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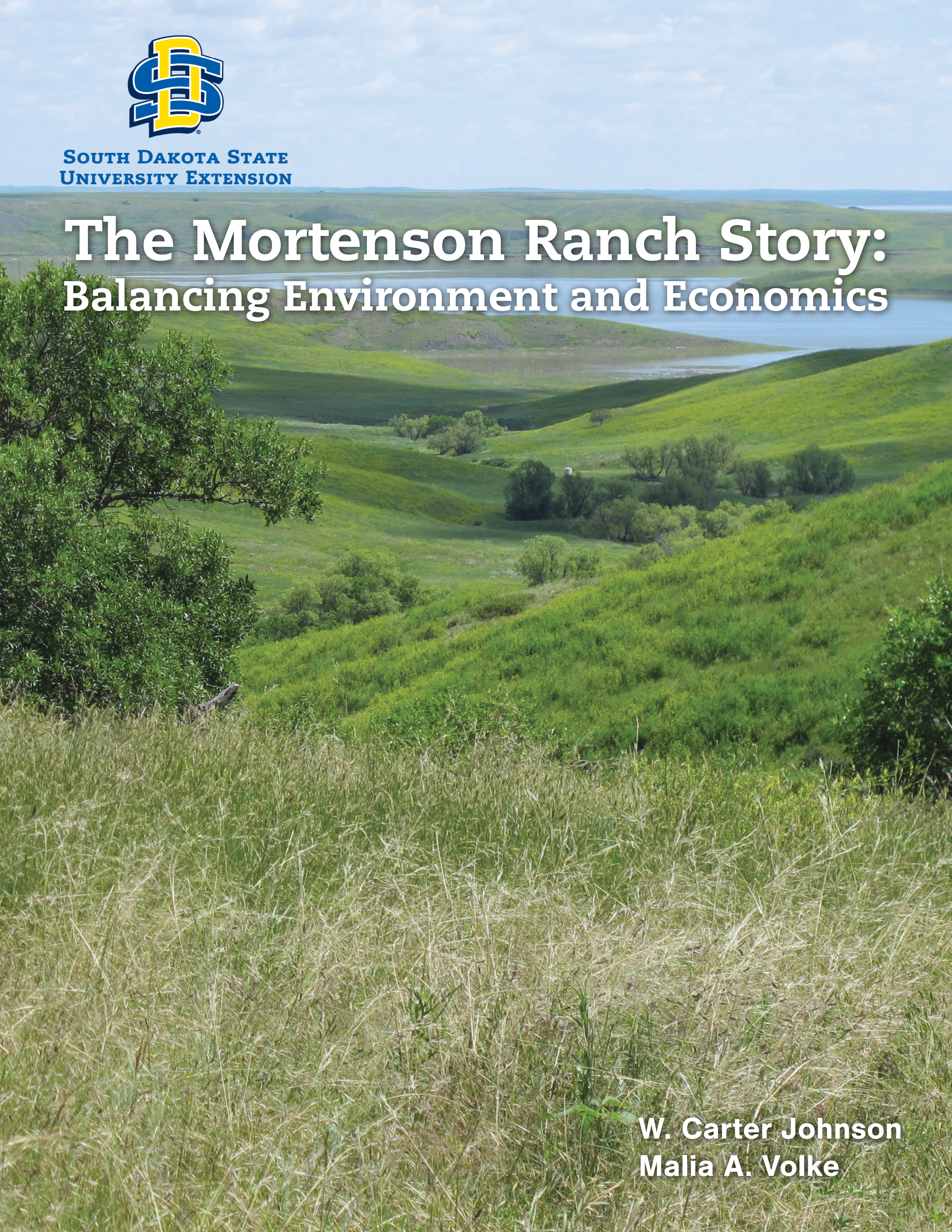
The Mortenson Ranch Story:
Balancing Environment and Economics



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SOUTH DAKOTA STATE UNIVERSITY EXTENSION

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We are greatly honored to present *The Mortenson Ranch Story: Balancing Environment and Economics*, a compelling story of how one family has restored their piece of South Dakota, overcoming the severe degradation of their land caused by exploitation, drought, and the unintended consequences of short-sighted actions, regardless of their intent. The holistic management of the prairie described in this book clearly has its roots in something much deeper than simply ranching. It is a beautiful story of the relationship between a family and the land. At its heart, it is a story of one family's core values and ethics that span not only generations, but centuries. For as members of the Cheyenne River Sioux Tribe, the Mortensons' heritage traces back to tribes of Lakota people who lived with the land, not from it; to a people whose land ethic and core values are indistinguishable from the flora and fauna catalogued in this beautiful book.

The Mortenson Ranch is a working cattle operation along and near the Cheyenne River in Stanley and Ziebach Counties of South Dakota. The actions of Clarence Mortenson, his sons, and his step-father, have not only rehabilitated the natural landscape, they have also improved the production capacity and value of their business assets. The result has been a secure and sustainable source of income for the family. This is a testament to conservation science working with agriculture for healthy outcomes. As many of us now know, these interests are not exclusive of each other. We are proud that South Dakota State University's College of Agriculture and Biological Sciences was chosen by the Mortensons to help them in their restoration efforts and to help document the exciting transformation of the ranch.

I hope that you will enjoy this account as much as I have, and that it will inspire others to follow in the footsteps of the Mortenson family to rehabilitate our rich South Dakota landscapes for the benefit of all. This story describes an important, replicable model for steady improvement of distressed lands with widespread application potential. Furthermore, this serves as a prime example of how we can be profitable in agricultural pursuits while maintaining and sustaining our natural resources.

President Teddy Roosevelt said: *"The nation behaves well if it treats the natural resources as assets, which it must turn over to the next generation increased; and not impaired in value."* I am confident that the Mortensons' commitment to leave the land in better condition than they found it, so that future generations can partake of its gifts, would make President Roosevelt very proud!

Thank you for taking the time to read this amazing story.

Barry H. Dunn*
President, South Dakota State University

**Title as of Original Publication: South Dakota Corn Utilization Council Endowed Dean of Agriculture and Biological Sciences, Director of SDSU Extension, Professor of Animal Science*

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We thank the Mortenson family for the long collaboration history, numerous collegial discussions, learning in both directions, and for their review and constructive comments on this report. Susan Boettcher took the woody draw project "under her wing" at the start in 1992 and deserves considerable credit for the initial establishment of the permanent transects and publication of many of the results of the project during its first decade. Craig Olawsky followed Susan on the woody draw project and helped us re-measure the Foster Creek cross sections. Todd Epp put together a splendid and popular video with South Dakota Public Broadcasting on the Mortenson Ranch that was shown on television dozens if not a hundred times in the early to mid-1990s. Bruce Harris tallied birds on the Mortenson Ranch and surprised us all when we found out how well the avifauna had recovered. Many assisted in putting together this report: Kent Jensen worked with Doug Backlund to provide us with the incredibly beautiful photos of birds for our report and assisted in the compilation of the master bird list for the ranch; Gary Larson worked with Jim Johnson to provide the comparably high quality photos of many of the key species of plants found on the Mortenson Ranch; Larry Janssen assisted in making economic data available to our project; Dave Archer, Cody Zilverberg, and Lora Perkins provided constructive comments on the manuscript.

ABSTRACT
The Mortenson Ranch Story is a remarkable account of the restoration of a western South Dakota landscape devastated early in the 20th century by homesteading and drought. The central figure in the story is Clarence Mortenson, who as a boy just after the Dust Bowl, learned from an old homesteader how beautiful and productive the heavily eroded and barren landscape once had been. Clarence vowed that if and when he took over the ranch he would get it back to its pre-settlement condition of thick grass, clear-water streams, dense woody draws, and abundant wildlife. But the ranch was not to be a "preserve," it had to provide a sustainable living for a large family. This story details Clarence's conservation and management philosophy and how it has been implemented by three generations of his family to restore the ranch's environment and economy that ultimately earned the Mortensons the coveted Aldo Leopold Conservation Award in 2011. Read the following account to discover event by event the deterioration of the landscape and what worked and what did not work to recover its beauty and bounty.

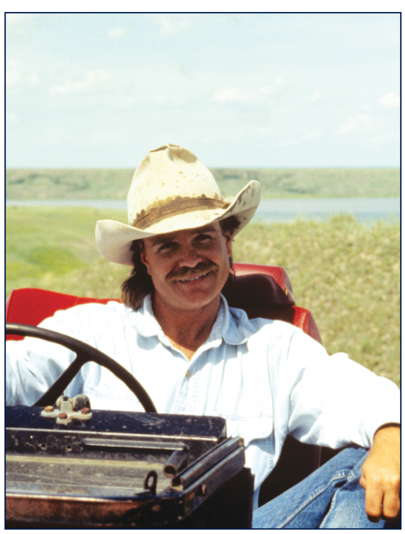


Figure 1. One of South Dakota's "Black Blizzards", 1934. Photo courtesy of South Dakota Agricultural Heritage Museum Photograph Collection, image number 94:27:05. Copyright 1934 Rosebud Photo at Gregory, South Dakota.

BACKGROUND

Historians agree that the Dust Bowl in the Great Plains was caused by two major factors: a long string of extremely dry years and the breaking up of large areas of native grass sod to grow grain, much of it planted on marginal farming land (Burns 2012). Crop failures from drought exposed the soil to strong winds that carried dust clouds as far to the east as Washington, DC (Figure 1). The environmental and economic consequences of the Dust Bowl were disastrous; huge areas of the Plains were vacated by many destitute and discouraged farmers leaving highly eroded and damaged land in their departing wagon tracks. Some of those who left had been severely tested before, in the less intense but still damaging drought in western South Dakota of 1910-1911, but had regained their footing in the early post-World War I years during a period of high commodity prices. But the boom was quickly followed by elements of a catastrophic bust: an early 1920s economic "retrenchment,"

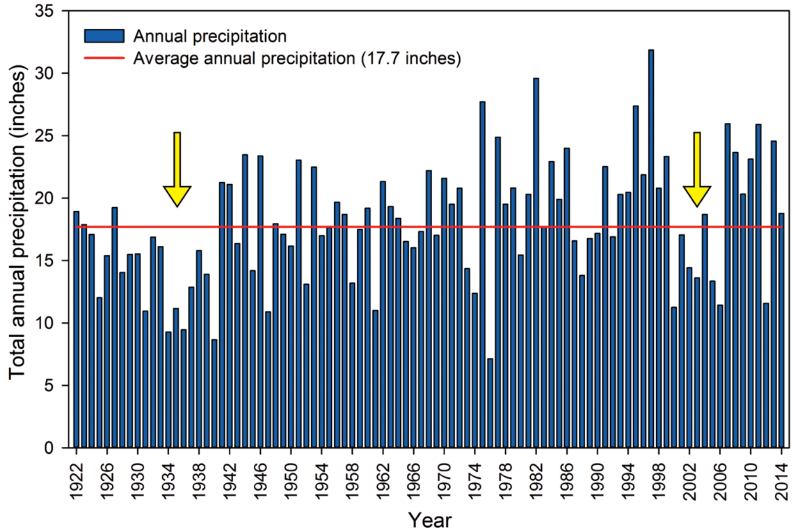


Figure 2. Annual precipitation from 1921-2014 at the Pierre, South Dakota weather station. The left yellow arrow shows Dust Bowl years, while the right yellow arrow shows a dry period in the early 2000s.

the nation-wide Great Depression triggered in 1928, and the drought and grasshopper hordes of the 1930s. These three events worked their will on the farmers in western South Dakota and beyond in other parts of the Great Plains (Nelson 1996).

Droughts of these magnitudes or worse have been recorded in the tree-ring and lake sediment climate proxy records going back many centuries, and as such, are considered an indelible characteristic of the Great Plains climate (Woodhouse and Overpeck 1998). Droughts of the 20th century have been characterized by moderate severity and comparatively short duration, relative to the full range of past drought variability. Droughts equal to or more extreme than that of the 1930s are expected in the future because they have occurred in the not-too-distant past. Since the Dust Bowl years in the northern Great Plains, however, no string of region-wide, severe drought years has occurred, just isolated dry years (e.g., 1976, 1988, 2012 in South Dakota). Tree rings from oaks in northeastern South Dakota are relatively wide in all other years from 1940-1999, indicating that this period should have been very favorable for agriculture (Shapley et al. 2005). More recently, western South Dakota experienced several dry years in the early 2000s; some were about as dry as those of the 1930s but the drought did not last as long. The earlier drought had a string of 12 years of below average precipitation, while the more recent drought had a string of six years below average (Figure 2).

Many written and oral accounts describe in great detail historic Dust Storm events and the heart-breaking consequences to the land and people (Burns 2012). But there has been little follow-up that chronicles who stayed to pick up the pieces, and how they helped to heal the land and return it to productive use. Events on what is now the Mortenson Ranch (Figure 3) can be pieced together to make such a compelling story of how a guiding land ethic, learning by trial and error, favorable weather, hardwork, and collaboration with scientists and land managers all combined to create a profitable, environmentally-resilient, and conservation-minded ranch out of the black dust clouds and buried fences.

Many ranches formed or expanded in western South Dakota when farming failed and the public and government questioned with hard data the wisdom of grain farming in a marginally dry climate, even

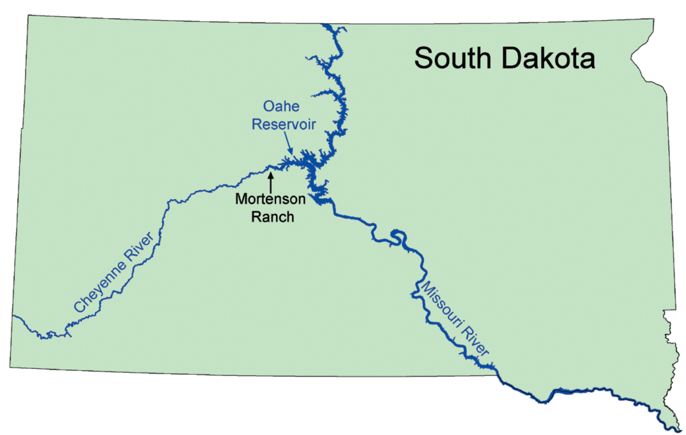


Figure 3. General location of the Mortenson Ranch in the state of South Dakota.

in good years. So why pick out the Mortenson Ranch to tell the story among other deserving ranches? Several factors contributed: Clarence Mortenson, the second generation owner of the ranch and father of Todd Mortenson, the current third generation manager, has lived a long life and possesses an incredible memory of historic events. Clarence is the step-son of Ben Young (generation one) who put the ranch together and started the healing. Clarence also has provided written historical records on a variety of relevant subjects that have been used in this report. In addition, he conceived and directed the plans to restore the ranch to its pre-homesteading condition and provided in written form an assessment of the successes and failures. Some of this background has been published elsewhere in peer-reviewed research papers (Boettcher et al. 1995, Boettcher and Johnson 1997, Boettcher et al. 1998, Johnson 1999, Boettcher and Johnson 2005).

