

Artists' Depictions of Catsteps in the Loess Hills of Iowa: Evidence for Mid-Nineteenth Century Climate Change

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Abstract. Catsteps (also known as terracettes) are the staircase-like features common on hillslopes of the Loess Hills of western Iowa. The record of artistic depictions of the Loess Hills was examined to determine when catsteps appeared. Landscape artists George Catlin and Karl Bodmer traveled up the Missouri River in 1832 and 1833, respectively, and between them, produced 30 works of art depicting either the Loess Hills or the loess bluffs on the Nebraska side of the river. Only one painting by Bodmer of Blackbird Hill on the Nebraska side possibly shows catsteps. Moreover, an engraving based on the painting and another painting of the same site by Bodmer do not show catsteps. The Assistant State Geologist, Orestes St. John, produced five sketches of the Loess Hills in 1868, three of which show well-defined catsteps. The appearance of catsteps during the period 1833-1868 may be related to the appearance of gullies during the period 1860-1900. An examination of census data shows that intensive grazing of the Loess Hills did not begin until about 1900 so that climate change is a more likely explanation for the appearance of both catsteps and gullies. Since catsteps are more common on the south- and west-facing slopes, which will dry most quickly, the most probable climate change is a decrease in the periodicity of precipitation cycles. Such a climate change is consistent with tree ring data from eastern South Dakota and eastern Montana, but not central and eastern Iowa.

1. Introduction

Catsteps are the staircase-like features common in the Loess Hills of Iowa (see Figs. 1-2). Catstep is a regional term first coined by Shimek (1910), elsewhere such features are known as terracettes. Catsteps are normally less than a foot wide and are most common on steep, grassy slopes that face to the south or west (Shimek 1910). Mutel (1989) has also drawn attention to "relict" catsteps that occur on forested slopes that were formerly occupied by prairie. Catsteps are a standard feature of contemporary artistic depictions of the Loess Hills, for example, Elizabeth Miller's painting "Hill Prairie," Ben Darling's painting "Soldier River," Dennis Dykema's painting "Loess Hills Overlook," David West's painting "Loess Hills Snow, #435," Genie Hudson Patrick's painting "High Road," and especially Randy Becker's woodcut "Crows over the Catsteps" (Pohlman 1994).

It has long been debated whether catsteps or terracettes are formed by grazing animals or result from the natural slumping of loess unaided by animal activity (Bettis et al. 1986; Mutel 1989; Prior 1991). Although most workers have argued in favor of catsteps as a natural process (Rahm 1961; Carson and

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Kirkby 1972), Rahm (1962) reversed his earlier position and argued strongly on the side of catsteps as a result of grazing animals. The real question is whether catsteps should be regarded as a symptom of environmental degradation, that is, whether they are a consequence of excessive grazing by domestic animals.



Figure 1. Catsteps in the Loess Hills of Iowa, Broken Kettle Grasslands Preserve, Plymouth County, Iowa.

What has been missing from the debate on the origin of catsteps is any historical perspective. If catsteps result from overgrazing by domestic animals, then they should have appeared only after intensive grazing began. On the other hand, if catsteps result from geological processes or if catsteps are formed by the grazing of non-domestic animals, then they should have been present prior to the initiation of intensive grazing. The objective of this paper is to determine when catsteps appeared in the Loess Hills of Iowa based upon the historical record of artistic depictions of the Loess Hills. Census data will also be examined in order to determine the history of grazing in the Loess Hills.

2. Results

2.1 Art of George Catlin

The painter George Catlin traveled by steamboat up the Missouri River from St. Louis to Fort Union in present-day North Dakota in 1832 and returned by canoe the same year. Catlin produced numerous excellent landscape paintings, but the challenge is to determine where Catlin was when he produced a particular painting. Most of the paintings of the Loess Hills were produced during the return trip, which Catlin described in Letter No. 32 of his

1841 book Letters and Notes on the Manners, Customs, and Conditions of the North American Indians (Catlin 1965, 1973). The letter is clearly not written in chronological order. However, there are some identifiable landmarks that place particular paintings in the Loess Hills.

