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Light on the Land

Construction Revolution in Farm Buildings of the Northern Rockies, 1890–1910

ABSTRACT
In the twenty years surrounding the turn of the twentieth century, the form and character of agricultural buildings in the Northern Rockies and the construction methods used to build them changed dramatically. This essay focuses on the Gallatin Valley of southwestern Montana to explore the nature and meaning of these changes. It places them within the context of the region's growth and development during its early agricultural settlement, which coincided with a period of tremendous advances in agricultural practices. The earliest Euro-American buildings in the region (1862 to the 1880s) reflect typical frontier construction, with logs the predominant material due to the plentiful local pine and fir and the limited tools available. However, this construction method presented structural limitations when the need for larger buildings arose due to regional economic development. Lacking other alternatives, farmers and stock growers put their faith in light balloon frame construction, although many of them had little experience with this method, particularly for sizable buildings. The demand for larger and more complex buildings spurred the introduction and subsequent adoption of an essentially new architecture. High elevation, climate, and the forces of national economic markets were the principal factors that influenced the rapid transition to light wood framing in Rocky Mountain agricultural buildings. This transformation, a real revolution in local design and construction, relates to the larger history of American architecture in the western United States, and it led to the broad diversification of farm building forms and types in the Northern Rockies.

A common theme in western American vernacular architecture is its rapid industrialization, marking an accelerated shift from frontier forms and methods to prevailing practices from the eastern United States. Euro-Americans settled subregions like the Northern Rockies within several decades, rapidly transitioning from the frontier occupation of Native American lands to the incorporation of the culture of the expanding United States. As Thomas Carter observes in his introduction to *Images of an American Land*, "The core values were essentially those of American industrial capitalism—free markets, individualism, private enterprise, technological progress, and Anglo-American virtues—and they exerted a powerful influence over the western peripheries."[1] The Gallatin Valley in southwestern Montana is no exception.

For thousands of years, this fertile valley, situated on the eastern side of the Continental Divide, was an abundant seasonal hunting ground of native peoples, with two known buffalo jumps and associated tipi rings still in evidence.[2] The valley, named by Lewis and Clark in 1805, was first cultivated for agriculture in the 1860s by Euro-Americans supporting the mining frontier. It spans about forty miles from east to west, with the large Gallatin River and its eastern tributary traversing it before they meet the headwaters of the Missouri River to the west of the valley (Figure 1). By the beginning of the twentieth century, the agricultural economy of the valley reflected the expanding American market systems, which had a profound effect on rural building patterns. The opening of Northern Pacific's transcontinental railroad in 1883 connected farmers and ranchers to national markets for their produce and livestock. Local circumstances, such as the vicissitudes of the climate at 5,000-feet elevation, also played an important role in shaping the built agricultural landscape of the Gallatin Valley.

Beginning in the 1870s, the promise of the railroad triggered a flood of white settlement throughout the region.[3] Rural growth became evident in both the total acreage being farmed and the value of the acreage.[4] Access to a national market introduced a new element of complexity and unpredictability to the price of agricultural products. While agricultural producers expanded they also diversified as a hedge against changing market conditions. This economic growth dramatically affected the architecture of farming and ranching in the region. In addition the deadly winter of 1886–87 and harsh conditions again in the 1890s highlighted the need for production and storage of winter feed for livestock, which established an additional demand for buildings on the farmstead. Acceptance of new construction methods lagged at first and involved experimentation at modest scales but rapidly evolved into increasingly larger-scale buildings as confidence and demand increased.

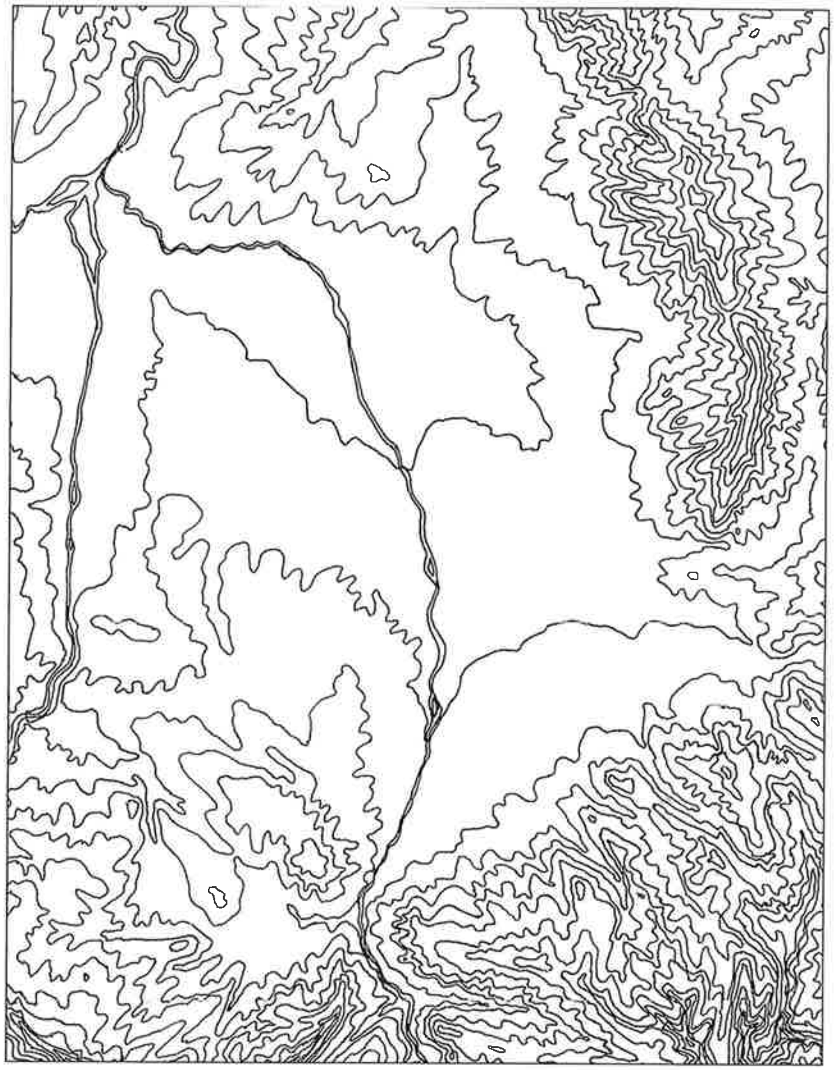


Figure 1. Topographic map of the Gallatin Valley in southwestern Montana. Topographic lines at five-hundred-foot intervals indicate the dramatic watershed supplied by snowmelt and the even slopes of the valley floor. Drawing by Maire O'Neill Conrad from U.S. Geological Survey maps.

Larger landholdings and herds, more diverse livestock, and enlarged hay and grain operations required bigger and more specialized work buildings.[5] Each facet of the farming and ranching operations increased demand for new building types. Some kinds of livestock (hogs, dairy cows, and poultry in particular) required more specialized buildings and pens for housing and feeding. Ranchers needed specific types of enclosures and shelter for calving, lambing, farrowing, and foaling, especially as livestock became more costly. Feeding larger herds and treating, handling, sorting, and shipping them demanded still more structures. Stock growers developed increasingly complex systems of corrals, branding and sorting pens, loading chutes, shearing sheds, and livestock shelters. More valuable stock, such as stallions, bulls, or special breeds, required intensive management and discrete forms of shelter.

Variety in crops necessitated more complex storage buildings such as multibin granaries to stockpile an assortment of grain. Expansion of crop production precipitated an increased demand for teams of work horses, farm hands, and implements used in the operations of sowing, cultivating, harvesting, threshing, and delivering to market. To maintain working draft horse teams year round, farmers needed great quantities of feed, prompting construction of large buildings for storage of high-quality hay as well as multiple tie stalls for graining and harnessing. Bunkhouses were needed for seasonal farm hands, while machine sheds helped shelter investments in new farming implements like the disk plow, seeder, sickle bar, binder, and thresher. The availability of a wide range of new machinery enabled a tremendous increase in productivity.

Against this backdrop of economic expansion, a widespread change occurred in both design and construction of buildings on Northern Rockies farms and ranches. Larger multiuse buildings and more complex assemblages of buildings constructed with light wood framing techniques replaced smaller log buildings with dedicated uses. As rail transport fostered large-scale lumber mills in the state, the availability of dimensional lumber and light frame building expertise made it possible to build larger structures with less material and smaller construction crews.

Transitional Construction Types

Settlers' adoption of light framing techniques for construction of the region's largest buildings occurred over a relatively short period of time, and in the transition they used some construction techniques that reflected shifting perceptions and priorities. In eastern and southern parts of the country, the historical progression of farm building construction was from log to heavy timber and then much later to light wood framing as wider, longer, and taller buildings were needed.[6] In these regions the transition in barn building from log to light frame construction spanned as much as two hundred years, depending on location. Heavy timber structures had substance and great strength but were slow to build and were best done with hardwood lumber and a large crew including a number of highly skilled craftsmen. In the East, where an abundant building stock of durable large timber-framed barns already existed, there was less demand for new methods of barn construction.[7] In the Northern Rockies, where settlement was comparatively late, construction time, financial resources, hardwoods, and skilled construction labor were in short supply, so heavy timber construction was rare in the Gallatin Valley. By the time agriculture in the Rocky Mountain region was beginning to thrive, the use of balloon frame barn construction was already expanding swiftly in the Midwest, where recent innovations in light framing were widely practiced.[8]

During the earliest settlement period in the Gallatin Valley, hand-hewn logs with fine dovetail corner notching were often used for dwellings (sometimes two stories in height), but outbuildings were rougher. End-entry gable forms with peeled, unhewn logs were most common for farm buildings, using simple V-corner notching. The earliest roofs were very low sloped, with ridgepole and purlin gable construction supporting a sod roof (Figure 2).[9] Steeper roofs were more desirable for their ability to shed the snow and rain but required building a challenging tall gable end and the expense of shakes or shingles. As needs grew, the scale of such buildings was limited by the length of logs, though a longer building could be made by lap-jointing lengthwise logs and adding structural partition walls. Both the double-crib log barn and the transverse-crib log barn defined by Terry Jordan in *American Log Buildings* were common forms used to increase the footprint of log buildings.[10] The largest early single-crib log structure might be about thirty feet in length and no more than twenty feet wide. Window and door openings were very limited as they weakened the log structure. A complete farmstead during the 1860s to early 1880s would typically consist of a loose cluster of low-profile log buildings of modest dimensions and post-and-pole-fenced corrals. By the 1880s a small building such as an outhouse or a chicken shed might have been constructed with light framing as an experiment with the new light construction.

Although this revolutionary light framing technique had been increasingly practiced in the Midwest since the 1830s, the Gallatin Valley could not widely benefit from it until after the opening of the region to the railroad in 1883 due to the shortage of mills for dimensional lumber and limited local knowledge of the framing technique.[11] During a period of rapid growth in the intermountain West in the 1880s, as better lumber mills were established with equipment arriving by rail, journeymen carpenters arrived to take advantage of the building boom. They brought with them knowledge of light balloon frame construction, which spread rapidly throughout the region. Even before light framing was in widespread use, smooth-planed board siding was an indicator of modernization and permanence, and it suggested a striving for legitimacy. Log dwellings in the Gallatin Valley, for example, were often masked with board siding as a means of updating them.[12]

A parallel phenomenon occurred in the mining camps of the region. As Kingston Heath observes in his study of the commercial false-front on the Montana mining frontier, "Within the framework of frontier awareness, the mere use of sawn and planed lumber was viewed as an expression of progressiveness that was part of the physical evolution from camp to town."[13] He goes on to explain that "from the outset the 'formula' applied to shaping these new urban landscapes aimed at transforming the wilderness into settings familiar to the recent arrivals from the industrialized East."[14] Heath illustrates that the use of planed board siding facades on log buildings preceded the introduction of balloon frame construction in early mining towns. The framed buildings that followed during this prerailroad era had inexact spacing between the studs, as strict standards had not yet developed. Even when builders were aware of norms, they generally did not feel the need to adhere closely to them. Since uniform dimensions of other building supplies like windows, sheathing, or roofing material were not yet available, precise spacing of studs seemed unnecessary.[15]

The Montana Agricultural Experiment Station, established in 1893, published bulletins offering recommendations based on scientific research on livestock breeding, range management, and farm production. In its second annual report in 1895, the director described two farm buildings erected at the experiment station on the Agricultural College campus in Bozeman, promoting a surprising construction technique for larger buildings. During an era when one might expect the experiment station to endorse light framing techniques, the article described a modified form of *piece sur piece* log construction as an affordable alternative.[16] Horizontal lengths of peeled log were toenailed, rather than mortised, into six-inch-by-six-inch upright posts: "Many Montana ranchmen, within reach of timber, can erect very much better buildings of these materials and on the same plan, for less money than either the old style log or frame buildings."[17] In 1895 researchers erected two such demonstration buildings on the campus, one of them was a barn thirty-two feet by fifty feet (Figure 3). The log segments were nonstructural infill within a post-and-beam structure, using milled lumber for the posts, sill plate, and top plate. The hay loft floor joists were supported by a ledger running continuously from post to post, with short log segments as blocking between the exposed joist ends. The distinctive chinking design used small wood dams nailed to the exterior of the logs. Three years later, in 1898, as the director promoted clover hay as a new legume feed, he endorsed this construction again in his description of a new hay barn (twenty-five feet by fifty feet), which the experiment station erected as necessary protection for the crop. His comments implied that the cost of milled lumber still placed it beyond the reach of most farmers:

> The structure is made of peeled round pine and fir logs, and the only manufactured lumber therein is the rough board sheeting used for roof boards, the wall plates and the cedar shingles with which it is covered, [*sic*] Using such material, it is possible for the Montana farmer, who is conveniently located to the mountains, to secure important buildings at a comparatively small outlay for material.

