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Distribution of Late Quaternary Wind-Deposited Sand in Eastern Colorado

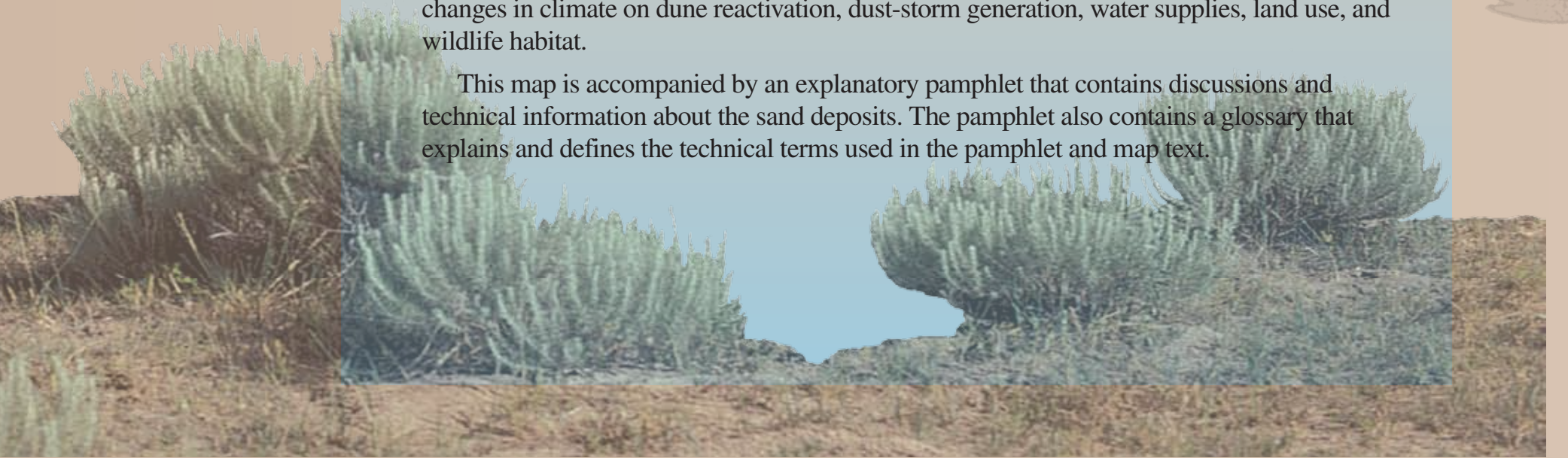
By Richard F. Madole, D. Paco VanSistine, and John A. Michael

Introduction

During historic time, inhabitants of the Great Plains have experienced a succession of climatically driven cycles of economic boom and bust. Drought has been the primary driver of bad times because of its impact on water supplies, crops, and grazing land. In addition, prolonged droughts have set the stage for massive wind erosion and huge dust storms. With or without global warming, droughts will continue to occur and will affect the economy and social fabric of the region. Droughts cannot be prevented, but an improved understanding of their causes and effects can provide a basis for planning that will minimize negative impacts on society.

The period during which meteorological data have been recorded in eastern Colorado is far too short to encompass the full range of variability possible under the present climate. An understanding of the long-term pattern of climate change is required to plan for changes that are likely to occur in the near future and to anticipate the effects that these changes will have on humans and the environment. This map is part of a U.S. Geological Survey project, the purpose of which is to determine the range of climate variability possible on the western Great Plains in the 21st century and to achieve a better understanding of the effects of slight changes in climate on dune reactivation, dust-storm generation, water supplies, land use, and wildlife habitat.

This map is accompanied by an explanatory pamphlet that contains discussions and technical information about the sand deposits. The pamphlet also contains a glossary that explains and defines the technical terms used in the pamphlet and map text.



Sand Dunes and Sand Sheets in Eastern Colorado

Wind-deposited sediment blankets about 60 percent of Colorado east of the Rocky Mountains. About 30 percent of this sediment is sand and about 70 percent is loess (dust deposits of mostly silt). Several different ages of wind-deposited sediment are present. They span many thousands of years and show that episodic mobilization of sediment by wind is not just a recent phenomenon in this region. Wind-deposited sand came primarily from stream channels and flood plains, as did much of the dust.

Typically, deposits of windblown sand are 3–10 meters thick, but in parts of the Wray dune field, the eastern South Platte sand area, and the Black Squirrel sand area, they are as much as 20–40 meters thick. Most dune sand is presently stable and covered with vegetation. Parabolic dunes are dominant throughout northeastern and central Colorado, whereas blowout dunes are the most common type in areas south of the Arkansas River. Both of these dune types are controlled primarily by vegetation and (or) moisture that partially stabilize the sand. In contrast, wind strength and direction are the primary controls of other dune types. Parabolic dunes approximate a parabola in plan view, and they have a convex, closed front that faces downwind and arms that trail upwind toward the open end of the parabola. Blowout dunes are simply circular or bowl-shaped features of deflation *(see diagrams of dune types on this map sheet).*

Two types of parabolic dunes deserve mention because they are widespread and represent two extremes in form and topographic expression. One type consists of long, low, topographically subdued, U-shaped (hairpin) simple parabolic dunes, whereas the other type consists of relatively high, topo-graphically rough, compound parabolic dunes *(fig. 8 on the map sheet and fig. 9 in the pamphlet).* The arms of the U-shaped simple parabolic dunes are notably straight and typically 2–3 kilometers long, but they are only about 5 meters higher than surrounding terrain. They are conspicuous on aerial photographs because of the length and linearity of the dune arms, but they are inconspicuous on the ground because of their low height. In some places, only the arms of this dune type are preserved; the concentric leading edge is missing due to continued wind erosion.

