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

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Catsteps 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. George Catlin, Karl Bodmer, and John James Audubon traveled up the Missouri River in 1832, 1833 and 1843, respectively, and between them, produced 31 works of art depicting either the Loess Hills or the loess bluffs on the Nebraska side of the river. Only three works by Bodmer of Blackbird Hill on the Nebraska side possibly show catsteps. The Assistant State Geologist, Orestes St. John, produced six sketches of the Loess Hills in 1868, half of which show well-defined catsteps. In illustrated atlases of the Loess Hills, published in 1875 and 1885, 45–55% of drawings show well-defined catsteps. The appearance of catsteps during the late 1860s may be related to the appearance of gullies during the period 1860–1900. Census data show that peak grazing of the Loess Hills was not attained until about 1900 so that climate change following the end of the Little Ice Age in the mid-nineteenth century is a more likely explanation for the appearance of catsteps and gullies. The most probable climate change is a decrease in the periodicity of precipitation cycles, which will increase the slumping tendency of loess. Such a climate change is consistent with tree rings and ostracode shell chemistry from northeastern South Dakota, tree rings from eastern Montana, and fire scars from northwestern Minnesota, but not tree rings from central and eastern Iowa.

INDEX DESCRIPTORS: catsteps, climate change, Little Ice Age, Loess Hills, terracettes.

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 (1989b) 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).

Darwin (1882) suggested that terracettes in England were initiated by the action of earthworms and later accentuated by grazing animals. Since that time, it has 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 1989a, Mutel 1989b, Prior 1991). Although most workers have argued in favor of catsteps as a natural process (Kay and Apfel 1929, Sharpe 1938, Kay and Graham 1943, Thorpe 1945, Hadley and Rolfe 1955, Brice 1958, Rahm 1961, Carson and Kirkby 1972, Vincent and Clarke 1980, Verster et al. 1985), Rahm (1962) reversed his earlier position and argued strongly on the side of catsteps as a result of grazing animals. Higgins (1982) is the most recent worker to favor a critical role for grazing animals in the formation of catsteps. Catsteps could simply be the paths that are

trampled by grazing animals or they could result from the increased slumping tendency of loess that would occur when the root structure of grasses is weakened by excessive grazing. The essential question in catstep research has been whether catsteps should be interpreted as a symptom of landscape degradation, that is, whether they are a consequence of excessive grazing by domestic animals.

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. Most of the argument against an important role for domestic animals in the formation of catsteps has focused on the supposed inaccessibility of slopes with catsteps to domestic animals (Rahm 1961, 1962), rather than on the timing of catstep appearance. 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. In a similar way, Muhs and Holliday (1995) used both the writings and artwork of early explorers to determine when sand dunes were active on the Great Plains during the nineteenth century. A much shorter version of the ideas in this paper was published by Dillon et al. (2006).

### RESULTS

#### Art of George Catlin

The painter George Catlin traveled by steamboat up the Missouri River from St. Louis to Fort Union in present-day

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



Fig. 3 "Floyd's Grave, Where Lewis and Clark Buried Sergeant Floyd in 1804," painting by George Catlin, 1832 (Dippie et al. 2002).

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 clearly is not written in chronological order. However, there are some identifiable landmarks that place particular paintings in the Loess Hills.

Plate 118 of Catlin (1965, 1973) is entitled "Floyd's Grave" (see Fig. 3). 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 (Carlin 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. 4). The lines on the hillslope in Figure 4 should not be interpreted as catsteps since catsteps are parallel to elevation contours in the manner of agricultural terraces (see Fig. 1). Additional paintings of the Loess Hills based on identifiable landmarks are "View from Floyd's Grave, 1300 Miles above St. Louis," "Nishnabottana Bluffs, Upper Missouri," (see Figs. 2 and 5), and "Mouth of the Platte River, 900 Miles above St. Louis" (see Fig. 2) (Dippie et al. 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).

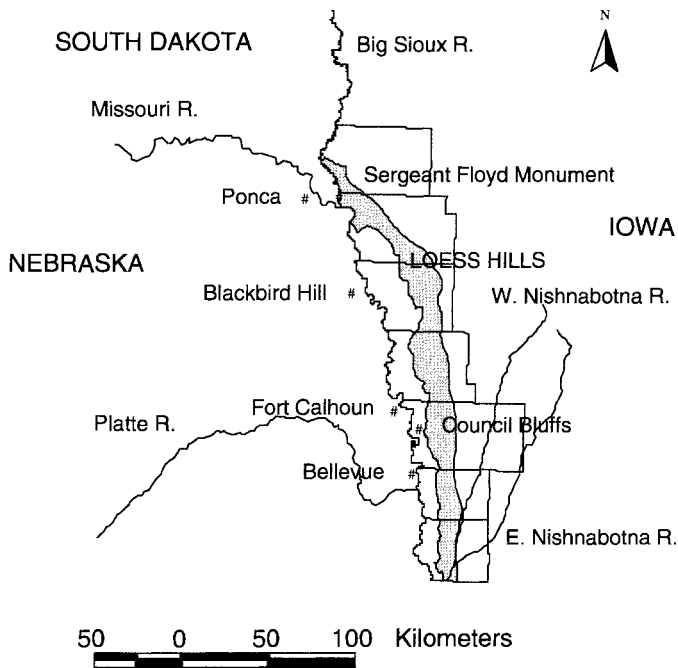


Fig. 2 Map of localities mentioned in the text.