Second, researchers and educators were invited by the Mortensons to study and quantify how the environment of their ranch was responding to changes in ranch management and environment since the Dust Bowl days. These include Dr. Robert Gartner (SDSU Extension Service) and Dr. Scott Kronberg (SDSU Animal Sciences), both specialists in range management; Dr. Carter Johnson (and research associate Susan Boettcher) of the Department of Natural Resource Management, SDSU, a specialist in the ecology of prairie woodland, wetlands, and streams; and Paul Ingle, North Central Resource Conservation and Development Association, who conducted an EPA-funded demonstration project on Foster Creek that flows through the Mortenson Ranch on its way to Oahe Reservoir (Missouri River). These four individuals, their associates, and projects provide most of the written and quantitative information available to assess the success of the methods used by the Mortensons to restore their ranch to pre-homesteading conditions. Others undoubtedly made contributions to the project but they were not recorded so, unfortunately, could not be acknowledged here.

Third, the work of the Mortensons has been observed and evaluated by thousands of visitors (including many students) and dozens of organizations that were part of numerous ranch tours over a several decade long period going back to the early class visits in the 1950s and 1960s led by Professor Tex Lewis, range scientist at South Dakota State University. A video titled "The Mortenson Ranch: Rebuilding History" was produced by Todd Epp and South Dakota Public Broadcasting in 1993. The impressive changes that have taken place on the ranch have led to a large number of regional and national awards to Clarence and to the Mortenson Family (Table 1). This acclaim makes the Mortenson Ranch an example for others to follow and worthy of special attention among the ranches that formed and grew their way out of the drifted, grassless soils of the Dust Bowl.

STARTING FROM SCRATCH

Clarence Mortenson first saw in 1941 the ranch he would later manage and own. He had been hired by Benjamin Young, who was to become his step-father, to fence pastures for a herd of registered Herefords to keep them from mixing with neighboring cattle. Ben Young ran the ranch for two and a half decades after the Dust Bowl. This was a crucial period

Table 1. Regional, state, and national awards given to Clarence, the Mortenson family, and the Mortenson Ranch.

- Outstanding Young Farmer Award, Central South Dakota, 1959
- South Dakota Conservation Districts Soil Conservation Award, 1964
- Stanley County Conservation District Conservation Award, 1964
- Rangeman of the Year, South Dakota Section, Society of Range Management, 1977
- Environmental Stewardship Award, South Dakota Stockgrowers Association, 1993
- George S. Mickelson Environmental Excellence Award, 1994
- Chevron/Times Mirror Magazines Conservation Award, 1994
- National Arbor Day Foundation Good Steward Award, 1994
- South Dakota Wildlife Federation/National Wildlife Federation, Conservation Award, 1995
- National Cattleman's Association, Region 7, Environmental Stewardship Award, 1995
- W. R. Chapline Land Stewardship Award, Society of Range Management, 1997
- National Wetlands Award for Land Stewardship and Development, Izaak Walton League of America, U. S. Environmental Protection Agency, Environmental Law Institute, and U. S Botanic Garden, 2002
- Full Circle Award, Society for Ecological Restoration, 2002
- Honorary Doctor of Science Degree, South Dakota State University, 2003
- Participant, Natural History Tour; Listening to the Prairie: Farming Nature's Image, National Museum of Natural History of the Smithsonian Institution, 2003
- Leopold Conservation Award to the Mortenson Family, Sand County Foundation in partnership with South Dakota Cattlemen's Association and South Dakota Grassland Coalition, 2011

Figure 4a. Buried machinery in barn lot, Nelsen farm in Gregory County, South Dakota. Photo courtesy of South Dakota Agricultural Heritage Museum Photograph Collection, image number 85:48:14.

Figure 4b. Child standing on drifted soil circa 1930s. Photo courtesy of South Dakota Agricultural Heritage Museum Photograph Collection, image number 76:26:16.

needed to recover the fundamental assets of a cattle ranch: productive grassland, low soil erosion, low runoff and high water percolation, and good cattle genetics and marketing. His importance in getting these key improvements underway and on target cannot be overestimated.

Cleaning up the old homestead sites had first priority. Most of the settlers' fencerows were still buried above the top wire with soils that had blown from the abandoned fields and overgrazed rangelands (Figure 4a,b). Almost every quarter section had been fenced, and the area was littered with downed posts and wire scattered throughout by horses and cattle getting tangled and cut up over the years. All of the sites remained as they were in the mid-1930s when they were abandoned. Nearly 40 families homesteaded on what is now the ranch headquarters (ca. 10,000 acres; Figure 5). The condition of the vegetation at the end of the drought was dismal, with every acre overgrazed or farmed and abandoned. Cool season grasses had disappeared on the alluvial soils and warm season grasses were severely depleted. Woody plants had been burned for cooking and heating and cut for fence posts and corrals. Any new plant reproduction was grazed off. Overgrazing assured that any seed that germinated would be consumed before it was a foot high and soon there were no seed sources. By the time the last settlers left in the late 1930s even the chokecherry and plum thickets had been used for fuel. Aging of the largest trees (green ash) in the 1990s determined that they had germinated in the 1930s when the settlers were departing. While tearing down a dilapidated settler shanty, Clarence saw the first deer (a stuffed wall mount) he had ever seen in West River country. Later his saddle horse spooked upon seeing its first living deer.

Converting abandoned crop fields to productive pasture was a high priority project, but one that took some years of trial and error management to attain. Choices of inexpensive, commercially available seed were very limited. Crested wheat grass was recommended by the Soil Conservation Service (SCS) because it was available and cheap. It was introduced to dry lands in North America because of its resistance to drought; it is native to the steppes of Russia. Clarence slowly learned that the best source of seed for re-vegetation came from recovered pastures on the ranch itself. Locally adapted seed of western wheatgrass, green needlegrass, sideoats grama, and highly desired prairie legumes (lead plant, dwarf indigo, sensitive briar) were harvested and drilled into former tilled land and degraded pasture with considerable success (Figure 6). An unforeseen benefit of restoring native grassland was that a good market developed for the seed that significantly improved ranch income in some years. In later years, Clarence's son Jeff established a business using native seed from the ranch.

The decision to restore grass to the land was confirmed to be the correct one when comparing the higher net income per acre from some ranch parcels, for example, compared to those from land that was being farmed. Rotation grazing of these restored pastures reflected the value of proper management, as production on the grassland has consistently improved. When summering yearling steers on the restored grassland, the gains were as good as any in the country.

"On a quarter section in this country, no one could've or should've been expected to make a living."

– Clarence Mortenson

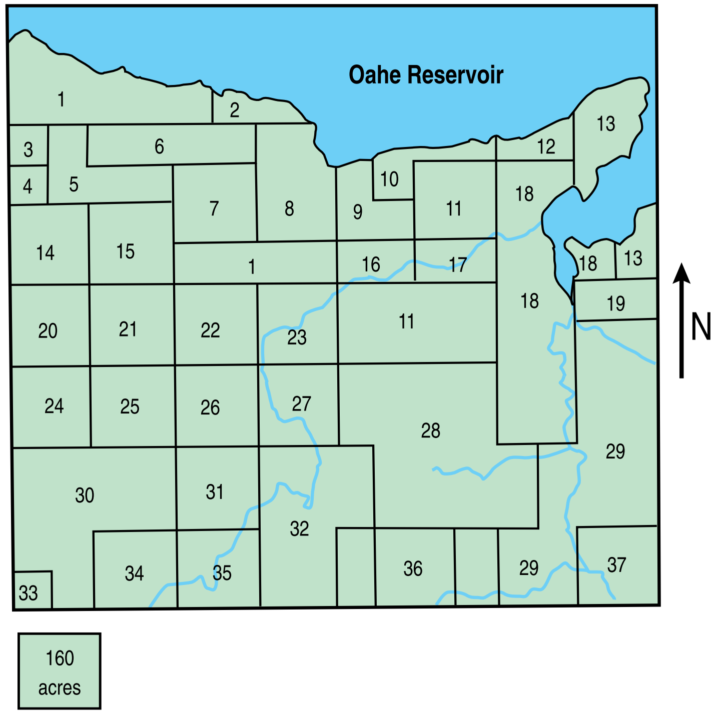


Figure 5. A map of Spring View Township in Stanley County where the Mortenson Home Place is located showing how the area was divided among 37 owners in 1890. Each number represents a different homesteader. Oahe Reservoir covers additional homesteads. (Redrawn from Centennial Atlas of Stanley County, 1989).

western wheatgrass

green needlegrass

sideoats grama

lead plant

dwarf indigo

sensitive briar

Figure 6. Examples of native plants found on the Mortenson Ranch. Photos courtesy of James R. Johnson.

One downside of the grassland restoration approaches was the planting of crested wheatgrass. Considerable effort has been expended to get rid of it. The native grasses, in contrast to crested wheatgrass, cure with a higher carbohydrate content enabling winter grazing (along with an all-natural protein supplement) with the cows retaining flesh and producing strong, healthy calves. The success of the bison living almost exclusively off grassland plants in all seasons is testimony to the high forage value of the native range.

A New Approach to Fencing

The 10,000 acre headquarters of the Mortenson Ranch (Home Place) lies in Stanley County, South Dakota, about 20 miles west of the Missouri River trench on the south side of the Cheyenne River, now part of the delta forming in the Cheyenne River arm of Oahe Reservoir (Figure 7). Planning for future operation of the ranch started in 1949. Two parcels (Bursch parcel and the Maupin parcel) north of the Cheyenne River (Ziebach County) totaling about 9,000 acres were added to the ranch between 1953 and 1956. Miles of fence that had been buried in three to four feet of soil were uncovered by hiring the county road maintainer. This machine would feather the soil away from the fences as close as possible leaving a smooth surface on which the grass could recover. Wires were rusted and posts rotted so a huge project of rebuilding started. Small breeding pastures were laid out for the growing herd of registered Hereford cattle using new posts and wire salvaged from old fences. New fence was also built for other breeding pastures.

In 1965, Clarence and his sons began building fences to facilitate better grazing. This time they fenced around vegetation and soil types, not just along property and survey boundaries. This fencing approach was continued on the Maupin and Bursch parcels.

VEGETATION, SOILS, AND GRAZING HISTORY

The Mortenson Ranch lies within the Mixed-Grass Prairie region of the northern Great Plains. The landscape is generally rolling with occasional rugged "breaks" where west-east running rivers have carved out deep, picturesque valleys. The Hollywood movie, "Dances with Wolves," was filmed in western South Dakota and includes scenes reminiscent of the Mixed-Grass Prairie landscape during the days of the great bison herds and Native American encampments. Average rainfall for this area is 16.5 inches, of which about 14 inches fall during the growing season. The Cheyenne River forms the northern boundary of the ranch; two high terraces have young alluvial silty soils underlain by a layer of gravel about 30 feet thick (ancient riverbeds). The remaining soils on the ranch are clayey, derived from the Pierre shale which is 2,000 feet thick.

The deeper soils derived from Pierre shale support pristine plant communities dominated by western wheatgrass. Associated plant species include green needlegrass, blue grama, buffalo grass, upland sedges, and a wide variety of forbs, depending on season and rainfall. The ranch's upland pastures with a slope of about 3-12 percent support this type of plant community. Rough breaks, with shallow soils on slopes of 9-40 percent support a different plant community. On sites with Excellent range condition, warm-season grasses dominate, including big bluestem,

The Mortenson Ranch

Rotation Among Parcels
Older cows
At H: from Dec. 1 to about May 20
At L: from May 20 to beginning of Nov.
(A simple two-pasture rotational system is used on leased land, and it is generally undergrazed.)
At B: from beginnin of Nov. until 1 to 6 weeks later
(The length of time spent at the Bursch parcel is determined by forage availability.)
At M: from time of leaving Bursch (usually in Nov.) until Dec. 1
(The goal is to use forage at the Maupin parcel to the desired level, then bring the cattle back to the Home Place by Dec. 1 or as early in Dec. as possible.)
Younger Cows and Heifers:
At H: from Dec. 1 to May 20
At B and/or M: from May 20 to Dec. 1

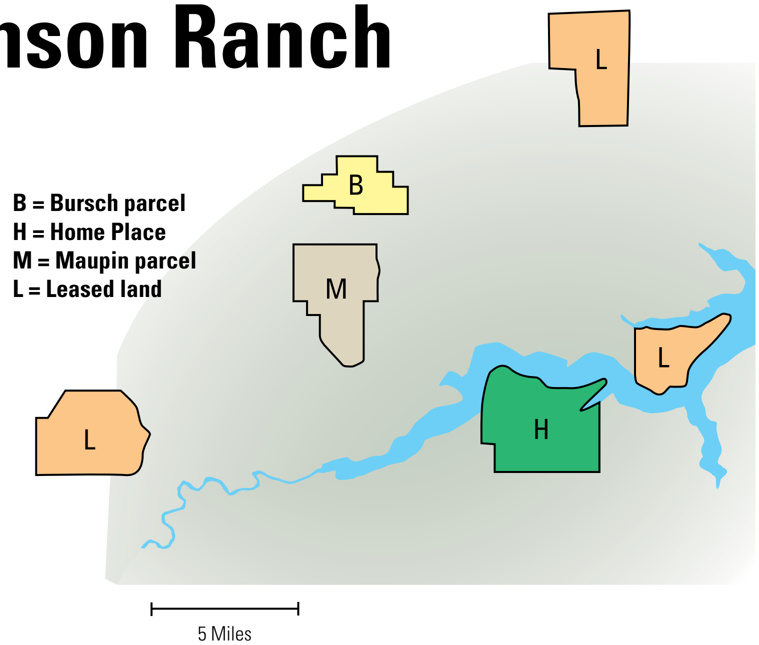


Figure 7. General size and location of parcels of the Mortenson Ranch along with pasture rotation plan.


big bluestem


little bluestem


blue grama


purple prairie clover


silver scurfpea


groundplum milkvetch

Figure 8. Examples of native plants found on the shallow soils of the Mortenson Ranch. Photos courtesy of James R. Johnson.

Table 2. Examples of pelt shipments through Fort Pierre on the Missouri River in 1832 from record books kept at the post. Data from Chittenden (1954).

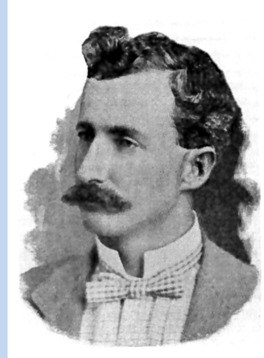
April 27	111 packs of beaver arrived from Fort Union (A pack of beaver contained from 60-80 pelts, average weight per pelt of about 1.5 pounds. This translates into about 7,500 beaver).
June 25	Steamer Yellowstone left with 1,300 packs of buffalo robes and beaver (sure to have included a trans-shipment of the robes from Fort Union).
July 9	Bateauxs left for St. Louis with 120 packs of beaver and 30 packs of buffalo robes (8,400 beaver).
July 11	Bateauxs left for St. Louis with 10,230 pounds of beaver skins (7,000 beaver).
August 30	6,000 pounds of beaver skins from Fort Union (4,000 beaver).

little bluestem, blue grama, and sideoats grama. Forbs and shrubs abound on Shallow and Shallow clay range sites. Abundant native legumes include leadplant, purple prairie clover, sensitive briar, silverleaf scurfpea, and groundplum milkvetch (Figure 8). A total of 20 species of woody plants grow in the "draws" that dissect the slopes between uplands and riparian areas. The more common of these are green ash, hackberry, American plum, chokecherry, hawthorn, riverbank grape, and skunkbush sumac.