◀ **(Left)** *Late Holocene dunes encroach onto the valley floor of Kiowa Creek about 4 kilometers west-southwest of map locality 11. Late Holocene dunes usually have topographically rough surfaces compared to middle Holocene dunes, which generally have smoother more subdued surfaces because they have been inactive longer.* Photograph by R.F. Madole.

***Types of sand dunes in eastern Colorado.** **A**, Blowout dunes are circular or bowl-shaped features of wind erosion. The shape and symmetry of the depression and the surrounding dune are functions of the direction(s) of the sand-transporting wind and the distribution of vegetation and moisture in the area. **B**, Simple parabolic dunes approximate a parabola in plan view. They have a convex front that faces downwind and arms that trail upwind toward the open end of the parabola. Parabolic dunes are products of wind that is chiefly unidirectional, and the greatest amount of erosion and deposition is at the downwind edge of the dune. The front part of the dune tends to build and migrate downwind over time, whereas sand piled along the flanks is left behind to form the trailing arms of the parabolic dune. A shallow water table or damp sand may limit the depth or growth of the dune, and vegetation tends to stabilize the dune arms. Parabolic dunes occur in many shapes and sizes. They range from U-shaped to V-shaped, and from long and narrow (hairpin like) to nearly as wide as they are long. **C**, Compound parabolic dunes consist of clusters of small parabolic forms and elongated blowouts that are superposed on larger parabolic masses of sand* (see fig. 8 on the map sheet). *Within the clusters of small parabolic forms, individual dunes tend to be aligned in rows and they often overlap in an orderly steplike arrangement or telescoping patterns. The main parabolic sand masses are generally 1 kilometer or more long and have steep flanks that rise 10–20 meters.* Drawings by Arthur Isom, USGS.

Dune orientations and the distribution of wind-deposited sand with respect to source areas show that the dominant sand-transporting winds were northwesterly in northeastern and east-central Colorado and southwesterly in southeastern and south-central Colorado. Eolian sand stratigraphy indicates that paleowind directions in latest Pleistocene time were similar to those in the Holocene. At present, prevailing winds over most of northeastern and east-central Colorado and adjoining parts of Kansas and Nebraska are northwesterly from October to April and southeasterly from June through September *(Muhs and others, 1996).* Southeasterly winds bring moisture inland from the Gulf of Mexico and are the reason why 70–80 percent of the annual precipitation in eastern Colorado is received between April and September *(Berry, 1959).*

Eolian sand deposits can be divided into at least three age groups primarily on the basis of differences in topographic expression of dunes and degree of soil development. Age determinations indicate that the three age groups were deposited within the late Holocene (4,000–0 years ago), middle Holocene (8,000–4,000 years ago), and latest Pleistocene (35,000–11,600 years ago).

Late Holocene eolian sand is particularly widespread in northeastern Colorado. Three sand units that are separated by two buried soils are recognized over much of the South Platte River area. Calibrated radiocarbon ages of the buried soils and optical ages *(see pamphlet for discussion and definitions of radiocarbon and optical dating)* of the three sand units indicate that (1) the upper sand unit was deposited mostly between about A.D. 1250 and A.D. 1650, (2) the middle sand unit was deposited between about A.D. 675 and A.D. 1020, and (3) deposition of the lower sand unit may have begun sometime between 3,500 and 2,800 years ago and ceased prior to 2,340 years ago.

Preservation of the late Holocene buried soils is due to their high content of silt and clay (as much as 70–86 percent in a few places), which is remarkable given that the soil parent material is generally 90 percent or more sand *(see fig. 7 and table 3 in the pamphlet).* The silt and clay presumably are dust that was blown in from elsewhere and deposited with sand or on sand and then translocated downward into the sand. Several age determinations indicate that the upper buried soil formed between about A.D. 1020 and A.D. 1250, and two calibrated radiocarbon ages of the lower buried soil and two optical ages of sand in the middle unit indicate that the lower soil probably was buried about A.D. 675.

Middle Holocene eolian sand is the least extensive and most poorly dated of the three age groups. The eolian history of this time is vague because good exposures of middle Holocene sand are few and unconformities (time gaps or interruption in stratigraphic succession) between deposits are difficult to discern. Two optical ages provide meager evidence that eolian sand was deposited during at least two intervals during the middle Holocene, but neither the beginning nor the end of any episode of sand deposition has been determined. Calibrated radiocarbon ages of buried soils developed in latest Pleistocene eolian sand, which underlies middle Holocene sand in some places, suggest a minimum date of about 7,000 years ago for the onset of eolian sand deposition in middle Holocene time *(table 4 in the pamphlet).*