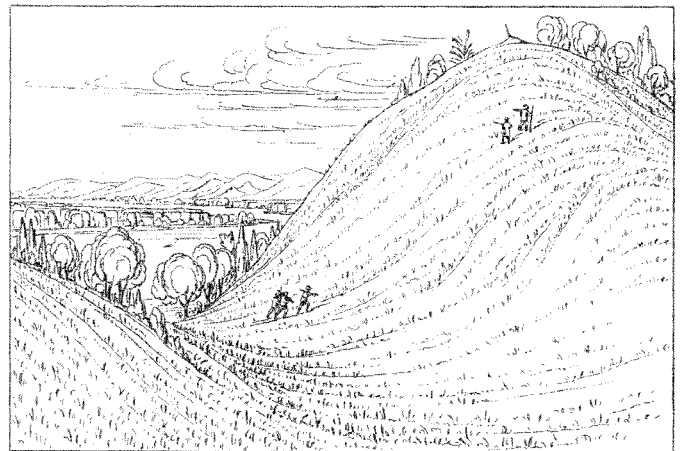


Fig. 4 "Floyd's Grave," line drawing by George Catlin based upon painting in Fig. 3, Plate 118 in Catlin (1965).



Fig. 5 "Nishnabottana Bluffs, Upper Missouri," painting by George Catlin, 1832 (Dippie et al. 2002).

Two additional paintings definitely can 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 [see Fig. 6]. 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

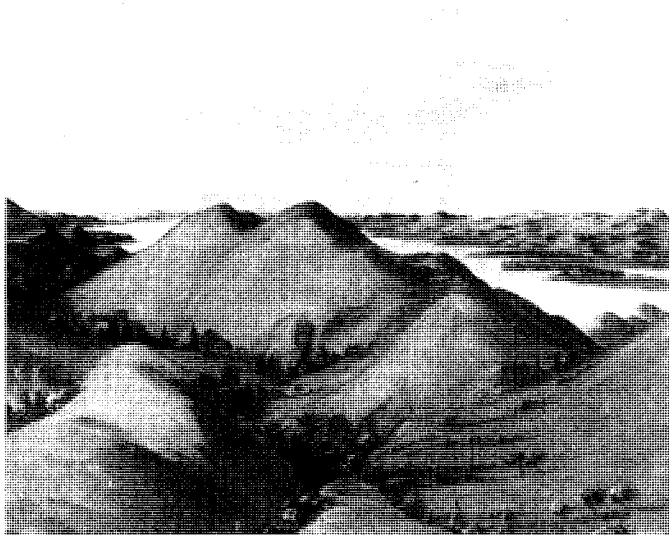


Fig. 6 "Grassy River Bluffs above St. Louis," painting by George Catlin, 1832, Plate 120 in Catlin (1973).



Fig. 7 "Blackbird's Grave, A Back View, Prairies Enamelled with Flowers," painting by George Catlin, 1832 (Dippie et al. 2002).

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) is similar to Figure 4 and does not show catsteps, but does show well-defined lines on hillslopes that do not parallel elevation contours. Catlin did not witness such a battle, but between 1846 and 1848 painted from imagination 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 of Iowa, but on the west bank of the Missouri in Nebraska. The very steep grass-covered slopes where catsteps are best-developed are less common on the Nebraska side. 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 must be taken into consideration 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 also are not catsteps (see Fig. 7) 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 corresponding line drawings, the line drawing of "Blackbird's Grave" shows a completely different view of Blackbird Hill and also does not show catsteps (Catlin 1965). 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 either present-day Nebraska or South Dakota. 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.

#### 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 (Maximilian, Prince of Wied 1904, Gallagher et al. 1984). 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 only work of art of Bodmer that does not show catsteps and can be definitely located on the Iowa side is "Mouth of the Big Sioux River" (see Fig. 2) (Gallagher et al. 1984). Paintings and drawings of Bodmer that do not show catsteps and could be located on either side are "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," and "Missouri in the Morning, below Council Bluffs" (see Figs. 2, 8) (Gallagher et al. 1984). Paintings and drawings of Bodmer that do not show catsteps and could be definitely located on the Nebraska side are "Mouth of the Platte River," "A Distant View of Bellevue," "Bellevue Agency, Post of Major Dougherty," and "Ruins of Fort Atkinson," (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

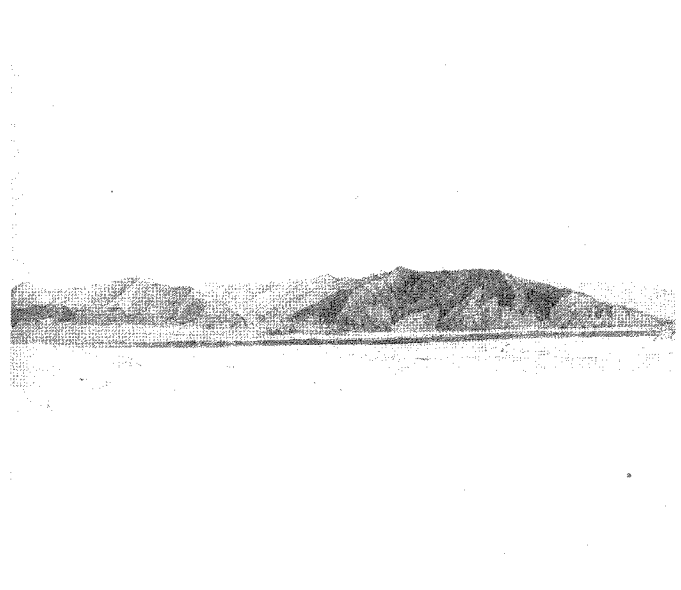


Fig. 8 "Missouri in the Morning, below Council Bluffs," portion of painting and drawing by Karl Bodmer, 1833 (Gallagher et al. 1984).

was engraved by Lucas Weber and Charles Beyer under Bodmer's supervision (Maximilian, Prince of Wied 2001, Ruud 2004).

