sanitary engineering and vital statistics, with elective work and a thesis. Our students have specialized as a rule either along bacteriological or statistical or sociological or administrative lines and in each one of these fields the cooperation of the other departments of the university has proved of incalculable value. We have made a special effort to fill the very real need for both men and women who can combine training in public health with training in sociology and economics to serve as directors of anti-tuberculosis societies and other voluntary agencies where the medical degree is by no means necessary for success; and bacteriologists with only the bachelor's degree and the C. P. H. have proved well qualified for good positions in state and city laboratories and universities. Two such men now hold positions as assistant professors in institutions of high standing.

Our Ph.D. students are in the main specializing either in bacteriology or statistics and are preparing for directorships of state and city laboratories or for university teaching positions. The combination of public health and home economics is, I believe, one that is likely to prove a peculiarly valuable one for women desiring to pursue a professorial career in the future.

For official administrative health work the C. P. H. (with appropriate specialization in health administration) may be taken by a medical graduate; but the doctorate in public health is the degree specially designed for this end. It is normally a two years' course, open only to graduates in medicine, with a rather full curriculum and special provision for practical field work with the Connecticut State Department of Health, the New Haven City Department of Health or some similar agency. If desired the candidate for this degree may specialize in industrial hygiene or in school hygiene, in both of which fields the opportunities offered through other departments of the university are of inestimable value.

The medical school and the graduate school are obviously the closest points of contact for a department of public health; but they are by no means the only points at which such a department touches the life of the university. The public health staff offers a course which forms a vital part of the program of the Yale School of Nursing and it is hoped in the near future to develop in the graduate department of bacteriology, pathology and public health a special program leading to the M.S. degree designed particularly for holders of the degree of bachelor of nursing, a program which will depend on the university departments of social science and education for a considerable portion of its work.

In Yale College the public health staff cooperates with the director of university health in giving a brief elective course on personal and public hygiene, the community aspects of which are of real value for students who may later enter public life. In one city in Connecticut the local health department has been reorganized by a mayor who became interested in the subject through taking this course a few years before. Students from the scientific school occasionally take our courses in industrial hygiene; and a number of very good men from the school of religion have taken the principles of public health as a part of their preparation for community service. Finally, the department of public health has been constantly and closely affiliated with the department of university health and the professor of public health is the chairman of the board which directs the general policies of health supervision of the student body.

It seems, from our experience at Yale, that public health has a real place as one of the fundamental disciplines in a university program. Organized in intimate contact with medical school and graduate school a department of public health may, with a modest endowment, offer graduate courses leading to the advanced degrees which qualify for professional service in this field. It may at the same time serve what is perhaps an even more essential service by becoming a permeating and controlling influence in the training of practitioners of medicine, on whose intelligent cooperation the progress of the public health movement so markedly depends. It may touch such widely separated schools as those of nursing, of religion, of social science, of education, of engineering, with glimpses of a field of human activity which is coming to play a significant part in every phase of modern social life.

C.-E. A. WINSLOW

YALE SCHOOL OF MEDICINE

DATE OF CHANNEL TRENCHING (ARROYO CUTTING) IN THE ARID SOUTHWEST[1]

INTRODUCTION

NEARLY all streams in southwestern United States flow between vertical banks of alluvium that vary in height from ten to as much as one hundred feet. Although subject to great floods, these streams no longer overflow their banks, nor build up their adjacent flood-plains. Floods merely deepen and widen the channels (arroyos) which continually grow headward into the undissected valley floors of headwater valleys and tributaries. The details of this process of dissection (channel trenching) have been elabo-

[1] Published by permission of the director of the United States Geological Survey.

rately described by Rich and named by Gregory the "Recent epicycle of erosion."

It is evident to all observers that the formation of the channel trenches is recent as early settlers in the region can remember the time when many of these valley flood plains were intact and the floods spread widely. At that time, meadows, belts of cottonwood or willow trees, and even swamps characterized the floors of valleys that now support only scattered sage, greasewood or mesquite.