Geologic Time Chart

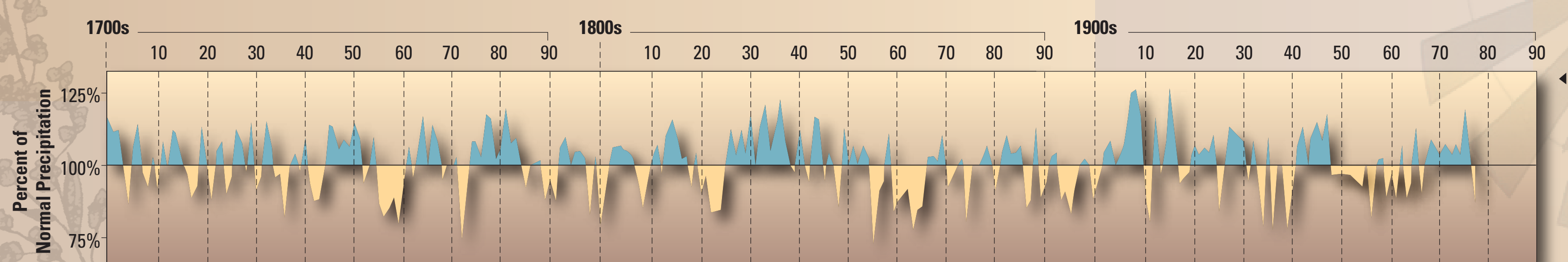
Eon	Era	Period	Epoch	Estimated Age
Phanerozoic	Cenozoic	Quaternary	Holocene	11,680 years
			Pleistocene	1.8
		Tertiary	Pliocene	5.3
			Miocene	23.8
			Oligocene	33.7
			Eocene	54.8
			aleocene	65.0
	Mesozoic	Cretaceous	Cretaceous	99.0
			Cretaceous	144
		Jurassic		206
		Triassic		248
	Paleozoic	Permian		290
		Pennsylvan		323
		Mississipp		354
		Devonian		417
		Silurian		443
		Ordovician		490
		Cambrian		543
Proterozoic	Late Proterozoic			900
	Middle Proterozoic			1.6
	Early Proterozoic			2.5
Archean	AGE OF THE EARTH			4.5

Million years (1.8–900); Billion years (1.6–4.5)

Drought and the Dust Bowl

Situated at the higher, drier western margin of the Great Plains, some part of eastern Colorado has experienced drought in nearly every decade since instrumental climate data began to be collected a little more than a century ago. Particularly severe droughts occurred during the 1930s, 1950s, and, to a lesser degree, the 1970s. Historical records in diaries and early newspaper articles indicate that severe droughts also occurred with similar frequency during the 19th century. In addition, dendrochronologic (tree-ring) data from areas outside of Colorado, but along or relatively near the margin of the Great Plains, reveal a pattern of recurring drought that extends back several centuries. Thus, it is reasonable to expect that severe droughts will continue to occur at least once every two to four decades during the 21st century *(see drought recurrence diagram below).*

Drought Recurrence on the Great Plains Reconstructed from Tree-Ring Records



◀ **(Left)** *Record of drought recurrence from A.D. 1700 to 1977 reconstructed from tree rings at 17 localities in four regions within or relatively near the Great Plains* (after Stockton and Meko, 1983). *The curve is the average of four regional tree-ring records. Percent of normal is based on instrumental data recorded from 1933 to 1977.*

A large part of eastern Colorado is in the "Dust Bowl," a term introduced during the 1930s to describe an area of nearly 100 million acres where drought is frequent and wind erosion is particularly severe. In addition to eastern Colorado, the Dust Bowl includes parts of western Kansas, easternmost New Mexico, and the panhandles of Texas and Oklahoma. Massive dust storms spawned by wind erosion in this region during the 1930s dramatically impacted the health, comfort, and livelihood of large segments of the population, both in the dust source areas and for long distances downwind of these areas. Blowing soil closed highways and railroads, cut off power, forced the population indoors, and blocked the sun, even at midday.

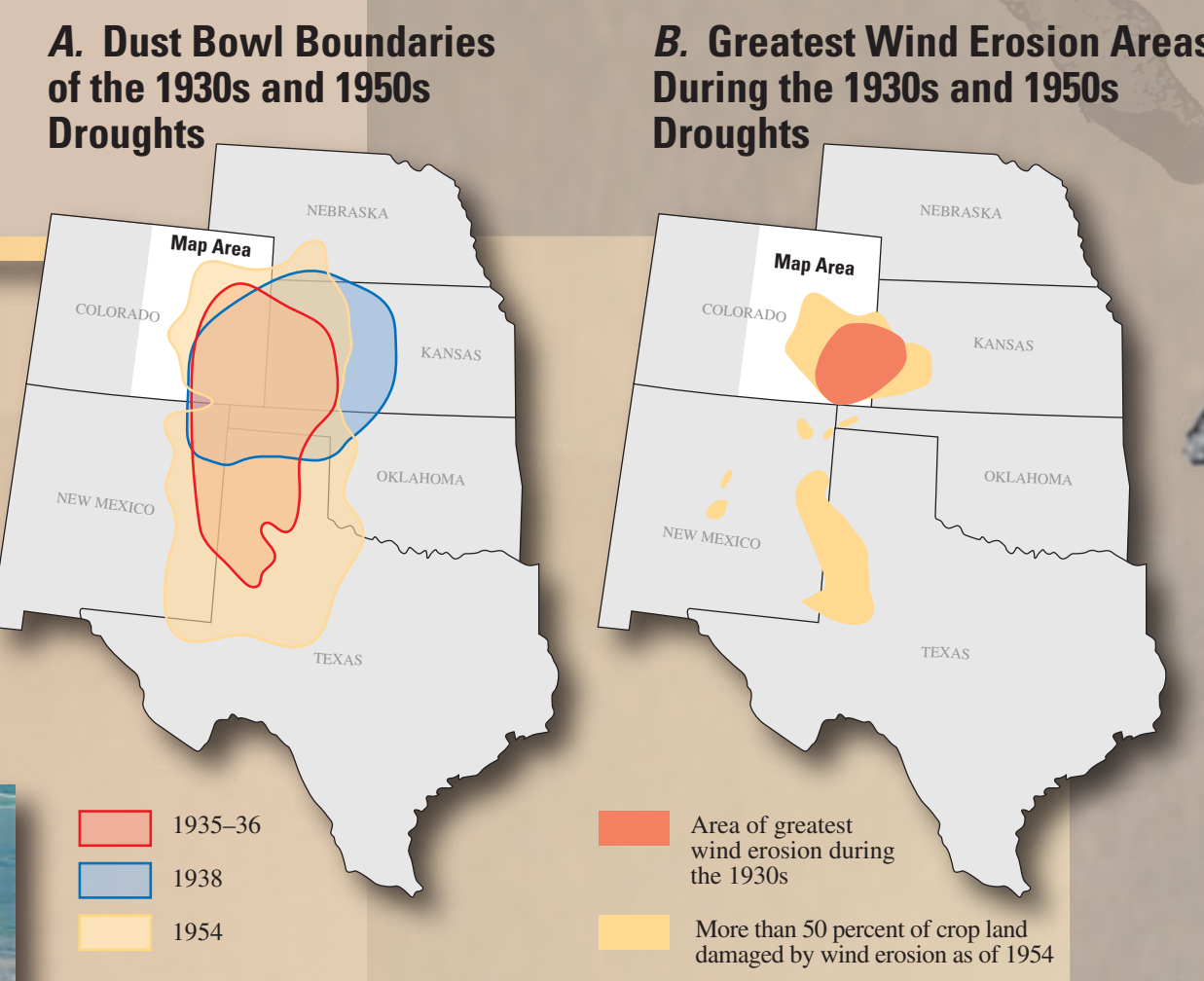
The threat of massive dust storms in this region did not end with the "dirty thirties," a fact that became evident during the late 1970s. On February 23, 1977, winter storms generated two large dust plumes, one in eastern Colorado and western Kansas and the other near the Texas–New Mexico border. Within 24 hours, dust totally obscured about 400,000 square kilometers of ground surface in the south-central United States. The huge dust storm continued to move eastward and was still visible on satellite imagery two days later over the middle of the Atlantic Ocean *(McCauley and others, 1981).*