In contrast to Catlin's painting of the same landform from the opposite side (see Fig. 7), Bodmer's "Washinga Sahba's Grave on Blackbird Hills" (see Fig. 9) (Moore 1997) shows lines on Blackbird Hill (see Fig. 2) that could be interpreted as catsteps. The 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 (Maximilian, Prince of Wied 2001, Ruud 2004), shows the same features. Another painting by Bodmer of the same hill from the same angle called "View on the Missouri, Blackbird's Grave" (see Fig. 10) (Gallagher et al. 1984) also shows lines that could be interpreted as catsteps.

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 three of a single location on the Nebraska side show possible catsteps.

#### Art of John James Audubon

As one of the most important American artists of the natural world, the work of John James Audubon in this region cannot be ignored. In 1843 Audubon traveled up the Missouri River by steamboat as far as Fort Union in order to find specimens for his final work *The Viviparous Quadrupeds of North America* (Audubon 1979). Unfortunately, Audubon's drawings cannot usually be treated as geomorphic evidence since he was too vague as to the location of his specimens. Moreover, many of the backgrounds were created not by John James Audubon, but by his son, Victor, who was not present on the voyage. The notable exception is Audubon's depiction of the "prairie wolf" (*Canis laterans*, now known as the coyote (Audubon 1897)) as Plate 71 of *The Viviparous Quadrupeds of North America* (Audubon 1979). On May 10, 1843 Audubon passed present-day Fort

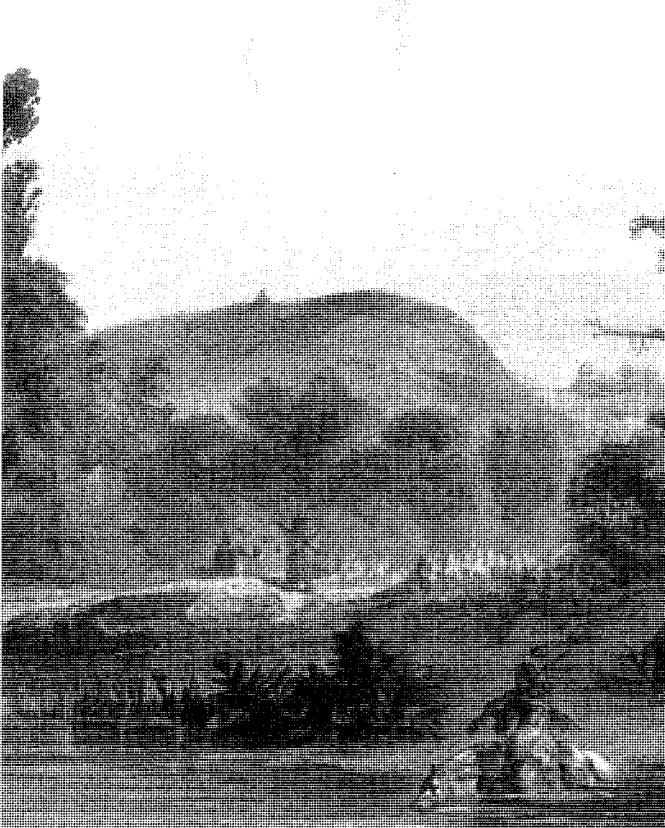


Fig. 9 “Washinga Sahba’s Grave on Blackbird Hills,” portion of painting by Karl Bodmer, 1833 (Moore 1997).

Calhoun (see Fig. 2) and wrote, “Prairie wolves are extremely abundant hereabouts. They are so daring that come into the camp both by day and by night; we found their burrows in the banks and in the prairie” (Audubon 1897). Moreover, for this particular painting Victor Audubon incorporated the landscape drawn by his father in the field (Tyler 2000). Audubon’s sole reliable drawing of the Loess Hills (see Fig. 11) does not show any features resembling catsteps.

#### Art of Nathan Parker and Sidney Roberts

Nathan Parker drew “Hills of Silicious Marl, Council Bluffs” (see Fig. 12) as an illustration for his book *Iowa as it is in 1856: A Gazetteer for Citizens, and a Hand-book for Immigrants* (Parker 1856). In this context, Parker (1856) is referring to the present-day city of Council Bluffs, Iowa (see Fig. 2). The hillslopes in Figure 12 seem to be ruled into multiple horizontal lines that may represent catsteps. However, Parker was in no way a landscape artist of the caliber of Catlin or Bodmer. Unlike Catlin and Bodmer, he often employed horizontal or vertical or slanting parallel lines as a landscape fill pattern. Out of the nine illustrations in Parker (1856), seven show some sort of hillslope, all but one of which uses parallel lines as a fill pattern. For example, the hillslopes in “L’Eclair’s Homestead” (see Fig. 13) show multiple horizontal parallel lines, but are located in Scott County in southeastern Iowa. On this basis, the illustration of catsteps in Parker (1856) cannot be trusted. Another artist who clearly drew horizontal lines on hillslopes as a fill pattern was Sidney Roberts (1848), who drew the Loess Hills surrounding