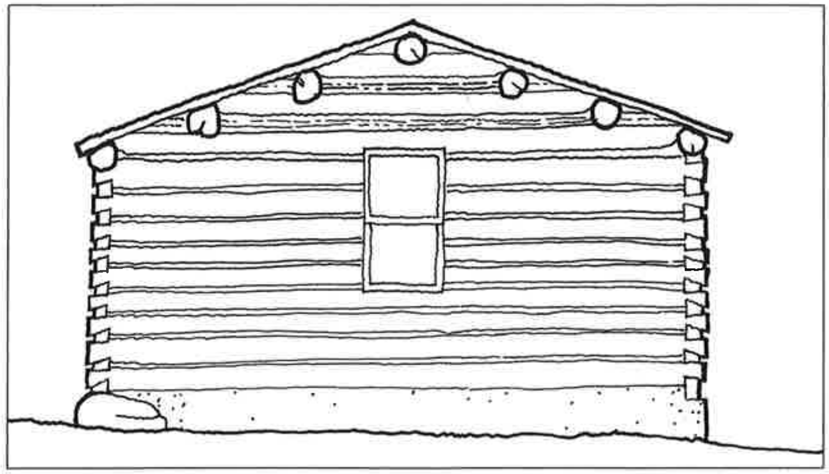


Figure 2. Elevation of log dwelling, Amos Williams homestead south of Bozeman, Montana, before 1889. Drawing by Maire O'Neill Conrad from field notes taken in 2016.

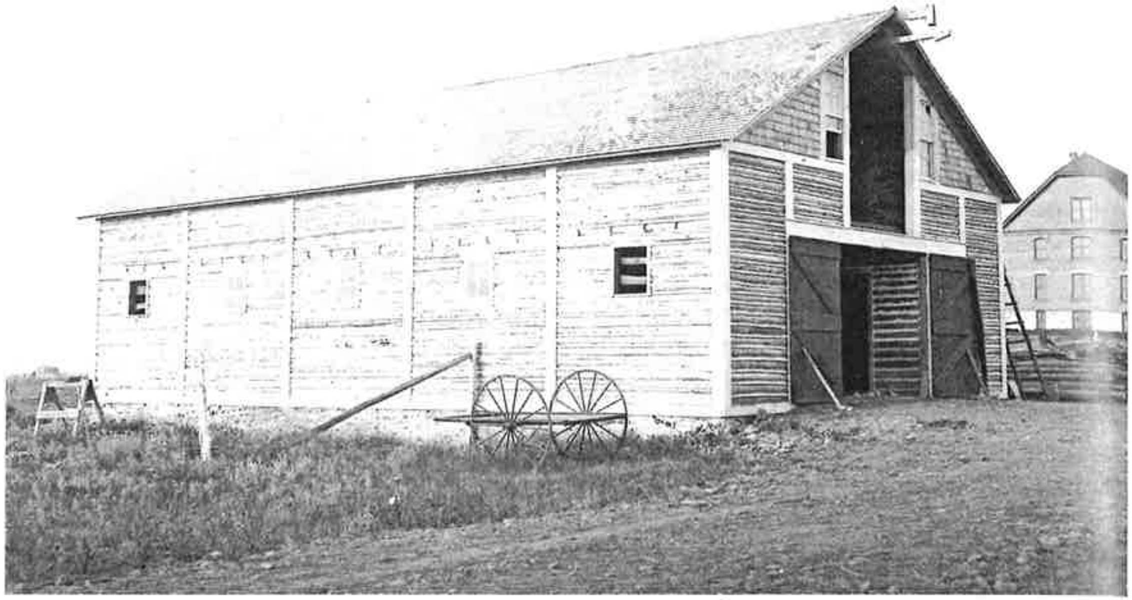


Figure 3. Demonstration barn built on the Montana State Agricultural Experiment Station in Bozeman, 1895. Photographer unknown, "Log Horse Barn," image #parc-001444, Historical Photographs Collection, Renne Library Special Collections, Montana State University, Bozeman.

> Diversified farming can never be exploited to advantage in Montana in the absence of suitable farm structures, and it is believed that in this way many can secure these much needed improvements, who would otherwise not be able to build.[18]

The view expressed in the *Experiment Station Bulletin* suggests widespread skepticism about the economy of light framing at the end of the nineteenth century. However, typical log construction was limited in scale by the length of the logs, which in turn limited the flexibility and openness of the plan. The hybrid method that the experiment station proposed allowed for a longer, taller building with an open floor plan but without the high costs of either heavy timber or light milled lumber. A rare remaining two-story barn of exactly this type of construction in the valley suggests this model may have influenced ranchers in the area who were willing to invest in experimental construction (Figure 4). This building exhibits similar proportions and identical construction details to the experiment station's demonstration building, suggesting one of two possibilities: it may have been built following the experiment station model not long after the 1895 publication, or it may have been a precedent and inspiration for the experiment station's building. Its condition, however, attests to the fact that the method did not hold up well over time. The logs were not mortised into the posts as in *piece sur piece* construction but were simply toenailed to them, and they pulled free of the nailing as the wood dried and shrank. The experiment station horse barn was replaced within twelve years.

As the demand rose for buildings with larger proportions that could be constructed rapidly, the declining cost of dimensional lumber increased the incentive to experiment with light framing techniques. One heavy timber frame barn in the northeastern part of the valley reflects a sequence of construction consistent with this period of experimentation. The farm was homesteaded in 1895 by Henry Crouse, and it remains in the Crouse family, whose members date the construction of the timber barn to sometime between 1900 and 1910.[19] Documentation drawings illustrate its three distinct volumes: a heavy timber gable structure and two longitudinal sheds (Figures 5 and 6). Shed additions often represent a phased growth strategy and can serve as a representation of construction chronology. The center bay of this barn was constructed with a series of eight-inch-by-eight-inch heavy timber

Figure 4. Log infill barn located about six miles southwest of the Montana State Agricultural College Experiment Station in Bozeman, circa 1895. Photograph by Maire O'Neill Conrad, 2017.

bents using mortise and tenon joints and diagonal bracing. These form a large interior volume, ideal for dry storage of loose hay. Longitudinal sheds run along each side of this main structure, attached slightly below the eaves and almost tripling the size of the footprint. The sheds were built using entirely light wood frame techniques and materials. One might presume the sheds were added at a later date, under different conditions. The construction of the shed on the west side, however, appears to have occurred before the completion of the main structure, as there is no evidence of planking or siding ever being nailed to the west face of the timber bents. This shed, designed to house ten draft horses in tie stalls, was built with an entirely different construction method but apparently at the same time as the heavy timber frame of the main section. Its light framing appears to rely upon the heavy timber structure for stability. This reflects the builder's acceptance of the economy of the light wood frame and a lack of construction knowledge, experience, or confidence in its structural potential for the main structure.

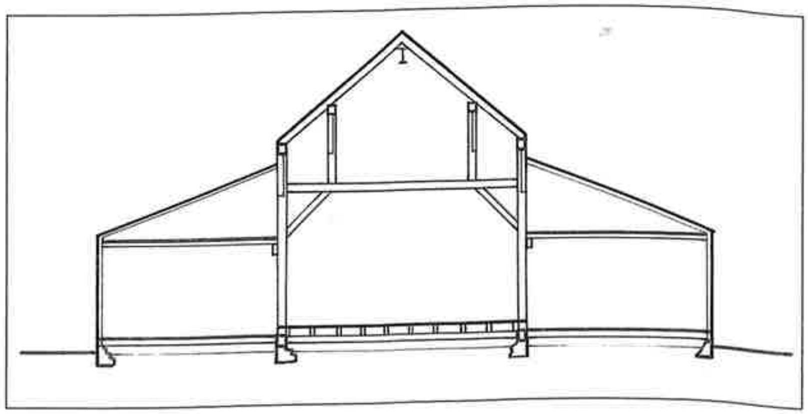


Figure 5. Section of the Crouse barn on the northeastern edge of the Gallatin Valley, Montana, 1900–1910. The builder apparently took advantage of the economy of light construction while relying upon the heavy timber framework at the center for stability. Drawing by Maire O'Neill Conrad, 2014.

When prevailing construction methods no longer satisfied the needs of the agricultural community, builders explored alternatives. This spirit of experimentation came easily in the West, where hardy, resourceful people encountered new challenges with limited means to solve them. In a transitional period of less than twenty years, many farmers and ranchers in the Gallatin Valley replaced their modest-sized log livestock barns with larger buildings that reflected their willingness to investigate the unfamiliar. These construction methods were speculative in nature, and some of them proved unsuccessful.

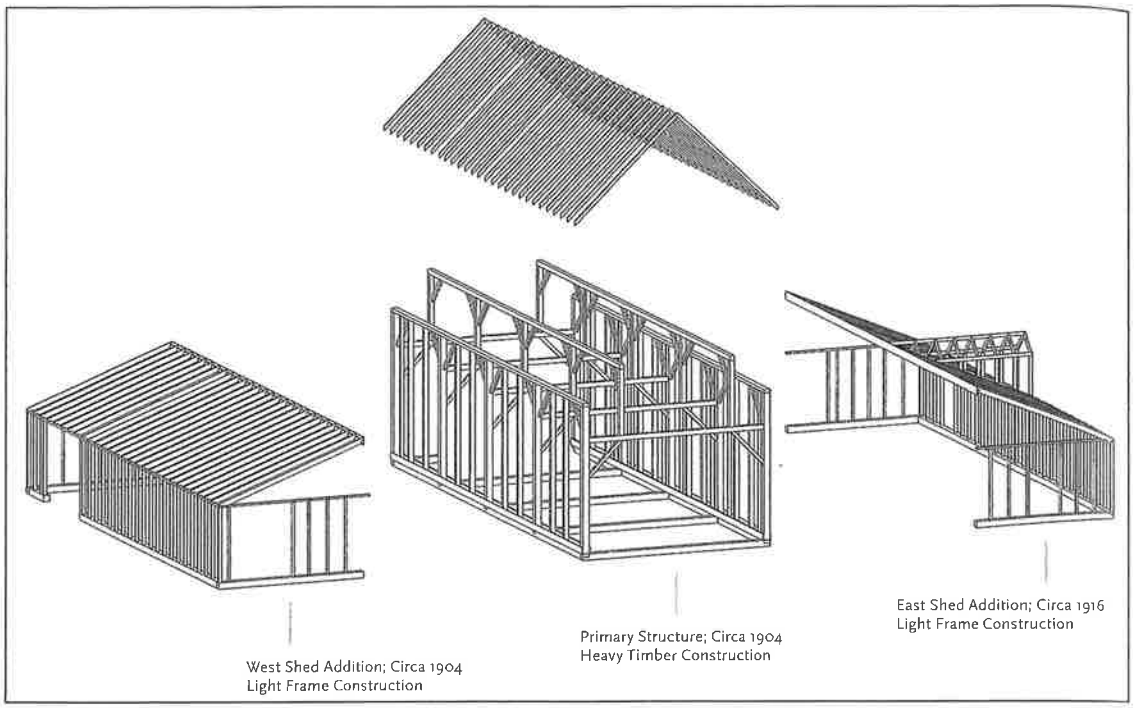


Figure 6. Exploded axonometric of the Crouse barn north of Bozeman, Montana, 1900–1910. Measured drawing by Montana State University students Steven Berkas, Trae Schwenneker-Dickerson, and Madison Gabig, "Crouse Homestead," Historic American Buildings Survey, Washington, D.C., Document MT-170 (June 2014), Sheet 5, www.loc.gov/item/mt0606.

Emergence of the Granary

The demands of the region's grain industry helped advance the production and use of dimensional lumber required for light frame construction. The earliest entirely light frame buildings were limited in size to ten or twelve feet in width, and many of these were built specifically for grain storage. In 1870 the Gallatin Valley produced almost half of the wheat, oats, and barley in the Montana Territory.[20] Much of this was freighted to the mining boomtowns by teams of oxen or mules. Productivity per acre of wheat by 1880 was as high as in any region in the country.[21] At the 1893 World's Columbian Exposition in Chicago, over 21 percent of the Montana grain exhibitors came from the Gallatin Valley.[22] This rapid growth in the grain industry necessitated larger, tighter granaries and helped trigger the transition from log construction to light frame. Small mill operators at the foot of the surrounding mountains, such as Charles Leverich on the south edge of the valley, used the creek current for power to drive primitive sawmills, which had wide tolerances. Because of this lack of precision, dimensional lumber from this prerailroad era is identifiable by its varied thickness. A light frame multibin granary built on the Leverich homestead during the 1870s has rough-sawn studs, which vary from one and three-quarter inches to over two and a quarter inches in thickness; the studs may have come from his own water-powered mill nearby (Figure 7). The 1869 Nelson Story house exhibits a similar degree of irregularity in stud milling.[23]

Abundant grain production was the hallmark of the Gallatin Valley for decades before and after the turn of the century. Not only were vast acreages of the valley in grain production by 1890, but the yield per acre was double and triple that in other parts of the state.[24] The geography presented some ideal growing conditions. A continuous supply of water from the snowmelt of surrounding mountains and advantageous topography enabled early establishment of irrigation ditch systems, which were a boon to farming. The development of a complex network of irrigation ditches, hundreds of miles of which were already in place by the 1900s, was facilitated by the natural distribution of surface water, the even slope of alluvial fans in the valley, and the measured release of water stored naturally in high-elevation snowfields to the east and the south of the Gallatin Valley (Figure 8). The availability of water on demand offered the farmer some assurance of successful production, and the alluvial fans provided fertile, well-drained soils.

The Manhattan Malting Company from New York advanced the development of grain in the valley in 1891 with out-of-state investment in a massive barley malting plant in the settlement of Moreland, changing its name to Manhattan. It recruited Dutch farmers and their families for their expertise in growing malting barley, and it sponsored their immigration to the United States. The corporation established the Dutch settlement of Amsterdam, west of Bozeman, and organized the financing of the ambitious West Gallatin Irrigation Company by purchasing thousands of acres from the Northern Pacific Railway. It constructed a system of more than a hundred miles of large irrigation canals, most of which are still in use, diverting a substantial quantity of water from the Gallatin River to the dry, well-drained bench land surrounding Amsterdam, producing ideal conditions for grain.[25] These irrigation systems dramatically changed the landscape of the Gallatin Valley, and they provided those growers who had water rights with considerable advantages. With good water rights, the intensity and scale of production on a farm could be dramatically increased. Members of the early Dutch community in the Gallatin Valley participated in barley production at an industrial scale. They were independent growers, yet their livelihood was inextricably linked to a large East Coast corporation positioned in the national marketplace.