Shifts to a slightly drier climate have the potential for serious socioeconomic consequences in the western Great Plains as well as in other parts of the semiarid and arid western United States. Population centers in these regions are generally dependent on water from river systems that originate in mountains or on ground water pumped from deep aquifers, and demands on these water sources are great and increasing. The short-lived drought in the upper Midwest during 1988, which was minor in duration and extent compared to other 20th century droughts, demonstrated that as population increases and society becomes more complex and interdependent, even minor droughts impact the national economy. For example, when the 1988 drought curtailed barge traffic on the Mississippi River, extreme measures, such as diverting water from the Great Lakes to the Mississippi River, were suggested so that shipping could proceed farther upriver.

Figure 2. *Wind raises dust nearly to the level of jet aircraft approaching Denver on May 19, 1991. Dust storms such as this one are common in late April and early May as weather and human activities combine to create conditions conducive to wind erosion. During spring, farm fields are tilled and various construction projects break ground at a time when the dampening effects of snowstorms are mostly past, afternoon thunderstorms are not yet frequent, and vegetation cover is minimal because the growing season has just begun.* Photograph by R.F. Madole.

Drawing by Carol Quesenberry, USGS.

▼ **(Below)** *Wind has eroded soil from around this abandoned house near the Nebraska–Colorado border, thus providing an example of the effectiveness of wind erosion in the western Great Plains.* Photograph from USGS Water-Supply Paper 969.



▲ **Figure 6 (above).** ***The Dust Bowl.*** ***A**, The boundaries of the areas affected most intensely by drought in the 1930s and 1950s were similar but not identical. Even during the same drought (the 1930s, for example), the boundaries of drought-stricken areas changed with time. **B**. In the 1930s and 1950s, southeastern Colorado was the locus of severe wind erosion. The area was the source of "black blizzards" (dense dust storms) during the 1930s, and many farms and ranches there were abandoned. During the 1930s, the Federal government began a program to purchase marginal agricultural land to establish land-management demonstration projects. One result of the program was the eventual creation, in June 1960, of a system of National Grasslands. The Comanche National Grassland in southeastern Colorado and the Pawnee National Grassland in northeastern Colorado are products of this program.*