Riparian areas are mapped as Dense Clay range sites with "slick spots". Following streambed restoration efforts, the native plants that occurred before homesteading are returning. These include western wheatgrass, prairie cordgrass, green needlegrass, and many wetland associated plants including cottonwood, willows, and cattails.

Discovery and early occupation of the northern Great Plains by Europeans began to change the landscape as early as the 1700s. The sheer number of pelts marketed (Table 2) suggests that beaver must have been living on most of the small streams and creeks. For that to have been possible, those water courses must have been live water most of the time and not intermittent as we know them today. Jack Holterman, in his book King of the High Missouri, described it this way: "First went the beavers, and with them went their beaver dams and beaver ponds, and down went the water table and up went the fire hazard. Year by year, the land grew more arid, the grass less luxuriant" (Holterman 1987). The near extirpation of beaver also very likely led to uncontrolled water erosion in upland draws and riparian areas during snowmelt and large rain events.

The buffalo herds were reduced to the point of extinction by the latter part of the 1800s only to be replaced by cattle and horses. Open range grazing was practiced in western South Dakota into the early 1900s before extensive farming and fencing, but practiced later on the Cheyenne Indian Reservation just north of the Mortenson Home Place across the Cheyenne River. A reservation lease by Cap (Burt) Mossman of the Diamond A Cattle Company in 1904, who was considered "the last of the great cowmen" (Hunt 1951), included up to 1.2 million acres of rangeland and as many as 50,000 cattle and horses. Hans Mortenson,



"Grass–that was it. Grass for hungry herds. Grass like he had never seen before. Fattening grass; tallow-making grass. And sunshine and water, and the warm wind blowing in his face."

– thoughts attributed to Cap Mossman by his biographer (Hunt 1951).

"They [homesteaders] had to have workhorses and when you consider that country, a good share of it takes 20 acres to run a cow on and probably 30 acres to run a horse on–you figure if someone had two teams and a couple of saddle horses plus a milk cow, they were overstocked. So they overgrazed the country."

– Clarence Mortenson

Clarence's father, worked for Cap, and Clarence as a young boy kept the wood box of an elderly Cap full at his Eagle Butte, South Dakota home. In this way, the two generations overlapped: an open range grazer and a progressive rancher who believed in fences (in the right places).

The first ranch to be established (1860s) in or near what is now the Mortenson Ranch was that of Frederick Dupris, a former employee of the American Fur Company. Fred and his 10 children ran several thousand cattle and 500 horses. The area was not fenced and no water development had taken place. The first person to take advantage of the opening of that country for settlement after statehood was Bruce Siberts (Siberts and Wyman 1954). He homesteaded after 1890 and ran 800 head of horses by 1906. His livestock would have depended on the Cheyenne River for water during most of the year. This part of the county remained thinly settled until after the railroad crossed the Missouri at Pierre in 1905 when settlement was rapid and the days of free grass were over. The horses trailing down the riparian bottomland of the creeks had beat out the grass and according to Louis Young, another settler from the early 1890s, the gullies started in the trails of the horses. Destruction was rapid in the highly erodible soils, and when the gullies were deep enough to cut through the gravel beds to the bedrock shale, destruction of the riparian areas was complete.

Wind erosion was especially severe during the Dust Bowl on the silty soils of the flats on the Home Place and on the uplands of the Maupin and Bursch parcels, most of which had been farmed. The overgrazed pastures on the flat land also lost much of their topsoil to the wind. Disc marks could be seen on the alluvial soils as the wind blew all of the loose soil from the land. Wind erosion also occurred on the shallow and very shallow soils. The bare ridge tops lost their thin topsoil, and when the wind reached the bedrock shale it dried and blew just like fine sand. When riding across these areas on horseback in a high wind, one's face was stung by the small pieces of shale. These most fragile of soils are still in the early stages of recovery and many centuries will pass before they achieve their former health. We are only now getting a glimpse of what they may have once looked like and the grass cover that clothed and protected them.

The loose piles of soil that formed during the Dust Bowl were ideal places for small, burrowing mammals to live and to eat the seeds of annual weeds that choked the abandoned farmland and abandoned pastures. Prey species responded quickly to the abundant food resources by the early 1940s. Coyotes ran in large packs and birds of prey and rattlesnakes were numerous. Deer and pronghorn antelope were missing; skulls of both species were scattered around the abandoned homesteads. It was evident that they had been food for hungry people. During the next decade white-tailed deer moved into the timbered river bottoms. A few antelope had survived in the nearby Crockett Mountain area and were the nucleus for a recovering herd.

The heavy weed cover on abandoned fields favored Sharp-tailed Grouse, Greater Prairie Chicken, and Ring-necked Pheasant numbers. All three species flourished through the 1940s, but tough winters and the return

Table 3. Unintended ecological consequences of 1080 poison on the Mortenson Ranch in the mid-1950s.

Clarence described the chain of events that followed 1080 poisoning of some of their prairie dog towns: "Within three days we found six or seven coyotes dead near the dog towns. No prairie dogs survived in the poisoned areas; the ground was covered with the dead. But whatever mammal or bird ate another that had been poisoned was poisoned themselves. We had heard that the poison would kill seven times. Within a year our bird population was decimated. Magpies and a small sub-species of crows that nested on the ranch, as well as other flesh eating birds, disappeared. All meat-eating mammals disappeared: coyotes, bobcats, badgers, skunks, raccoons, mink and others of which we were not aware. Unknowingly we had started a killing spree that would last for years. The poisoning was encouraged/promoted by sheep growers and carried out by government trappers in surrounding counties to kill coyotes. The method of poisoning was to intra-veniously inject a live horse with 1080 which would kill the horse, but before it died, poison would be carried to all parts of its body. The horse was then cut into small pieces and the meat scattered by vehicles or airplanes over the countryside. Even though I didn't allow this to be done by the government on the ranch, we found dead animals on our land near the exterior fences. The boundaries had been flown and baits thrown out.

The consequences were an explosion of rodents and secondary disastrous effects on recovering woody vegetation. Within one year (1956), the region that had been depopulated of predators was overrun with rabbits, both cottontails and jackrabbits. For several winters in a row, we could go out every night and shoot a pickup box full of jackrabbits, about 50 of which we sold for 25 cents each to pay for the ammunition and gas used. Deer and pronghorn populations also boomed. By the 1960s we were wintering 100 mule deer and 300 pronghorns. The first predators to appear were red fox, unknown to the ranch before that time. Soon all of the pre-1080 predators returned, but red fox have not been seen since. Avian predators were much slower to recover. It wasn't until the 1990s that magpies and hawks returned to nest. The small species of crows has not returned.

During the period of exploding rabbit, deer, and pronghorn populations, we were trying to re-establish trees and shrubs to areas where they grew before homesteading. With all of the browsing pressure from herbivores, especially rabbits, young woody plants had little to no chance to survive. It was disheartening to see seedlings appear and then to see them stripped of their bark and dead in a year or two. We lost the years from the mid-1950s to the late 1980s to get trees and shrubs back on the ranch in woody draws and along stream courses. Fortunately, in the mid-1980s a virulent form of tularemia ended the rabbit problem in a few short weeks. The deer and pronghorn problem has been solved with the return of a healthy coyote population, occasional severe winters, and managed hunting. And trees and shrubs have flourished as the system has come back into balance."

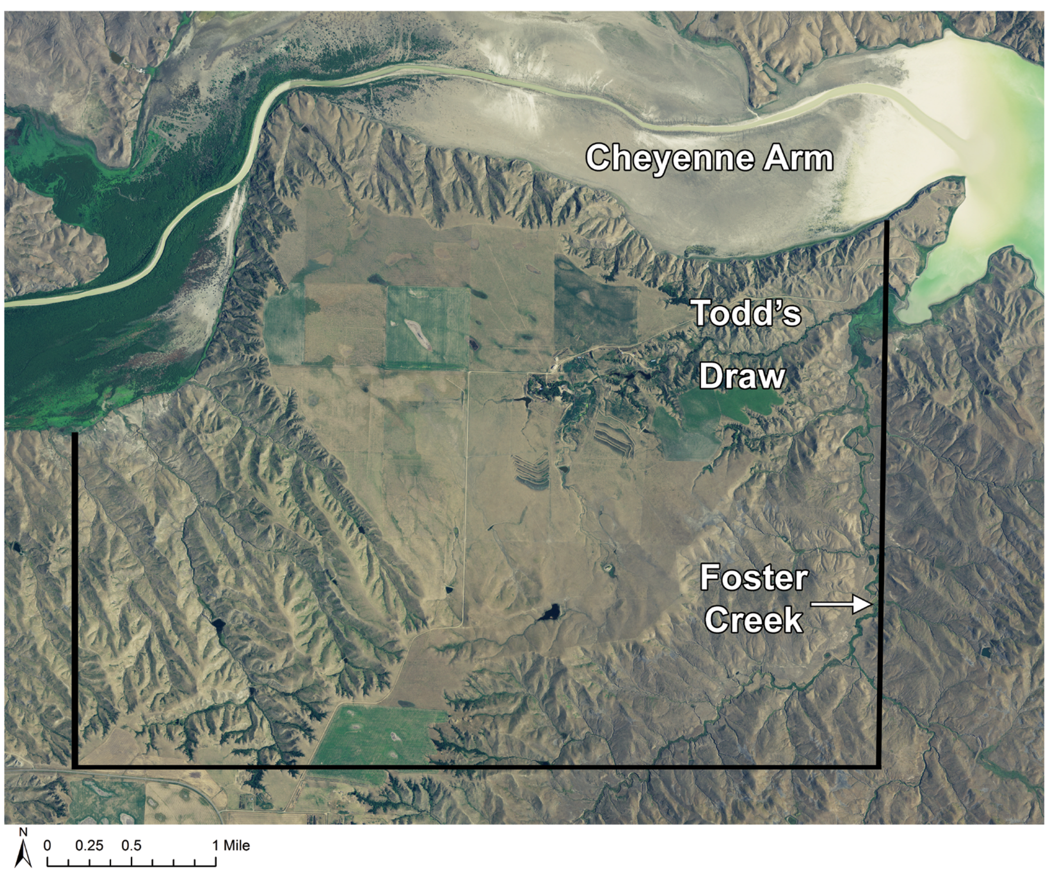


Figure 9. Aerial photograph of the property boundaries of the Mortenson Ranch Home Place. Image source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

Figure 10. Location of “speed bump” dams in Todd’s Draw on the Mortenson Ranch Home Place. Image Source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

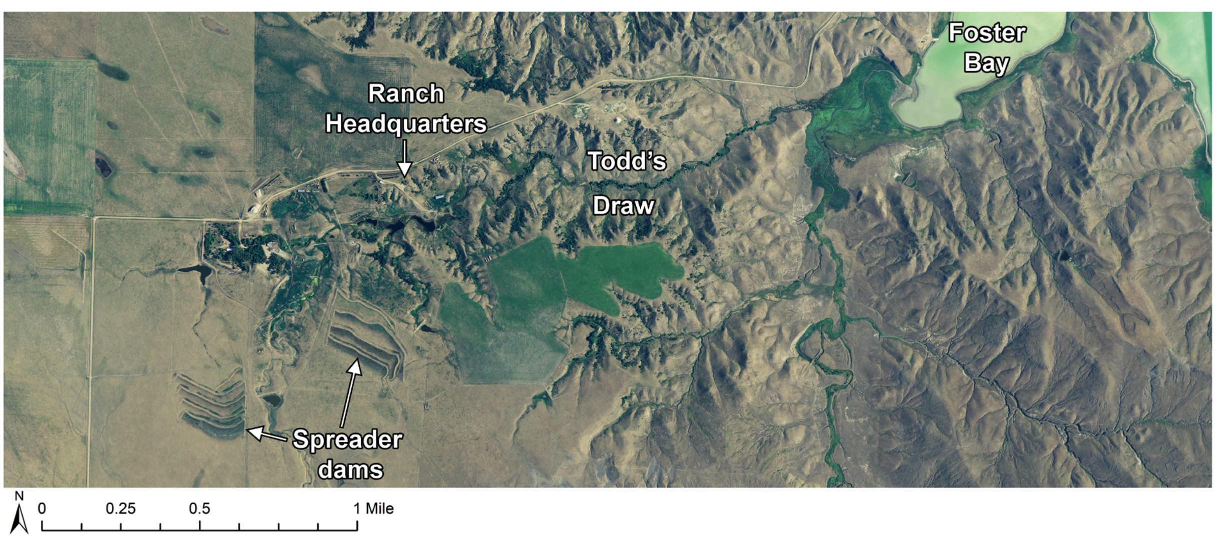


Figure 11. Aerial photograph of part of the Mortenson Ranch showing location of Todd’s Draw, spreader dams, and ranch headquarters. Image source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

of grass to the weedy fields knocked out pheasants. Prairie dogs found the sparse grass cover on the alluvial flats ideal habitat. Six prairie dog towns occurred on the ranch by the early 1950s when government agencies began promoting the use of 1080 poison, a deadly organoflourine chemical labeled as a rodenticide. Unintended consequences of the wide use of 1080 are described in Table 3.

RANCH RESTORATION

Slowing Water

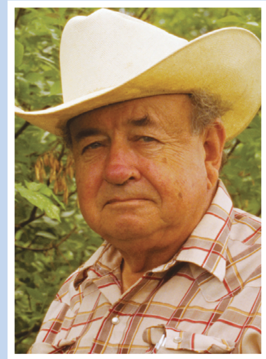
Water erosion was a major problem following homesteading. The 1940s were among the wettest decades of the 20th century, and the bare soil washed away in the heavy rains and snowmelt runoff. Gullies cut back as the head cuts advanced up the water courses; grazing was severely affected because cattle sometimes had to travel a half mile to get around a deep draw. Some gullies got started during this wet period from erosion on wagon trails between homesteads and Marion Spring that was a reliable source of water for household use.

Gullies on the ranch were sore spots that needed healing. Accelerated rates of soil erosion in drainages probably started during the fur trapping days and worsened during homesteading when the land was overstocked and cultivated. A landscape that once functioned more like a sponge by slowing the movement of water and allowing it to soak into the ground recharging shallow and deep aquifers, was now producing massive amounts of surface runoff and soil erosion. Clarence knew that loss of soil and water from the ranch was economically consequential and its continuation would make ranching marginal at best. He adopted the management goal that every drop of water that falls on the ranch should stay on the ranch to support plant and animal growth and human needs.