The success of grain production prompted new construction of storage buildings. On the south side of the valley at Middle Creek in about 1878, George Flanders established a planing mill and sash factory, an operation that boasted production of ten thousand board feet of lumber and ten thousand shingles per day for many years, making light framing lumber and siding more widely available. However, his prices were undoubtedly high for lack of competition.[26] During the 1880s and 1890s, granary construction generally progressed from log to inside-out construction, where a smooth and tight interior surface was provided by milled planks mounted on the interior of closely spaced two-inch-by-six-inch studs, leaving the light frame exposed to the weather (Figure 9).[27]

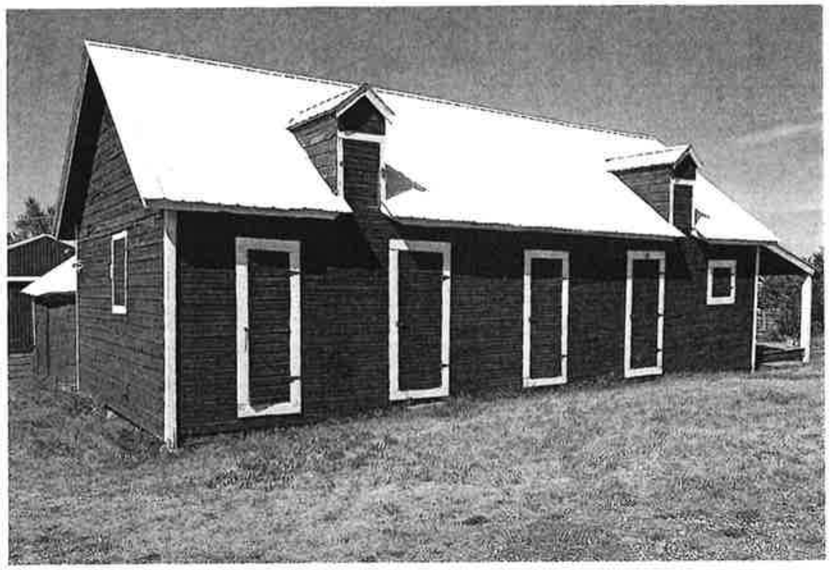


Figure 7. Five-bin granary on Charles Leverich homestead, on the south edge of the Gallatin Valley, Montana, 1870s. The estimated date of construction is derived from the records of annual grain harvests penciled on the granary interior. Photograph by Maire O'Neill Conrad, 2016.

For granaries the inside-out construction type presented great advantages of scale, cleanliness, rodent proofing, and ease of construction. The boards were held against the studs by the pressure of the grain, and exterior siding was thought to be an unnecessary expense. Most of these structures were of simple gable-end form, with a half-pitch roof.[28] The Butterfield granary exemplifies the suitability of simple light wood construction for building to almost unlimited length. Only fifteen feet wide and strategically situated on a bench, its multiple bins could be easily accessed and filled from the high side, and they could be unloaded into a wagon by gravity on the low side (Figure 10). The narrow building form is tied together by the partition walls and a single tie beam at each bin. The lack of siding was not only economical, as the interior planks provided adequate enclosure of the structure, but also avoided the problem of rodents inhabiting a cavity in the wall. In spite of the studs' exposure to the weather, this method of construction held up relatively well in the dry air of high-elevation valleys. The inside-out light frame granary proved to be a dramatic advancement, and it became ubiquitous in the Gallatin

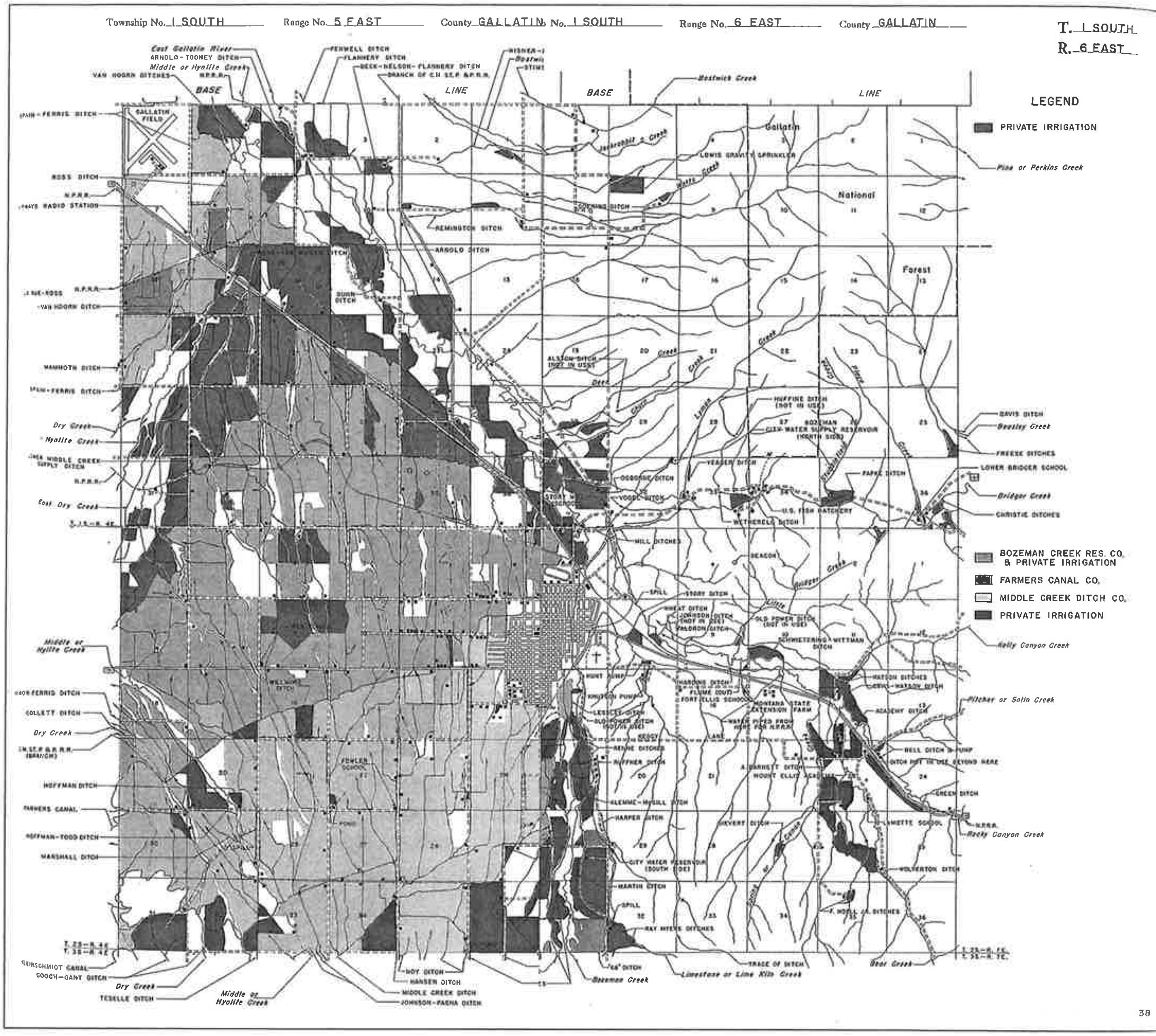


Figure 8. Land use and surface water map of the Gallatin Valley, Montana, 1953. Gray lines indicate natural creeks; black lines with arrowheads are engineered irrigation ditches, sometimes running laterally for miles. Map is the author's composite of four pages from *Montana Water Resources Survey, Part II: Gallatin County* (Helena, Mont.: State Engineer's Office, 1953), 31, 32, 37, 38. Courtesy of Montana Department of Natural Resources and Conservation. Please see JSTOR version of this article for a larger image.

Valley. Its widespread presence was a constant and highly visible demonstration of the potential of light frame construction for farm buildings overall, contributing to the rapid acceptance of this machine-age construction method.

The nationally determined price of grain experienced seasonal fluctuations and limited profitability for average producers who sold their grain at harvest time. Those growers who could safely store their harvest in a good granary for months could sell when the price was highest. With good grain-storage capacity and state-of-the-art farm machinery, independent growers could produce a large volume of grain and wait for months until prices were most advantageous, as long as their grain stock was well protected from the weather. As larger storage capacity was needed the scale of the inside-out construction type reached its limits. The height and footprint of the cribs were limited by the strength of the light framing system and length of the studs.

Private and cooperative investment in the construction of multiple-bin grain cribs for large-scale stockpiling led to yet another form of granary construction. Cribbed construction, consisting of two-inch-by-four-inch or two-inch-by-six-inch planks stacked flat on top of one another, nailed throughout and lapped at the corners, required far more lumber than the former inside-out construction, but it provided a very strong, durable, and dry environment for grain. An important prerequisite for the lumber used, however, was that it be dimensionally consistent

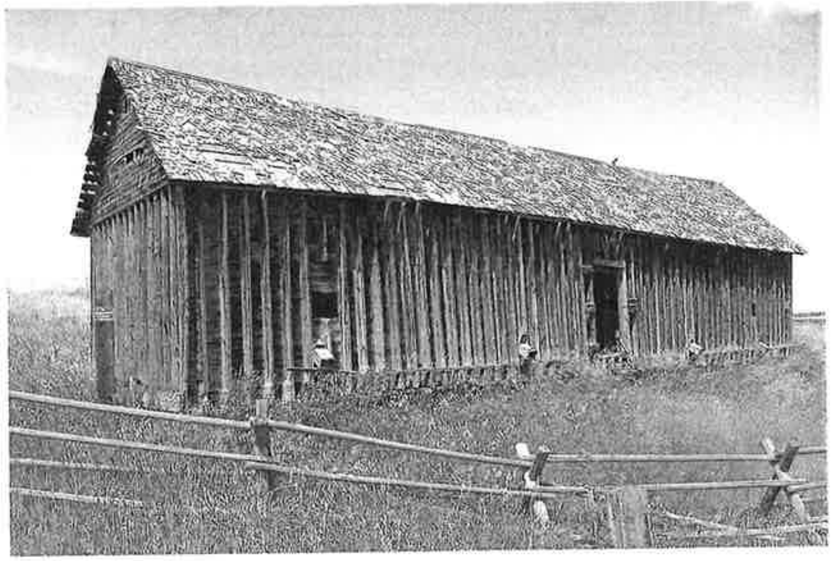


Figure 9. Four-bin Butterfield granary, southern edge of the Gallatin Valley, Montana, circa 1900. Photograph by Maire O'Neill Conrad, 2016.

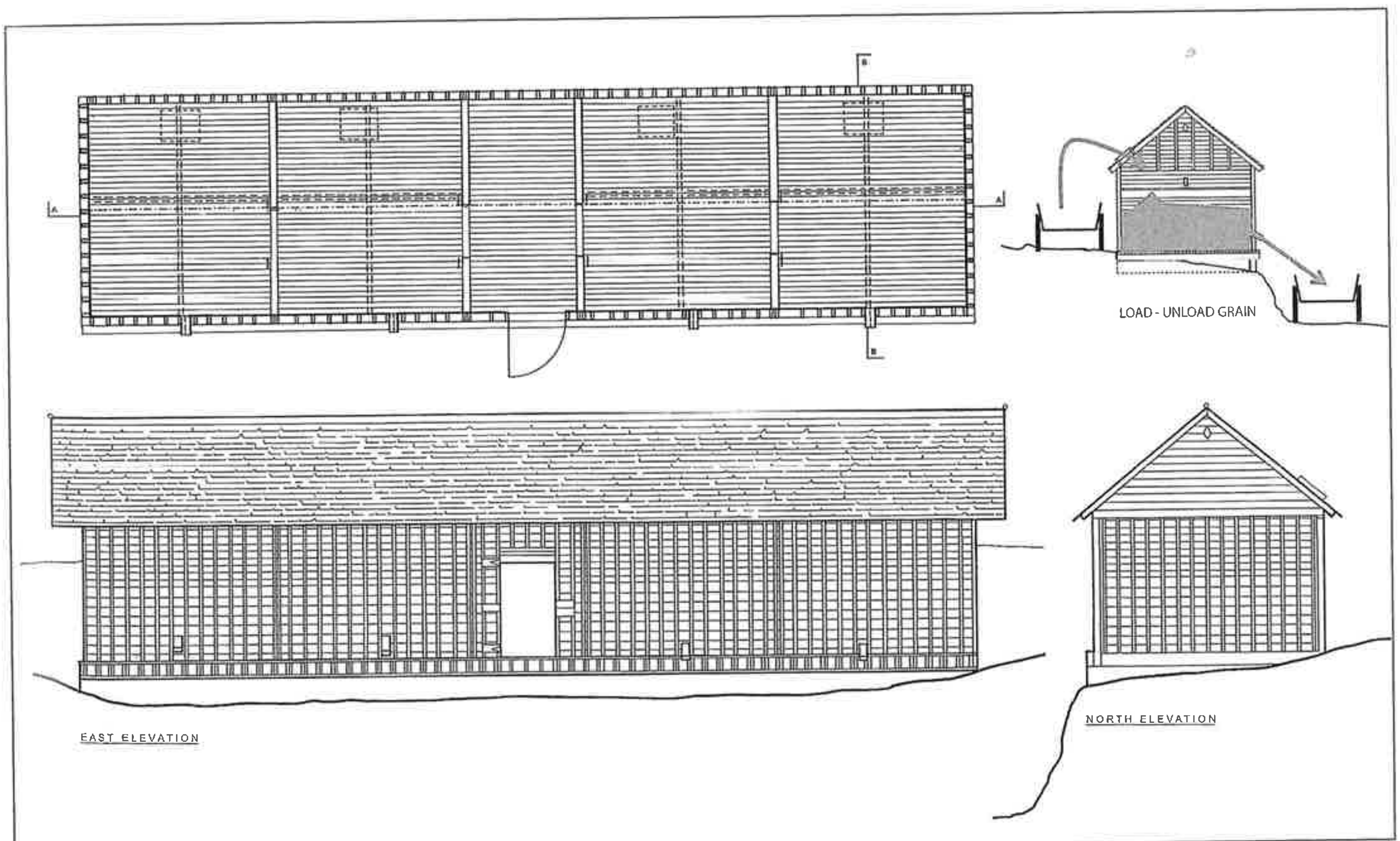


Figure 10. Floor plan, section, and elevations of the Butterfield granary on the southern edge of the Gallatin Valley, Montana. Illustration from the author's fieldwork archives of 2007, drawing by Montana State University student Sara Darlington, with grain loading diagram by Maire O'Neill Conrad. Courtesy of School of Architecture, Montana State University, Bozeman, Montana.

within very fine tolerances, so as not to produce horizontal gaps in the construction. Improved sawmills were more capable of producing such lumber than the early mills. The proliferation of this construction type, therefore, dramatically increased the demand for more advanced milling equipment in the region.