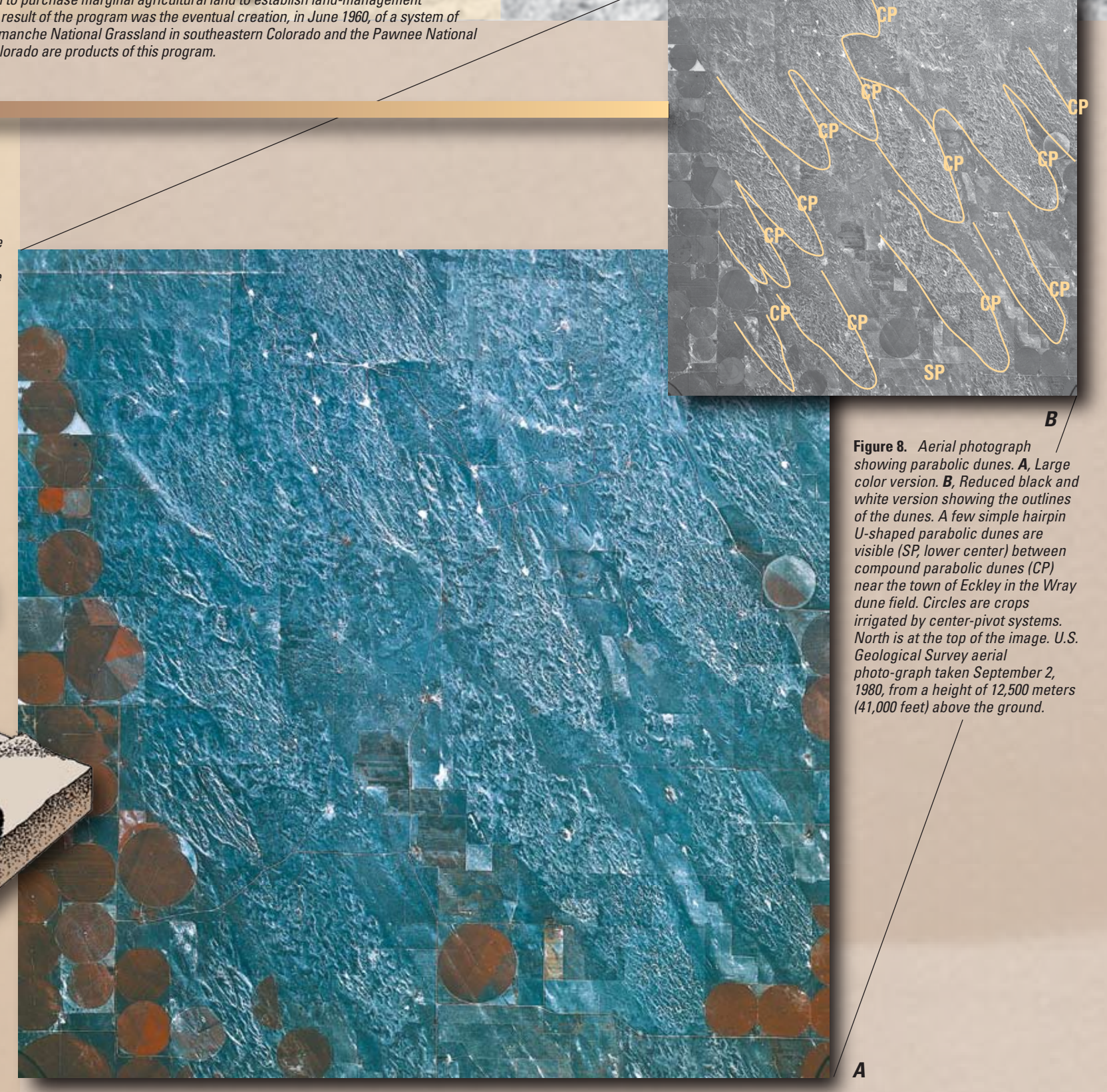


Figure 8. *Aerial photograph showing parabolic dunes. **A**, Large color version. **B**, Reduced black and white version showing the outlines of the dunes. A few simple hairpin U-shaped parabolic dunes are visible (SP, lower center) between compound parabolic dunes (CP) near the town of Eckley in the Wray dune field. Circles are crops irrigated by center-pivot systems. North is at the top of the image. U.S. Geological Survey aerial photo-graph taken September 2, 1980, from a height of 12,500 meters (41,000 feet) above the ground.*

Latest Pleistocene eolian sand is more extensive than Holocene eolian sand, although much of it was remobilized into younger eolian deposits during the Holocene or was buried by Holocene eolian sand. It is present primarily in sheets that extend several kilometers downwind beyond the limits of middle and late Holocene sand units. Numerical ages (radiocarbon and optical) and archeological data suggest that most windblown sand in eastern Colorado was deposited initially at about the same time that glaciers last filled valleys in the higher parts of the Southern Rocky Mountains *(Pinedale glaciation; see Geologic Time Chart on this map sheet).* Deposition of eolian sand apparently was in progress as early as 30,000 years ago and continued, probably intermittently, until perhaps as late as 13,000 years ago.

During the last glaciation, winter winds probably blew stronger and for a longer time each year than they do at present. In addition, more sand was available to be blown away than at any time during the Holocene because the valleys of the South Platte and Arkansas Rivers and their tributaries were not deeply incised and were not covered by vegetation as they are today. Furthermore, channels and flood plains were many times wider than those of today and were occupied by braided streams, which tended to shrink to rivulets during the winter months leaving large expanses of bare, dry sand exposed to wind erosion.

During the Holocene, the character and focus of wind erosion and deposition of sand changed. Flood plains became less important as sources of windblown sand, and terrace deposits and older wind-deposited sand sheets on adjacent uplands became more important. Rivers that originated in the Southern Rocky Mountains were perennial and maintained greater flows than streams originating on the plains. Thus, rivers draining from the mountains cut new valley floors to levels many meters lower than their late Pleistocene flood plains, and these new valley floors supported vegetation that inhibited wind erosion. Also, during the Holocene, runoff dwindled in drain-age basins located wholly on the Great Plains, and streams in these basins became markedly underfit (disproportionately smaller than their valleys), and they were minor sources of eolian sand compared to their Pleistocene counterparts.

Subdivisions of the Quaternary Period and Provisional Ages of Mountain Glaciations

Period	Epoch	Informal Geologic Time Terms		Mountain Glaciations	Estimated Age[1] (years before present)
Quaternary Period	Holocene Epoch			?	≈11,680
	Pleistocene Epoch	late Pleistocene		Pinedale glaciation	≈35,000
				?	≈128,000
		middle Pleistocene	late	Bull Lake glaciation	≈310,000
			middle	Pre-Bull Lake glaciation	≈640,000
			early		≈778,000
		early Pleistocene			≈1,806,000
Tertiary Period (part)	Pliocene Epoch				

[1] After Fullerton and others (2003).

Land-Use Practices and Consequences

During the droughts of the past 1,300 years (since about A.D. 675), sand was mobilized in about two-thirds of the approximately 26,370 square kilometers of eolian sand *(table 2 in the pamphlet)* in eastern Colorado. Model simulations of atmospheric circulation indicate that during this time, average surface temperature and estimated annual precipitation have varied only slightly in this region *(Kutzbach, 1987).* Given that climate changed little during the time that wind repeatedly mobilized sand over large areas suggests that under the present climate, eastern Colorado is near the threshold at which wind erosion becomes prevalent. This underscores the need to carefully manage land uses that disturb the sand deposits shown on this map.