To make progress toward this goal, many operational changes would need to be made. Four were the most important: (1) reduce runoff in uplands by re-configuring pastures and adopting a rest-rotation grazing system; (2) rebuild floodplains and shallow aquifers associated with deeply eroded streams and creeks by building dams to slow water and capture sediment; (3) improve the biodiversity of an impoverished grassland vegetation using local ecotypes of native plant species that are best adapted to protect land by surviving through natural disturbances and weather extremes; and (4) adopt a comprehensive management approach whereby all working parts of the ranch (environment, soils, vegetation, cattle, economics) are considered to be connected and must be managed together as a unit. This approach is now called "holistic management," named by its founder Alan Savory, but was put into practice by Todd Mortenson before the concept became popular. Formalization of the concept by Savory, however, has given the Mortensons and other progressive ranchers a "handle" by which to describe their approach to managing all facets of a large ranch in synchrony.

Re-building Floodplains with Small Dams

Two valleys on the ranch drained by streams (Todd's Draw, Foster Creek Watershed) had undergone excessive erosion and gulley formation. Both streams flow into what is now Oahe Reservoir (Cheyenne Arm) and were early priorities for restoration (Figure 9). The head cut in Todd's Draw



"There is no one part of the whole broad picture that can be isolated as more important than another. A goal is to put the entire picture together. The process has been similar to building a puzzle without having the picture on the box to go by. Though close to complete, there are still a few pieces missing."

– Clarence Mortenson

"Trees were hand planted along Todd's Draw in the 1950s and were surviving until 1961 when a severe drought killed all of them. I'd become plumb discouraged with planting; I had other things to do. It became obvious that without water development and the scattering of seeds where there were no parent plants the woodies would never come back and stay."

– Clarence Mortenson

was of particular concern because it was advancing near the gravel beds (former Cheyenne River channels) atop the shale that served as an aquifer draining 2,000 acres of land. Several dams (Figure 10) were constructed to slow runoff and divert it into the underground gravels rather than above ground through the stream course. Some of these dams held, some cut through and were rebuilt, and some filled with sediment. A spreader dam system (Figure 11) was added later to hold back more water from the upper watershed and give it time to leak into the gravels below the larger dams. The eventual outcome of this dam building during the late 1940s and 1950s was to direct more water underground than through the stream in Todd's Draw as a means of slowing or altogether stopping the gullying and keeping the groundwater on the ranch longer to support plant growth in riparian areas. Clarence had learned from experience that trees along the streams cannot survive dry years unless the streamside aquifers are restored. Trees hand-planted throughout the 1950s along the stream all died during a dry period in the late 1950s that ended in 1961, a year with almost no moisture. This system of dams has worked so well that today very little water flows down Todd's Draw that has not moved through the gravels. Moreover, the success of the small dams became evident in the early 1970s as trees and shrubs began to cover the banks, and wetland plants such as cattails and prairie cordgrass became established on the once scoured bottoms of the water course.

Once Todd's Draw was clearly on the mend, attention in the 1980s turned to Foster Creek. It had remained a sore spot on the ranch with its dense clay soils devoid of any vegetation except prickly pear cactus and sagebrush. Its banks were vertical and the bottom scoured to shale during every runoff event. In 1942, while looking down into the deep gullies on Foster Creek without a tree in sight for miles, Clarence recalled a conversation with Louis Young, one of the first homesteaders in the area. Louis recalled "Young man, when I came here this creek could be crossed at a trot with team and buggy anywhere; it was tree-lined and grassy-bottomed and it had a water hole that never went dry about every mile and the grass was belly-deep on a team of horses." At that moment, Clarence promised himself to do what it would take to restore Foster Creek to its pre-homesteading condition, for both environmental and economic gain.

The first dams were built on Foster Creek in the mid-1980s with the goal of filling gullies and rebuilding the floodplain and adjacent aquifers (Figure 12). Building dams for the purpose of capturing sediment and to leak slowly to sub-irrigate riparian vegetation was not approved of by the Soil Conservation Service (SCS) at first. The main purpose of SCS funded dams then was to hold water tightly to water stock and provide wildlife habitat and recreation opportunities (fishing and hunting). Hence, the first two dams were paid for by the Mortensons. In 1993, the SCS reconsidered and developed a cost-share plan to help build more dams on Foster Creek.

The first dams did their work in a few short years. Both dams filled with mud up to 15 feet deep at the grade and created habitat for the germination of thousands of cottonwood and willow seeds. The deep gullies of that portion of Foster Creek would no longer drain the groundwater

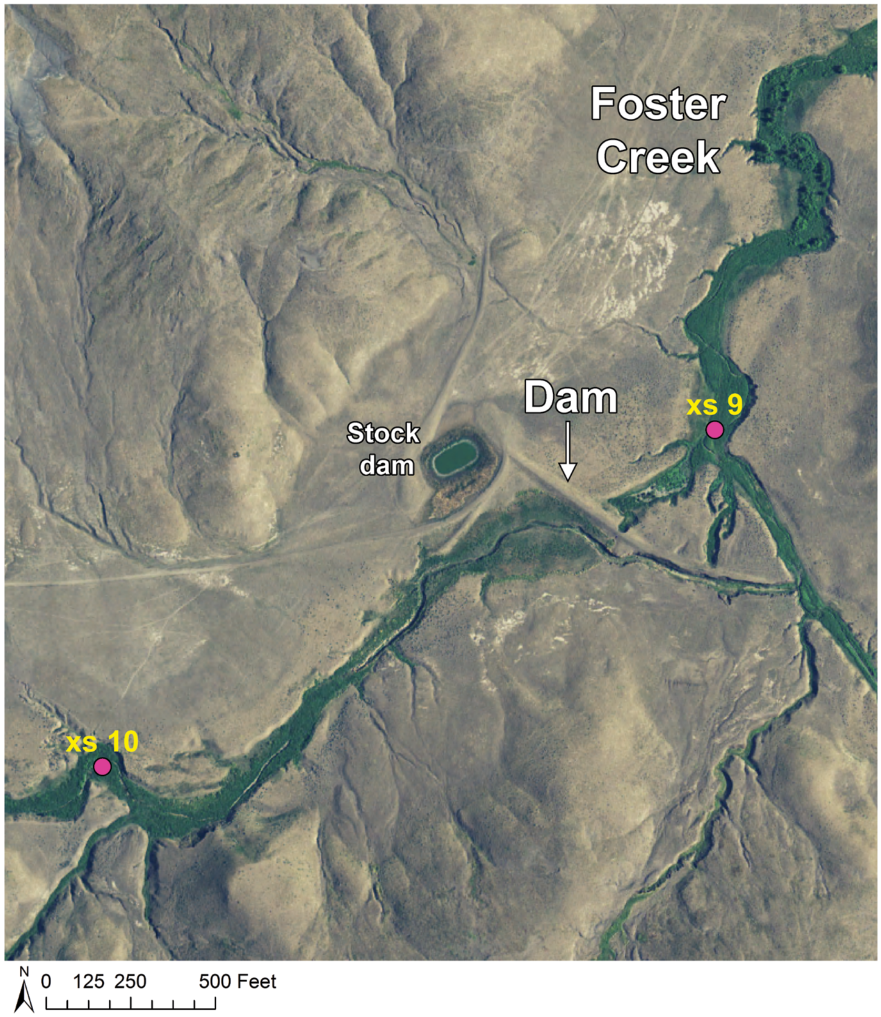


Figure 12. Close-up aerial view of two cross section locations, one silt-collecting dam, and a stock dam along Foster Creek on the Mortenson Ranch. Image source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

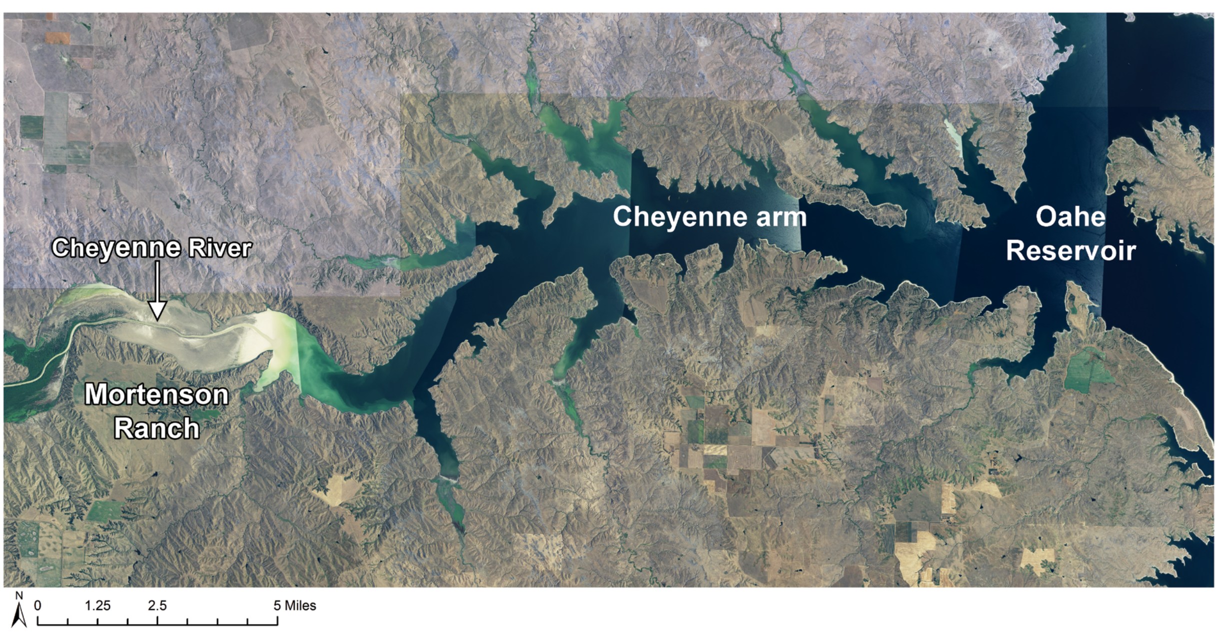


Figure 13. Location of the Mortenson Ranch headquarters in relation to the lower Cheyenne River and the Cheyenne Arm of Oahe Reservoir (Missouri River). Image source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

Figure 14. View of the Cheyenne River delta (September 2008) looking west from the Mortenson Ranch Home Place during low water levels of Oahe Reservoir. The Cheyenne River channel is in view along with scattered trees. The vegetation matrix is primarily sandbar and peachleaf willows.

Figure 15. View of the Cheyenne River delta (July 1997) looking west from the Mortenson Ranch Home Place during high water levels of Oahe Reservoir. Most established vegetation is either dead or dying from prolonged submergence.

Figure 16. Sample of what the Cheyenne River bottoms of the Mortenson Ranch looked like before being flooded out by Oahe Reservoir. This photograph taken in July, 2002 shows the Cheyenne River floodplain far enough upstream of the Oahe Reservoir to not be affected by it.

from the fringes of the floodplain and send it ahead of schedule with a heavy silt load to the Missouri River. Rather, the dams would re-build the floodplain close to its original elevation and sub-irrigate desirable plants by backing up groundwater moving towards the channel from the uplands. The higher, newly sub-irrigated floodplain surfaces would also promote the growth of western wheatgrass on the clay flats, a highly palatable forage plant well-known to ranchers to quickly put weight on young beef cattle. The dams built later followed suit. They also filled with silt over the next half decade, and water again moved through the gravel beds in the riparian zone.

The reader may wonder where all of this sediment (mud) to fill the dams came from. Most originated from public (Bureau of Land Management) and private (non-Mortenson) land higher in the watershed that was overgrazed. In a strange sort of way, the Mortenson Ranch needed the soil eroded from land managed poorly to successfully raise and restore their portion of the floodplain adjacent to Foster Creek.

Arrival of the Big Dam

The northern boundary of the Mortenson Ranch Home Place forms a rugged border with the Cheyenne River and its broad floodplain. Extensive cottonwood and willow dominated forest occurs on the floodplain for a hundred or more miles upstream to near the Black Hills. These mature cottonwood forests have trees several feet in diameter and nearly 100 feet tall, and as such, are used by ranchers up and down the valley to provide critical shelter for stock during the winter and during spring calving season. It was no different for the Mortenson Ranch until their timbered bottomland, hay meadows, and calving facilities, totaling about 1,500 acres, were flooded by water backed up by Oahe Dam, completed in 1958. The portion of the valley adjacent to the ranch that is intermittently flooded is called the Cheyenne Arm of Oahe Reservoir (Figure 13).

The pre-dam Cheyenne River forests at the ranch were all killed by the reservoir water, as was the use of the floodplain as protective shelter for cattle. Because water levels in the reservoir vary by as much as 40 feet between periods of drought and deluge, and that the ranch occurs near the maximum pool level of the reservoir, their former bottomland dries out occasionally. During the dry periods, dense riparian vegetation including young cottonwood and willow trees re-establishes (Figure 14). However, this new growth is flooded and destroyed once the reservoir recovers to full pool levels (Figure 15). In short, this long reach (37 miles) of the Cheyenne River floodplain, that has been re-constituted into an alluvial delta has collected over 50 feet of sediment in lower sections (Volke et al. 2015). It no longer reliably provides the shelter for domestic stock, wildlife, and human occupation that it did in the past (Figure 16).

Once it was apparent that spring calving operations would no longer be possible on the Cheyenne River floodplain, plans for replacement habitat on the ranch were worked out. This need strengthened Clarence's resolve to restore protective riparian woodland, including cottonwoods and willows, to the streams in Todd's Draw and lower Foster Creek, areas that are protected from the strongest winds and adjacent to or near

"This gentleman Louis Young came here and squatted before the homestead days when it was a pristine area about 1890 or shortly thereafter. I met him when I was 12 years old and was riding that country; I used to stop and get a drink of water from him. Nothing that he described to me was still there."

– Clarence Mortenson

"The channel [Foster Creek] at that time was very narrow and steep-sided, the banks were vertical, no vegetation grew in the creek bed. Following a heavy rain, the channel would be almost bank-full and huge chunks of soil continually fell into the current and were dissolved and carried away."

– Clarence Mortenson

current ranch operations (hay yards, corrals, ranch house, out buildings). Another part of the plan was to encourage regrowth in the woody draws of Todd's Draw. Getting woodland back in both riparian and upland locations would create an ideal area for winter use by cattle and spring calving on the ranch.

A first step in the plan was to exclude summer-long grazing in woodland or in areas that could potentially support woodland, such as the rebuilt areas of the floodplain along Foster Creek. For woodland to expand and thicken, young trees and shrubs would need to be protected from trampling, browsing, and rubbing by cattle during the growing season. Journal notes from explorers, letters from and recorded conversations with early homesteaders, notebooks from original land office surveys, and beaver pelt inventories all support the conclusion that woodland was a natural and important part of the grassland vegetation of this region. Hence, it should grow back and persist if the forces that destroyed it initially, such as overgrazing, cutting, and erosion by wind and water, are reduced or eliminated. Step two would require monitoring of the woody plant community to determine if the new cattle management plan is building a healthy, resilient, and expanding woody plant community along streams and in woody draws. Step three would be to evaluate the plan and make adjustments as needed to reach the goal of creating sufficient replacement protective habitat for spring calving to replace that lost under Oahe Reservoir.