The high-volume cribbed granaries could be built with an unlimited number of adjacent grain bins. Some examples in the valley have bins of different sizes, which suggests they may have been built cooperatively or leased to neighbors with varied acreages and different types of grain. There is a well-preserved example on the south side of the valley with thirteen bins. The height of these structures was limited only by the technology required to hoist the grain into them from the top. One very tall example is a beautifully preserved octagonal granary connected to a dairy barn in the Springhill area, standing at least thirty feet in height. The large-scale commercial grain elevators at flour mills and railroad sidings throughout the region also used cribbed construction, producing incredible demand for dimensionally consistent lumber. The availability of various forms of mechanical grain-handling devices, such as augers driven by belts from a power source, made it possible to use granaries of greater size. This handling equipment, largely coming from the Midwest, was available in the Gallatin Valley via rail. Private investment in the grain industry led to the widespread construction of multiple-bin granaries for stockpiling, and the lumber demanded for construction of those granaries helped stimulate the lumber milling industry.

Investment in Land and Farming Implements

The success of the Gallatin Valley as an agricultural center is evidenced by the value of its farmland, which, along with that of several other fertile valleys, had been consistently valued higher than average in the Montana Territory since 1870. Although statewide farm and ranch acreage expanded by almost thirty times between 1880 and 1900, farms in Gallatin County remained among the most valuable per acre (almost three times the state average), and they were among the most profitable.[29] By 1900 the farms in the valley were generally smaller than in many other parts of the state, reflecting an inverse correlation between acreage per farm and value per acre. According to the 1900 U.S. census, growers in fertile, well-watered valleys like Gallatin invested more heavily in farm implements than those in other regions of the state.[30] During the decade prior to the opening of the railroad, when local blacksmiths built farming implements or such implements were brought into the region at great expense by riverboat and overland freight, the county reported machinery values per farm at 63 percent above the state average.[31] The quantity and value of the grain that famers produced allowed them to spend heavily on machinery, which in turn made them more productive.

After 1883 the latest advances in horse-drawn farm machinery from the Midwest were available by rail through local implement dealers. State-of-the-art farming implements were designed and manufactured in the Midwest, largely in Iowa and Illinois. Benepe-Owenhouse Company in Bozeman was the exclusive Montana agent for Deering Agricultural Implements by 1898, suggesting that there was a particularly strong demand in the Gallatin Valley.[32] Local farmers took advantage of some of the best farm technology available, and they invested at a rate 58 percent higher than the state average by 1900 and 52 percent higher than the average by 1910, even though the average farm size remained among the smallest in the state.[33] Considering the relatively small acreages of operations in the valley, this investment suggests that the productivity of the land was great enough to promise good returns on grain and that farmers had confidence their investments in implements would pay off. By 1900 grain production in the county constituted over 80 percent of Montana's barley yield and over a quarter of the state's wheat.[34]

Rural free mail delivery reached Montana in 1902. Once they received regular mail, farmers and ranchers had access to knowledge of new agricultural methods through farm journals, promotional literature, and catalogs. The expansion of agricultural production, aided by access to the goods of midwestern implement manufacturers, also made local industries like hardware and farm implement suppliers more profitable. Gallatin Valley farmers showed an early interest in the latest technology for large-scale production and enthusiastically adopted the efficiencies of industrialization. In many instances well-organized teams of men and draft horses using the most efficient equipment worked closely together on very large acreages as a cohesive planting or harvesting operation. Crews consisting of ten or more teams moved from one field to the next directed by a foreman, following a commercial production model (Figure 11).

Plans of model buildings published in midwestern pattern books, mail-order catalogs, and farm journals played an important role in influencing architectural aspirations in the West. By the turn of the century, an increasing number of these buildings were "plank frame" or light frame construction using only dimensional lumber (Figure 12).[35] Many dairy equipment manufacturers promoted the modernization of dairy barns as a marketing strategy, and the endorsement of light framing techniques for dairy barn construction served to advance their modernization agenda, resulting in parallel advances in contemporary farm architecture. A widely circulated publication, James Harvey Sanders's 1893 collection of barn building plans and techniques, illustrated a large, circular dairy barn designed by the Wisconsin Agricultural Experiment Station, which was built entirely with two-inch dimensional lumber. The two-story barn was ninety-two feet in diameter and twenty-eight feet high at the eave, and its light lumber construction was described in detail in the text (Figure 13).[36] Its round form was a progressive aspiration to achieve the greatest possible operational efficiency, yet it was most remarkable for its time because it was so large and was built entirely with light lumber: "The frame of the barn consists almost wholly of two-inch stock and the only long timbers are the eleven posts carrying the purline [*sic*] plates. No mortise and tenon work was used in its construction, all work being done with the hammer and saw."[37] If western builders were seeking authoritative models of progressive construction methods for a region where hardwood timbers were unavailable, they found them in many midwestern publications. These sources had a profound influence on the materials and forms of construction in the Rockies, sometimes leading to building forms that did not work well in the mountain environment.[38]

Investment in farm buildings in Gallatin County did not keep pace with that in land and machinery during the 1890s. In spite of very high land values and considerable procurements of the latest machinery, Gallatin producers invested a smaller percentage of their farm value

Figure 11. Shocks of grain drying in the Gallatin Valley, Montana, circa 1905. Photographer unknown, "Farm Scene," 1905, image #6378, Milburn Lincoln Wilson Agricultural Photographs Collection, Renne Library Special Collections, Montana State University, Bozeman.

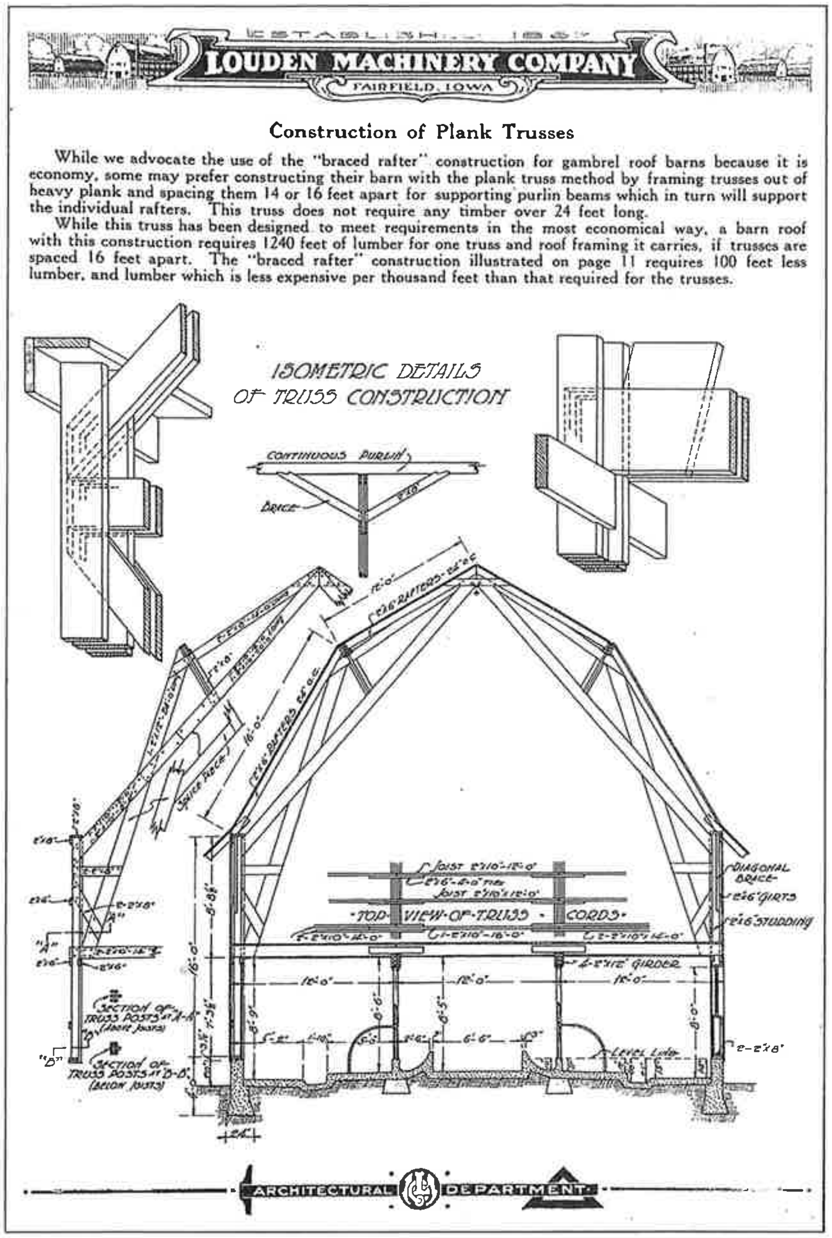


Figure 12. Gambrel roof framing with light dimensional lumber employing a Shawver truss. Columns and other large members are composites of multiple two-inch planks. *Louden Barn Plans* (Fairfield, Iowa: Louden Machinery Co., 1914), 13, manufacturer's catalog.

in buildings than did farmers in many other parts of the state. Given the relatively small size of farms in the Gallatin Valley, expenditures on buildings represented a high cost per farm. Gallatin farmers had financial resources tied up in their land, development of irrigation ditches, and implements and therefore had less capital available for buildings.[39] Because the vast majority of their produce was grain (wheat, oats, and barley), they also had more modest building requirements than those in other parts of the state who sheltered livestock.

Eager investment in mass-produced equipment illustrates the confidence of western American farmers in industrial and technological progress. Gallatin Valley farmers' close tie to midwestern technological advancement preceded their widespread adoption of the architectural design and construction methods of midwestern farm buildings. By the time Gallatin Valley farmers were ready to build in the twentieth century, they were saturated with information and images of midwestern farm construction. This profoundly influenced the form, scale, and materials of buildings in the agricultural landscape of the region.

Diversification Leads to New Buildings

By the turn of the century, stock growers and farmers in the high-elevation valleys of the Northern Rockies experimented with varieties of crops and breeds of livestock. Their diversification served as a survival strategy to accommodate market fluctuations, climatic variation, and other influences out of their control. With the rapid growth of agriculture in the area, some stock growers produced livestock, such as draft horses and breeding cattle, for sale to other local producers, while others shipped replacement breeding stock out of state.[40] Ranches and dairies imported new breeding stock to the region by rail, and many Gallatin Valley breeders experimented with purebreds.[41] The diversity of livestock and produce required a variety of new building types, such as lambing sheds, stall barns, milking parlors, and stout corrals for stallions or breeding bulls.

With the expansion of farming around 1900, farmers needed more draft horse teams to power their machinery, which in turn demanded greater hay production. Once the hay reached maturity in midsummer, there was a relatively short window when it could be cut to optimize nutritional value. The frequency of rains in the region during haying season made getting hay successfully cut, dried, and stored all the more challenging. The weather patterns required farmers to employ still more horsepower and implements to work quickly. As a result, they needed yet more buildings to shelter the additional work horses and equipment.

Houses and moderate-sized farm buildings made use of light wood construction, but producers were undoubtedly skeptical about the use of light framing for expansive livestock barns. Heavy snow and wind placed significant stresses on the broad roofs and high walls of large buildings. Farmers were also aware of the damage their draft horses and cattle could do to any shelter by kicking, rubbing, leaning, or chewing. These conditions of climate and livestock surely made the two-inch studs and toenailed connections of light wood construction seem insubstantial. However, several compelling arguments favored the use of light framing. Like many early ventures in the unfamiliar territory of the West, stock raisers invested in buildings in a speculative manner, and they built them as economically as possible. Most families had modest financial resources for building, even if the future was promising. Large structures, therefore, were realized in the most affordable way, even if it meant sacrificing longevity.

Once dimensional lumber was readily available, light frame construction was faster and less costly for a large building than heavy timber framing or log construction. It was economical because it cost less to buy and transport the lighter lumber to the building site, it required only a small construction crew compared to heavy timber framing, and the construction process required less skilled craftsmanship and a shorter time frame. Light wood frame buildings were not limited in length like log structures, as the placement of sills and studs could be endlessly repeated. The only limitation in the building width was the length of its joists and rafters. A wider building could be realized with the use of girders to support lapped floor joists and the use of purlin posts to support lapped rafters. Purlin posts were typical members of heavy timber barn frames, hence their use in light framing produced a somewhat hybrid construction type.

One transitional method of construction used widely in the Gallatin Valley, which was influenced by midwestern builders and publications, was a post-and-beam structure in which the large members were built up from two-inch lumber and the exterior walls were in-filled with light studs (Figure 14). The main portion of the Hupka barn is over fifty feet wide, employing four rows

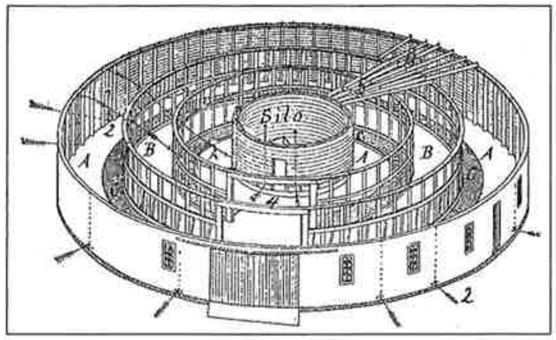


Figure 13. Two-story round dairy barn designed by Wisconsin Agricultural Experiment Station, built in Whitewater, Wisconsin, for C. E. King, prior to 1893. J. H. Sanders, *Practical Hints about Barn Building* (Chicago: J. H. Sanders Publishing, 1893), 103.