Improved land-use practices and soil conservation techniques adopted after the 1930s drought reduced soil erosion and the frequency of severe dust storms. Unfortunately, by the 1970s, certain soil conservation practices ceased to be followed in some places, and the consequences were similar to the 1930s. Thus, on February 23, 1977, a windstorm eroded as much as 600 tons of sediment per acre in parts of southeastern Colorado in a 24-hour period. This amount of sediment is considered to be equivalent to that removed during 30 years of typical erosion *(Curry, 1977, in McCauley and others, 1981).*

A study of the source areas of the 1977 dust storm *(McCauley and others, 1981)*, which included southeastern Colorado and adjoining western Kansas and an area near the Texas–New Mexico border, revealed that specific land-use practices had contributed to extreme wind erosion. Among these practices was the removal of windbreaks and shelter belts (the term for trees planted after the 1930s drought) in order to install center-pivot irrigators. Other ill-advised land-use practices included attempts to produce crops on irrigated sand dunes, removing natural vegetation from rangeland on wind-deposited sediment and converting it to grain production, installing center-pivot irrigators on fields that included bare sand, and plowing and planting crops parallel to the prevailing wind.

Indian paintbrush (Castilleja sp.), *a colorful perennial plant found on plains and mountain areas of Colorado.* Watercolor by Margaret Austin, USDA.

Drawing by Carol Quesenberry, USGS.

Blue grama (Bouteloua gracilis), *the State grass of Colorado, is symbolic of the short-grass prairie. It is one of two dominant species in this grassland, the other dominant being buffalo grass* (Buchloë dactyloides). *Blue grama has a broader range than buffalo grass because it grows on sandy and clayey soils alike, and it also grows in montane grassy areas to altitudes higher than 2,500 meters (8,200 feet). Buffalo grass does not do well on loose sandy soil, but thrives on hard and clayey soils. Blue grama and buffalo grass, as well as many other grasses on the eastern Colorado plains, are C_4 plants. C_4 plants use moisture more efficiently than C_3 plants, but to achieve this efficiency, they require more energy (in the form of solar radiation) and higher temperatures (so that chemical reactions proceed faster) than C_3 plants. C_3 plants can thrive in cooler temperatures and with fewer hours of daylight than C_4 plants because they use energy more efficiently, but they do so at the expense of being less moisture efficient. Thus, C_3 plants can out compete C_4 plants in areas where growing season temperatures are lower and the hours of sunshine received are fewer, but only if moisture supply is not limited. The semiarid, nearly treeless plains of eastern Colorado, where summer days are hot and clear skies predominate, favor C_4 grasses but not to the complete exclusion of C_3 grasses.* Drawing by Jennifer Shoemaker, USGS.

▲ **Figure 1 (above).** ***A**, Native vegetation (chiefly grasses and sand sage) cover late Holocene eolian sand protecting it from wind erosion. **B**, Aerial view of strip plowing in the vicinity of map locality 7 that removed large areas of native vegetation. **C**, The plowing under of native vegetation led to massive wind erosion that drifted sand across plowed and unplowed areas alike and buried roads. In some places, road cuts were filled with as much as 3–5 meters of sand.* Photographs by R.F. Madole.

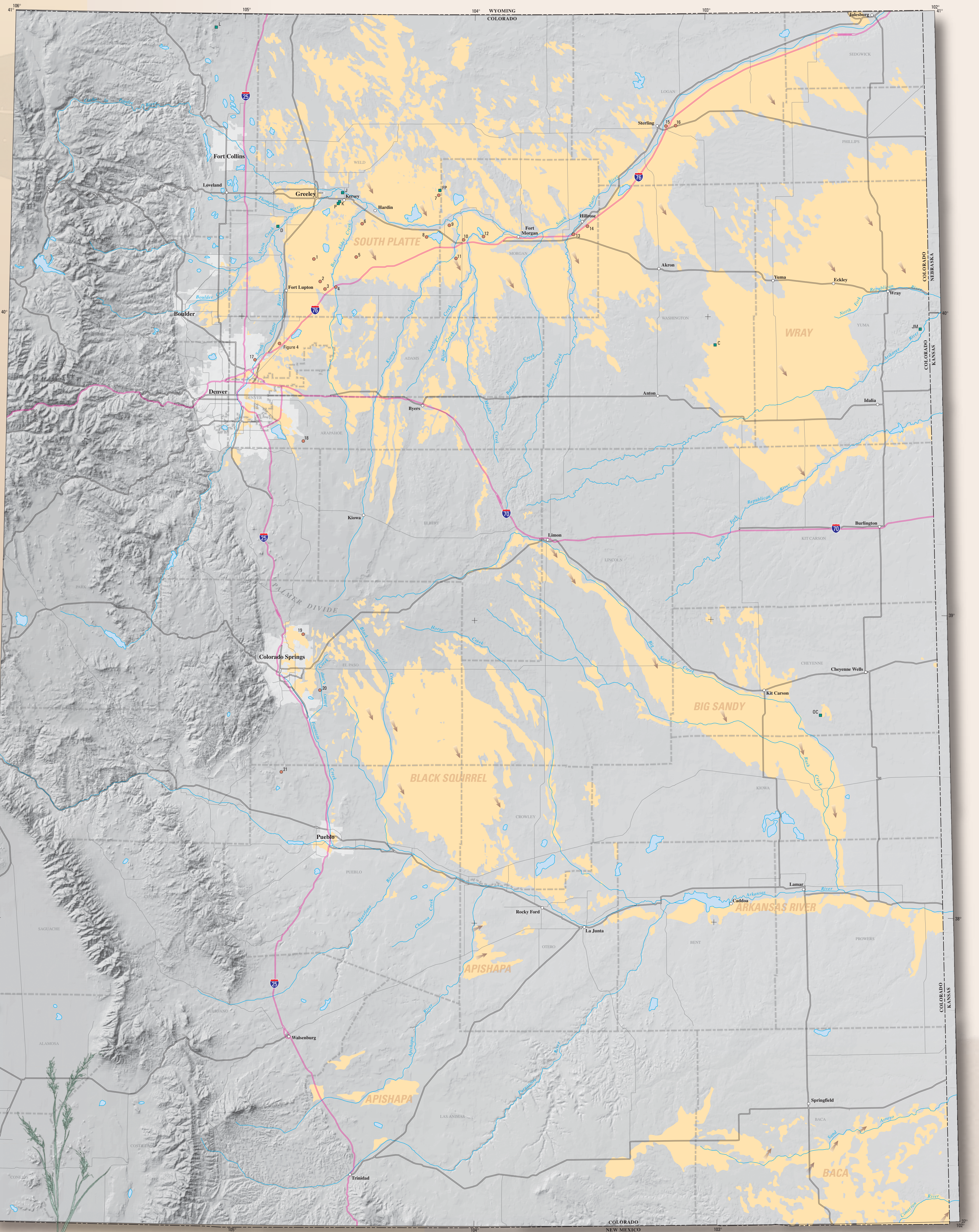
▼ **(Below)** *The Western Meadowlark* (Sturnella neglecta) *is one of the more common and colorful songbirds in the eastern Colorado grasslands. Its delightful songs, made while perched on a fence post, atop a yucca, or on some other tall plant, are heard almost everywhere across the plains, especially in the early spring.*