RESEARCH AND MONITORING

Links to SDSU

Consultations between the Mortensons and faculty from South Dakota State University began in the late 1950s and early 1960s when range classes taught by Professor Tex Lewis toured the ranch to observe the improvements taking place. Most certainly, these visits produced an active exchange of information in both directions that helped fine-tune grazing management plans on the ranch and educate students and Tex on novel restoration approaches that were being tried out by Clarence at the time. As far as is known, no quantitative data were collected by Tex or his students. This changed when Dr. Robert Gartner met Clarence in the late 1970s when they planned collaborative studies that aimed to quantify both the successes and failures of ranch management in preceding decades: what worked and what did not work. This collaboration produced analyses of stocking rate and land value histories, both of which increased over time when fencing and other grazing management changes were made and the landscape continued to recover from the homesteading days. In short, as the grass improved the land became more valuable and supported higher densities of cattle. Stocking rates, cash rent, and land value for the ranch nearly doubled between 1960 and 1996 (Boettcher et al. 1998). Stocking rates increased by 17 percent over a 10 year period (1986-1995) (unpublished data, Robert Gartner).

Foster Creek Restoration Project

Once the new grazing plan was successfully underway (Figure 7), attention turned to seeing if the land in Todd's Draw and lower Foster Creek used for winter pasture and spring calving was achieving the desired results. To evaluate progress, two studies were initiated, one called the "Foster Creek

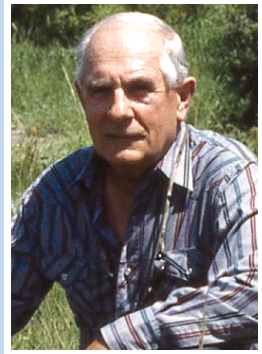
Riparian Demonstration Project" (short title: Foster Creek Project) by the North Central Resource Conservation and Development Association (NCRC&DA) together with the SDSU Cooperative Extension Service, and another called "Monitoring restoration progress of woody vegetation along streams and in woody draws at the Mortenson Ranch, SD" (short title: The Woodland Restoration Project) by the SDSU Agricultural Experiment Station (McIntire-Stennis Program). The geographic focus of both studies was the heavily-gullied portion of Todd's Draw and lower Foster Creek that were being converted over to specialized seasonal usage: winter pasture and spring calving.

The Foster Creek Study was jointly funded by state and federal agencies, principally the Environmental Protection Agency (EPA), Natural Resource Conservation Service (NRCS), and the South Dakota Conservation Commission. Dr. Robert Gartner was a co-investigator with the project coordinator (Paul Ingle). The study period was from 1993-1996 (some components extended through mid-1997). The objectives of the study were to:

1. Measure and evaluate the effect of the dams installed in Todd's Draw and on Foster Creek on the water volume and quality (sediment load) reaching Oahe Reservoir.
2. Determine whether (a) deferred summer pasturing along Foster Creek improved grass cover and reduced the amount of bare soil, (b) the planting of trees along Foster Creek could be successful, and (c) cut banks along Foster Creek could be stabilized by planting fast-growing willow trees.
3. Increase awareness of the benefits of healthy streams and riparian areas by (a) inviting ranchers/farmers to attend a course in Holistic Resource Management, and (b) by project personnel presenting the findings of this study at conservation-oriented conferences and meetings in central and western South Dakota.
4. Determine if improvements in the environment of the Foster Creek Watershed lead to increased land values and productivity.

The final report of the Foster Creek Project (NCRC&D 1997) concluded that:

1. Sediment yield to the Missouri River was dramatically lower (174 fold less during a large flow event) from Todd's Draw, a tributary of Foster Creek, than from the lower section of Foster Creek itself. Todd's Draw was much farther along in the restoration process than was Foster Creek. These results indicate that the series of dams in Todd's Draw was having the desired effect of trapping sediment, reducing bank erosion, and slowing the siltation of the Foster Bay portion of Oahe Reservoir. Knowledge of the effectiveness of the dams in Todd's Draw was a hopeful sign that the newer dams on Foster Creek may show similar results over time.
2. Establishment in 1994 of 20 stream cross sections and re-measurement of a portion of these (12 of 20) after three years by the NRCS Grazing Lands/Wetlands Regional Technical Team following a major flood showed that dam building on Foster Creek had initiated floodplain aggradation by an average of eight inches



"It is evident that the vegetation along Foster Creek has changed from undesirable species (cactus, annual grasses and forbs) to favorable forage grasses (western wheatgrass and green needlegrass) as a result of the rebuilding of the floodplain."

– Dr. Robert Gartner

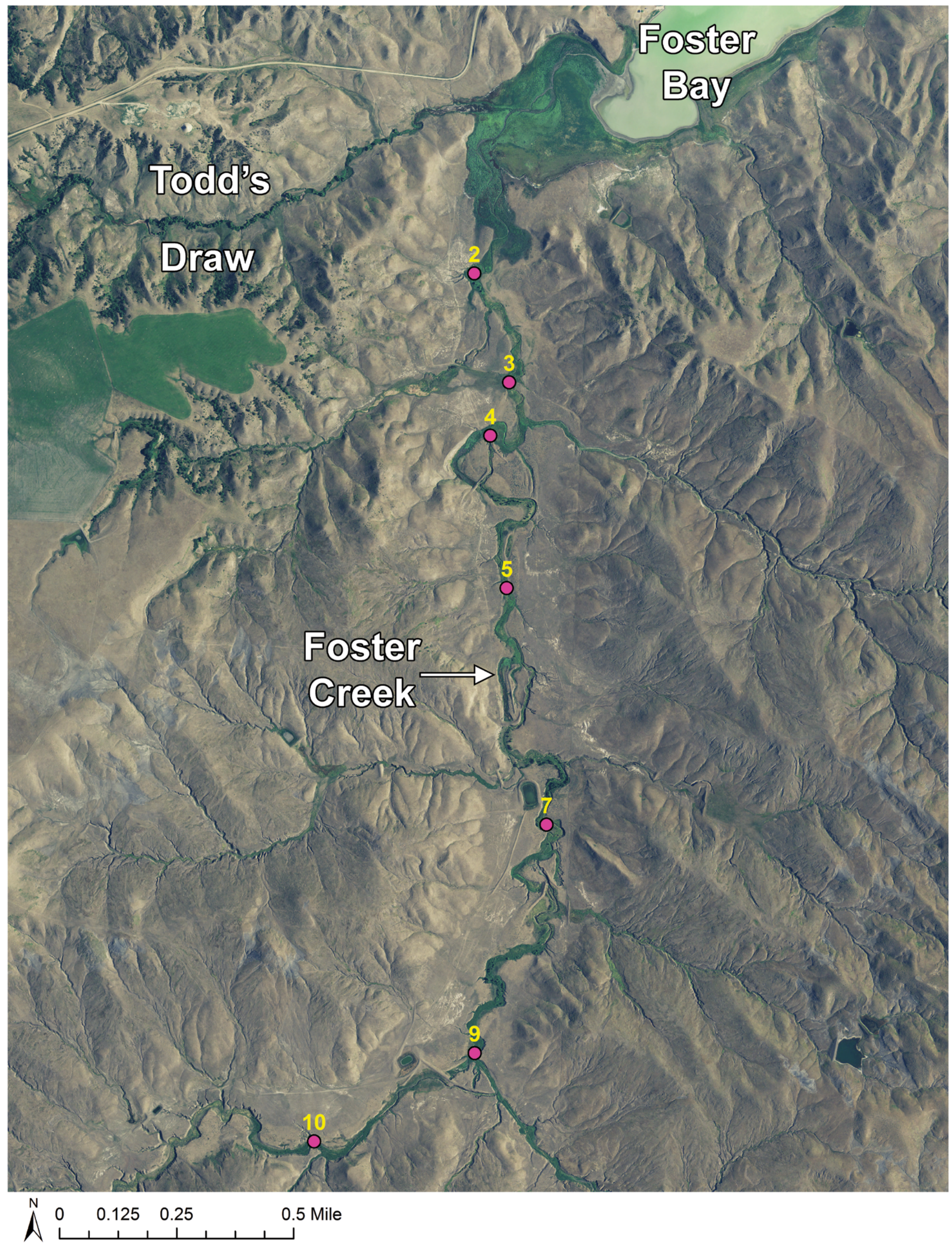


Figure 17. Location of Foster Creek on the Mortenson Ranch and the stream cross sections re-measured in 2004 and analyzed in this report. Image source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

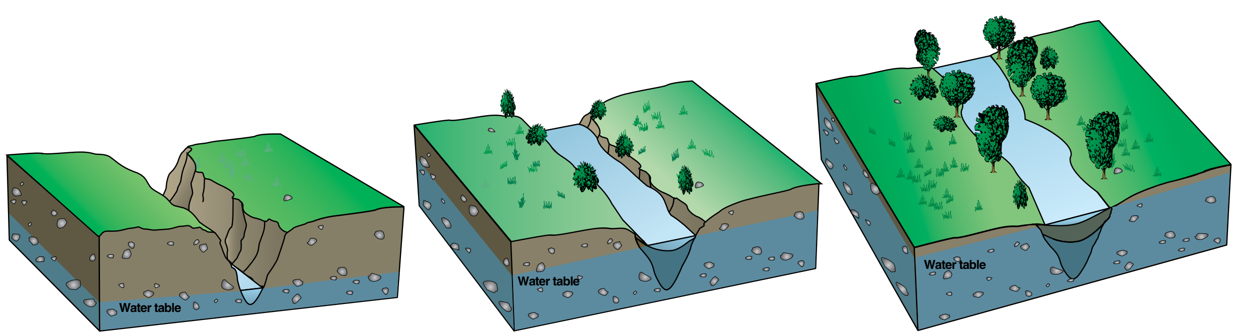


Figure 18. Process of riparian zone healing. Dams and new vegetation collect sediment and raise the floodplain back to pre-gullying levels. This rebuilds the streamside aquifer and enables woody vegetation to survive during droughts.

(range among cross sections was 1-34 inches); restructuring of the floodplain and spreading out of stream water also was thought to have caused the measured increase in the cover of western wheatgrass by 472 percent and the cover of warm season grasses by 131 percent over a three year period; rapidly expanding cover of prairie cordgrass, a rhizomatous, soil-binding, warm season grass also was observed along the new channel and adjacent floodplain.

3. Tree and shrub densities increased along Foster Creek from planting and from natural reproduction. While the trends observed during the NCRC&D study were going in the right direction, rebuilding the severely damaged floodplain of a very flashy stream is a slow process; the shortness of the study was insufficient to claim ultimate success.

Foster Creek: Is Restoration Working?

Re-measurements of a sub-set of cross sections on Foster Creek (Figure 17) were conducted in 2004 by Dr. Carter Johnson, research associate Craig Olawsky, and Jeff Mortenson to see if firmer conclusions could be reached about the success of the sediment-trapping dams to raise the floodplain and restore function to the Foster Creek riparian area as diagrammed in Figure 18. Thus, the most recent measurement of seven cross sections captured changes in the stream over an 11 year period (1993-2004). Relocation of all of the cross sections over a decade time period was not possible because not all of the end stakes, other markers, and reference elevation points could be found amidst the volatile sedimentary regime of Foster Creek. The original GPS coordinates for cross sections and elevation control points can be found in Appendix Table 1.

Data from the seven cross sections show a consistent trend of floodplain aggradation, and in many spots, elevation of the channel itself. For example, the depths of sediment accumulated since 1993 range from about 1.5-6 feet among the cross sections (Figure 19). Rates of sedimentation appear to be highest for most cross sections during the 1993-1996 period. The most sediment deposited during any period was for 1997-2004 (cross sections 4 and 9); however, this was the longest period of years. The flood early in 1997 did redistribute sediment in the channel and on the floodplain, but except for channel degradation in several of the cross sections the rate of change was not unusual. About half of the channels in 2004 were higher in elevation than in 1993, while about half were lower. Overall, the goal of raising the floodplain was met during the resurvey period. A massive volume of sediment (soil) was sequestered on the monitored floodplain of Foster Creek and held in place by expanding patches of wetland-adapted vegetation. The goal of raising the whole channel from past gullying and preventing new cuts from forming during floods, however, is not yet reached. Complete healing of Foster Creek appears to be a very slow process. Considerable improvements have resulted from the construction of sediment-trapping dams and reductions in runoff from the uplands. Monitoring of progress, or lack thereof, should be continued in the future.

The goal of restoring a tree-lined channel to Foster Creek also has not been reached. However, there are scattered patches of cottonwoods and willows along the creek (Figure 20a,b), and seedlings of these trees

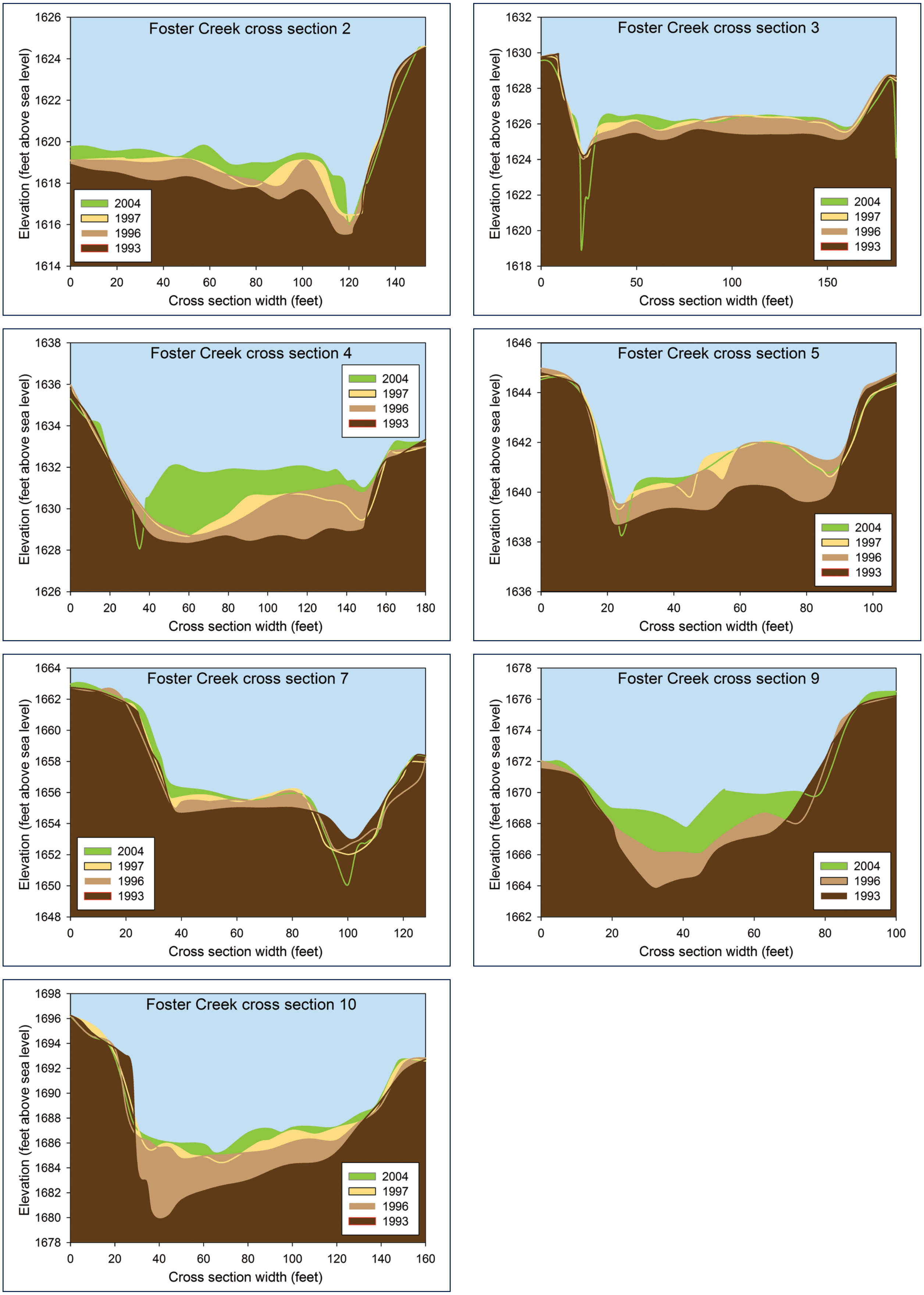


Figure 19. Re-measured cross sections along Foster Creek showing changes in sediment deposition and removal on the floodplain from 1993-2004.