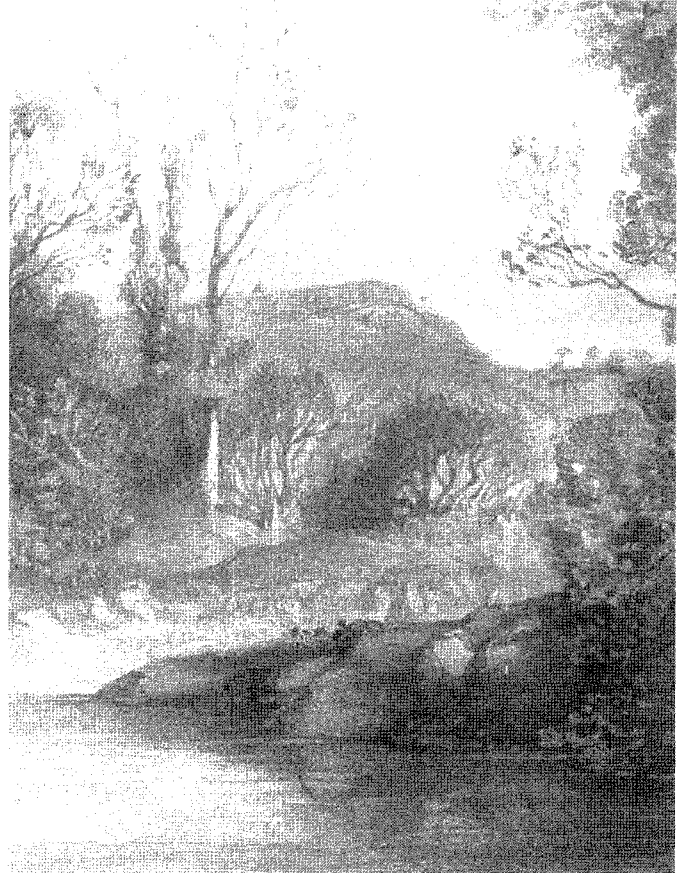


Fig. 10 “View on the Missouri, Blackbird’s Grave,” portion of painting by Karl Bodmer, 1833 (Gallagher et al. 1984).

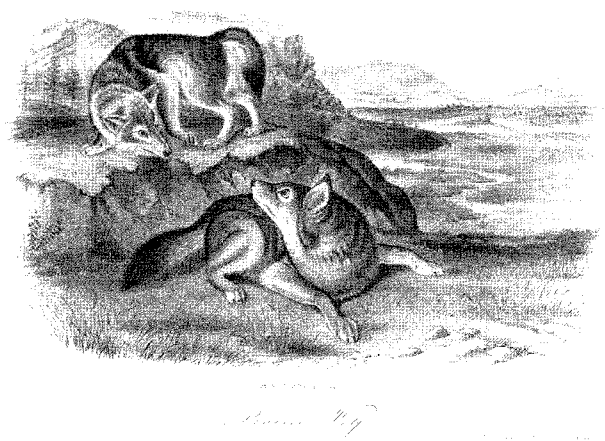


Fig. 11 “Prairie Wolf,” drawing by John James Audubon, 1843, Plate 71 in *The Viviparous Quadrupeds of North America* (Audubon 1979).



HILLS OF SILICIOUS MARL, COUNCIL BLUFFS.

Fig. 12 "Hills of Silicious Marl, Council Bluffs," portion of drawing by Parker (1856).

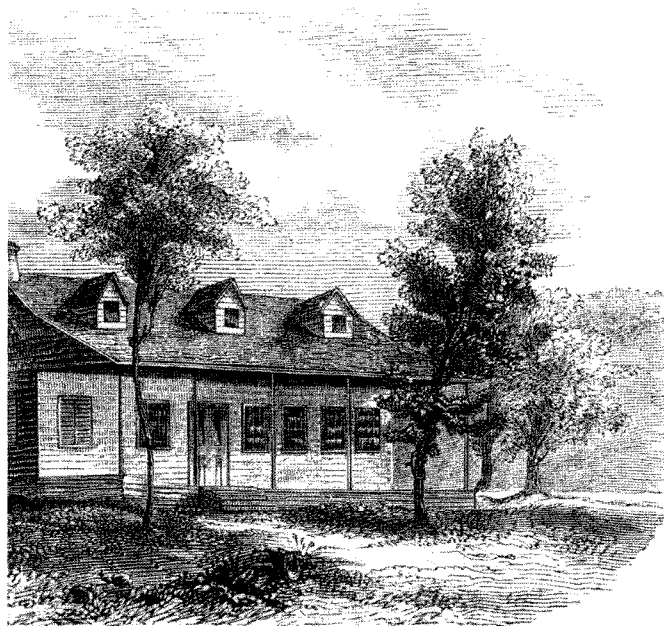
Council Bluffs as an illustration for his plea for aid for the Mormons. There are no other known illustrations by Sidney Roberts.

#### Art of George Simons

George Simons produced 16 sketches and seven oil paintings that include good views of the Loess Hills. None of his work has been published. One oil painting is possessed by the Joslyn Art Museum in Omaha and the remainder is in the possession of the Council Bluffs Public Library. Not all of the artwork is dated, but the earliest date is 1853 and the latest is 1867. Catsteps are not visible in any of the sketches or paintings (see Fig. 14). On the other hand, Babbitt (1916) includes the sketch "The Old Blockhouse, Fort and Mission," which Simons drew in 1896 from memory of the blockhouse in Council Bluffs that was constructed in 1839 (see Fig. 15). This sketch incorporates horizontal lines on hillslopes as a fill pattern in the manner of Roberts (1848) and Parker (1856). The landscape art of the later Simons is clearly inferior to his earlier work and cannot be regarded as reliable.

#### 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



L'ECLAIRE'S HOMESTEAD.

Fig. 13 "L'Eclair's Homestead," portion of drawing by Parker (1856).