The formation of the arroyos has had a large effect on the distribution of vegetation, and on the use of the valley floors for farming and grazing. The subject, therefore, is of interest to a number of groups, including geologists, botanists, engineers, agriculturalists and grazing experts. Notable changes in population, including the abandonment of villages, have occurred and therefore the cutting of the arroyos is an outstanding event of interest to historians.

It is not, however, the purpose of this paper to discuss the origin of the arroyos but to put in compact and usable form the existing information as to the dates when this process of erosion began. Since each arroyo is lengthened from the mouth headward its formation is spread over a considerable time, which is generally measured in years. Details of the process have been recorded in only a few instances, and the more or less hazy recollections of early settlers are the only source of information regarding some streams. In the accounts of travelers, in the notes of early land surveys and in other local records there are many valuable historical data that as yet are largely unused in a systematic way. With the passage of years such information becomes more difficult to obtain, and it is hoped that the notes presented herewith will stimulate the gathering of more complete data on the time of stream trenching in the arid southwest. In an ideal presentation the material would be assembled by drainage basins. The existing material is, however, too fragmentary to be assembled in this fashion and is here presented in large poorly defined areas.

SOUTHERN COLORADO AND NORTHERN NEW MEXICO

Duce[2] has described the formation of arroyos (channel trenches) in southern Colorado. The pioneer settlers found the bottom land low and rounded, with no suggestion of an arroyo in the center. He gives various types of evidence that the arroyos are recently formed and sets the time as since the early government surveys of 1860 and 1870 and since the settlement of the country—that is, since 1860–65 in southeastern Colorado and since 1870–80 in southwestern Colorado.

According to the local inhabitants, the present channel trench of the Rio Puerco, a tributary of the Rio Grande in New Mexico, was cut in the late 80's. The flood waters are confined between banks and no longer spread widely, so that they are not easily diverted for irrigation. Subsequent to this entrenchment the towns of San Ignacio, San Fernando y Blas and San Francisco, located on the river, have been abandoned.[3] The natural hay fields of the area have largely disappeared. However, above Cabezon, where Simpson[4] crossed the river in 1849, there was at that time a trench, for he states that the channel was one hundred feet wide, it contained pools of stagnant water, the banks were twenty and thirty feet high, and had to be cut down to allow passage of the artillery. Jackson,[5] in 1877, crossed on a bridge at Cabezon, five or six miles below the point at which Simpson crossed. In 1846, Lieutenant J. W. Abert[6] reached the Rio Puerco at a point west of Albuquerque, where the banks of the river were "10 or 12 feet high" and vertical. Further upstream he camped near a ruined town which he heard afterwards was called "Poblazon" and here the banks of the river were about thirty feet high. From his general description he reached the river above San Ignacio, which was occupied until 1911, and the abandoned town was San Fernando y Blas, of which only the faintest traces remained in 1909. From the foregoing account it seems that erosion had begun on the Rio Puerco in the 40's, and therefore about forty years before the time given by the oral statements of local residents.

The arroyo of Chaco Canyon, a tributary of San Juan River, is now twenty to thirty feet deep and 150 to 450 feet wide. Many of the tributary canyons, such as Mocking Bird Canyon, are yet undissected, although a falls that recedes each year

[2] Duce, J. T., "The effect of cattle on the erosion of canyon bottoms," SCIENCE, n. s., Vol. 47, pp. 450–452. 1918.

[3] Bryan, Kirk, "Erosion and sedimentation in the Papago Country, Arizona," U. S. Geol. Survey Bull., 730-B, p. 80, 1922.

[4] Simpson, J. H., "Journal of a Military Reconnaissance from Santa Fe, New Mexico, to the Navajo Country," etc.: p. 27, Philadelphia, 1852.

[5] Jackson, W. H., "Report on the ancient ruins examined in 1875 and 1877," Chap. II, "Ruins of the Chaco Canyon examined in 1877," U. S. Geol. and Geogr. Surveys Terr. (Hayden Survey) 10th Ann. Rept., p. 432, 1878.