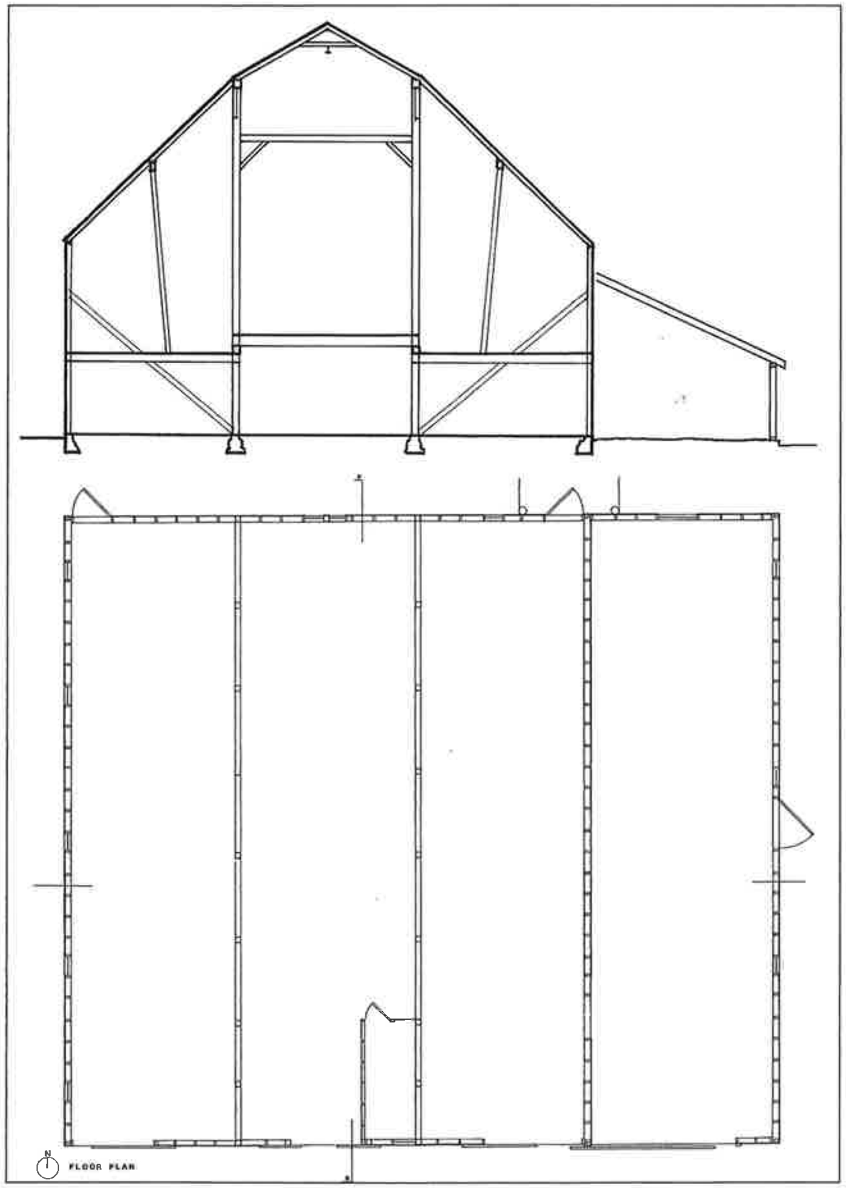


Figure 14. Section and ground-floor plan of Hupka dairy barn on the southern edge of the Gallatin Valley, Montana, circa 1900s. Drawing by Montana State University student Laura Landon, 2004. Courtesy of School of Architecture, Montana State University, Bozeman, Montana.

of purlin posts to support the roof. It was massive for its time in the Gallatin Valley and was built entirely with two-inch dimensional lumber. In his essay "Affordable Barns for the Midwest," Lowell Soike credits Joseph Wing with the innovation of built-up lumber in place of heavy timbers to make longer and stronger columns and beams, a technique he utilized in the construction of his family barn in Champaign County, Ohio, in 1893.[42] The built-up lumber was a simple form of lamination, still in use today, where three to five layers of planks were sandwiched together and nailed to form a thicker column or girder. These could be made to any length by staggering the joints between layers. Once manufactured nails were readily available and inexpensive, this became a very economical substitute for heavy timbers.

To create a wider building, as at the Hupka barn, farmers could employ diagonal bracing and purlin posts at the roof. With shed additions on each side, this could produce an enormous building. The resulting structures borrowed principles from heavy timber framing while using only two-inch dimensional lumber, producing a relatively common hybrid construction type as light milled lumber became more available. These buildings combined traditional structural knowledge with modern materials and represented a transitional period before light framing was fully understood and accepted for use in large buildings.

Experimentation

Speculation, economy of means, seasonal shortages of time and labor, and a self-sufficient spirit are all recurring themes reflected in the character of the region's agricultural buildings. Evidence of experimentation with light framing can still be seen in the sagging ridge lines, bowing eaves, and leaning walls of extant buildings (Figure 15). Some of the early light-framed barns in the region were extremely lightly built, with weak connections, inadequate lateral bracing, and undersized members. They did not stand up well over time. Although carpenters with light framing expertise came from the thriving dairy regions of Illinois and other midwestern states, they were in high demand. As a result many of the early light frame structures seen in the Rockies may have been designed and built by hard-working individuals who lacked adequate light construction experience. The regional phenomenon of structural failure in buildings constructed with light dimensional lumber suggests two important things.

Figure 15. Goodman barn, southern edge of the Gallatin Valley, Montana, construction date unknown. Undersized ridge beam and inadequate cross-bracing have led to structural failure. Photograph by Maire O'Neill Conrad, 2016.

First, farmers and ranchers during this building boom may have had inadequate resources to hire a carpenter with appropriate expertise or found them unavailable, taking both design and construction into their own hands. Farmers and builders may have based their knowledge of framing on the success of smaller structures, assuming the methods were readily transferable in scale. The longer spans, increased dead loads, and larger roof planes of sizable buildings, therefore, may have been constructed with framing members that were too light and without the necessary depth or bracing to resist snow and wind loads. Builders may have unwittingly taken liberties on the principles and details of light wood frame construction due to inexperience and their limited familiarity with scale-appropriate framing techniques. Undersized ridge beams and rafters, lack of lateral bracing or collar ties, inadequate nailing, or loose-fitting connections are possible design and construction flaws with structural consequences for medium- to large-sized buildings utilizing this optimized construction method.

Second, the prime season for building in a high mountain valley like the Gallatin coincided with the busiest season for farming. With long, harsh winters, virtually all work associated with crop production and harvest as well as livestock management had to happen during a few short months when daylight lasted longer, the ground was thawed, and temperatures were moderate. If labor was in short supply, the brief summers intensified the problem. The season between the spring thaw when grain was planted and the hay harvest in the Gallatin Valley could be as little as six weeks depending on the year. During that period, farmers and ranchers were branding calves, clearing irrigation ditches of debris, and driving herds to summer pastures often at a distance of several days' ride. As the summer progressed they were starting colts, repairing fences, and managing flood irrigation daily. The haying season began in July and may have taken weeks, depending on acreage, weather, and available horsepower and labor. The grain harvest occurred in the late summer and fall, after which stock raisers gathered cattle and drove them back to the home ranch for separating and sorting. The fall was occupied with shipping cattle, still fat from summer grazing, to market, which also involved long drives, depending on the distance to the railroad stockyards. Hence, while there was a shortage of carpentry expertise available in the region, there was also a shortage of hands for construction in general to accommodate the building boom, resulting in design and construction that was hasty and of poor quality.

By 1903 the Montana Agricultural Experiment Station promoted diversification of agricultural production based on statistics that showed the state was importing (and consuming) millions of dollars' worth of meats, poultry, dairy products, vegetables, and grain annually.[43] The Montana Agricultural College bulletins encouraged farmers to diversify their livestock and other agricultural produce to satisfy local and regional consumer demands. They advocated new farm settlement using as a model the highly profitable diversified farm, which included poultry, hogs, and dairy production. These endeavors, of course, involved the construction of new varieties of farm buildings. To encourage diversification, the experiment station in Bozeman built demonstration buildings and published affordable designs that could be constructed with simple techniques (Figure 16).[44] Most of these buildings were erected using forms of light construction in dimensional lumber.

Explosive growth and rising land values characterized the decade leading up to 1910.[45] In contrast to the 1890s, Gallatin Valley farmers began to make a more substantial investment in farm buildings. The 1910 federal census reported the average value of buildings per farm had soared to one of the highest statewide.[46] The county continued to exceed state averages in farm building value for at least the next thirty years, reflecting a prolonged construction boom. Burgeoning agricultural growth and diversification demanded more and larger buildings, and Gallatin Valley growers had developed enough equity in their farms to qualify for loans and had confidence in the return on their investment.

Robust growth in the early years of the new century was due in part to the railroad's vigorous promotion of new settlement and the

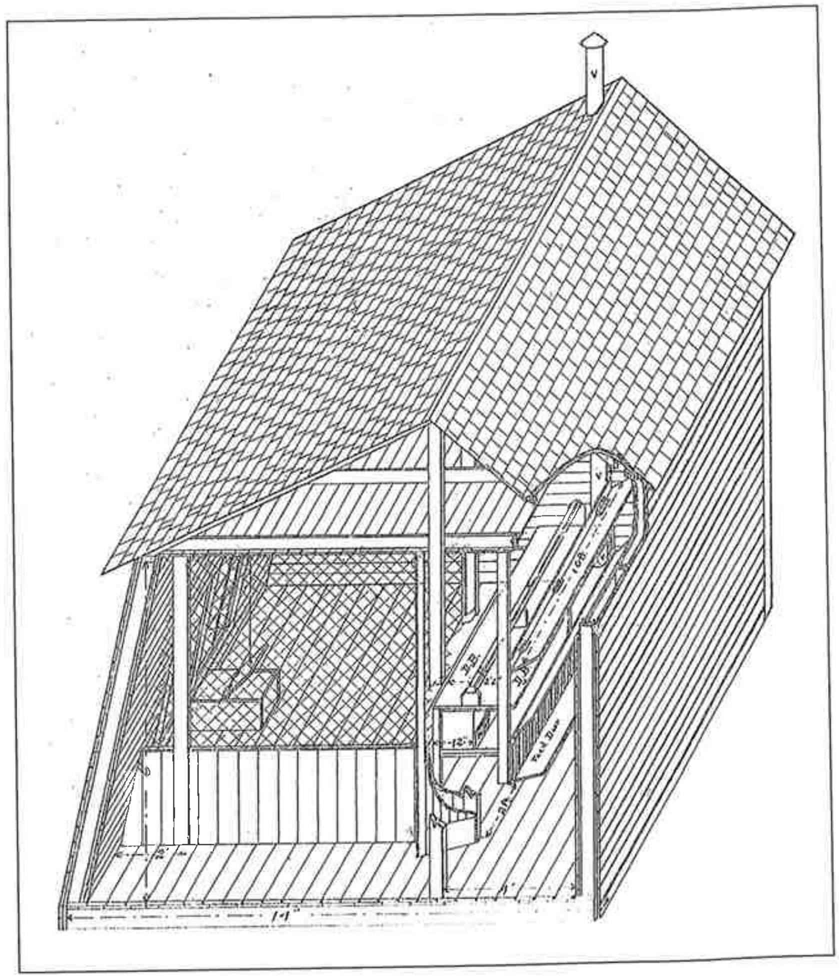


Figure 16. Isometric section drawing of a model poultry building promoted by the Montana Agricultural Experiment Station in Bozeman, 1900. H. C. Gardiner, "Poultry Raising," *Montana Agricultural Experiment Station Bulletin*, no. 26 (April 1900): 12.

availability—by rail—of farming equipment, breeding stock, and supplies from the East, the Midwest, and the West Coast. Another essential factor contributing to the rapid growth of agriculture during this period was the knowledge and practice of dry land farming techniques. These were first put to use in Great Falls, Montana, in the 1880s and were vigorously promoted to potential settlers by the railroad beginning in 1905 and by the Montana Agricultural Experiment Station in 1907.[47] These techniques made vast stretches of the less expensive, drier ground on the north and northwest sides of the valley more attractive for homesteading and agricultural settlement. Land previously thought to be unworkable for agriculture could now be farmed with methods publicized in agricultural experiment station bulletins and circulars. Growers could develop viable businesses in hay, grain, and range cattle on vast stretches where there were no snow-fed drainages from which to run irrigation ditches.

While many other regions of the state succeeded in grain production, growers in Gallatin County produced 15 percent of the state's grain on less than 4 percent of the farmland in the state in 1909.[48] As new farmers settled the area, the established Gallatin Valley farms and ranches were well positioned to grow or to profit from land sales, as the value of Gallatin Valley farmland per acre in 1910 was twice the state average.[49] By 1910 the Gallatin Valley produced over three-quarters of the state's clover hay, highly desirable for the local dairy industry but requiring large buildings for dry storage.[50] Investment in Gallatin County farm buildings soared to 66 percent higher than the average farm in the state, while the farms remained some of the most modest in size.