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 Fig. 16 (near background), Fig. 17 (center, near background), and Fig. 18 (left). 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. One additional field sketch called "View of the

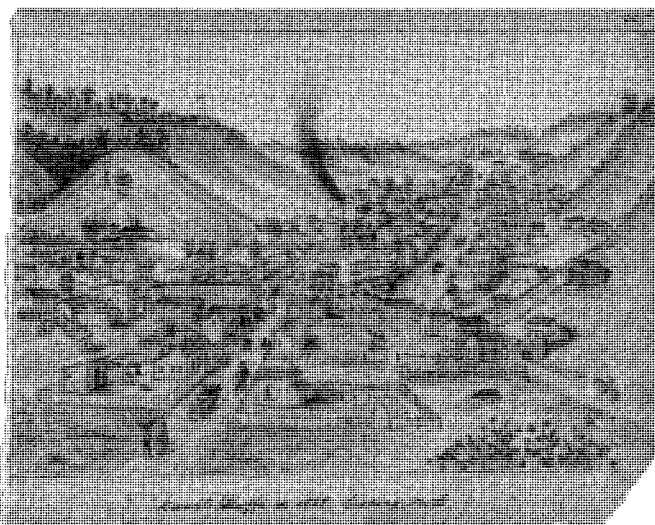


Fig. 14 "Council Bluffs in 1858. Looking North," drawing by George Simons, 1858. Council Bluffs Public Library, Council Bluffs, Iowa.

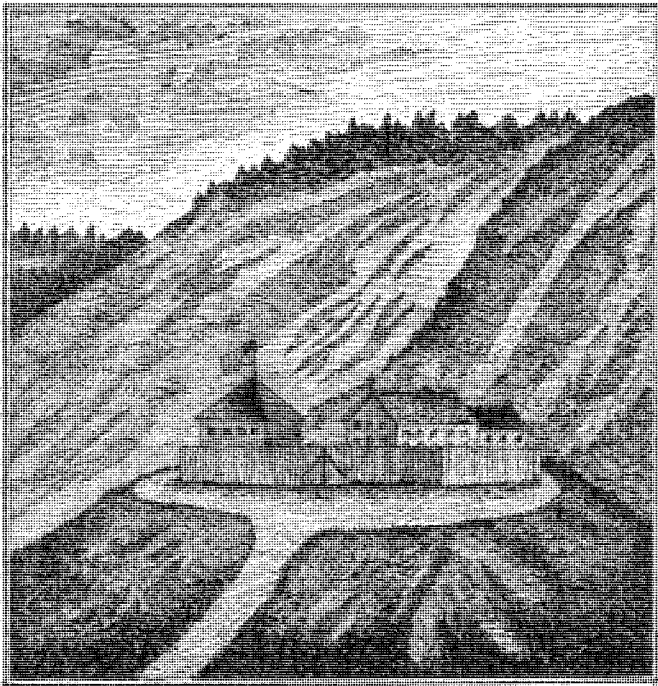


Fig. 15 "The Old Blockhouse, Fort and Mission," drawing by George Simons in 1896 from memory of blockhouse constructed in 1839 (Babbitt 1916).

Valley of the Missouri, looking up the stream to the Northwestward, from bluff on south side of Thompson's Creek (Floyd Bluff) Woodbury Co., Iowa - 13<sup>th</sup> Aug., 1868" was not discovered until 1975 (Prior and Mulligan 1985) and also does



Fig. 16 "View Looking Up the Valley of Soldier River, Jackson Township, Harrison Co., Iowa, Terraces of the Bluff Formation," portion of drawing by Orestes St. John, 1868 (White 1870).

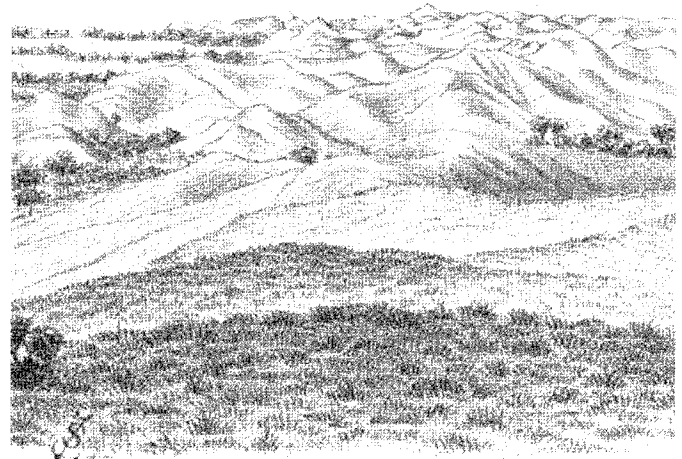


Fig. 17 "View Looking Northwestward up the Big Sioux, 7 Miles North of Sioux City, 1868," portion of drawing by Orestes St. John, 1868 (White 1870).

not show catsteps. Therefore, 50% of St. John's sketches show catsteps.