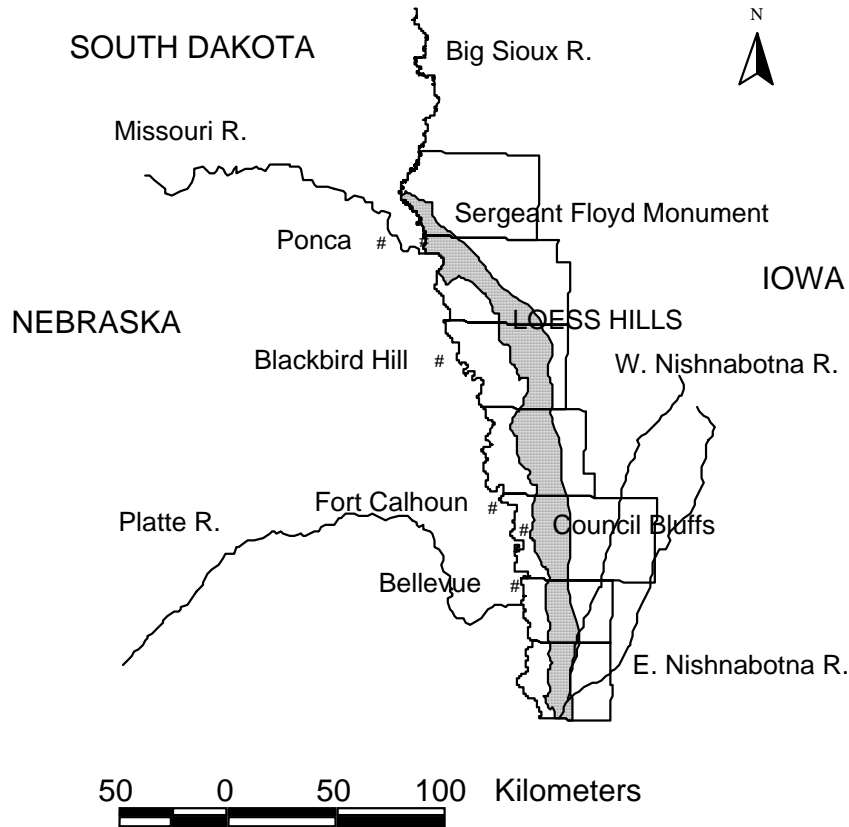


Figure 2. Map of localities mentioned in the text.

Plate 118 of Catlin (1965, 1973) is entitled “Floyd’s Grave”. Elsewhere, Catlin called the same painting “Floyd’s Grave, Where Lewis and Clark Buried Sergeant Floyd in 1804” (Dippie et al. 2002). The burial site of Sergeant Floyd was about 600 feet west of the present-day Sergeant Floyd National Monument (see Fig. 2). The landscape painting does not show any features resembling catsteps. For his 1841 book Catlin created line drawings based upon his original paintings (Catlin 1965). (The edition of Catlin (1973) replaces the line drawings with photographic reproductions of the original paintings.) Even more informative than the painting of Floyd’s Grave is the fact that Catlin’s corresponding line drawing shows no lines resembling catsteps (see Fig. 3). The lines on the hillslope in Figure 3 cannot be catsteps since catsteps are parallel to elevation contours in the manner of agricultural terraces (see Fig. 1). Additional paintings that can be located in the Loess Hills based on identifiable landmarks are “View from Floyd’s Grave, 1300 Miles

above St. Louis,” “Nishnabottana Bluffs, Upper Missouri,” (see Fig. 2), and “Mouth of the Platte River, 900 Miles above St. Louis” (see Fig. 2) (Dippie at el. 2002). The last painting is also Plate 124 in Catlin (1973) where it is called simply “Mouth of the Platte River.” Catsteps are not seen in any of the above paintings or the line drawing corresponding to Plate 124 (Catlin 1965).



Figure 3. “Floyd’s Grave,” line drawing by George Catlin, Plate 118 in Catlin (1965).