[6] Abert, Lieutenant J. W., "Report of his examination of New Mexico in the years 1846–47," Ex. Doc. 41, 30th Congress, 1st sess., pp. 466–467, 1848; also printed as Sen. Ex. Doc., 23, pp. 50–51, 1848.

marks the head of the tributary arroyo which will eventually destroy the alluvial plains in these canyons. The arroyos have increased since the early expeditions to the canyon, as recognized by Dodge.[7]

According to Simpson,[8] the "Rio Chaco" had, at the time of his visit in August, 1849, a width of eight feet, and a depth of one and a half feet at his camp near Una Vida. It is evident that this description applies to the muddy water that was then flowing. No mention is made of a channel or arroyo, although Simpson described the steep walled arroyos of three other streams that were crossed on the way to Chaco Canyon.

Lieutenant C. C. Morrison[9] visited the canyon in 1875, but does not mention an arroyo. Oscar Loew[10] visited the ruins, but his description of the topography of the canyon is too vague to be of value.

William H. Jackson[11] visited and spent five days in Chaco Canyon in 1877. Five or six miles above Pueblo Pintado the arroyo was so shallow that the Navajos had formed "water pockets" (reservoirs) by obstructing the channel (p. 432). Near this ruin the arroyo was ten or twelve feet deep and dry (p. 433). Between the ruins known as Pueblo Pintado and Weji-Ge, the dry bed of the arroyo with its vertical banks almost entirely cut off communication from one side of the canyon to the other. Numerous small cottonwoods grew along the bank (p. 436). Near Una Vida he notes that the arroyo is dry, although Lieutenant Simpson had found running water in 1849. He explains that at the time of his visit (spring) floods are rare, but that Simpson was there in August when floods are more common (p. 437). At Pueblo del Arroyo the arroyo was sixteen feet deep and forty to sixty feet wide (p. 443 and Pl. LIX). Two hundred and fifty yards below there were shallow pools of water in the arroyo, and here Jackson camped. New grass, young willows and cottonwoods in the bed of the arroyo, whose vertical banks were used to confine their animals, extended for half a mile up and down stream (p. 446).

It is evident from this account that in 1877 an arroyo existed, but it was yet small, for at Pueblo del Arroyo, where the greatest dimensions are recorded, sixteen feet deep and sixty feet wide, the arroyo was thirty feet deep and two hundred to three hundred feet wide in 1924. Unfortunately, no one has described in detail conditions in Chaco Canyon previous to Jackson's trip in 1877, but the very vagueness of the earlier accounts may be taken as evidence that no such arroyo as Jackson saw existed.

NORTHERN ARIZONA AND SOUTHERN UTAH

The evidence for the Navajo Country lying largely in northern Arizona has been reviewed and conditions summarized by Gregory,[12] based on his surveys of 1909, 1910, 1911 and 1913.

A lake in Bonito Canyon described by Simpson[13] in 1850 has disappeared, and the canyon now has an arroyo twenty to thirty feet deep. The lakes in Laguna Canyon, shown on the United States Geological Survey's Marsh Pass map, published in 1882, no longer exist and their floors are trenched.

In 1880 a perennial water body existed in Tyende Valley and as late as 1893 a road traversed this valley, crossing and recrossing the stream, which is now an arroyo twenty feet deep. In 1894 the alluvial floors of Walker Creek and Chinle Creek were cultivated by the Indians, but in 1913 Walker Creek flowed in an arroyo eighty feet deep and Chinle Creek in an arroyo one hundred feet deep. Since the Mormons colonized Tuba in 1870 the Moenkopi has entrenched itself fifteen to forty feet. As a result of reviewing this evidence and from all data gathered from local inhabitants, Gregory concludes that the trenching took place within twenty-five to thirty-five years of this work—that is, from 1880 on. The evidence brought forward by Gregory is reiterated by Reagan.[14]

[7] Dodge, R. E., "The formation of arroyos in adobe-filled valleys in the southwestern United States" (abstract), Brit. Assoc. Advanc. Sci. Rept., Vol. 79, pp. 531–532. 1910. Also, "Arroyo formation" (Abs.), *Amer. Geologist,* Vol. 29, p. 322, 1902.