#### Commercial Art of the Loess Hills

The 1870s and 1880s saw the introduction of "illustrated atlases" with excellent drawings of farms and businesses, often in carefully drawn natural settings. Andreas (1875) produced nine drawings set in the Loess Hills (see Fig. 19), five of which (55%) show well-defined catsteps. Allen (1885) produced twelve

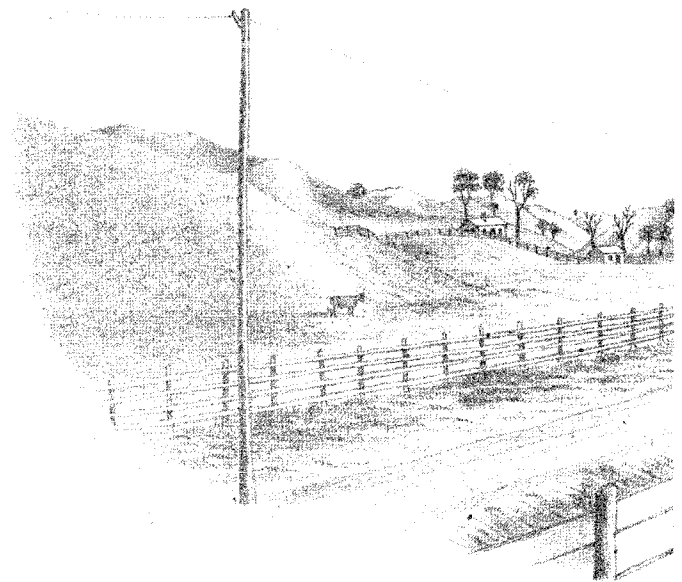


Fig. 18 "View of Bluffs at Crescent Station (N.W.R.R.), 6 miles above Council Bluffs, Iowa, 1868 (Looking Southeast)," portion of drawing by Orestes St. John, 1868 (White 1870).



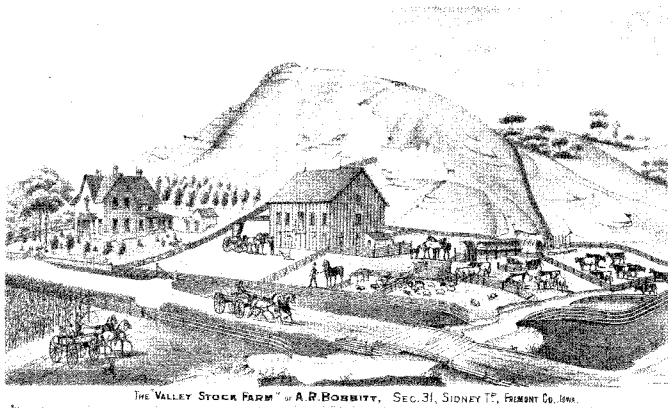


Fig. 19 "The 'Valley Stock Farm' of A.R. Bobbitt, Sec. 31, Sidney Tp., Fremont Co., Iowa," drawing by A.T. Andreas (Andreas 1875).

drawings set in the Loess Hills (see Fig. 20), four of which show well-defined catsteps. However, in three of Allen's drawings, the bluffs are either too close or too far for catsteps to be visible. Therefore, it is more accurate to state that four out of nine (45%) of Allen's drawings depict catsteps. The percentage of drawings that show catsteps after 1868 is remarkably similar. In three related commercial works (Cochran 1886, Heizer 1888, Hayden 1889) the Loess Hills are too stylized in the manner of Roberts (1848), Parker (1856) and the later Simons (Babbitt 1916) to be regarded as realistic depictions of nature.

#### Early Photographs and Later Paintings of Catsteps

Craig et al. (1887) published the first known photographs of the Loess Hills. Their two photographs "Bird's Eye View No. 1 from Fairmount Park" and "Fairmount Park Glens" show excellent catsteps. In all other photographs in Craig et al. (1887) the Loess Hills either are not visible or are too far in the distance for discernment of catsteps. Shimek (1910) included numerous photographs of catsteps (see especially Plates 22, 31, 33, 34, 36 and 38). The Calvin Collection at the University of Iowa includes two photographs (Nos. 1117 and 1170) of catsteps in Plymouth County, but the photographs are undated. By the late nineteenth century, catsteps had become an expected feature of landscape paintings of the Loess Hills. An excellent example is H.H. Bagg's 1894 painting of Council Bluffs called "Dodge House, from Fairmount Park," which hangs in the Council Bluffs Public Library.

#### Written Descriptions

Rahm (1962) used the fact that Lewis and Clark (Thwaites 1904) did not mention terracettes in the Pacific Northwest as part of his evidence that terracettes are caused by overgrazing by domestic animals. Therefore, it is important to consider when the first description of catsteps in the Loess Hills was written. Catsteps were not described by numerous explorers and naturalists who traveled through the Loess Hills and otherwise made extensive geological observations, including the Lewis and Clark expedition of 1804–1806 (Thwaites 1904, Osgood 1964, Moulton 1983–2001), the Brackenridge and Bradbury expedition of 1809–1811 (Brackenridge 1904, Bradbury 1904), the Long expedition of 1820 (Bell 1957, James 1966), Maximilian, Prince of Wied (1904) in 1833, Culbertson (1952) in 1850, and

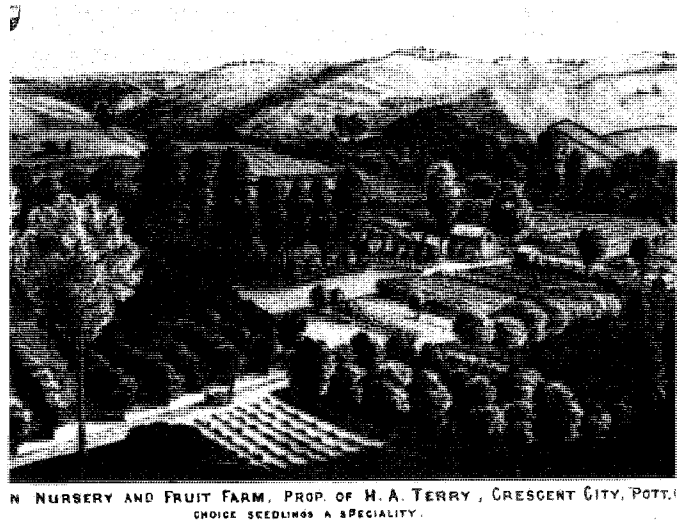


Fig. 20 "Flora Garden Nursery and Fruit Farm, Prop. of H.A. Terry, Crescent City, Pott. Co., Iowa," drawing by C.R. Allen (Allen 1885).