Photograph by John and Karen Hollingsworth, U.S. Fish and Wildlife Service.

▼ **(Below)** *Center-pivot irrigators, which are large sprinkler systems, create circular patterns on the plains of eastern Colorado* (also see fig. 8 on the map sheet). *Center pivots typically span a quarter section (one-fourth of a square mile or 160 acres) or more. Center-pivot irrigation has a potential for negative environmental consequences when used to irrigate crops on wind-deposited sand.* Photograph by R.F. Madole.

EXPLANATION

- ▭ **Wind-deposited (eolian) sand**—Seven named sand areas are shown on the map. The Wray sand area is also referred to as the Wray dune field
- → **Direction of prevailing sand-transporting paleowind determined from dune orientation**
- ● 18 **Locality mentioned in text**
- ■ P **Archeological site**—C, Claypool; D, Dent; FP, Fowler–Parrish; J, Jurgens; JM, Jones–Miller; K, Klein; L, Lindenmeier; OC, Olsen–Chubbuck; P, Powars



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◀ **(Left)** *Little bluestem* (Andropogon scoparius), *a perennial grass found on plains and mountain areas of Colorado.* Drawing by Margaret Austin, USDA.

Eolian sand areas compiled by *R.F. Madole* in 1991–94

GIS database created by *PacoVanSistine* in 2004
Base map created from USGS DEMs,
ESRI Data and Maps 2000 data set, and USGS National Atlas files
Lambert Conformal Conic projection, Clark Spheroid of 1866
North American Datum of 1927