[8] Simpson, J. H., "Journal of a Military Reconnaissance from Sante Fe, New Mexico, to the Navajo Country," etc., p. 37, Philadelphia, 1852.

[9] Morrison, Lieutenant C. C., "Notice of the Pueblo Pintado and of other ruins in the Chaco Canyon," U. S. Geol. and Geogr. Surveys west of 100th Mer. (Wheeler Survey) Vol. VII, p. 367, 1879. Abstract from Report of Chief Engrs., for 1876, Appendix JJ.

[10] Loew, Oscar, "Report on the ruins in New Mexico," U. S. Geogr. Surv. w. 100th Mer. (Wheeler), Vol. VII, pp. 341–342, 1879. Also, Ann. Rept. Chief of Engineers for 1875, appendix LL.

[11] Jackson, W. H., *op. cit.,* pp. 431–450.

[12] Gregory, H. E., "Geology of the Navajo Country—a reconnaissance of parts of Arizona, New Mexico and Utah," U. S. Geol. Survey Prof. Paper 93, pp. 130–131, 1917.

[13] Simpson, J. H., 31st Congr., 1st sess., Ex. Doc. 64, p. 110, 1850.

[14] Reagan, A. B., "Archeological notes on the Pine River valley, Colorado, and the Kayenta-Tuba region, Arizona," Kansas Acad. Sci. Trans. vol. 30, pp. 244–331, 394–420, 1921. "Recent changes in the plateau region," SCIENCE, n. s., Vol. 60, pp. 283–285, 1924. "Stream aggradation through irrigation," *Pan-Amer. Geologist,* vol. 42, pp. 335–344, 1924.

At Flagstaff, in a comparatively humid climate where twenty-four inches of rain a year allows the growth of a pine forest, the Rio de Flag, a small creek flowing through a grassy flood plain, has entrenched itself in an arroyo from ten to twenty feet deep. This change took place in 1890 to 1892, according to Douglass.[15]

According to data gathered by Davis,[16] at Kanab, Utah, the arroyo, which was sixty feet deep in 1903, was begun by a great flood on July 29, 1883, and largely completed by the high waters of 1884 and 1885.

According to Meinzer,[17] Meadow Creek, which flows north in Washington County from high mountains to the Escalante Desert, once furnished irrigation water for a small settlement at Hamblin in the well-known Mountain Meadow, but between 1857 and 1908 heavy floods cut a deep gully through the meadow and robbed it of most of its water supply. The water of the creek was then used for irrigation at a ranch farther downstream.

Williams[18] has described the recent deposits of silt in Montezuma Canyon, a tributary of San Juan River, in southeastern Utah. He says that according to local cattlemen, up to about twenty-five years ago, that is the year 1900, there was no definite stream channel in the canyon or its tributaries, but that then deep washes (arroyos) began to form and within three years had worked headward thirty miles in the canyon. These washes are ten to thirty feet deep. The recent date given by Williams for the formation of the washes must be in error, for in 1875 W. H. Jackson[19] made extensive journeys in the region and says:

> Every canyon and valley has its corresponding wash, worn perpendicularly down through the dry, easily eroded soil forming circuitous but excellent pathways. In some valleys where the drainage is considerable these washes frequently attain a depth of from 30 to 40 feet, and are impassable for miles.

Regarding Montezuma Canyon he states:

> A narrow but deep wash meandered from side to side containing a few scattered pools of stagnant water while dense thickets of oak brush thickly interwoven with vines rendered progress anything but pleasant.

SOUTHERN ARIZONA, SOUTHERN NEW MEXICO AND SONORA

In southern Arizona, Santa Cruz River has trenched its flood plain since the late 80's.[20] Thornber[21] also places the erosion of this channel and others in southern Arizona as since 1885 to 1890.