the 1855–57 geological survey of Iowa (Hall and Whitney 1858). It is surprising that, although St. John produced three sketches of catsteps in 1868, they are not mentioned in the accompanying geological report (White 1870). Even though Tostevin (1870), Smith (1888) and Hoskins (1890–91) discuss the geography of the Loess Hills at great length, there is no description of catsteps. Despite the fact that Shimek (1910) describes catsteps as "familiar," he appears to be the first to produce any written description of catsteps.

An accomplished geologist-artist, such as Orestes St. John, will draw catsteps because he sees them, even if does not understand their significance. Since he does not understand their significance, they are not mentioned in the accompanying text (White 1870). For this reason, contrary to the assertion of Rahm (1962), the artistic record of catsteps is more reliable than the written record.

#### 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. 21a). The number of cattle peaked in 1905. In fact, there were only slightly fewer cattle 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.

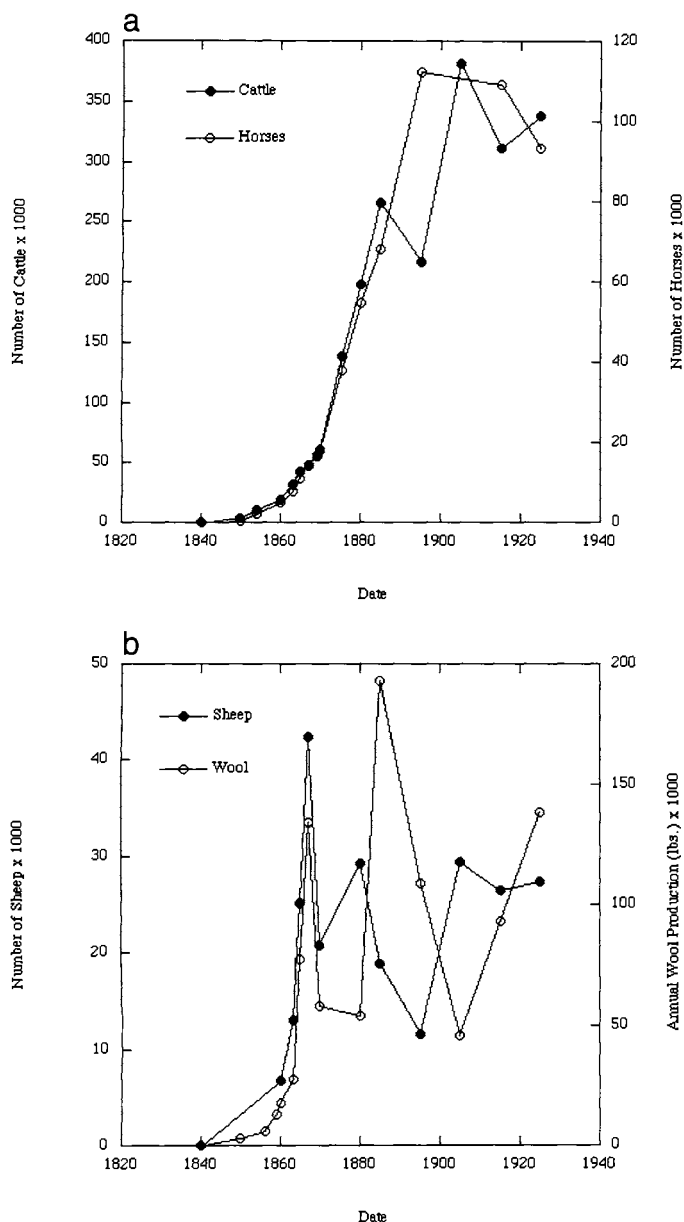


Fig. 21a Numbers of cattle and horses in the seven counties of the Loess Hills, 1840–1925 (compiled from Hull (1883), Jackson (1885), McFarland (1896), Executive Council (1905), Executive Council of the State of Iowa (1915, 1925)).

Fig. 21b Numbers of sheep and annual wool production (lbs.) in the seven counties of the Loess Hills, 1840–1925 (compiled from Hull (1883), Jackson (1885), McFarland (1896), Executive Council (1905), Executive Council of the State of Iowa (1915, 1925)).

The numbers of sheep peaked in 1867 and annual wool production peaked about 1880 (see Fig. 21b), 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. 21b). 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. 21a–b). Based on the above data, peak grazing by domestic animals in the Loess Hills was attained by the period 1895–1905.

## DISCUSSION

### Psychological or Environmental Interpretation?

The art-historical evidence is that, aside from possible features in Bodmer's depictions of Blackbird Hill, no artist of the 1830s, 1840s or 1850s drew catsteps in their representations of the Loess Hills. The artist-geologist Orestes St. John drew catsteps in 1868, after which all artists drew catsteps. There are two possible interpretations of the evidence. The first is the psychological interpretation, according to which nobody paid attention to catsteps until they were pointed out by St. John. That interpretation cannot be dismissed, although it is curious that catsteps are not mentioned in the text that accompanies St. John's drawings (White 1870). On the other hand, the evidence could have the environmental interpretation that catsteps appeared only during the late 1860s. Artistic depictions would not normally be regarded as geologic evidence except when they originate from the mid-nineteenth century, which was the pinnacle of realism in landscape painting (Bedell 2001).

