. The maximum of the last such lowering in the region took place about 30,000 years ago (Clisby and others, 1957). At the same time, a large lake 150 to 200 feet deep, and requiring a rainfall of 30 inches per year to support its high lake levels, occupied the closed Estancia basin (Harbour, 1958).

If one accepts the revised estimates for the length of the Pleistocene (Kummell, 1961), the time involved in the cutting of the terraces and deepening of the valley is on the order of 200,000 years. Miller and Wendorf

AGE RELATIONS?	ELEV. ABOVE FLOOD PLAIN (FEET)	NORTH (NO CORRELATION IMPLIED BELOW ORTIZ SURFACE) SOUTH					
		ESPANOLA BASIN	SANTO DOMINGO BASIN	RIO PUERCO DRAINAGE	ALBUQUERQUE-BELEN BASIN	SAN ACACIA AREA	SOUTHERN NEW MEXICO
KANSAN OR POST-KANSAN (Ruhe, 1960)	500	ORTIZ	ORTIZ	ORTIZ	ORTIZ	ORTIZ	
200,000 YRS. (Kummel, 1961)							JORNADA-LA MESA (SAN MARCIAL)
	400						JORNADA-LA MESA (EL PASO)
PREVIOUS LOWERING OF LIFE ZONES (ILLINOISAN) (Emiliani, 1958)	300	NUMBER 3			SEGUNDO ALTO		
100,000 YRS.			LA BAJADA			TIO BARTOLO	
	200	NUMBER 4	PEÑA BLANCA (COCHITI)	LA JARA	PRIMERO ALTO	VALLE DE LA PARIDA	
LAST LOWERING OF LIFE ZONES (WISCONSIN) (Clisby and others, 1957)	100		RIO GRANDE	RITO LECHE	LLANO DE SANDIA	CAÑADA DE MARIANA	PICACHO TERRACE TERRACE
2,000 YRS. (Ruhe, 1960)		HIGH TERRACE LOW TERRACE	SILE	UPPER TERRACE LOWER TERRACE			FORT SELDEN

Figure 6. Geomorphic surfaces along the Rio Grande in New Mexico.

(1958) have determined that the upper (18-20 feet above stream level) young terrace in the Espanola basin was formed after A.D. 1200 and the youngest terrace (Fort Selden) in southern New Mexico is less than 2,600 years old (Ruhe, 1960). This means that the precipitation changes and life-zone shifting of two glacials and interglacials is involved in the formation of the complex of terraces between the lowest bench and the Ortiz surface (Fig. 6; the chronology is only suggestive and no correlation in either time or terrace levels in the space between the Ortiz and Fort Selden surfaces is implied).

Present vegetation in the Belen-Albuquerque-Santo Domingo basin consists mainly of desert shrubs (catclaw, salt-bush, white sage, rabbit-brush, mesquite, and creosote-bush), cacti, and short grasses. Several plants from the Old World, such as Russian olive and tamarix, are found along many watercourses in addition to the native Rio Grande cottonwood. One introduced plant, Russian thistle (tumbleweed), has been most successful, particularly in areas disturbed by man. An Indian name characterizes it as the "white man's plant". Common mammals are the kangaroo rat, mice, ground squirrels, prairie dogs, and rabbits.

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