Two additional paintings can definitely be located in the Loess Hills several hours by canoe downstream from Blackbird Hill (see Fig. 2) based on a reading of the text of Catlin (1965, 1973). Catlin wrote, “Ba’tiste and Bogard used their rifles to some effect during the day we loitered here [in the vicinity of Blackbird Hill]...From this lovely spot we embarked the next morning...until we landed our canoe at the base of a beautiful series of grass-covered bluffs, which, like thousands and thousands of others on the banks of this river, are designated by no name, that I know of; and I therefore introduce them as fair specimens of the grassy bluffs of the Missouri. My canoe was landed at noon...As soon as we were ashore, I scrambled to their summits, and beheld, even to a line, what the reader has before him in Plates 119 and 120. I took my easel, and canvass and brushes, to the top of the bluff, and painted the two views from the same spot; the one looking up, and the other down the river.” Plates 119 and 120 are both called by Catlin (1973) “Grassy river bluffs above St. Louis.” Neither the original paintings (Catlin 1973) nor the corresponding line drawings (Catlin 1965) show any hillslope features resembling catsteps. Catlin’s painting “Battle between Sioux and Sac and Fox” (Moore 1997) does not show catsteps, but does show well-defined lines on

hillslopes that do not parallel elevation contours similar to Figure 3. Catlin did not witness such a battle, but painted from imagination between 1846 and 1848 in Paris (Moore 1997). Based upon Catlin's "Outline map of Indian localities in 1833," which showed the Sac and Fox Indians in central and eastern Iowa and the Sioux Indians in western Iowa (Catlin 1965, 1973), Catlin may have been imagining such an event to have taken place in the Loess Hills. Catlin was never in the interior of Iowa, but traveled only along the Missouri and Mississippi Rivers.

Further paintings by Catlin of grassy bluffs along the Missouri River can be located not in the Loess Hills, but on the west bank of the Missouri in Nebraska. The loess is thinner and less extensive than on the east bank of the Missouri. Loess-covered bluffs occur sporadically and do not constitute a well-defined landform region as in Iowa. The underlying bedrock is much closer to the tops of the bluffs on the Nebraska side so that slopes tend to be less steep than in Iowa (Mutel 1989). Perhaps as a consequence, catsteps are less common on the Nebraska side of the river. Therefore, less historical weight should be given to artistic depictions of the loess bluffs on the west bank of the Missouri. On the other hand, artistic depictions of the loess bluffs on the Nebraska side cannot be ignored due to the scarcity of nineteenth-century art of the Loess Hills.

Catlin's painting of loess-covered Blackbird Hill on the Nebraska side (see Fig. 2), "Blackbird's Grave, A Back View, Prairies Enamelled with Flowers" (Dippie et al. 2002), shows well-defined lines that are not catsteps since they are not parallel to elevation contours. The same painting occurs as Plate 117 in Catlin (1973), where it is called "Blackbird's Grave." In contrast to the other line drawings, Plate 117 in Catlin (1965) shows a completely different view of Blackbird Hill and also does not show catsteps. Another painting of the Nebraska side with an identifiable landmark and without catsteps is "Belle Vue, Indian Agency of Major Dougherty, 870 Miles above St. Louis" (see Fig. 2) (Dippie et al. 2002). The same painting occurs as Plate 122 with the title "'Belle Vue,' the Indian agency of Major Dougherty" in Catlin (1973) with a corresponding line drawing in Catlin (1965). Two additional paintings of river bluffs without catsteps that can possibly be located on the Nebraska side of the Missouri River are "River Bluffs, 1320 Miles above St. Louis" (Dippie et al. 2002) and Plate 5 of Catlin (1965, 1973) called "Beautiful prairie bluffs above the Poncas." As mentioned earlier, Catlin identified Floyd's Grave as 1300 miles above St. Louis (Dippie et al. 2002), so that a point only 20 miles farther upstream would certainly be in present-day Nebraska. However, Catlin's river distances cannot always be trusted as he titled another painting "Fort Pierre, Mouth of the Teton River, 1200 Miles above St. Louis" (Dippie et al. 2002) and Fort Pierre is in the middle of present-day South Dakota. Catlin's river distances cannot be compared to modern river distances as the Missouri River has been considerably straightened since the time of Catlin. Catlin's Plate 5 was produced during the upstream journey and is discussed in Letter No. 3 (Catlin 1965, 1973). The Poncas must refer to the Ponca Indians, which according to Catlin's map of Indian localities, lived close to the present-day

town of Ponca, Nebraska (see Fig. 2). Otherwise, it is not clear where Catlin met the Ponca Indians and how far upstream from the meeting he created the painting. As with the depictions of Bellevue, none of the above paintings or line drawings of the loess bluffs of Nebraska show catsteps.