Figure 20a,b. Vegetation established following dam construction and changes in grazing on the Foster Creek floodplain. Woody vegetation in (a) is dominated by cottonwood and willow trees; (b) is dominated by willows (Todd Mortenson checking progress).


Figure 21. Prairie cordgrass establishment along Foster Creek following rehabilitation work. Clarence Mortenson is standing next to a tall and dense sward.

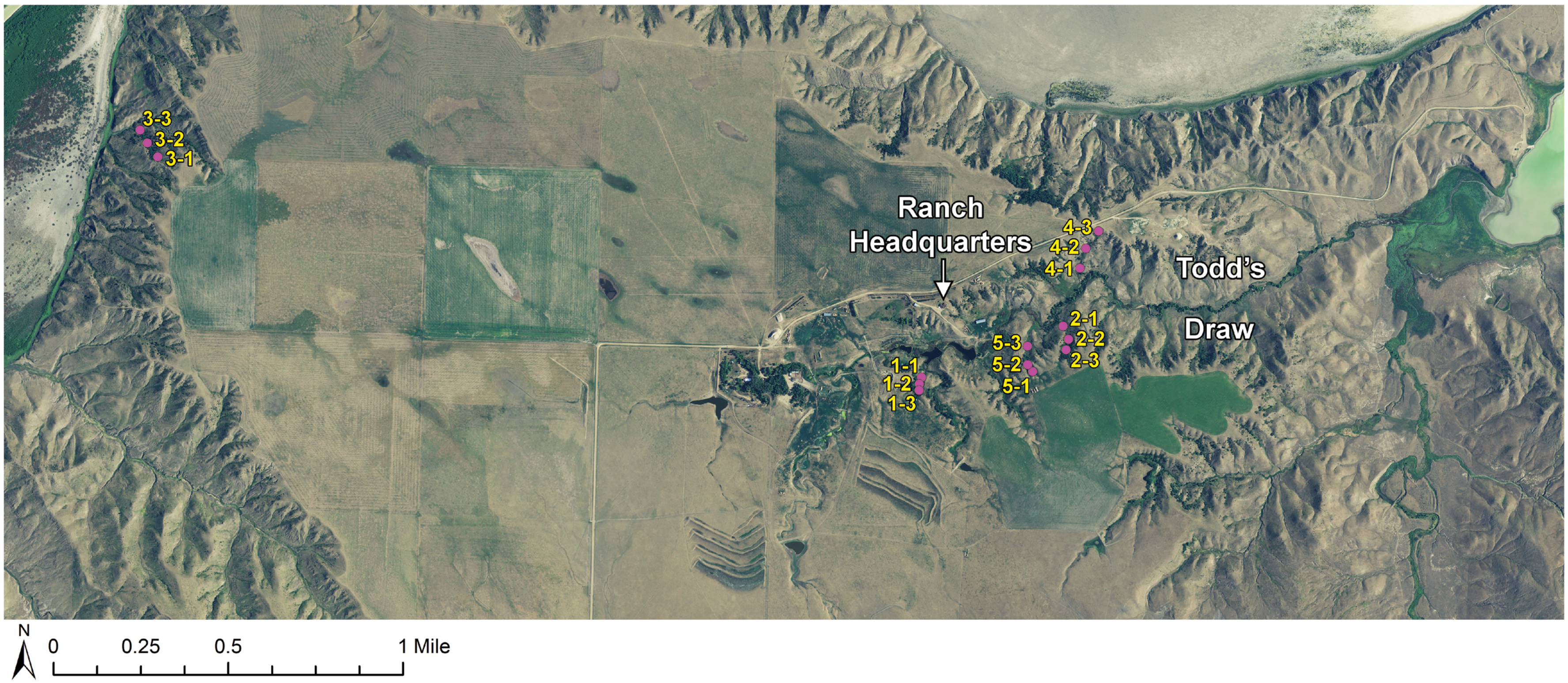


Figure 22. Aerial photograph of part of the Mortenson Ranch showing the location of permanent vegetation transects in woody draws. The first number of the pair is the site number; the second number is the transect number. Image source: U.S. Department of Agriculture, National Agriculture Imagery Program (2012).

have appeared along most reaches at one time or another. This indicates that the physical environment for germination and establishment has improved with the re-engineering of the channel. The absence of a more continuous and thicker stand of trees along the creek, however, appears to have three causes: competition with prairie cordgrass, physical damage of young trees by cattle during the non-growing season, and felling by beaver. Trees may have been a "victim" of the success of prairie cordgrass, a highly desirable, native wetland plant that spreads by rhizomes, holds soil tightly, outcompetes most other plants, and forms a thick mat or mattress of "hay" over the winter (Figure 21). These cordgrass mattresses insulate wintering herds of cattle while bedded down on frozen ground, significantly improving their energy budget and overall condition. In places where cordgrass dominates, trees do not have much of a chance to grow large enough to escape physical damage from cattle and to compete with cordgrass for nutrients and light. On the other hand, cordgrass also captures sediment during floods by adding surface roughness and helping the ranch managers to reach their other goal to build-up the floodplain, thus improving the long-term chances for trees to establish and survive and keeping more sediment out of Foster Bay and Oahe Reservoir.

Recovery of Woody Draws

Trees and shrubs began to grow back in the draws of the ranch after the Dust Bowl during the return to more favorable weather for woody plant establishment and growth and curtailed summer grazing. However, the first quantitative field data on the species composition, extent, and dynamics of woodland were not collected on the ranch until the early 1990s as part of the Woodland Restoration Project when permanent and re-locatable transects and plots were established (Figure 22). Two questions in particular were the focus of this research and monitoring effort: (1) is the woodland in draws continuing to grow and expand even with winter cattle use, and (2) is the new woodland resilient, i.e., will it survive and maintain its areal extent and biodiversity in spite of occasional droughts?

The five draws selected for study and monitoring were diverse in environment and vegetation. One was south-facing (warmest and driest environment) and sparsely wooded; one was west-facing (warm and dry); and three were north-facing (cool and moist). Four were in Todd's Draw and one was on a slope bordering the Cheyenne River floodplain. Trees, shrubs, and woody plant seedlings were first sampled along the three transects

Table 4. List of common and Latin names of woody species encountered along vegetation transects in five woody draws on the Mortenson Ranch.

Common Name	Latin Name
Trees	
American plum	*Prunus americana*
Chokecherry	*Prunus virginiana*
Cottonwood	*Populus deltoides*
Rocky Mountain juniper	*Juniperus scopulorum*
Green ash	*Fraxinus pennsylvanica*
Hackberry	*Celtis occidentalis*
Peachleaf willow	*Salix amygdaloides*
Shrubs	
Buffalo currant	*Ribes odoratum*
False indigo	*Amorpha fruticosa*
Skunkbush sumac	*Rhus aromatica*
Hawthorn	*Crataegus chrysocarpa*
Juneberry	*Amelanchier alnifolia*
Leadplant	*Amorpha nana*
Missouri gooseberry	*Ribes missouriense*
Poison ivy	*Toxicodendron rydbergii*
Woods' rose	*Rosa woodsii*
Silver sagebrush	*Artemisia cana*
Western snowberry	*Symphoricarpos occidentalis*
Woody vines	
Riverbank grape	*Vitis riparia*
Woodbine	*Parthenocissus vitacea*

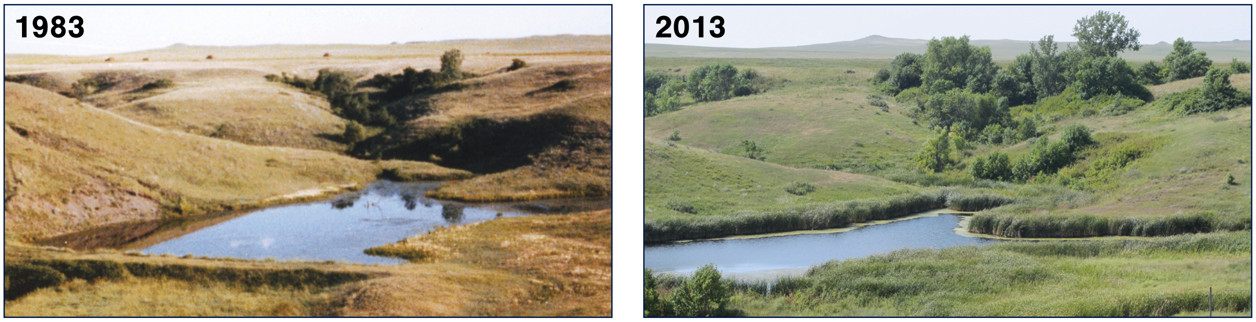


Figure 23a. Photographs of site #1 taken at two time periods, 1983 (left) and 2013 (right) on the Mortenson Ranch Home Place.

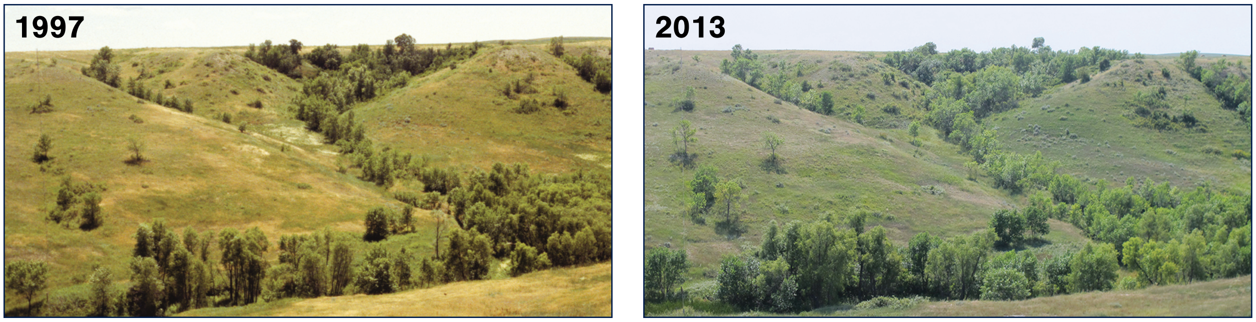


Figure 23b. Photographs of site #2 taken at two time periods, 1997 (left) and 2013 (right) on the Mortenson Ranch Home Place.

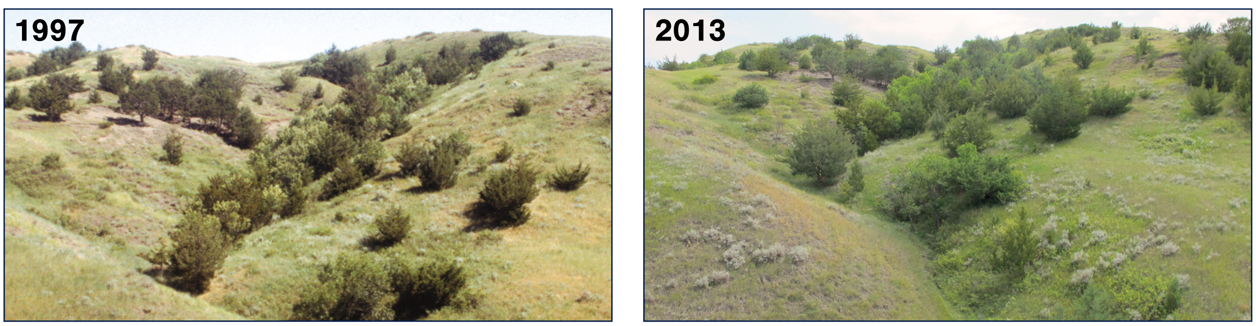


Figure 23c. Photographs of site #3 taken at two time periods, 1997 (left) and 2013 (right) on the Mortenson Ranch Home Place.

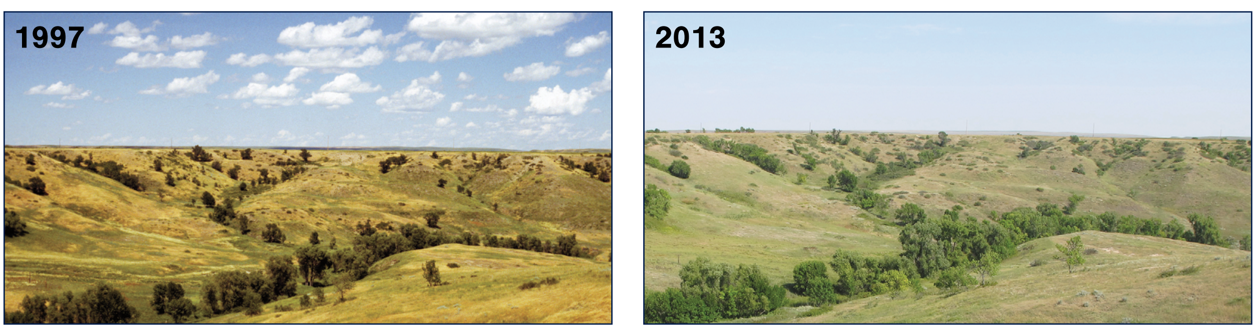


Figure 23d. Photographs of site #4 taken at two time periods, 1997 (left) and 2013 (right) on the Mortenson Ranch Home Place.