The valley of Rillito Creek, a tributary of Santa Cruz River that enters from the east a few miles north of Tucson, was, as recorded by Smith,[22] an unbroken forest of mesquite in 1858, when the first settlement was made. Between the trees was a good growth of grass and the river course was indefinite and lined by an almost continuous growth of cottonwood, ash, walnut and willow trees. These conditions continued until 1872, when the United States Army post was moved from Tucson to Fort Lowell on the Rillito largely because natural grass could be cut for hay. Thereafter the Rillito cut a wide channel from ten to fifteen feet deep. Pantano Wash, a tributary of Rillito Creek, did not have a great flood until 1881, and the present broad arroyo with vertical banks was not cut until the 90's. At the time of the first settlement on Tanque Verde Creek, another tributary of the Rillito, there was a stagnant pond 150 feet long and 30 feet deep which gave rise to the name. The present deep channel has cut into and has drained the pond since that time.

Arivaca Creek, a tributary of Santa Cruz River, was entrenched about ten feet below its flood plain in 1917, but when Lieutenant Michler[23] visited the

[15] Douglass, A. M., "Some aspects of the use of the annual rings of trees in climatic study," Smithsonian Ann. Rept. for 1922, p. 238, 1924, and personal communication.

[16] Davis, W. M., "An excursion to the plateau province of Utah and Arizona," Harvard Coll. Mus. Comp. Zool. Bull., Vol. 42, p. 11, 1903.

[17] Meinzer, O. E., "Ground water in Juab, Millard and Iron counties, Utah," U. S. Geol. Survey Water-Supply Paper 277, p. 152, 1911, and personal communication.

[18] Williams, George O., "Radium-bearing silts of southeastern Utah," *Engr. & Min. Journal-Press*, Vol. 119, pp. 201–202, Jan. 31, 1925.

[19] Jackson, W. H., "A notice of the ancient ruins in Arizona and Utah lying about the Rio San Juan," U. S. Geol. and Geogr. Survey Terr. Bull., Vol. II, No. 1, pp. 25–45, 1876.

[20] Spaulding, V. M., "Distribution and movements of desert plants," Carnegie Inst. Washington Pub. 113, p. 9, 1909; Huntington, Ellsworth, "The climatic factor," Carnegie Inst. Washington Pub. 192, pp. 33–34, 1914; Visher, S. S., "Climate and geology" (abst.), SCIENCE, n. s., Vol. 51, pp. 522–523, 1920; Bryan, Kirk, "Erosion and sedimentation in the Papago Country, Arizona," U. S. Geol. Survey Bull. 730, pp. 77–80, 1922.

[21] Thornber, J. J., "The grazing ranges of Arizona," Univ. Arizona Agr. Exper. Sta. Bull. 65, pp. 335–338, 1910.

[22] Smith, G. E. P., "Ground water supply and irrigation in the Rillito Valley," Univ. of Ariz. Agri. Exper. Sta. Bull. 64, pp. 98–99. 1910. Also, Amer. Soc. Civil Engr. Trans. Vol. 78, p. 227, 1915.

[23] Emory, W. H., "Report on United States and Mexican Boundary Survey," Vol. I, p. 119, 1857.

locality in 1855, there were springs among the tule (bulrushes), and when Major Ferguson[24] passed this way in 1863, there was a fine "cienega" or swamp, and near the old reduction works a "laguna" or pond. Thus, between my visit in 1917 and these visits in 1855 and 1863, the channel had been deepened and the flood plain drained.

The trench on San Pedro River was cut progressively headward between the years 1883, when the arroyo first formed at the mouth of the river, and 1892, when the head water fall cut through the boundaries of the Boquillas Grant 125 miles upstream.[25] The floor of the valley was originally covered by sacaton grass with groves of cottonwood, ash and willow. Since the arroyo was cut a great forest of mesquite has sprung up.

According to Olmstead,[26] the main street of Silver City, New Mexico, is a drainage channel that was originally two or three feet lower than the adjacent ground. In 1887 this channel began to deepen, bridges were built for crossing and a wooden drop was constructed to prevent further headward cutting. This drop was carried away in a flood about 1892 (?). [1896 according to Rich[27]] and erosion proceeded until, in 1917, the channel was over one hundred feet wide and thirty-seven feet deep. Numerous buildings have been carried away in the progress of this erosion.