The art of George Catlin can be summarized as follows. There are five paintings and four line drawings that can definitely be located in the Loess Hills of Iowa, one painting that can possibly be located in the Loess Hills, two paintings and two line drawings that can definitely be located in the loess bluffs on the Nebraska side, and two paintings and one line drawing that can possibly be located on the Nebraska side for a total of 17 works of art. None of the works of art show any hillslope features that could be interpreted as catsteps.

2.2 Art of Karl Bodmer

In 1833, the year following Catlin's journey along the Missouri River, the Swiss painter Karl Bodmer traveled by steamboat in the company of the German naturalist Maximilian, Prince of Wied, from St. Louis to Fort McKenzie in present-day Montana. Bodmer's landscape paintings are easier to locate in space due to the detailed diary kept by Prince Maximilian (Gallagher et al. 1984). In contrast to Catlin's painting of the same landform from the opposite side, Bodmer's "Washinga Sahba's Grave on Blackbird Hills" (Moore 1997) shows lines on Blackbird Hill (see Fig. 2) that could be interpreted as catsteps. However, an engraving by Charles Vogel in 1839 called "Vignette 12: Washinga Sahba's Grave on Blackbird Hills," which was based on the above painting and supervised by Bodmer (Ruud 2004), does not show any catsteps. Moreover, another painting by Bodmer of the same hill from the same angle called "View on the Missouri, Blackbird's Grave" (Gallagher et al. 1984) does not show catsteps.

Additional artwork of Bodmer not showing catsteps include "The Missouri in the Evening" (just below the mouth of the Platte River, see Fig. 2), "Hill Overlooking the Missouri" (just below the mouth of the Platte River), "The Missouri below the Mouth of the Platte," "Mouth of the Platte River," "A Distant View of Bellevue," "Bellevue Agency, Post of Major Dougherty," "Missouri in the Morning, below Council Bluffs," "Ruins of Fort Atkinson," and "Mouth of the Big Sioux River" (see Fig. 2) (Gallagher et al. 1984). Note that the Council Bluffs named by Bodmer is not the present-day city of Council Bluffs, but a site discussed by Lewis and Clark that is close to the present-day town of Fort Calhoun, Nebraska (see Fig. 2) (Thwaites 1904). Fort Atkinson was also close to the present-day Fort Calhoun (Gallagher et al. 1984). Another version of Bodmer's painting of Bellevue (see Fig. 2) is "Vignette 31: Bellevue, Mr. Dougherty's Agency on the Missouri," which was engraved by Lucas Weber and Charles Beyer under Bodmer's supervision (Ruud 2004). Although the location of each painting along the Missouri River is well defined, it is not always clear which bank of the river Bodmer was painting.

The art of Karl Bodmer can be summarized as follows. There is one painting of the Iowa side, six paintings of the Nebraska side, four paintings that could be either of the Iowa or Nebraska side, and two engravings of the Nebraska side. Out of 13 works of art, only one shows possible catsteps and two other works of art of the same location show no catsteps. Based on the art of Catlin and Bodmer, the bulk of the evidence is that catsteps did not exist on either the Iowa or Nebraska sides of the Missouri River in the early 1830s.