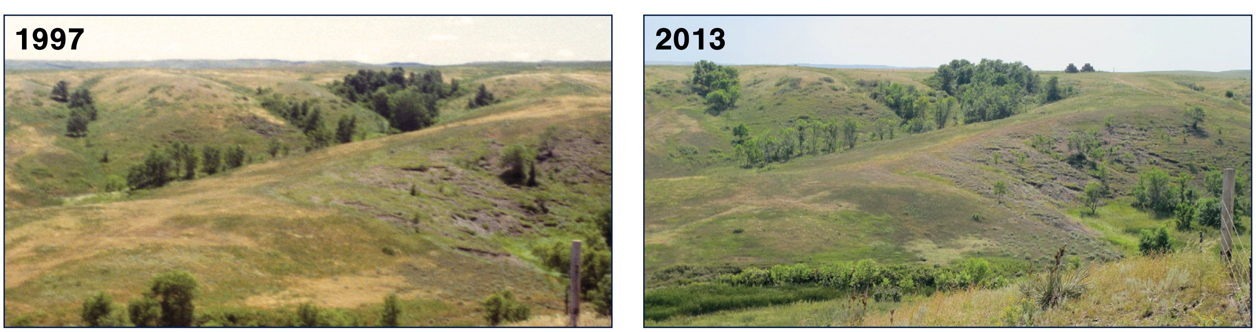


Figure 23e. Photographs of site #5 taken at two time periods, 1997 (left) and 2013 (right) on the Mortenson Ranch Home Place.

American plum

American plum

Chokecherry

Riverbank grape

Figure 24. Examples of wild fruit that grow in the woody draws of the Mortenson Ranch.

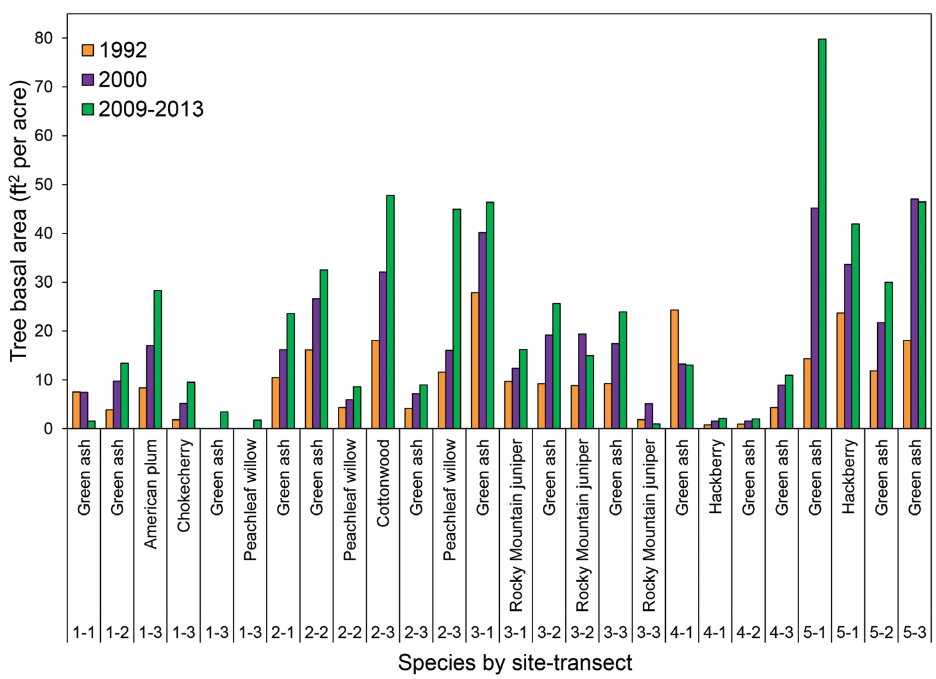


Figure 25. Wood volume (basal area) by tree species, site-transect, and sample date in five woody draws at the Mortenson Ranch (Home Place).

in each of the five woody draws in 1992-1994 using methods appropriate for each life form. Transect end and middle points were permanently marked with rebar pins and re-sampled twice at approximately seven year intervals. Photographs of each sampled draw were taken from permanent photo points at similar time intervals (Figure 23a-e). GPS coordinates for transects and photo points are provided in Appendix Table 2.

A total of 20 species of woody plants (trees, shrubs, woody vines) was encountered along the 15 transects (Table 4). Many of these are highly valued for their fruit (American plum, chokecherry, juneberry, buffalo currant, riverbank grape, and Woods' rose; Figure 24). Riverbank grape, in particular, is sought after for juice, wine, and jelly. The diversity of woody plant species that occurred along the transects changed little during the sampling period (1992-2013). Interestingly, all 20 species are native to the region. This stands in sharp contrast to the large number of undesirable, exotic plants that have invaded most parts of the United States.

Basal area (sum of the cross-sectional area of trees in the sample at 4.5 feet above the ground) is a simple measure of how much wood in living trees was present at each measurement. Wood volume could change over time in response to many factors: wet and dry weather cycles; mortality from drought, cattle rubbing, wind, lightning, fire; and from a lack of reproduction to replace trees that have died.

Green ash was clearly the dominant tree in woody draws (Figure 25). It occurred on all of the 15 transects. Rocky Mountain juniper occurred in and dominated only in draw #3, while cottonwood occurred only along one transect (#2-3). Hackberry occurred on two transects, one at each of 2 draws. Some individuals of chokecherry and American plum grew to tree size (>2.4 inch diameter) during the 20 year period.

The data from 1992-2013 show that basal area varied over time depending on the draw/transect and the species of tree (Figure 25). First, tree basal area to start with in 1992 was lowest in two draws: #1 and #4. Draw #1 is a small draw and #4 is south-facing (warm and dry). Tree basal area in draw #1 increased along most transects and for most species during the 20 year period. Gains were smaller in dry draw #4; ash basal area decreased along one transect. The remaining 3 draws (#2, 3, 5) were

Table 5. Average changes in woodland characteristics in five woody draws on the Mortenson Ranch (Home Place) from 1992-2013 based on data collected from 15 permanent transects.

Measure	Early 1990s	2000	2009-2013	Percent change (early 1990s to 2000)	Percent change (early 1990s to 2009-2013)	Percent change (2000 to 2009-2013)
Tree basal area (ft^2/acre)	17	31	39	+82	+129	+26
Tree density (trees/acre)	130	182	184	+40	+42	+1
Sapling density (saplings/acre)	326	510	397	+56	+22	-22
Seedling density (seedlings/acre)	52510	1745	1239	-97	-98	-29
Shrub cover (%)	42	59	47	+40	+12	-20

larger, deeper and more mesic since they face north. Trees along the large majority of transects in these draws increased sharply in basal area. For example, ash basal area on transect 5-1 nearly doubled; cottonwood basal area on transect 2-3 nearly tripled (Figure 25). Basal area did decline on a few transects for some species. After looking over the causes of the decline, we discovered that the few dead trees were sub-dominant trees shaded by much larger canopy trees. The dead trees showed no obvious causes of mortality such as bark scuffing, uprooting, mechanical damage, or disease; however, tree damage by beaver and porcupines has been observed on the ranch. We think this kind of mortality will continue at similarly low levels in the future because of natural thinning as the woody cover and shade in the draws gets denser.

To address question 1 above, there is now strong quantitative evidence from the field that the expansion of woody draws, observed qualitatively by the Mortensons, has continued. Across all five draws, tree basal area increased by 118 percent during the 20 year period (Table 5). Tree density (trees per acre) increased by 38 percent. Rates of increase were larger between the first and second measurements than between the second and third measurements, suggesting that some factor may have slowed tree growth and expansion. The most likely factor is weather, since the second period included a rather severe dry period (Figure 2); however, the maturing woodland also may be approaching an equilibrium stage whereby the environmental limits of moisture and light do not allow further wood accumulation on the site.

The vegetation data further suggest that there is adequate reproduction "waiting in the wings" to replace the occasional tree that dies. The sapling densities were larger by a factor of 2-2.5 than were the densities of trees. But as with the tree data, the sapling densities rose during the first re-measurement period and leveled off or dropped during the second period. The causes of this pattern may be the same as for trees. Tree seedling data fall into a different pattern, with huge densities at the start and 30-40 fold reductions later. However, the much lower densities still are about four times greater than the densities of saplings. The huge initial densities may have been stimulated by wet conditions in 1993 (Figure 2), the year that sampling was carried out on most transects. Moreover, field records show that nearly all seedlings sampled were first-year (i.e., produced in the year of sampling).

Biodiversity and Wildlife

A census of summer birds was conducted over a three-day period by ornithologist Bruce Harris on the Mortenson Ranch Home Place in June of 1997 to determine the diversity of the avifaunal community and how well it had recovered from the dark days of the Dust Bowl. Harris recorded about 70 species of birds on the ranch, including the shoreline of Foster Bay (Oahe Reservoir; Table 6). Clearly, his survey discovered a rich assemblage of birds, most of which would have been nesting. The expected grassland birds were present, such as the Lark Sparrow, Grasshopper Sparrow, Horned Lark, Bobolink, Western Meadowlark, Lark Bunting, and Dickcissel. Two uncommon grassland species prized by birders were recorded, the Long-billed Curlew and the Burrowing Owl. Large numbers of prairie grouse (Greater Prairie Chicken and Sharp-

"We're just trying to help the birds along and get back to that condition where we've got woodies all over the place in every area where they might be able to grow. The plums, the chokecherries, and that type of plant, the skunks, coons, and coyotes are doing a real nice job of planting them around the place for us."

– Clarence Mortenson

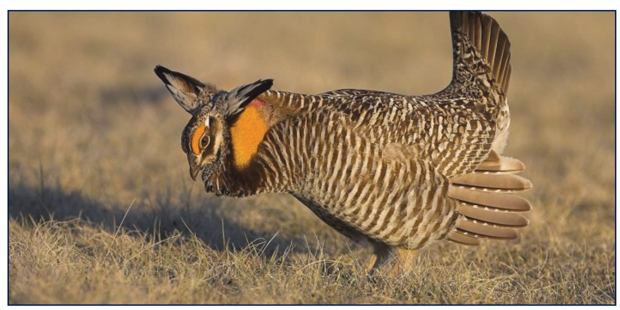
Table 6. Bird species found on the Mortenson Ranch (Home Place) over a three day period in June, 1997 (survey conducted by Bruce Harris).

- Anatidae (Waterfowl)
  - Mallard
  - Gadwall
  - Northern Pintail
  - American Wigeon
  - Blue-winged Teal
  - Hooded Merganser
- Phasianidae (Upland Gamebirds)
  - Wild Turkey
  - Ring-necked Pheasant
- Pelicaidae (Pelicans)
  - American White Pelican
- Ardeidae (Herons and Egrets)
  - Great Blue Heron
- Phalacoracidae (Cormorants)
  - Double-crested Cormorant
- Carthidae (New World Vultures)
  - Turkey Vulture
- Accipitridae (Hawks and Eagles)
  - Red-tailed Hawk
- Rallidae (Rails and Coots)
  - American Coot
- Charadriidae (Plovers)
  - Killdeer
- Scolopacidae (Shorebirds)
  - Upland Sandpiper
  - Spotted Sandpiper
  - Long-billed Curlew
  - Marbled Godwit
  - Wilson's Phalarope
- Laridae (Gulls and Terns)
  - Ring-billed Gull
  - California Gull
  - Franklin's Gull
- Columbidae (Doves and Pigeons)
  - Mourning Dove
- Cuculidae (Cuckoos)
  - Black-billed Cuckoo
  - Yellow-billed Cuckoo
- Strigidae (Owls)
  - Burrowing Owl
- Caprimulgidae (Nighthawk)
  - Common Nighthawk
- Picidae (Woodpeckers)
  - Northern Flicker
  - Red-headed Woodpecker
- Tyrannidae (Flycatchers)
  - Western Wood Pewee
  - Say's Phoebe
  - Eastern Kingbird
- Laniidae (Shrikes)
  - Loggerhead Shrike
- Vireonidae (Vireos)
  - Bell's Vireo
  - Warbling Vireo
- Corvidae (Jays and Crows)
  - Blue Jay
  - Black-billed Magpie
  - American Crow
- Alaudidae (Larks)
  - Horned Lark
- Hirundunudae (Swallows and Martins)
  - Northern Rough-winged Swallow
  - Barn Swallow
- Paridae (Chickadees and Titmice)
  - Black-capped Chickadee
- Troglodytidae (Wrens)
  - House Wren
- Turdidae (Thrushes)
  - American Robin
- Mimidae (Mockingbirds and Thrashers)
  - Brown Thrasher
- Sturnidae (Starlings)
  - European Starling
- Bombycillidae (Waxwings)
  - Cedar Waxwing
- Parulidae (Wood Warblers)
  - Yellow Warbler
  - Common Yellowthroat
- Emberizidae (Sparrows)
  - Spotted Towhee
  - Field Sparrow
  - Lark Sparrow
  - Lark Bunting
  - Grasshopper Sparrow
- Cardinalidae (Cardinals and Grosbeaks)
  - Black-headed Grosbeak
  - Blue Grosbeak
  - Dickcissel
- Icteridae (Blackbirds and Orioles)
  - Bobolink
  - Red-winged Blackbird
  - Western Meadowlark
  - Common Grackle
  - Brown-headed Cowbird
  - Orchard Oriole
  - Baltimore Oriole
- Fringillidae (Finches)
  - Red Crossbill
  - American Goldfinch
- Passeridae (Weaver Finches)
  - House Sparrow

Bobolink

Burrowing Owls

Dickcissel



Greater Prairie Chicken

Lark Bunting

Long-billed Curlew

Figure 26. Examples of summer grassland birds on the Mortenson Ranch Home Place. Photos courtesy of Doug Backlund.

Baltimore Oriole

Blue Grosbeak

Cedar Waxwing

Figure 27. Examples of summer woodland birds found on the Mortenson Ranch Home Place. Photos courtesy of Doug Backlund.

Common Yellowthroat

Red-winged Blackbird

Wilson's Phalarope

Figure 28. Examples of summer wetland birds found on the Mortenson Ranch Home Place. Photos courtesy of Doug Backlund.

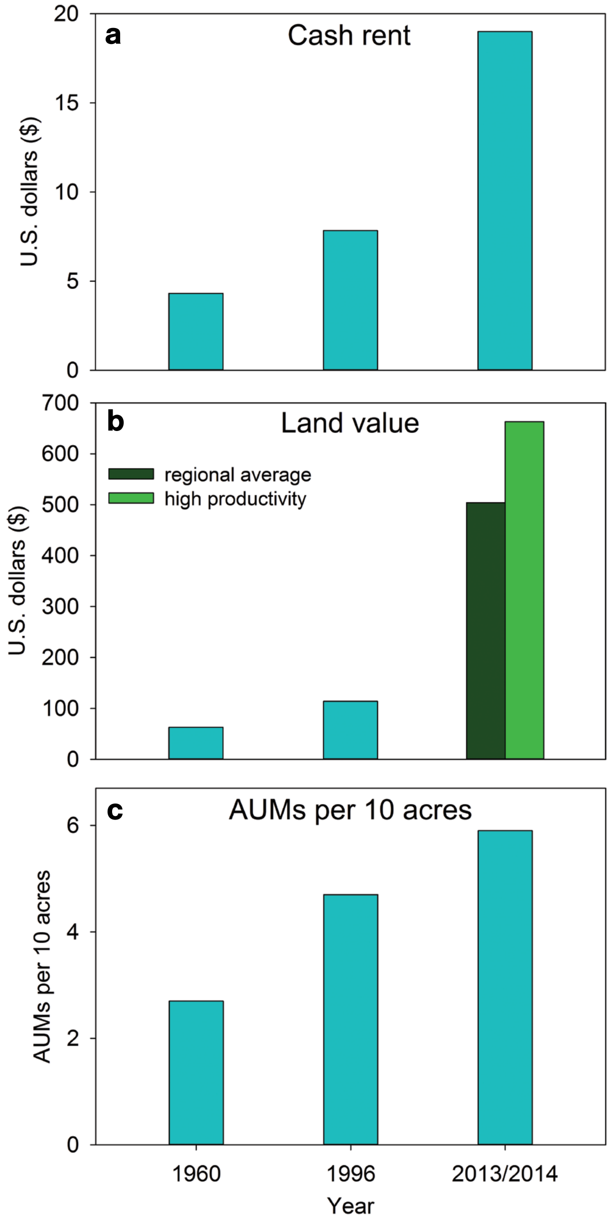


Figure 29a. Cash Rent per acre changes applicable to the Mortenson Ranch. The 1960 and 1996 data (averaged for the three ranch parcels) were from Boettcher et al. (1998). The basis for the 1996 cash rent estimate was $16.50 per AUM. The 2013 estimate was calculated using the basis of $32.15 per AUM (average of the southwest and northwest South Dakota survey regions from Janssen et al. 2014) and actual AUM values in Fig 29c.

Figure 29b. Land Value changes applicable to the Mortenson Ranch. The 1960 and 1996 estimates (averaged for the three ranch parcels) were reported by Boettcher et al. (1998); the 2014 estimate is the average of northwest and southwest South Dakota survey regions from data reported by Janssen et al. (2014) for average and high productivity native rangeland.

Figure 29c. Changes in Animal Unit Months (AUMs) for the Mortenson Ranch. The 1960 and 1996 data (averaged for the three ranch parcels) were from Boettcher et al. (1998). The 2014 estimate is based on the land's (16,840 owned acres) ability to carry 900 AUs during an 11 month grazing season, with protein supplementation (1 lb. "cake"/cow/day in winter).

tailed Grouse) and other species of birds were encountered during field work after the Harris survey (Figure 26).

Most noteworthy was the fact that about thirty species of woodland nesting birds were present on the same ranch where virtually all woodland had been destroyed by homesteading and drought six decades before. Some of these species require well-developed woodland or forest as habitat, such as the Black-headed and Blue Grosbeaks, Baltimore Oriole, Spotted Towhee, Red-headed Woodpecker, Yellow- and Black-billed Cuckoos and the Cedar Waxwing (Figure 27). Also, many of the woodland species on the list are Neotropical migrants that breed in North America but winter in the American tropics. A complete surprise was the discovery of a Red Crossbill with young. Birds associated with wetlands, riparian areas, and stock ponds also were numerous, such as five species of ducks, Upland and Spotted Sandpipers, Wilson's Phalarope, Yellow Warbler, Common Yellowthroat, and the Red-Winged Blackbird (Figure 28). Professional ornithologists rank this bird community in western South Dakota landscapes highly for diversity and numbers of summer birds. Spring and fall surveys would have greatly lengthened the bird list for the ranch, especially woodland birds such as vireos and warblers that nest in Canada and use woodlands as stopover habitat as they migrate through South Dakota each spring and fall. The abundance of fruit in the late summer and fall in the ranch's woody draws (Rocky Mountain juniper, chokecherry, American plum, riverbank grape) provides fuel and nutrition for many migratory bird species.

ECONOMIC PAY-OFF

Environmental improvements to the ranch, in the form of more productive and healthier grassland and better calving conditions, translate into more pounds of beef produced and more ecosystem services. Most ecosystem services are not monetized, yet contribute to the sustainability of the forage system and lead to profitability. For example, a grazing system that includes rest and rotation will increase pasture resilience via seed production, increased plant vigor and recruitment, and will lead to higher income. Likewise, the insulating blanket of native prairie cordgrass hay along Foster Creek is not worth much as winter forage, but will increase the winter survival of calves, improve the condition of cows, and raise ranch income.

Several measures can be used to estimate how the value and income potential of the ranch have changed in the past half century as affected by internal factors (e.g., environmental improvements, ranch management) and external factors (real estate and beef markets). The measures used here are: Animal Unit Months (AUMs), which quantify how much forage is available each month on a sustaining basis for one cow and calf unit; cash rent, an estimate of potential income should the ranch be rented; and land value, an estimate of potential income should the ranch be sold.

Cash rent per acre has increased by about fourfold since 1960 (Figure 29a). This increase was driven by both internal (AUMs) and external (supply and demand for land) economic factors. Internal factors were largely controlled by the Mortenson decision to restore the natural productivity on as many acres of their ranch as was possible. That goal and the hard work done to reach it added value to the ranch. Simply put, land with better grass raises AUMs that bring higher rental rates.

Much larger increases occurred in land value from 1960 to 2014. Value of land in the category and subregion closest to that of the Mortenson Ranch rose from $63 per acre in 1960 to $663 per acre (high productivity category) in 2014, an order-of-magnitude increase (Figure 29b). Again, both internal and external factors contributed to the increase. The difference between average and high productivity land value categories in 2014 was about $175 per acre. Much of this amount can be attributed to soils and the improvement of the productivity of the land.

AUMs, largely affected by internal factors such as environmental improvements and cattle management, also have increased since 1960, ranging from 2.7 in 1960, to 4.7 in 1996, to 5.9 in 2014 (Figure 29c). The rate of increase between years, however, has decreased, falling from a 75 percent increase between 1960 and 1996 to 25 percent increase between 1996 and 2014. Note that the time interval between the first time period was 36 years long compared to 18 years long for the second time period. A decline in the AUM growth rate, however, should be expected as the restored land approaches an equilibrium point in its potential productivity that is largely determined by soils and climate.

The Mortensons find themselves in 2015 in a highly favorable economic situation. Potential income sources such as land rent and land value are at record levels. Bread and butter factors such as cattle prices are also at record levels. It is clear that the approach they have taken to repair their

Figure 30. Todd Mortenson family. Photos courtesy of USDA Natural Resources Conservation Service, Colette Kessler, Pierre, South Dakota.

"If I damaged or destroyed this place, or continued to add to its destruction, I don't think I could have anything on my conscience that would bother me worse than the thought that future generations would be deprived of sufficient food or even a beautiful place to live that God has given us here. We who are privileged to use land as agriculturalists, carry a heavy responsibility to leave the land in better condition than we found it."

– Clarence Mortenson

"Sunlight, soil nutrients, and water are the basic resources needed to manufacture our crop–native vegetation–that can be harvested by cattle. It is a simple management philosophy. We merely cooperate with nature and let the sun do the work, rather than throwing money into costly inputs like equipment, chemicals, and fossil fuels."

– Todd Mortenson

"I'm the third generation on this ranch. Each generation has done something different to improve it. I still see areas I can improve upon, and I want to be sure that when I hand it to my boys that it's as good as I could do and, hopefully, it will continue with them."

– Todd Mortenson, from the Leopold Conservation Award bulletin 2011

Photo courtesy of USDA Natural Resources Conservation Service, Colette Kessler, Pierre, South Dakota.

land to regain its production potential and to manage their operation holistically has kept them in business for three generations. Because of Todd Mortenson's management of personnel and grazing, the increase in Animal Units has been accomplished without an increase in the work force since 1976 (two full time employees and several part timers). They stopped doing the things they did poorly, i.e., farming and feeding, and concentrated on the things they excelled at and enjoyed doing. Resilience in management and in their ranch environment has enabled them to hang in there economically through some times with low cattle prices and dry weather to be present when the good times roll.

CONSERVATION ETHIC

Clarence Mortenson is a registered member of the Cheyenne River Sioux Tribe. He was born to a Danish American rancher father and to an American Indian mother, whose family tree included French fur traders. His Indian heritage is the root of strong feelings about land conservation and harmony with the environment; these roots run deep and are fed by both nature and nurture. He often says, "the Indian belief was that the earth was your mother." Driven by his conservation ethic and the often-conflicting need to "live off the land," Clarence has spent his long life working to repair the land on his ranch to meet both ethical and economic goals. This tradition continues with his sons, Todd, Jeff, and Curt, who have operated the ranch since 1976; this conservation ethic remains front and center in their holistic management of the ranch. Todd Mortenson and his wife Deb and sons Jack and Quinn have been the principal managers of the ranch in the past several decades (Figure 30).

ECOSYSTEM RESILIENCE

Ecosystem resilience is an emergent property of the Mortenson Ranch. Resilience has been defined by ecologists as the ability of an ecosystem to resist change in the face of disturbances (weather extremes, disease, climate change) or to recover quickly with little change should disturbances be severe or chronic. The main elements of resilience on the ranch are:

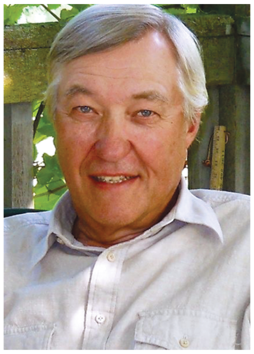
- Use of locally-adapted native plants during restoration.
- Retaining water in ranch soils to promote grass production.
- Let the sun do most of the work (always push for low input operations and management).
- Avoid tillage and high input farming.
- Lessen the impact of winter/spring storms on cattle by managing for protective woody plant cover.
- Implementation of a rest-rotation grazing system to stabilize grass production, including reductions in stocking during dry years and droughts (the Mortensons move a portion of their cattle to pastures in the usually wetter climate of eastern South Dakota in dry years to avoid damaging their grassland from overgrazing).
- Manage the ranch as a whole, knowing that all of the parts are interacting and part of a human and natural ecosystem.

This resilient system, characterized by low input costs and perennial crops, contrasts sharply with tillage agriculture practiced in much of western South Dakota, characterized by high input costs and annual cropping. Because the natural vegetation has been removed, planting and field management are required every year to produce an annual crop. The input costs may range up to $350 per acre, depending on the crop. That system is stabilized economically from large swings in weather and grain prices by government subsidized crop insurance.

It remains to be seen whether dry land that has lost its protective grass cover can be farmed sustainably when droughts of the magnitude of the 1930s (or more severe) return. Most opinions right after the Dust Bowl were that farming should no longer be practiced in western South Dakota, and that grass should be replanted and livestock grazing resumed. Farming practices since 1940, however, have improved and most likely have reduced the occurrence of the "bust" portion of past boom and bust cycles. These improvements include: no-till farming; higher yielding varieties of crops; fallowing; and an economic safety net in the form of crop insurance.

The main cause of the Dust Bowl, however, was extremely dry weather for many consecutive years. A look at the precipitation record for the Pierre weather station shows a relatively "rosy" climate after 1940 that has been trending wetter (Figure 2). Tree ring data confirm the presence of a more equable climate for plant growth in northeastern South Dakota since then (Shapley et al. 2005). The climate data show that our tillage system in western South Dakota has not been thoroughly tested. Since the tillage system currently rests on government subsidies, the system could collapse should government decide not to or be unable to continue subsidies, thereby increasing the economic risk of tillage agriculture. The willingness of taxpayers to continue the subsidy system may be challenged even more during this century if climatologists turn out to be prophetic that the future climate is warmer and drier.

The low input, resilient system of the Mortenson Ranch that rests on the foundation of restored, perennial native grassland should be able to withstand most future shocks to the system. These "sustainable" properties have been built into the ranch by the determination and vision of three generations of managers, principally Ben Young, Clarence Mortenson, and Todd Mortenson. All the evidence we have about this ranch that grew out of the soil drifts of the Dust Bowl indicate that this beautiful, biologically-rich, and economically-viable ranch will be around for a long, long time.



"In my 40 years of studying riparian woodlands in many states, never have I met producers with more enthusiasm, dedication, and genuine interest in restoration and conservation than the Mortensons."

–Dr. Carter Johnson, from a letter to the Leopold Conservation Foundation

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Appendix

Appendix Table 1. GPS coordinates for end points of Foster Creek cross sections and locations of tire wheels used as elevation reference points. R = right bank location; L = left bank location; T = tire.

Cross section	Latitude	Longitude
2-1L	335976	4953900
2-2R	336011	4953865
3-1L	336114	4953499
3-TL	336119	4953494
4-1L	336059	4953366
4-2R	336067	4953318
4-TL	336079	4953372
5-1L	336101	4952793
7-1L	336253	4951959
7-2R	336252	4951993
8-1L	336131	4951796
8-2R	336161	4951817
9-TL	335989	4951196
10-1L	335466	4950914
10-2R	335454	4950872
10-TL	335477	4950920
11R	335165	4950961
12-TL	334575	4950454

Appendix Table 2. GPS coordinates for end pins that define vegetation transects and locate permanent photo points on the Mortenson Ranch. The first number is the site number and the second number is the transect number. E = east; W = west; S = south; N = north; C = center; PPP = permanent photo point.

Site-transect	Latitude	Longitude
1-1C	333835.9375	4953728.5
1-1E	333843	4953725
1-1W	333827.0625	4953732.5
1-2C	333825.5938	4953698.5
1-2E	333838	4953692
1-2W	333805.0938	4953713
1-3C	333824	4953669
1-3E	333836	4953667
1-3W	333808	4953667
2-1E	334492	4953971
2-1W	334487	4953964
2-2E	334522	4953908
2-2W	334491	4953897
2-3E	334513	4953851
2-3W	334479	4953862
3-1N	330323	4954755
3-1S	330316	4954734
3-2N	330280	4954814
3-2S	330261	4954799
3-3N	330242	4954874
3-3S	330232	4954861
4-1C	334564.4063	4954231
4-1E	334574	4954234
4-1W	334557.625	4954230.5
4-2C	334591.4063	4954321.5
4-2E	334601.6875	4954316
4-2W	334570.2188	4954333.5
4-3C	334649.5	4954402
4-3E	334656.8125	4954405
4-3W	334644.3125	4954399
5-1E	334354	4953762
5-1W	334341	4953748
5-2E	334336	4953802
5-2W	334320	4953778
5-3E	334326	4953871
5-3W	334319	4953873
PPP1	333922	4954005
PPP2	334431	4954224
PPP3	330169	4954929
PPP4	334468	4953894




"The Mortenson Ranch is a working cattle operation along and near the Cheyenne River in Stanley and Ziebach Counties of South Dakota. The actions of Clarence Mortenson, his sons, and his step-father, have not only rehabilitated the natural landscape, they have also improved the production capacity and value of their business assets. The result has been a secure and sustainable source of income for the family. This is a testament to conservation science working with agriculture for healthy outcomes."

Barry H. Dunn*
President, South Dakota State University

"If I damaged or destroyed this place, or continued to add to its destruction, I don't think I could have anything on my conscience that would bother me worse than the thought that future generations would be deprived of sufficient food or even a beautiful place to live that God has given us here. We who are privileged to use land as agriculturalists, carry a heavy responsibility to leave the land in better condition than we found it."

Clarence Mortenson

"In my 40 years of studying riparian woodlands in many states, never have I met producers with more enthusiasm, dedication, and genuine interest in restoration and conservation than the Mortensons."

Dr. Carter Johnson

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