According to Bedell (2001), "In asserting, as many artists began to do in the second quarter of the nineteenth century, that a knowledge of the natural sciences was essential preparation for the pursuit of landscape art, they were establishing a firm intellectual and factual (rather than imaginative and subjective) foundation for their art. The realistic style that prevailed in American landscape painting in the middle decades of the nineteenth century, with its sharp focus, precisely described detail, and careful evocation of particular species of plants and types of rocks, likewise helped to align landscape painting with the much-admired methods of scientific observation and data collection."

The most influential art critics of the mid-nineteenth century, especially in the area of landscape art, were John Ruskin in England and Asher Brown Durand in America (Bedell 2001). Bedell (2001) wrote, "In these volumes, Ruskin argues for Turner's supremacy as a landscape artist and presents his work as models for younger artists to follow. Ruskin bases his case for Turner's greatness on the artist's unsurpassed fidelity to nature. Turner, he avows, 'paints more of nature than any man who ever lived.'" Bedell wrote further, "Durand later echoed Ruskin's advice in his own directives to the beginning landscape painter. These were offered in his famous 'Letters on Landscape Painting,' published in the *Crayon* (co-edited by his son John) in 1855. Like Ruskin, Durand encouraged the 'truthful representation' of all aspects of the natural world with special attention to the characteristics of species. 'If your subject be a tree,' he advised, 'observe particularly wherein it differs from those of other species.' Also like Ruskin, he laid special stress on geological forms. He gave the artist license to subordinate or even omit various details of the observed world (one could, for example, 'displace a tree...if disagreeable'). But, he warned, 'the elevations and depressions of the earth's surface...may not be changed in the least perceptible degree, most especially the mountain and hill forms. On these God has set his signet, and Art may not remove it when the picture professes to represent the scene.'"

Of course, it is critical to distinguish between the greater artists who were committed to fidelity to nature and the lesser

artists who were technically incapable of fidelity to nature. Catlin, Bodmer, Audubon, the early Simons, St. John, Andreas and Allen fall into the first category, while Roberts, Parker, Cochran, Heizer, Hayden, and the later Simons fall into the second category. Obviously, this is an artistic judgment, but the subsection Art of Nathan Parker and Sidney Roberts gives guidelines on how to make that judgment.

### Evidence for Climate Change

Peak grazing by domestic animals was not attained until 1895–1905 and the photographs of Craig et al. (1887) show beyond any doubt that catsteps were fully developed before this period. The role of domestic animals in the formation of catsteps cannot be entirely dismissed, since the threshold for impact of grazing animals is not known. Although Higgins (1982) observed the formation of terraces after the introduction of sheep onto grassy slopes, he had no control over the density of sheep. A related phenomenon to the appearance of catsteps in the Loess Hills in the late 1860s 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. From radiocarbon dating, it is known that a previous episode of gully growth took place around 1250 A.D. (Daniels et al. 1963, Daniels and Jordan 1966, Bettis et al. 1986). A more likely explanation than grazing by domestic animals for the apparent near simultaneous development of both catsteps and gullies is a possible mid-nineteenth century climate change in the Loess Hills. The timing for this climate change is consistent with a number of recent studies showing that the climatological conditions that accompanied the Little Ice Age in the Midwest began to subside about 1860 (Grimm 1983, Williams and Wigley 1983, Leonard 1986, Clark 1990, Grove 2004).

Any climate change that promotes the slumping tendency of loess could result in the initiation of catsteps and gullies. It is well-known that almost all earth materials become more susceptible to slumping through wetting and drying cycles that cause alternating expansion and contraction in the finer materials (Bloom 1998). The most likely climate change is that the end of the Little Ice Age resulted in an increase in the frequency of precipitation cycles. This is consistent with the greater abundance of catsteps on the south- and west-facing slopes (Shimek 1910), which would dry faster following a precipitation event. The north- and east-facing slopes would not moisten any faster during a precipitation event.

### 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 mid-nineteenth century. 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.

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. Their conclusions were similar to those of earlier studies that identified no long-term precipitation trends (Duvick and Blasing 1981, Blasing and Duvick 1984). 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. Clark (1990) used fire scars on red pine (*Pinus resinosa*) trees and charcoal stratigraphy to show that the interval between fires in northwestern Minnesota decreased from  $(44 \pm 16)$  years to  $(13 \pm 10)$  years after 1860. None of the above studies showed an increase in the amount of precipitation in the latter part of the nineteenth century. The formation of catsteps is promoted by an increase in the frequency of precipitation cycles, not by an increase in the amount of precipitation. Otherwise, it would be impossible to explain the greater abundance of catsteps on the drier south-facing and east-facing slopes.

The climatic trends from northeastern South Dakota, eastern Montana and northwestern Minnesota are broadly consistent with our interpretation of the appearance of catsteps and gullies in the mid-nineteenth century. However, the question remains as to whether the recent climatic history of the Loess Hills is more like that of northern Minnesota or 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 1989b, Truett 2003). The question draws attention to 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.

### CONCLUSIONS

We have shown that the record of artistic depictions of the Loess Hills apparently reflects climate changes occurring in that region in the mid-nineteenth century. We have also drawn attention to the concept of catsteps or terraces as landforms that evolve in time in response to changes in climate. This concept could be explored further by monitoring catsteps for movement on time scales on the order of years or by studying the persistence of relict catsteps on former grass-covered slopes that have been occupied by forest (Mutel 1989b).

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