The floor of the canyon of Blue River,[28] a mountain tributary of the Gila, was in 1885 covered with grama grass, hardwood trees and pine. The stream had many trout. In 1900 floods began to cut an ever-widening channel and active erosion was in full swing by 1906. In 1921 the bottom of the canyon was ruined for agriculture and pasturage. The forty-five ranches with three hundred inhabitants that existed in 1900 were decreased to twenty-one ranches and ninety-five people in 1921.

San Simon Creek, which enters the Gila near Solomonville, once flowed through uninterrupted meadows and flats from a point near Rodeo more than one hundred miles to its mouth. According to Olmstead,[29] settlers near Solomonsville, in 1883, excavated a small channel twenty feet wide and four feet deep to confine the flood water. Since that time a channel formed and progressed headward through the flats for sixty miles to the lower end of San Simon Cienaga. Above this point there is no definite channel, but the new channel of the creek downstream is ten to thirty feet deep and six hundred to eight hundred feet wide. Schwennesen[30] describes the drainage of the area and states that the channel has formed since the advent of American settlers. Carpenter and Bransford[31] make the same comment but also say that in large floods the channel is still overflowed.

Rich[32] has described in much detail the arroyos or channel trenches of the streams tributary to Gila River by way of the Mangas River, an ephemeral stream of large drainage area that heads in the Silver City quadrangle. The arroyos are still working headward, but Rich fixes the date of their beginning between 1881 and 1891.

While these changes were taking place Gila River, the master stream of southern Arizona, was undergoing more complex changes. In its upper reaches it entrenched itself in its flood plain much after the fashion of its tributaries, and below the mouth of Mangas River the channel is increasing in width by the erosion of its banks and is consequently destroying its former flood plain that is now valuable irrigated farm land. Between October, 1915, and September, 1916, 2,145 acres of this land were swept away in Safford Valley and the San Carlos Indian Reservation.[33] On that part of the Gila, from the mouth of Santa Cruz River to Yuma, the channel

[24] Ferguson, Major David, "Letter of the Secretary of War communicating copy of report of Major D. Ferguson on the country, its resources and the route between Tucson and Lobos Bay," 37th Congr. Special sess., Senate Ex. Doc. No. 1, pp. 1–22, 1863.

[25] Bryan, Kirk, and Smith, G. E. P., "Geology and water resources of the San Pedro Valley, Arizona," U. S. Geol. Survey Water-Supply Paper (in preparation). See also: Carpenter, E. J., and Bransford, W. S., "Soil survey of the Benson area, Arizona," U. S. Bureau of Soils Field Operations for 1921, pp. 248 and 252, 1924.

[26] Olmstead, F. H., "Report on flood control of the Gila River in Graham County, Arizona, Letter from the Secretary of the Interior transmitting," Sen. Doc. No. 436, 65th Congr., 3d sess., pp. 24–25, 1919.

[27] Rich, J. L., "Recent stream trenching in the semi-arid region of southwestern New Mexico, a result of removal of vegetative cover," *Amer. Jour. Sci.*, 4th ser., Vol. 32, p. 244, 1911.

[28] Leopold, Arno, "A plea for recognition of artificial works in forest erosion control policy," *Jour. Forestry*, Vol. 19, pp. 269–270. March, 1921.

[29] Olmstead, F. H., *Idem*, p. 79.

[30] Schwennesen, A. T., "Ground water in San Simon Valley, Arizona, and New Mexico," U. S. Geol. Survey Water-Supply Paper 425, pp. 5–6, 1917.

[31] Carpenter, E. J., and Bransford, W. S., "Soil survey of the San Simon area, Arizona," U. S. Bureau of Soils Field Operations for 1921, pp. 584 and 594, 1924.

[32] Rich, J. L., *op. cit.*, pp. 237–245, 1911. (Abstract) Assoc. Amer. Geogr. Ann., Vol. 1, p. 135, 1911.

[33] Olmstead, F. H., *Idem*, p. 10.

has been filling up. As collected by Ross[34] the accounts of early travelers and of early settlers indicate that the channel when first seen by white men was narrow with firm sloping banks eight to ten feet high that were lined by large cottonwood and willow trees. There was a considerable low water flow and fish were plentiful. Here beavers flourished and furnished lucrative business for the early American trappers. Since 1880 the old channel has been filled and the existing channel is a sandy waste from a quarter to a half mile wide, in marked contrast to the channel of former times.