2.3 Art of Orestes St. John

The Report on the Geological Survey of Iowa (White 1870) is illustrated by the outstanding sketches of the Assistant State Geologist, Orestes St. John. The report includes five sketches of the Loess Hills, all of which were drawn in 1868. St. John never used a fill pattern and his landscape art can be trusted as realistic. Prominent catsteps can be seen in “View of Bluffs at Crescent Station (N.W.R.R.), 6 Miles above Council Bluffs, Iowa, 1868 (Looking Southeast),” “View Looking Up the Valley of Soldier River, Jackson Township, Harrison Co., Iowa, Terraces of the Bluff Formation,” and “View Looking Northwestward up the Big Sioux, 7 Miles North of Sioux City, 1868” (see Fig. 4). The two other sketches of the Loess Hills, “Cretaceous Exposures on the Big Sioux at St. Onge’s, Woodbury Co. (Looking Southward, 1868)” and “View of Sargent’s Bluffs from Thompson’s Bluff, Looking Southward, 1868,” do not show catsteps, which reinforces the judgment that St. John did not draw catsteps as a fill pattern. The result from an examination of the work of all of the above artists is that catsteps appeared in the Loess Hills sometime in the 35-year period between 1833 and 1868.

2.4 Census Data on Domestic Animals

The time of onset of intensive grazing should be determined by the numbers of cattle, horses and sheep per acre of pasture in the Loess Hills. However, the available census data give only the numbers of cattle, horses, and sheep, and wool production for the seven counties that contain the Loess Hills (see Fig. 2) with no information as to how much land was in pasture (Hull 1883; Jackson 1885; McFarland 1896; Executive Council 1905; Executive Council of the State of Iowa 1915, 1925). These data show that the numbers of cattle and horses rose sharply from 1840 until the turn of the century, after which they declined slightly until the 1920s (see Fig. 5a). The number of cattle peaked in 1905. In fact, they were only slightly fewer cattle in 1905 (381,537 according to Executive Council (1905)) than in 1990 (398,000 according to Iowa Agricultural Statistics (1991)). The number of horses peaked in 1895, although the date might have been later since data on horses are not available for 1905 (Executive Council 1905). The correlation between the numbers of cattle and horses for the period 1840-1925 is remarkably good.



Figure 4. “View Looking Northwestward up the Big Sioux, 7 Miles North of Sioux City, 1868,” portion of drawing by Orestes St. John, 1868.

The number of sheep peaked in 1867 and annual wool production peaked in 1880 (see Fig. 5b), much earlier than the peaks for cattle and horses. There were nearly twice as many sheep in 1867 as in 1990 (42,403 compared with 24,200 according to Hull (1883) and Iowa Agricultural Statistics (1991)). The lack of correlation between number of sheep and annual wool production after 1870 is curious (see Fig. 5b). In order to determine the onset of intensive grazing, greater emphasis should be placed on numbers of cattle and horses, both due to the greater size of cattle and horses and the much greater numbers of cattle and horses than sheep (see Figs. 5a-b). Based on the above data, intensive grazing by domestic animals in the Loess Hills began in the period 1895-1905, much later than the period of 1833-1868 when catsteps appeared. Therefore, it is concluded that catsteps in the Loess Hills do not result from overgrazing by domestic animals.

3. Discussion

3.1 Evidence for Climate Change

A related phenomenon to the appearance of catsteps in the Loess Hills in the period 1833-1868 may be the initiation of gully cutting between about

1860 and 1900 (Bettis et al. 1986). Multiple cycles of gully cutting and filling have occurred during the Holocene Epoch. From radiocarbon dating, it is known that the previous episode of gully growth took place around 1250 A.D. (Bettis et al. 1986). The near simultaneous appearance of both catsteps and gullies suggests the two phenomena may both be related to a possible mid-nineteenth century climate change in the Loess Hills.