Archeology and Eolian (Wind-Deposited) Sand Chronology

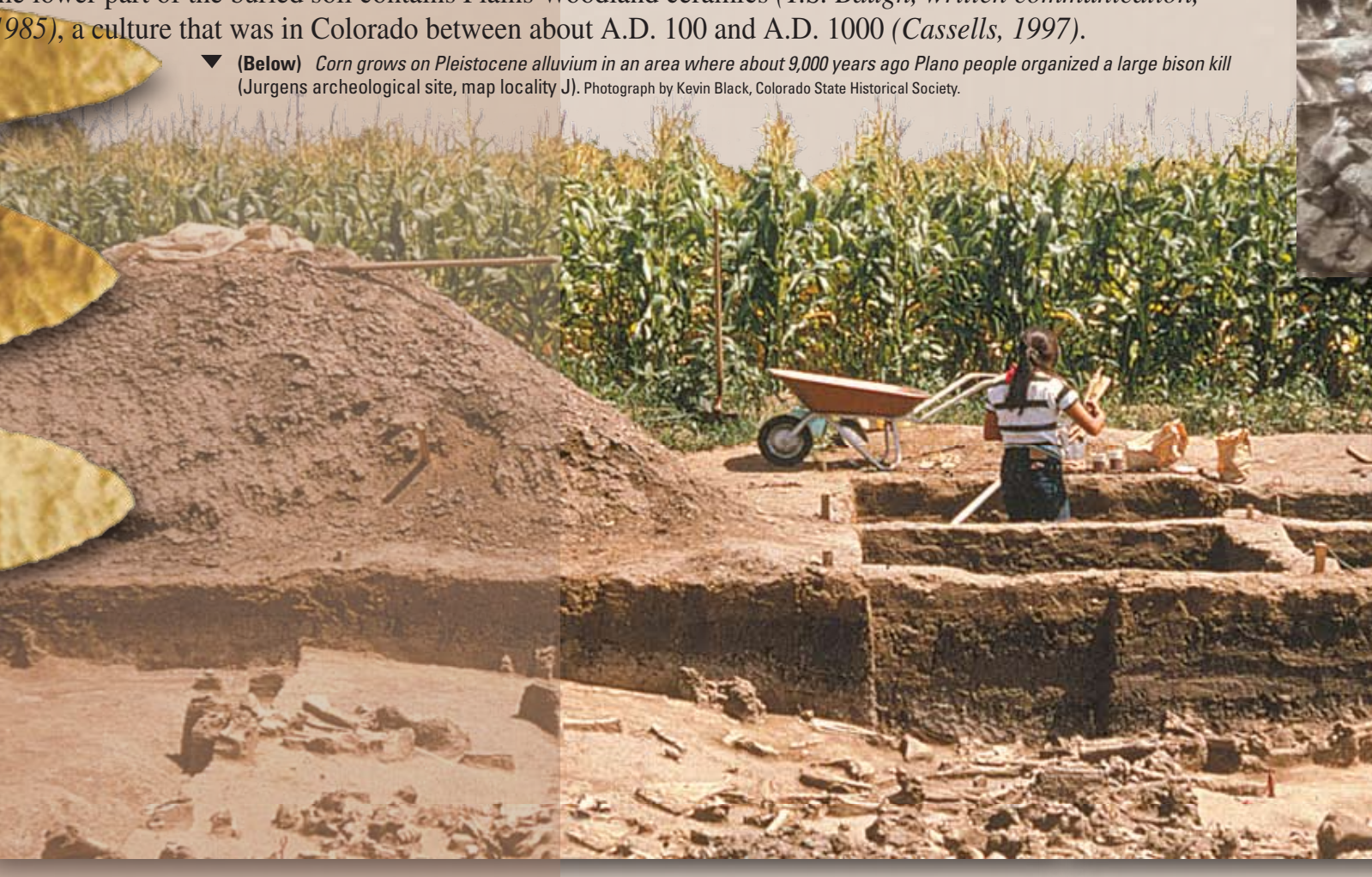
Archeological data are useful in helping to determine when deposition of late Pleistocene eolian sand ended, and they also help date Holocene eolian events. Archeological data indicate that deposition of latest Pleistocene eolian sand ended prior to occupation of the area by Folsom people, a culture that existed between about 10,900 and 10,400 radiocarbon years ago *(Dennis Stanford, oral communication, 2005),* which is equivalent to about 12,700–11,300 calendar years ago. *(See glossary in the pamphlet for an explanation of the difference between radiocarbon years and calendar years.)* Numerous Folsom projectile points were found at the Fowler–Parrish site, a bison kill site in an area of late Pleistocene eolian sand just north of map locality 7. Also, the Powars site, which is in late Pleistocene eolian sand near Kersey, Colorado *(map locality P)*, is a Folsom camp or habitation site that contained abundant cultural materials equivalent to those found at the famous Lindenmeier site farther north *(map locality L).* In addition, a Clovis projectile point was found near the top of eolian sand just south of the Powars site *(Lou Klein, oral communication, 1995)*, and Clovis points were found at the nearby Klein site *(map locality K)*, which is on Pleistocene terrace alluvium. The Clovis Culture existed between about 12,000 and 10,600 radiocarbon years ago *(Dennis Stanford, oral communication, 2005)*, which is equivalent to about 13,000 and 12,300 calendar years ago.

Although a few radiocarbon ages in eastern Colorado place the Upper Republican culture there between A.D. 1100 and 1300 *(Cassells, 1997)*, radiocarbon ages in nearby Nebraska, Kansas, and southeastern Wyoming suggest that this culture could have been in Colorado between A.D. 1000 and 1400 *(K.D. Black, written communication, 2005).* The presence of Upper Republican ceramics in two late Holocene buried soils at Friehauf Hill *(T.S. Baugh, written communication, 1985)* indicates that deposition of an intervening middle sand unit there began after A.D. 1000 and probably had ceased by A.D. 1300, or possibly as late as A.D. 1400; deposition of a younger upper sand unit above the buried soils did not begin sooner than A.D. 1300.

A radiocarbon age of the late Holocene lower buried soil at Friehauf Hill indicates that the lower eolian sand was deposited before 1,380 ± 90 radiocarbon years ago. Artifacts in the lower part of the lower buried soil support this date. In addition to the Upper Republican ceramics in the uppermost part of this buried soil, the lower part of the buried soil contains Plains Woodland ceramics *(T.S. Baugh, written communication, 1985)*, a culture that was in Colorado between about A.D. 100 and A.D. 1000 *(Cassells, 1997).*

▲ **(Above)** *Projectile points from the famous Olsen–Chubbuck archeological site* (map locality OC), *a Plano site somewhat older than the Jurgens site, which was exposed by wind erosion between spring 1954 and winter 1957, a time of severe drought in this area. Plano hunters used points such as these to kill a large number of bison that had been driven into an arroyo north of Big Sandy Creek about 10,000 radiocarbon years ago.* Photograph by Ray Lyons, courtesy of Colorado State Historical Society.

▼ **(Below)** *Corn grows on Pleistocene alluvium in an area where about 9,000 years ago Plano people organized a large bison kill* (Jurgens archeological site, map locality J). Photograph by Kevin Black, Colorado State Historical Society.



▲ **(Above)** *Bones, mostly of bison, are unearthed at the Jurgens archeological site* (map locality J) *near Kersey, Colorado. The Jurgens site is one of the older Plano sites in eastern Colorado. The Plano culture existed on the plains of eastern Colorado between about 10,000 and 7,000 radio-carbon years ago* (Cassells, 1997). *It appeared as the Folsom culture was ending. Like Folsom people, Plano people utilized long, finely flaked projectile points, but without the fluting characteristic of Folsom points. Plano people also hunted big game, but apparently did so with more hunters and more organization than Folsom people, which in some places resulted in massive, complex kill sites.* Photograph by Kevin Black, Colorado State Historical Society.

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Box 25286, Federal Center, Denver, CO 80225
This map is also available as PDF and GIS files at http://pubs.usgs.gov

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