The arroyo of Sonoita River in Sonora was cut during a flood on August 6, 1891.[35] As recorded by Meinzer,[36] Whitewater Draw, which drains the southern part of Sulphur Springs Valley and is a tributary of Yaqui River, lies in a narrow valley less than twenty-five feet deep, which decreases in depth upstream and disappears. In this valley is a freshly cut stream channel sixty feet wide and ten feet deep that in 1910 was cutting headward into a grassy meadow. "According to William Cowan, a pioneer ranchman, the entire channel north of the Mexican boundary has been cut since 1884."

CONCLUSION

Of the writers known to have considered the problem, Hough[37] alone has attempted to give a date for the whole area. He says that the process began with the active occupancy of the region by white men thirty years before the date of his address, or in 1875. However, the foregoing review of the existing evidence as to the date when trenching began in southwestern United States indicates that these changes were initiated at slightly different times in each stream and occupied a considerable period in their accomplishment. The change from aggradation and the building of flood plains to dissection and the formation of arroyos in many streams of southern Arizona can be confidently placed in the decade 1880 to 1890, although many tributary streams were not affected until the 90's and some are still undissected. The date in southern Utah, northern Arizona and southern Colorado is apparently earlier, and cutting probably began at some time after 1860. The evidence as to the Rio Puerco in north-central New Mexico is conflicting and needs review. The statements of the early explorers indicate that the arroyos were already well formed at the time of the American conquest in 1846 and 47.

Most of the writers[38] who have considered the question attribute the erosion of the arroyos to the introduction of livestock and the consequent decrease in the vegetative cover and the formation of trails. These changes promoted rapid run-off and increased the rate of erosion.

The possibility that erosion of the arroyos is caused by slight uplift with increased gradient of the streams has been generally rejected because erosion of equal magnitude affects streams of different drainage systems that flow in all possible directions. Uplift so nicely adjusted to the drainage pattern is inconceivable.

Huntington has suggested that a slight change of climate toward dryer conditions would decrease the vegetative cover, promote run-off and be equally effective in producing channel trenching. Gregory, Visher and Bryan have taken a favorable attitude toward this hypothesis and have brought forward supporting but not conclusive evidence.

Reagan has presented the interesting postulate that in northern Arizona the numerous prehistoric inhabitants built so many dams and diverting embankments in the smaller streams that floods were sufficiently retarded so that alluviation took place farther downstream. With the disappearance of these people their works fell into decay and erosion then began.

Dellenbaugh,[39] in a comment on Rich's paper, points out that years ago he saw arroyos in places where there were no cattle and never had been. He believes that the channels of main streams are lowered by sudden floods in which the tributary does not share. Thereafter the channel of the tributary cuts back by headwater erosion ("retrogrades") and the channels of the secondary tributaries are also cut back ("cross-cuts").

Whatever the merits of these several hypotheses, it is evident that an essential element in the problem is the exact date and rate of progress in the erosion of each channel. The material assembled in this paper, although valuable, is meager in detail and

[34] Ross, C. P., "The lower Gila region, Arizona—a geographic, geologic and hydrologic reconnaissance with a guide to desert watering places," U. S. Geol. Survey Water-Supply Paper 498, pp. 64–65, and pp. 94–95, 1923.

[35] Lumholtz, Carl, "New Trails in Mexico," pp. 178–180, 1912.

[36] Meinzer, O. E., and Kelton, F. C., "Geology and water resources of Sulphur Springs Valley, Arizona," U. S. Geol. Survey Water-Supply Paper 320, p. 28. 1913.

[37] Hough, Walter, "Pueblo environment," Amer. Assoc. Advanc. Sci. Proc., Vol. 55, pp. 447–454, 1906.

[38] Dodge, Rich. Olmstead, Duce, Williams, Thornber, Leopold, Hough and Smith, in the works cited.