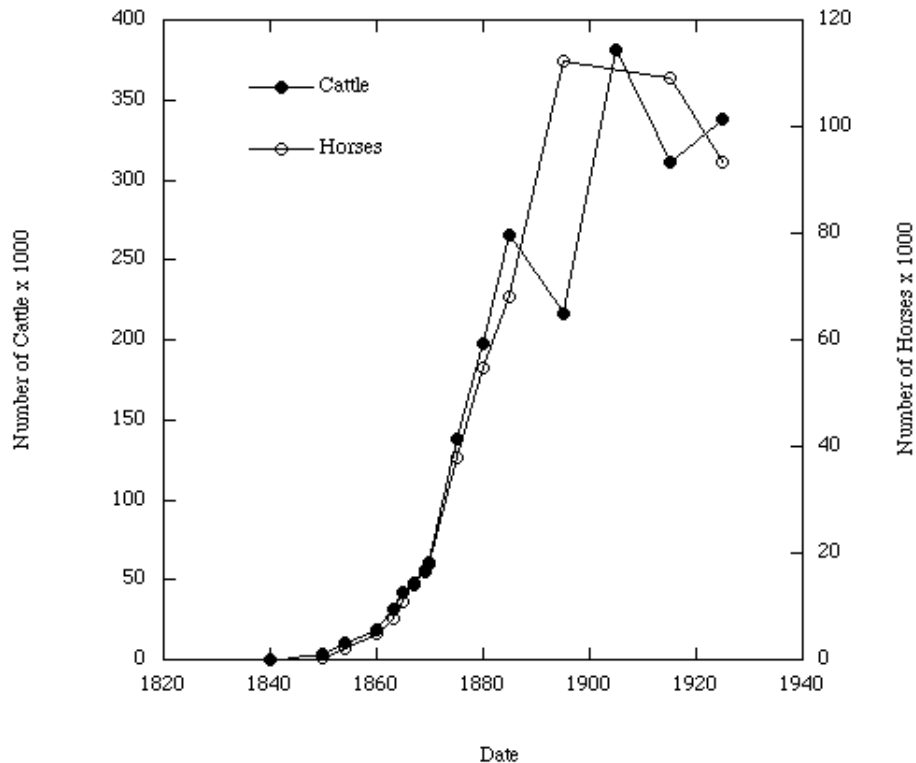


Figure 5a. Numbers of cattle and horses in the seven counties of the Loess Hills, 1840-1925.

Any climate change that promotes the mobility of loess could result in the initiation of catsteps and gullies. It is well-known that loess becomes highly mobile when saturated (Bettis et al. 1986). Therefore, an increase in precipitation that increases the frequency of saturation events could increase the mobility of loess. However, it is difficult to reconcile this standpoint with Shimek's (1910) observation that catsteps are more common on south-facing and west-facing slopes. The south- and west-facing slopes tend to be drier because they receive more sun exposure and wind, respectively. There are no data on preferential direction of gullies in the Loess Hills.

On the other hand, it is also known that almost all earth materials can be mobilized by wetting and drying cycles that cause alternating expansion and contraction. A more likely climate change is that the frequency of precipitation cycles increased throughout the nineteenth century. This is consistent with the greater abundance of catsteps on the south- and west-facing slopes, which

would dry faster following a precipitation event. The north- and east-facing slopes would not moisten any faster during a precipitation event.

3.2 Comparison with Other Data on Climate Change

There are no direct climatic data from the Loess Hills that could be compared with the proposed increase in frequency of precipitation cycles during the period 1833-1868. Even by 1888, a weather station in Logan (Harrison County, Iowa) had the only precipitation record in western Iowa extending back to 1860. No other weather station in Iowa west of Des Moines had continuous precipitation records longer than 10 years (Smith 1888). Even statewide precipitation averages are regarded as entirely unreliable prior to 1873 (Cleaveland and Duvick 1992). Moreover, in general, precipitation records prior to 1860 cannot be compared with later measurements. Prior to 1860, rain gauges were kept at least eight feet (2.44 m) off the ground. Due to instructions issued by the Surgeon General's Office in 1860, rain gauges were lowered to the current standard of 0.58 m (Mock 1991). Higher rain gauges will underestimate precipitation due to higher wind speeds.

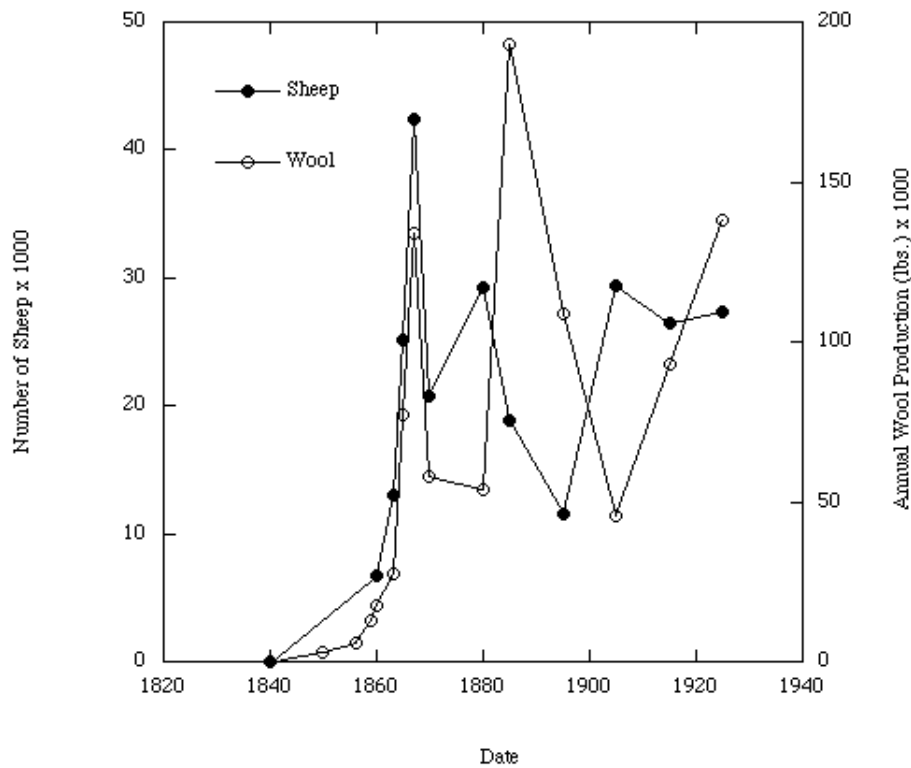


Figure 5b. Numbers of sheep and annual wool production (lbs.) in the seven counties of the Loess Hills, 1840-1925.

Climatic records can be extended beyond the period of direct measurements by the use of dendroclimatology. Unfortunately, no dendroclimatology has been carried out in western Iowa. Cleaveland and Duvick (1992) used tree rings from central and eastern Iowa to reconstruct

climatic history since 1640 and found no long-term trends in precipitation. On the other hand, Shapley et al. (2005) used tree rings from northeastern South Dakota to show that the periodicity of long-term precipitation cycles decreased from 140 years to 60 years after about 1800. Shapley et al. (2005) reached the same conclusion using the shell chemistry of ostracodes. Sauchyn et al. (2003) used tree rings from eastern Montana to show that precipitation cycles became considerably shorter after 1900.

The climatic trends from northeastern South Dakota and eastern Montana are broadly consistent with our interpretation of the appearance of catsteps and gullies in the mid-nineteenth century. However, many questions still remain. First, is the recent climatic history of the Loess Hills more like that of the northern Great Plains or more like that of central Iowa? Although central Iowa is closer, the answer is not obvious in light of the floral and faunal assemblage of the Loess Hills that is much more similar to the mid-height grass prairie found in eastern South Dakota and parts of eastern Montana than to the tallgrass prairie found in the rest of Iowa (Mutel 1989). Second, does loess become more mobile in response to wetting-drying (expansion-contraction) cycles on the order of decades to centuries or only to cycles on the order of weeks to years? A third related question is whether a shortening of long-term precipitation cycles implies a shortening of shorter-term precipitation cycles. The first question is merely a current spatial gap in the study of tree rings since there should be sufficient long-lived, drought-sensitive bur oak (*Quercus macrocarpa*) trees in the Loess Hills for dendroclimatology. The last two questions are unsolved problems of geomorphology and climatology.

References

- Bettis, E. A. III, J. C. Prior, G. R. Hallberg, and R. L. Handy, 1986: Geology of the Loess Hills region. *Proceedings of the Iowa Academy of Science*, **93**, 78-85.
- Carson, M. A., and M. J. Kirkby, 1972: *Hillslope form and process*. Cambridge University Press, 483 p.
- Catlin, G., 1965: *Letters and notes on the manners, customs, and conditions of the North American Indians, written during eight years' travel (1832-1839) amongst the wildest tribes of Indians in North America*, 2 vols., Ross & Haines, 560 p.
- Catlin, G., 1973: *Letters and notes on the manners, customs, and conditions of the North American Indians, written during eight years' travel (1832-1839) amongst the wildest tribes of Indians in North America*, 2 vols., Dover Publications, 560 p.
- Cleaveland, M. K., and D. N. Duvick, 1992: Iowa climate reconstructed from tree rings, 1640-1982. *Water Resources Research*, **28**, 2607-2615.
- Dippie, B. W., T. T. Heyman, C. Mulvey, and J. C. Troccoli, 2002: *George Catlin and his Indian gallery*. Smithsonian American Art Museum and W. W. Norton & Co., 294 p.
- Executive Council, 1905: *Census of Iowa for the year 1905*. B. Murphy, State Printer, 908 p.
- Executive Council of the State of Iowa, 1915: *Census of Iowa for the year 1915*. R. Henderson, State Printer, 777 p.

- Executive Council of the State of Iowa, 1925: *Census of Iowa for the year 1925*. State of Iowa, 1120 p.
- Gallagher, M. V., W. H. Goetzmann, D. C. Hunt, and W. J. Orr, 1984: *Karl Bodmer's America*. Joslyn Art Museum and University of Nebraska Press, 376 p.
- Hull, J. A. T., 1883: *Census of Iowa for 1880*. F. M. Mills and G. R. Roberts, State Printers, 744 p.
- Iowa Agricultural Statistics, 1991: *Iowa livestock county estimates, 1975-1990*. Iowa Department of Agriculture and Land Stewardship, 71 p.
- Jackson, F. D., 1885: *Census of Iowa for the year 1885*. G. E. Roberts, State Printer, 517 p.
- McFarland, W. M., 1896: *Census of Iowa for the year 1895*. F. R. Conway, State Printer, 885 p.
- Mock, C. J. 1991: Drought and precipitation fluctuations in the Great Plains during the late nineteenth century. *Great Plains Research*, **1**, 26-57.
- Moore, R. J. 1997: *Native Americans: A portrait, the art and travels of Charles Bird King, George Catlin, and Karl Bodmer*. Stewart, Tabori & Chang, 279 p.
- Mutel, C.F., 1989: *Fragile giants: A natural history of the Loess Hills*. University of Iowa Press, 284 p.
- Pohlman, L. L., 1994: Explorations and interpretations: Artistic views of the hills, pp. xv-xxii. In *Land of the fragile giants: Landscapes, environments and peoples of the Loess Hills*. C. F. Mutel and M. Swander (eds.), University of Iowa Press, 117 p.
- Prior, J. C., 1991: *Landforms of Iowa*. University of Iowa Press, 153 p.
- Rahm, D. A., 1961: Terracettes – an index of erosional environment of slopes. *Northwest Science*, **35**, 164.
- Rahm, D. A., 1962: The terracette problem. *Northwest Science*, **36**, 65-80.
- Ruud, B. K. (ed.), 2004: *Karl Bodmer's North American prints*. Joslyn Art Museum and University of Nebraska Press, 382 p.
- Sauchyn, D. J., J. Stroich, and A. Beriault, 2003: A paleoclimatic context for the drought of 1999-2001 in the northern Great Plains of North America. *Geographical Journal*, **169**, 158-167.
- Shapley, M. D., W. C. Johnson, D. R. Engstrom, and W. R. Osterkamp, 2005: Late-Holocene flooding and drought in the Northern Great Plains, USA, reconstructed from tree rings, lake sediments and ancient shorelines. *The Holocene*, **15**, 29-41.
- Shimek, B., 1910: Geology of Harrison and Monona Counties, pp. 273-485. In *Iowa Geological Survey, vol. 20, annual report, 1909, with accompanying papers*. S. Calvin and J. H. Lees (eds.), Iowa Geological Survey, 542 p.
- Smith, J. H., 1888: *History of Harrison County, Iowa*. Iowa Printing Company, 491 p.
- Thwaites, R. G. (ed.), 1904: *Original journals of the Lewis and Clark expedition, 1804-1806, Vol. I*, Dodd, Mead & Co., 374 p.
- White, C. A., 1870: *Report on the geological survey of the state of Iowa, to the Thirteenth General Assembly, January, 1870*, 2 vols. Mills & Co., 834 p.