Incorporation of the Hay Carrier

As the demand for larger buildings increased, technological advances in hay handling helped to build the case for light framing of large roof structures. By 1890 a mass-produced labor-saving system for stacking loose hay in the barn loft—comprised of the hay carrier, hay hoist, and sling or fork—was widely available from many midwestern manufacturers (Figures 17 and 18).[51] The hay carrier was a pulley system that rolled along a track suspended from the ridge of the barn loft and projected several feet beyond one gable end. Various types of slings or hay forks could be hung from this carrier to hoist large bundles

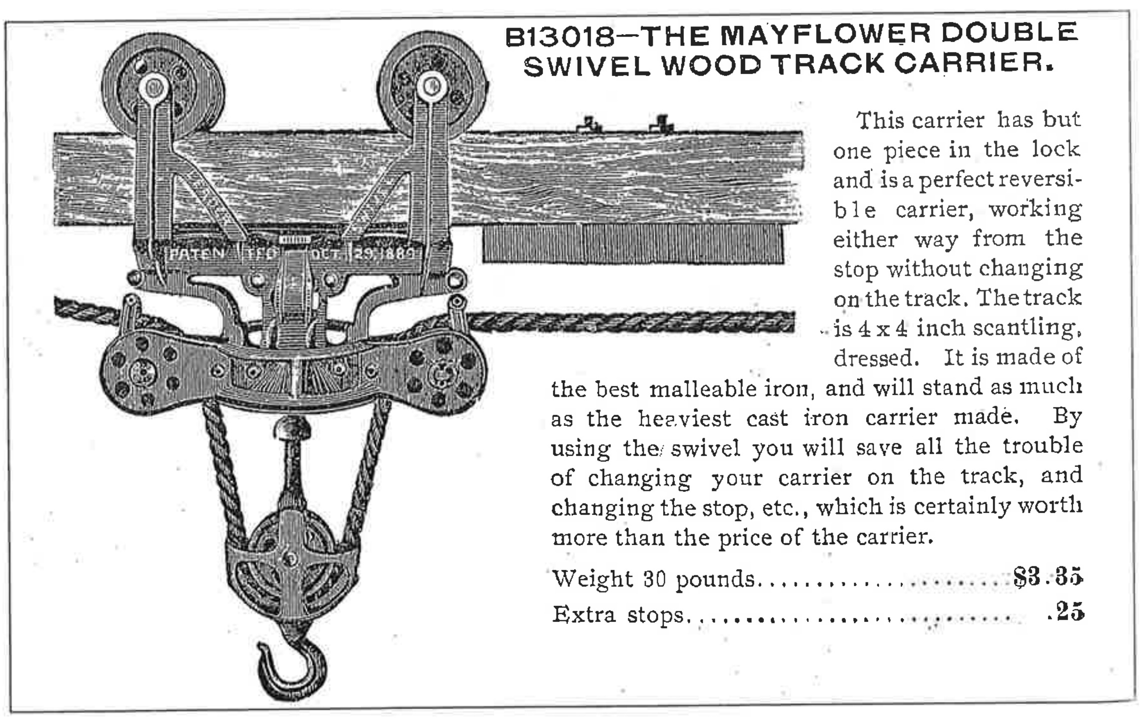


Figure 17. "Mayflower" double-swivel wood-track hay hoist and carrier, one of five carriers available in an 1898 catalog. *Montgomery Ward & Co.: Importers, Manufacturers & Jobbers* (Chicago, 1898), 115, catalog.

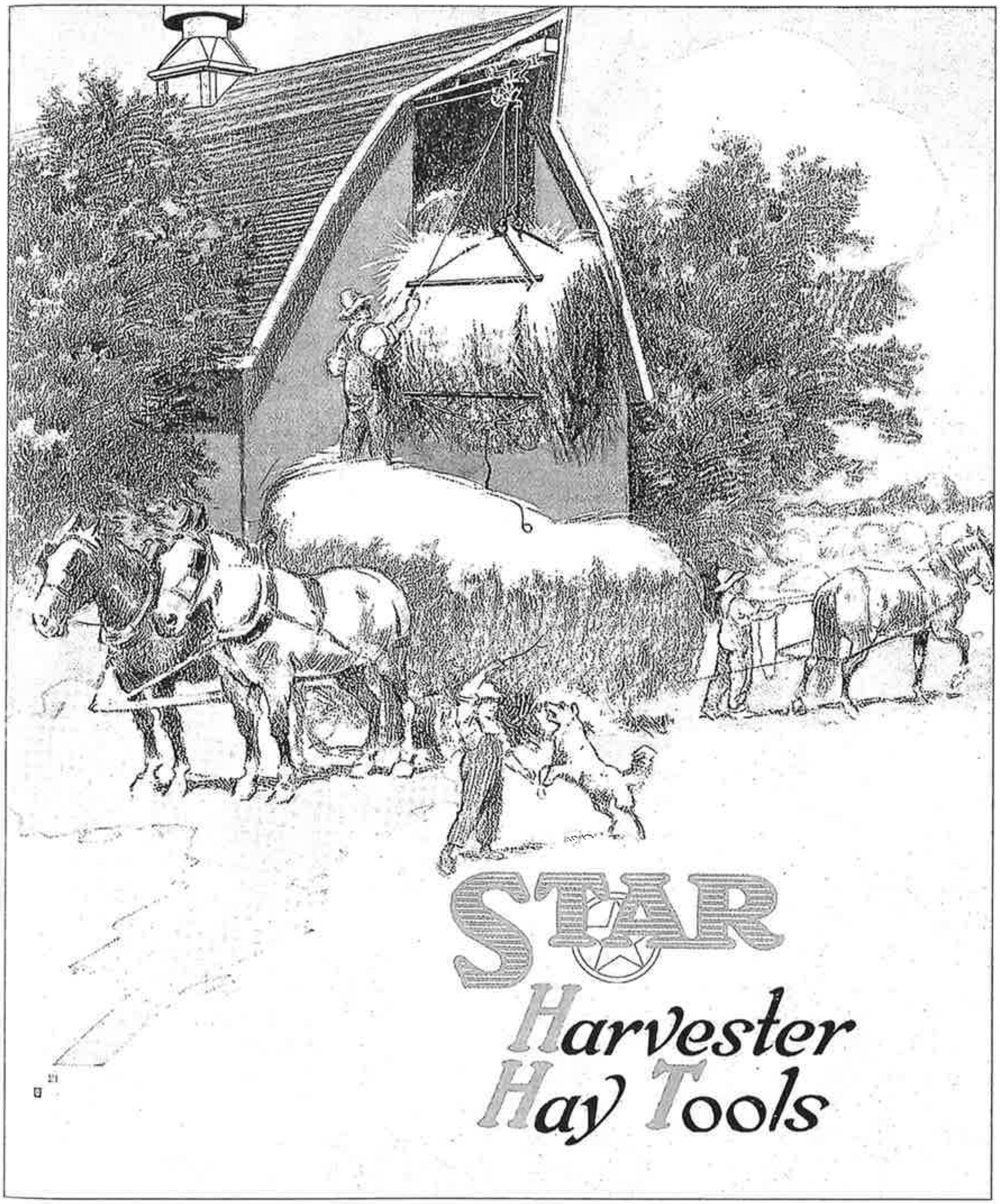


Figure 18. Star Harvester Hay Tools demonstrating the use of a hay hoist and sling. *Star Line: Hunt Helm Ferris & Co.* (Harvard, Ill., 1921), 261, catalog.

of loose hay from a wagon below. One person, often a child, could power the system from the ground using a horse to draw the pulley while another person in the hay loft directed the carrier and sling to drop the load in the desired location. Such systems were first designed and introduced in 1867 by William Louden in Fairfield, Iowa, and were subsequently mass produced by several manufacturers.[52] This industrial technology was particularly useful in the Gallatin Valley because the mountain weather conditions made it necessary to get large quantities of hay under the protection of the roof as quickly as possible between frequent and unpredictable summer rains.

Effective use of the hay carrier required open space under the roof, unobstructed by tie beams characteristic of heavy timber construction. This motivated the rapid development of roof-framing systems that provided resistance to thrust at the eave without structural members crossing the hay loft volume. As hay-handling devices became more available at the turn of the century, the advantages of the hay carrier system created pressure to design barn roofs for free movement of the hay sling within the loft, so that hay could be deposited throughout the space. The ease of raising and moving hay horizontally with the carrier allowed barns to assume longer and taller proportions than when the hay was forked by hand into the loft.[53] With the new equipment the access was by necessity at one end where the hay carrier projected from the ridge. While advances in light wood roof-framing design proliferated with agricultural expansion in the Midwest, the influx of midwestern carpentry knowledge in the Gallatin Valley combined with burgeoning growth allowed for rapid dissemination and application of these ideas shortly after the turn of the century, and farmers readily adopted them.[54]

With light dimensional lumber, various innovations in trusses and bracing essentially moved the roof structure outward toward the skin of the building, enabling the clear span of buildings with increased width (Figure 19). The design of one of the earliest of these roof-framing systems is widely attributed to Joseph Wing, though he gave credit broadly to carpenters who experimented with and evolved a variety of framing methods over time.[55] In 1905 the *Breeder's Gazette* referred to the new gambrel roof framing as Wing's joist-frame, but in Wing's own words, "The frame is an arrangement, an adaptation, and I have not hesitated to adopt other men's ideas. The roof was invented many years ago and used in New York and New England. . . . Built in the form of an arch it supports itself."[56] It is not clear from his statement how much of the adaptation was his own; however, Wing can be credited with recognizing the value of this construction method and disseminating knowledge of it with widely published articles. The earliest evidence of light framing experimentation in the Gallatin Valley illustrates a maximization of the gable roof span with light lumber by employing a modified version of the Wing joist-frame (Figure 19a) or scissor truss (Figure 19b). Both of these designs maintained clear space for operation of the hay carrier and sling. Another approach made use of purlin posts to clear the path of the hay carrier along the center of the building (Figure 19c). These designs were not unique to the Gallatin Valley, but they indicate the degree to which local builders were informed by—and receptive to—the emergent engineering of midwestern builders.

Descriptions of plank frame barn construction techniques based on engineering and experience emerged in print in the 1880s and 1890s. Livestock authors James Harvey Sanders, who founded the *Breeder's Gazette* in Chicago in 1881, and his son Alvin H. Sanders published numerous articles and later books promoting new forms of light construction for farm buildings, most notably by Joseph Wing, who was one of their staff writers.[57] Another highly influential midwestern carpenter, John Shawver from Bellefontaine, Ohio, described plank framing in an address to the Wisconsin Farmers' Institute in 1896 and published his description two years later in the widely circulated journal *Carpentry and Building*.[58] He later became known for the Shawver truss (see Figure 12), a dimensional lumber roof-framing design used widely in gambrel roofed barns throughout the Midwest. Lowell Soike asserts that the *Iowa Homestead* journal and the *Ohio Farmer* were particularly instrumental in promoting new ideas for farm buildings between 1865 and 1905: "These two journals not only printed news about farm buildings, but also became leaders in the major nineteenth-century innovations in barn building."[59] Both of these publications were in the journal collection at the Montana Agricultural Experiment Station by 1904 and may have influenced both researchers and local builders alike.[60]

Coincident with the development of these roof-framing systems was the increased use of the gambrel roof form (Figure 19c–f). The form itself was not new in the American agricultural landscape, but it had new utility when using

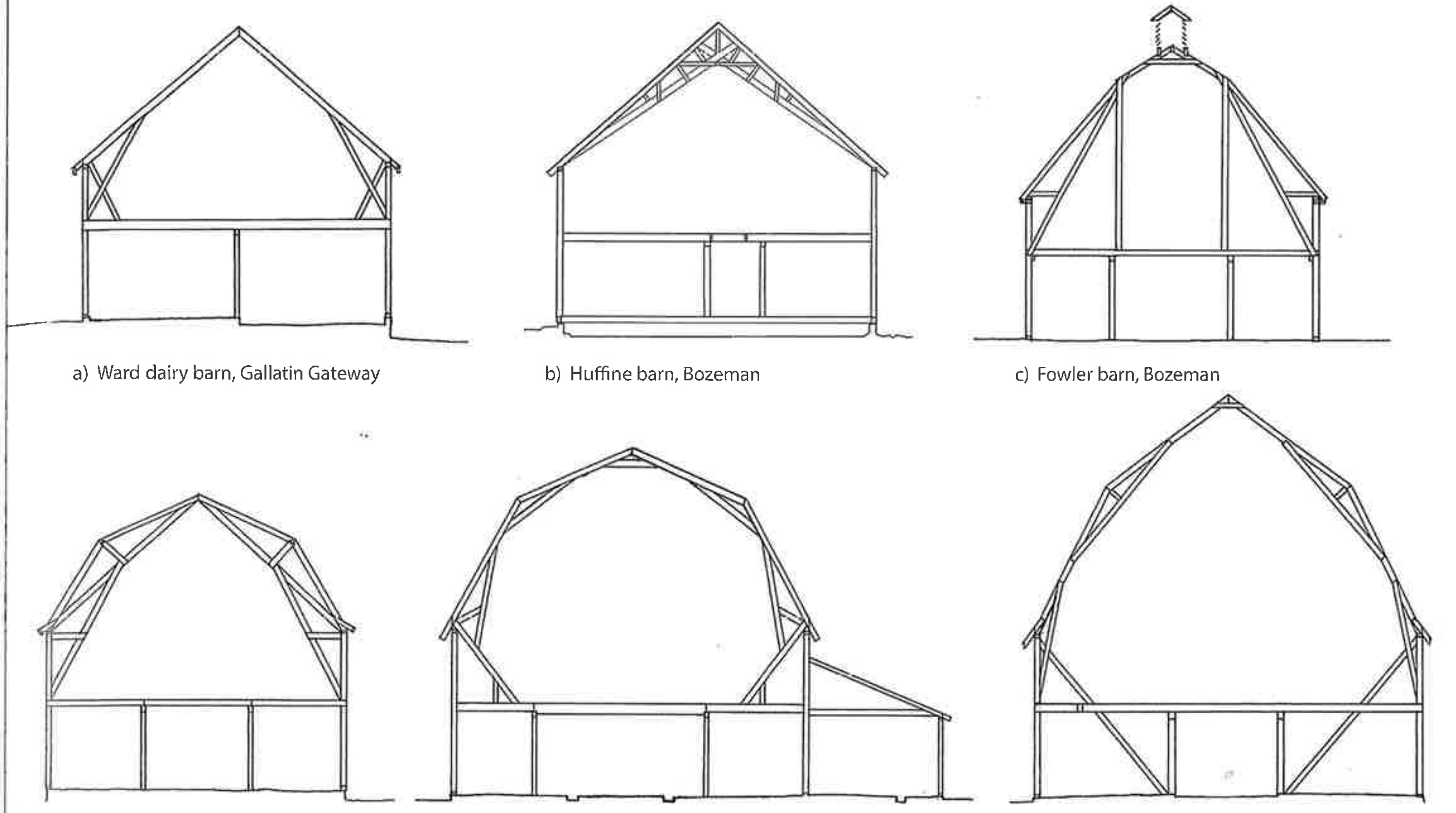
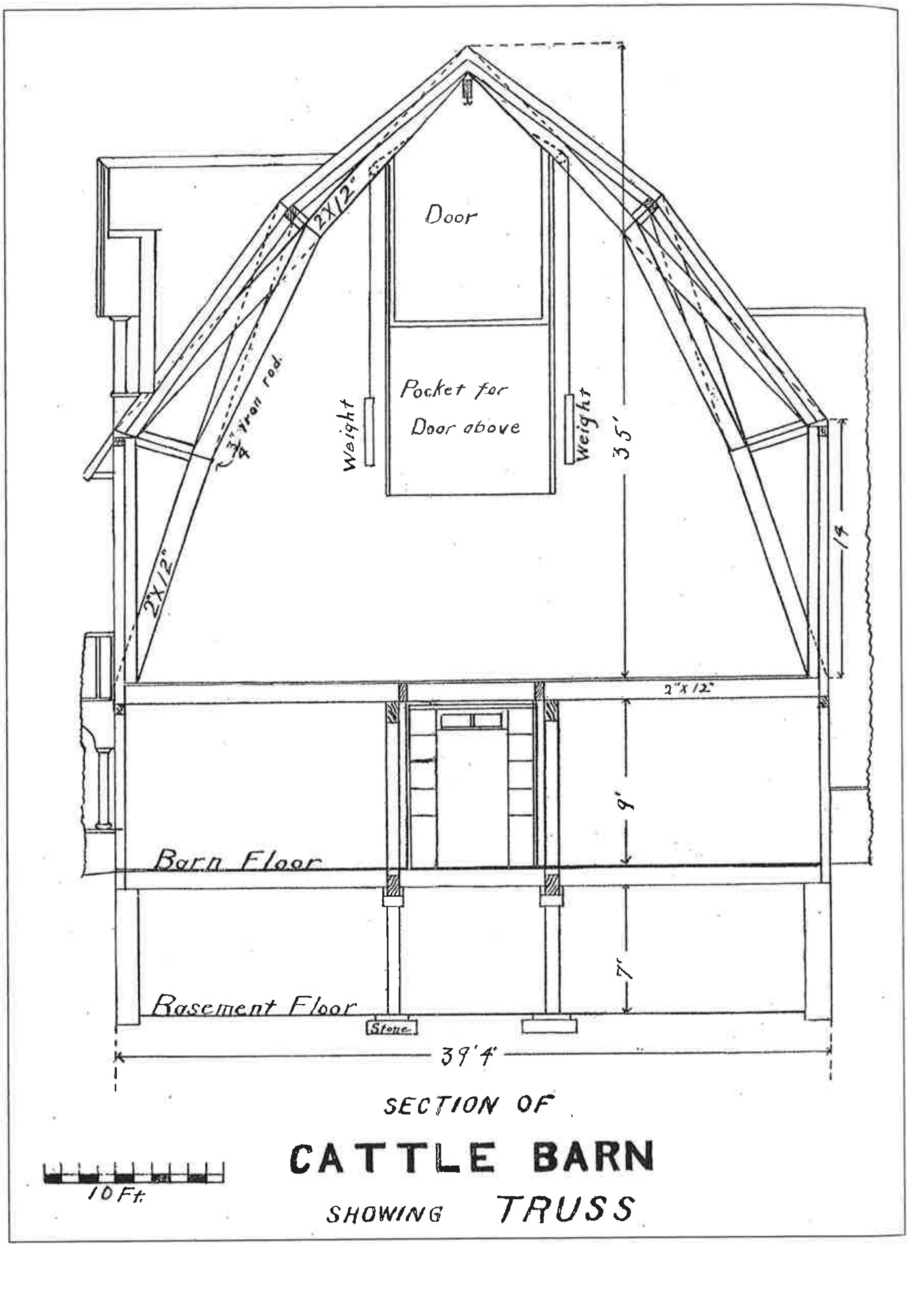


Figure 19. Roof-framing comparison of livestock buildings documented in the Gallatin Valley, Montana, which explored the potential of light lumber to span a wide roof without tie beams: *a*, Gable with modified Wing joist-frame; *b*, Gable with scissor truss; *c*, Gambrel with purlin posts and collar ties; *d*, A plank frame gambrel with Shawver truss; *e* and *f*, Wing joist-frame gambrel with braced rafters. Drawings from field notes by Maire O'Neill Conrad, 2012.

light trusses, as its geometry created structural depth that was advantageous for the rigidity of the roof while leaving the central volume clear of obstructions. The increased volume this form provided for loose hay storage is often cited as the rationale for its use, but the depth and consequent rigidity it afforded the light trusses may be an equally valid explanation. At high elevation with heavy snow loads, this rigidity proved critical. The earliest of these designs involved closely spaced trusses on each side of the ridge, which were tied to the floor joists to resist outward thrust (Figure 19d). Pairs of trusses, joined by collar ties at the ridge, became the primary structural members, with the purlins and ridge secondary and the rafters tertiary members. The rafters were shallow in profile and needed only to reach the purlins, allowing the use of shorter members. The roof span overall could be wider because it was no longer limited by rafter length and stiffness. The truss was made stronger by widening the roof profile at the purlins—a great strategy for larger buildings. Due to the Gallatin Valley's heavy snow loads, however, this form was often adapted to a steeper, narrower form than in other locations to reduce snow and ice accumulation (Figure 19e).

In 1904 the Montana Agricultural Experiment Station published a drawing of the roof truss used in the construction of a new gambrel roof cattle barn, a major demonstration building on the college campus.[61] The barn was three stories tall and almost forty feet wide, and it served as an important model for barn builders throughout the valley (Figure 20). The planning, construction, and promotion of this building represented a reversal of the experiment station's former reticence to promote light framing, and it suggests that the cost of milled lumber was becoming more competitive. This early and very public example of a large building built with a light frame was undoubtedly a landmark in the

Figure 20. Section of Montana Agricultural Experiment Station's 1904 cattle barn, Bozeman, illustrating a plank frame Shawver truss. F. B. Linfield, "The Agricultural Department," in *Montana Agricultural College Experiment Station, Eleventh Annual Report* (Bozeman, Mont.: Montana Agricultural College Experiment Station, December 1904), plate following p. 214.



transition to the widespread use of light framing for agricultural buildings in the Gallatin Valley. By about 1910 most livestock barns were built entirely with light dimensional lumber.

A Progressive Landscape

Several significant factors influenced the rapid transition to the use of light framing in farm buildings of the Gallatin Valley, beginning only about twenty-five years after initial Euro-American settlement of the region: the need to store large quantities of grain; increasing availability and affordability of dimensional lumber; a growing demand for large-capacity buildings for livestock and hay; the proliferation of light construction carpentry knowledge; shifting public perception of light framing; a desire to reflect progressiveness; evolving structural engineering of the wider roof span; and the need for unencumbered operation of the hay carrier system in the hay loft. Underlying most of these factors, of course, was the opening of the transcontinental railroad, which dramatically changed the economy of so much of the rural West. The formerly remote Rocky Mountain region was increasingly tied to industrializing parts of the country that lay far from its boundaries. The swift transition in the Gallatin Valley, however, reveals the degree to which it, like several other parts of the Northern Rockies, was exceptionally poised to take advantage of the progress and industrialization of the eastern and midwestern United States.

As one of the last regions of Euro-American settlement, the Rocky Mountain frontier was able to benefit from the advancement of other regions, and its agricultural economy was rapidly coupled with the larger economic systems of the United States. In terms of Frederick Jackson Turner's concept of successive frontiers, midwestern cities during the 1880s were becoming an industrial frontier with major advances in agricultural machinery design, engineering, and manufacturing. Western farmers, as entrepreneurs, understood the importance of being competitive in the national marketplace, and they readily adopted new machinery, methods, and building techniques in "a process of cross-fertilization of ideas and institutions."[62] While these events can be interpreted as a confirmation of Turner's thesis, they can support a critique of it just as well. Although they were physically remote, farmers in the productive regions of the Rocky Mountain West did not assume a provincial outlook as lone frontiersmen. They understood that their long-term success in agriculture was dependent on establishing and exploiting strong economic ties to more developed regions of the country. Farmers and ranchers sought the latest ideas from outside the region to give them an advantage in a vast competitive market. Accompanying the adoption of new machinery, new farming techniques, new breeds of livestock, and new varieties of crops, they replaced small vernacular log buildings with sizable state-of-the-art light wood frame structures.

Early success in intensive, large-scale grain production in the Gallatin Valley played an important role in the acceptance and proliferation of light framing techniques for moderate to large agricultural buildings. Both inside-out and cribbed granary construction methods, which required light lumber, were far superior in performance to log construction due to their tight enclosure and smooth interiors. These buildings were a necessary investment for the highly profitable grain business, despite the high cost of milled lumber in the 1890s. The widespread construction of these new granaries dramatically increased the demand for two-inch lumber. As lumber mills stepped up production of dimensional material and were forced to compete at national market prices, light lumber became more available and affordable. This added to the attractiveness of light framing techniques for larger buildings, while increased experience with the methods bolstered confidence in its suitability.

The light lumber was inexpensive to transport; the framing was very fast to erect (making it possible to put up a large building in a short season); and the length of the building was not limited by the length of the wood. The profitability and growth of grain production required the housing and feeding of large, valuable teams of draft horses that powered the machinery. Wintering large herds of livestock, however, in the high-elevation valleys of the Rockies proved to be more challenging than expected. Particularly after the devastating winter livestock losses on the open range in the 1880s and 1890s, the threat of extreme weather immediately increased demand for larger buildings with great hay-storage capacity to feed cattle and draft horses. This unmet demand provided the stimulus for an increasing number of farmers in the Rockies to risk the investment in light wood construction.

Shifting public perception of light construction for large farm buildings was stimulated by experimentation with its use for a great diversity of small and moderate-sized buildings needed on the farmstead, by seeing examples in midwestern farm publications, and by visiting the Montana Agricultural Experiment Station's demonstration buildings constructed in Bozeman after the turn of the century. The influx of experienced and largely midwestern journeymen carpenters during a period of intense agricultural growth aided proliferation of knowledge and confidence in design and construction. The rapid acceptance of the light wood frame reflected a western willingness—or perhaps necessity—to make speculative business decisions. As producers embraced a business model of diversification, they were more likely to build economically even if the techniques seemed risky.

Swift adoption of innovations in roof-framing design enabled larger uninterrupted spans constructed with two-inch lumber and facilitated the use of the hay carrier. This was a critical factor in the acceptance of light framing techniques. The use of the hay carrier was essential for an effective hay operation in a region with a shortage of labor, frequent rains during the haying season, and an absolute need to store large quantities of high-quality winter feed. All of these developments took place largely between 1890 and 1910, resulting in a rapid and dramatic change in the agricultural landscape of the Gallatin Valley.

AUTHOR BIOGRAPHY

Maire O'Neill Conrad is professor of architectural design and historic preservation at Montana State University School of Architecture, where she has taught since 1990. As a licensed architect she approaches the study of vernacular buildings with a particular interest in structure, materials, and construction methods. Her students have been recognized several times by the national Peterson Prize at the Historic American Buildings Survey for their documentation of vernacular buildings in southwestern Montana.

NOTES

1. Thomas Carter, ed., *Images of an American Land: Vernacular Architecture in the Western United States* (Albuquerque: University of New Mexico Press, 1997), 11.

2. The buffalo jump, or game jump, was a bison hunting method in use by native peoples generally before 1500 when horses were introduced, suggesting that their occupancy of the valley was very early. Archeological evidence supports the view that such sites were in use for nearly six thousand years. "Head-Smashed-In Buffalo Jump," UNESCO World Heritage List, whc.unesco.org/en/list/158.

3. The population of Gallatin County increased 131 percent between 1870 and 1880 and grew another 72 percent in the following decade. Department of Commerce and Labor, Bureau of the Census, *Thirteenth Census of the United States Taken in the Year 1910*, vol. 2, *Population* (Washington, D.C.: Government Printing Office, 1913), 1154.

4. The 1880 Census reports that farm acreage in Gallatin County and throughout the Montana Territory had expanded approximately threefold from 1870 to 1880. Gallatin Valley farms were not by any means the highest value per acre in the territory, but they were well above the territorial average and above the values of other agricultural valleys that had supplied the mining boom of the 1860s and 1870s. Department of the Interior, Census Office, *Report on the Productions of Agriculture, Tenth Census*, June 1, 1880 (Washington, D.C.: Government Printing Office, 1882), 125.

5. According to U.S. Census figures, by 1900 the average farm size in Montana was almost three and a half times the average size in 1880. Department of Commerce and Labor, Bureau of the Census, *Thirteenth Census of the United States Taken in the Year 1910*, vol. 6, *Agriculture* (Washington, D.C.: Government Printing Office, 1913), 945.

6. Allen G. Noble, *Wood, Brick, and Stone: The North American Settlement Landscape*, vol. 2, *Barns and Other Farm Structures* (Amherst: University of

Massachusetts Press, 1984), 43; Allen G. Noble and Hubert G. H. Wilhelm, eds., *Barns of the Midwest* (Athens: Ohio University Press, 1995), 147; Carter, *Images*, 75–76; Cynthia G. Falk, *Barns of New York: Rural Architecture of the Empire State* (Ithaca, N.Y.: Cornell University Press, 2012), 1–8.

7. In the East and, perhaps, also in the South, barns continued to be constructed in heavy timber, even as balloon frame construction was commonly used for dwellings and other structures. In 1901 George Hill from Falls Church, Virginia, authored a USDA farm bulletin that promoted the use of light wood frame construction for farm dwellings, whereas his recommendations for barn construction were still based on the principles of heavy timber framing. Hill credits Atlanta, Georgia, architect B. R. Padgett for his advice regarding the text, giving legitimacy to his recommendations. George G. Hill, "Practical Suggestions for Farm Buildings," *USDA Farmers' Bulletin*, no. 126 (Washington, D.C.: Government Printing Office, 1901).

8. In 1893 James Sanders published design and construction ideas from existing farm buildings built predominantly in the Midwest. Among the larger barn types, he included three examples of light frame barns. By 1905 a subsequent edition with a different title illustrated sixteen light frame barns, the majority of which were in the Midwest. This edition, produced with the influence of his son, Alvin H. Sanders, also featured an introduction to the concept of the "modern barn," promoting the use of light lumber with "no solid timber at all in the frame." J. H. Sanders, *Practical Hints about Barn Building* (Chicago: J. H. Sanders Publishing, 1893), 75–77, 100–108; Sanders Publishing, *Farm Buildings* (Chicago: Sanders Publishing, 1905), 15–19.

9. Terry G. Jordan, Jon T. Kilpinen, and Charles F. Gritzner, *The Mountain West: Interpreting the Folk Landscape* (Baltimore: Johns Hopkins University Press, 1997), 80–81.

10. Terry G. Jordan, *American Log Buildings: An Old World Heritage* (Chapel Hill: University of North Carolina Press, 1985).

11. Paul E. Sprague, "The Origin of Balloon Framing," *Journal of the Society of Architectural Historians* 40, no. 4 (December 1981): 311–19.

12. Three Gallatin County examples of log dwellings that were obscured by wood siding have been documented by the author: Charles Leverich homestead, south of Bozeman, Thirteen Mile Farm, Springhill (recently restored), and the Woosley house in Sedan. Unpublished drawings are in the author's fieldwork archives at the School of Architecture, Montana State University, Bozeman.

13. The date that planed siding began to appear on farm dwellings is not known, though it likely occurred considerably later than on the commercial false-fronts of the mining boom towns. One of the motivations that Kingston Heath emphasizes was an entrepreneurial interest in attracting and promoting commercial business. The more refined surface reflected an association with more settled regions of the country and therefore projected a sense of familiarity, substance, and permanence. The lack of public presence of the farmhouse was obviously different, but farming families clearly cared about how their neighbors thought of them. Kingston Heath, "False-Front Architecture on Montana's Urban Frontier," in Carter, *Images*, 26–27.

14. Heath, "False-Front Architecture," 29.

15. An example of a very early light wood frame reflecting this irregularity can still be found in what is thought to be the first light wood frame house in the region, built in 1869 by Nelson Story, a cattle baron who famously drove the first herd of Texas longhorn cattle into the Gallatin Valley. The spacing between studs in this small house varies by about two inches. Michael Shamblin, Eli Oldham, Boone Nolte, and Maire O'Neill, "1869 Nelson Story House: Research on Its Origin" (student research paper, Montana State University, School of Architecture, 2002), 14.

16. Fred Kniffen defines true *piece sur piece* construction as "horizontal timbers mortised into vertical corner posts." He attributes the technique to both French and German influence in North America, particularly in Canada, Louisiana, and Pennsylvania. Fred Kniffen, "On Corner Timbering," *Pioneer America* 1, no. 1 (January 1969): 1–8. Other sources refer to the *piece sur piece* construction type as "Red River frame," "poteaux et piece coulissante," or "Manitoba frame." J. Gottfred, "Fur Post Construction" *Northwest Journal*, 1994–2002, www.northwestjournal.ca; Andrea Cordonier, "Adaptive Reuse (and Reuse and Reuse) at the Grey Nun's Convent," May 7, 2012, www.habicurious.com.

17. S. M. Emery, "Annual Report of the Director," *Montana Agricultural College Experiment Station, Bulletin*, no. 8 (July 1, 1895): 193–94. The article does not include illustrations, and it does not explain whether the thirty-two-foot-by-fifty-foot barn was braced to resist lateral forces.

18. S. M. Emery, "Annual Report of the Director," *Montana Agricultural College Experiment Station, Bulletin*, no. 16 (February 1, 1898): 58.

19. Steven Berkas, Madison Gabig, and Trae Schwenneker, "Crouse Homestead, Barn" historical report for Historic American Buildings Survey documentation, HABS No. MT-170. Washington, D.C.: Library of Congress, (2014), http://lcweb2.loc.gov/master/pnp/habshaer/mt/mt0600/mt0606/data/mt0606data.pdf.

20. Author's calculations from census records show that Gallatin County produced 48 percent of the wheat, 46 percent of the oats, and 44 percent of the barley in Montana Territory. Francis A. Walker, *Ninth Census*, vol. 3, *The Statistics of the Wealth and Industry of the U.S.* (Washington, D.C.: Government Printing Office, 1872), 196–97.

21. The 1880 Census reports that the valleys of southwestern Montana Territory were producing over twenty bushels of wheat per acre. Department of the Interior, *Tenth Census*, 452, map 5.

22. *World's Columbian Exposition: Official Catalog of Exhibits*, part 1, *Agricultural Building* (Chicago: W. B. Conkey, 1893), 97–100.

23. Shamblin et. al, "1869 Nelson Story House," 14.

24. Montana earned statehood in 1889.

25. In the 1880s and 1890s, the agricultural census reports show Gallatin County produced 83 and 81 percent, respectively, of the barley in the territory. Productivity of grain crops per acre were due in part to good soils and well-developed irrigation ditches. William Merriam, *Census Reports*, vol. 6, *Agriculture*, part 2, *Crops and Irrigation* (Washington, D.C.: Government Printing Office, 1902), 173.

26. George Flanders established two of the early sawmills in the valley—one in Bear Canyon in 1870 and another on Middle Creek in 1878—extracting lumber from Middle Creek Canyon (now Hyalite Canyon). It is likely, however, that these mills were not producing enough lumber to meet demand, and costs remained high. "History of Flanders Saw Mill," George W. Flanders Sr. Papers, 1863–1975, Box 1, Folder 2, Collection 1104, Renne Library Special Collections, Montana State University, Bozeman.

27. The inside-out granary construction type is found throughout the intermountain West. Elaine Thatcher, Lisa Duskin-Goede, and Thomas Carter, *Historic Barns of Northern Utah: A Self-Guided Driving Tour* (Logan, Utah: Watkins Printing, 2007), 30; John Michael Vlach, *Barns* (New York: W. W. Norton, 2003), 338.

28. Half pitch is the equivalent of the twelve-in-twelve pitch or a forty-five-degree slope. Sanders Publishing, *Farm Buildings: New and Enlarged Edition* (Chicago: Breeder's Gazette, 1911), 22.

29. The Agricultural Census of 1900 Gallatin County reports an average farmland value of $12.50 per acre, almost three times the state average; the value of all farm products per acre was almost double the state average. U.S. Census Office, *Census Reports*, vol. 5, *Twelfth Census of the United States Taken in the Year 1900*, part 1, *Agriculture* (Washington, D.C.: Government Printing Office, 1902), 287.

30. Counties with smaller average farm acreages and higher land values reflect the highest investment in machinery per acre. U.S. Census Office, *Census Reports*, vol. 5 (Washington, D.C.: Government Printing Office, 1902), 287.

31. Department of the Interior, *Report on the Productions of Agriculture*, 125.

32. W. E. Ellsworth, *A History of the Gallatin Valley and City of Bozeman, with Sketches of Men, Firms, and Corporations* (Bozeman, Mont.: Avant Courier, 1898), 12.

33. Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 958–59.

34. Merriam, *Census Reports*, vol. 6, *Agriculture*, 173.

35. The term *plank frame* has varied definitions depending on the context, but here it refers to barn construction using nothing larger than two-inch dimensional lumber. Early uses of plank framing took many forms, but generally in the Rocky Mountain region they involved the balloon frame or platform frame using two-inch studs and roof trusses built with two-inch planks. The roof-framing of large barns with "plank" lumber is where these buildings significantly depart from their heavy timber predecessors. William A. Radford, *Framing* (Chicago: Radford Architectural

Co., 1909), 254–62; Byron D. Halstead, ed., *Barn Plans and Outbuildings*, new and rev. ed. (New York: Orange Judd Company, 1914), 9–13; W. E. Frudden, *Farm Buildings, How to Build Them* (Charles City, Iowa: W. E. Frudden, 1916), 8–9; W. A. Foster and Deane G. Carter, *Farm Buildings* (New York: John Wiley & Sons, 1922), 74.

36. The barn was designed by Professor F. H. King for dairy farmer C. E. King in Whitewater, Wisconsin. Its design required stone foundation walls in concentric circles to support two stories of light framing. Sanders, *Practical Hints*, 100–108.

37. Sanders, *Practical Hints*, 104.

38. This subject is worthy of more lengthy examination beyond the scope of this article. The eave entry, for example, was unsuitable for a livestock barn in a climate with heavy snowfall and frequent summer rains, as accumulated snow, ice, and mud obstructed the entry. Jon T. Kilpinen, "The Mountain Horse Barn: A Case of Western Innovation," *Pioneer America Society Transactions* 17 (1994): 30; Jon T. Kilpinen, "Material Folk Culture of the Rocky Mountain High Valleys," *Material Culture* 23, no. 2 (Summer 1991): 30.

39. Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 961–63.

40. Replacement cattle are purchased by ranchers, usually for breeding, to take the place of aging cows or bulls. They are selected to represent the best conformation and growth traits of the breed, and they command a higher price than cattle sold for beef.

41. From recorded and transcribed interviews with Gallatin Valley ranching families. Maire O'Neill, "Learning Rural Perceptions of Place: Farms and Ranches in Southwest Montana," (Ed.D. diss., Montana State University, Bozeman, 1997), 202, 218.

42. Lowell J. Soike, "Within Reach of All: Midwest Barns Perfected," in Noble and Wilhelm, *Barns*, 148.

43. F. B. Linfield, "Report of the Director: The Diversified Farm," in *Montana Agricultural College Experiment Station, Ninth Annual Report* (Bozeman, Mont.: Montana Agricultural College Experiment Station, 1903), 9–10.

44. H. C. Gardiner, "Poultry Raising," *Montana Agricultural Experiment Station, Bulletin*, no. 26 (April 1900): 10–17; F. B. Linfield, "The Poultry House," *Montana Agricultural College Experiment Station, Bulletin*, no. 50 (October 1903): 182–90; W. J. Elliott, "Creameries and Cheese Factories: Organization, Building, and Equipment," *Montana Agricultural College Experiment Station, Bulletin*, no. 53 (August 1904): 59–68; R. W. Clark and H. P. Griffin, "Hog Management in Montana," *Montana Agricultural College Experiment Station, Circular*, no. 13 (December 1911): 47–67; Wm. F. Schoppe, "Poultry Houses," *Montana Agricultural College Experiment Station, Circular*, no. 9 (July 1911): 1–13.

45. The rural population of Gallatin County grew by 46 percent, and the value of farm property per acre increased by 147 percent. Farmland remained among the most valuable in the state, at almost double the state average. The value of crops per acre in the county was almost two and a half times the state average. Department of Commerce and Labor, *Thirteenth Census*, vol. 2, *Population*, 1154; Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 958–60.

46. Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 958–60.

47. F. B. Linfield and Alfred Atkinson, "Dry Farming in Montana," *Montana Agricultural College Experiment Station, Bulletin*, no. 63 (January 1907): 2–14; Alfred Atkinson and J. B. Nelson, "Dry Farming Investigations in Montana," *Montana Agricultural College Experiment Station, Bulletin*, no. 74 (December 1908); Alfred Atkinson and F. S. Cooley, "Dry-Farming Practice in Montana," *Montana Agricultural College Experiment Station, Circular*, no. 3 (February 1910); Alfred Atkinson, and J. B. Nelson, "Dry Farming Investigations in Montana," *Montana Agricultural College Experiment Station, Bulletin*, no. 83 (January 1911).

48. Author's calculations from 1910 census statistics. Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 958–65.

49. Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 958–60.

50. Clover hay, high in energy and protein, was used to feed valuable, highly productive livestock such as working horses or dairy cows. Department of Commerce and Labor, *Thirteenth Census*, vol. 6, *Agriculture*, 973.

51. William Louden patented the first hay carrier system in 1867, but due to his challenges in manufacturing and marketing, it was not until 1889 that these systems were effectively mass produced and became

more widely available. In 1890 the Montgomery Ward catalog illustrated three types of mass-produced hay carriers available. Terry Wilson, "Louden, William," in *The Biographical Dictionary of Iowa* (Iowa City: University of Iowa Press, 2009), http://uipress.lib.uiowa.edu/bdi; William Colgan Page, *Intensive Historical and Architectural Survey: The Louden Machinery Company, Fairfield, Iowa* (Des Moines, Iowa: William C. Page, 1996); *Montgomery Ward & Co. General Catalog,* no. 47 (Spring 1890): 534.

52. Lowell J. Soike, "Affordable Barns for the Midwest" in Noble and Wilhelm, *Barns,* 88–90.

53. Soike, "Affordable Barns for the Midwest," 88.

54. Large areas of midwestern agricultural settlement occurred after the 1830s when light framing was first being explored in the Chicago area. Unlike the East and the South, where large heavy-timber barns preceded light wood, the Midwest lacked native hardwood forests and was therefore primed to take advantage of new construction methods.

55. Joseph E. Wing, "The 'Open Center' Barn Frame," *Ohio Farmer* 93 (March 24, 1898): 1.

56. Sanders Publishing, *Farm Buildings,* 17. Later, Wing appeared to have accepted recognition for the framing design when he discussed "Wing joist-frame" construction and "Kassens rib-frame" construction, both of which were light framing techniques used with gambrel roofs. Joseph E. Wing, "Other Types of Barn Construction," in *Cyclopedia of American Agriculture,* vol. 1, *Farms,* ed. Liberty Hyde Bailey (New York: Macmillan, 1909), 259.

57. Frank Luther Mott, *A History of American Magazines,* Vol. 3, *1865–1885* (Cambridge, Mass.: Belknap Press of Harvard University Press, 1938), 159; Richard Bryan Helmer, *James and Alvin Sanders: Livestock Journalists of the Midwest* (Bryn Mawr, Penn.: Dorrance and Co., Inc., 1985), 87, 101, 134.

58. Robert C. Vogel, "Common Farm Barns of South Dakota, 1857–1958," National Register of Historic Places, Multiple Property Documentation Form, U.S. Department of the Interior, September 2007, Section E, 12, 16–18, history.sd.gov/preservation/otherservices/sdbarns.pdf; John L. Shawver, "Constructing a Plank Frame Barn" *Carpentry and Building* 20 (January 1898): 21; John L. Shawver, "Constructing a Plank Frame Barn" *Carpentry and Building* 20 (February 1898): 35–36; John L. Shawver, "Constructing a Plank Frame Barn" *Carpentry and Building* 20 (March 1898): 73–74; John L. Shawver, *Plank Frame Barn Construction* (New York: David Williams Co., 1904).

59. Soike, "Affordable Barns for the Midwest," 91.

60. *Montana Agricultural College Experiment Station, Eleventh Annual Report* (Bozeman, Mont.: Montana Agricultural College Experiment Station, December 1904).

61. F. B. Linfield, "The Agricultural Department," in *Montana Agricultural College Experiment Station, Eleventh Annual Report* (Bozeman, Mont.: Montana Agricultural College Experiment Station, December 1904), plates following p. 214.

62. Frederick Jackson Turner, "Significance of the Frontier in American History," in *The Frontier in American History* (New York: Henry Holt, 1921), 29.