[39] Dellenbaugh, F. S., "Cross-cutting and retrograding of stream beds," SCIENCE, n. s., Vol. 35, pp. 656–658, 1912.

lacking in exactness. Each author has gathered historical material as an incident to other work, but the problem is deserving of intensive and continued effort. The human interests involved are considerable, for in these areas of small population every meadow and every small area of good pasturage is important. The investigator is ever confronted with questions: Has the formation of arroyos been wholly adverse to man or productive of good? If desirable, can former conditions be restored? How can existing property, fields, buildings and even towns be best protected against encroachment of the ever-widening channels? A proper solution of the practical problem will rest on considerations based on our theory of the cause of this erosion. If overgrazing or other artificial factors are the cause, regulation and a few simple structures may restore the conditions of the past. If erosion is the result of climatic change, a swing in the climatic cycle may at some future time restore the alluvial floors of the valleys without human intervention. The present need is for more facts in order that one or another of the proposed theories may be established. With the date at which cutting began definitely fixed and the date of introduction of livestock also fixed, a much better judgment as to the influence of overgrazing can be made. These historical data must be gathered locally for the many individual streams, and it is hoped that the large group of scientists interested will collect and publish the facts.

KIRK BRYAN

U. S. GEOLOGICAL SURVEY

FRANCIS HENRY PARSONS

THE death of Francis Henry Parsons on July 25 at the age of seventy years removes one who had a lifelong interest in the advancement of science. Though he left no written contribution to scientific literature, his work as librarian successively of two scientific collections is of undoubted importance.

His fifty-two years of government service comprised work in the United States Coast and Geodetic Survey, the United States Naval Observatory, and the Library of Congress. While in the Coast Survey, 1873–1894, he was made chief of library and archives, and assembled, from the scattered field parties and vessels, a library of from 12,000 to 15,000 volumes which is especially valuable for its source-material.

As assistant in charge of the Smithsonian Division of the Library of Congress, 1900–1925, he augmented the collection of transactions of learned societies and academies already gathered there, until, at the time of his retirement, it comprised 450,000 volumes. The significance of the collection is not, however, in the number of volumes, but in the nature of the material to be found there, which is unequalled in this country, in resources for the research student.

While others will build upon this foundation and will make it more widely known, Mr. Parsons's years of earnest and constructive work will remain a contribution of permanent scientific value.

H. W. PIERSON

SCIENTIFIC EVENTS

THE FOURTH INTERNATIONAL PHYTOGEOGRAPHIC EXCURSION

IN 1908, at the International Geographic Congress in Geneva, A. G. Tansley, of England, proposed that the plant geographers and other interested botanists should get together for an extended field trip. The British vegetation committee, which was approached with the proposition, favored it. They made plans to receive the visiting botanists and in 1911 conducted them through England, Scotland and Wales on what was officially called the "First International Phytogeographic Excursion" (I. P. E.).

The second excursion was held in the United States in 1913. Then came the war and the third was not held till 1923. A neutral country, Switzerland, was chosen as the field.

The fourth International Phytogeographic Excursion was held this past summer from July 2 to August 24 in Sweden and Norway. The excursion began in Lund (South Sweden) on July 2 and continued northeasterly for eight days toward Stockholm. On July 10 began the excursion through Middle and North Sweden. In Middle Sweden interest centered upon the vegetation of the Archipelago off Stockholm, the coniferous forests and the moors. The scientific institutions in Stockholm and Uppsala were also visited and the places associated with the work and life of Linnaeus.

The route from here lay northward to Abisko (Lat. 68° N.), where five days were spent at this most northerly station in Sweden. At this point commenced the Norwegian section of the trip which lasted for three weeks and ended on August 22 in Oslo. On this date the party left for Sweden and after two days spent in and around Gothenburg, adjourned for the summer on August 24.

The Swedish botanists were hosts for the excursion and under their able secretary, G. Einar Du Rietz, should be congratulated on the efficiency with which the excursion was conducted. The Swedes set an example as guides and hosts which other nations must find hard to equal.

Twenty-eight botanists representing the following 15 countries (exclusive of Sweden) were present for all or a part of the excursion: