Pressing Hay in the Commonwealth:Using Tree-ring Growth Patterns to Date the Construction of Two Kentucky Beater Hay Press Barns

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This article describes Mormon beater hay press barns located in Gallatin and Henry County, Kentucky, and the use of tree-ring growth patterns to date their construction. Beginning in the early decades of the nineteenth century, Mid-Ohio River farmers took part in a commercial agriculture system where timothy hay was produced, baled, and exported to feed horses in East Coast cities. In 1843 Samuel Hewitt of Allensville, Indiana invented the Mormon beater hay press to improve the efficiency of baling hay. This three-story tall, animal powered machine was housed in an architectural barn type designed with specific spaces for storing, curing, and pressing hay. Northern Kentucky farmers William H. Gridley and Frank D. Pollard were participants in this system, and each constructed a beater hay press and barn. The goals of this paper are to describe the two markedly different vernacular structures, use tree-ring data to establish their dates of construction, and to place the hay press barns in the broader context of a regional culture of commercially exporting hay. This study establishes construction dates for the two Kentucky barns, concludes that they display the character-defining features typical of the vernacular building type, and explains how they also display their own distinct characteristics.

Commercial Hay Production in the Mid-Ohio River Valley

Throughout the nineteenth century, the growth of urban horse populations created a steadily increasing demand for hay (McShane and Tarr 2007; Tarr and McShane 2005). Compressed hay is easier to store, ship to market, and sell, so techniques were developed to reduce its bulk properties through pressing and baling. Early presses required the undesirable process known as "tramping in" where human weight and movement was used to compress the grass before pressing a bale (Harris 1851:260). Initial press forms evolved from, or along with, technologies for baling cotton and utilized screws, gears, levers, and pulleys to apply compression pressure (Scientific American 1863:65).

By the 1840s Mid-Ohio Valley farmers were supplying distant markets with timothy (grass) hay via the Ohio and Mississippi Rivers, with the New Orleans market being the primary destination of western hay exported for East Coast cities. The navigable waters of the Kentucky River allowed the commercial system of producing and shipping hay to extend into the Commonwealth at least as deep as Henry County. Switzerland County, Indiana, was recognized as the heart of the commercial system, and it was in the rural village of Allensville that Samuel Hewitt invented and patented the beater hay press in 1843 (United States Patent and Trademark Office 1843). Hewitt's automated, animal-powered machine compacted timothy by dropping a massive wooden block—guillotine style—into a hay-filled box (Figures 1 and 2). The invention was typically referred to as a "beater press," but since Hewitt was a well-known Mormon, it became commonly known as the "Mormon Hay Press," or "Mormon Beater Hay Press" (Baas and Rubino 2013a; Lake 1886:11).

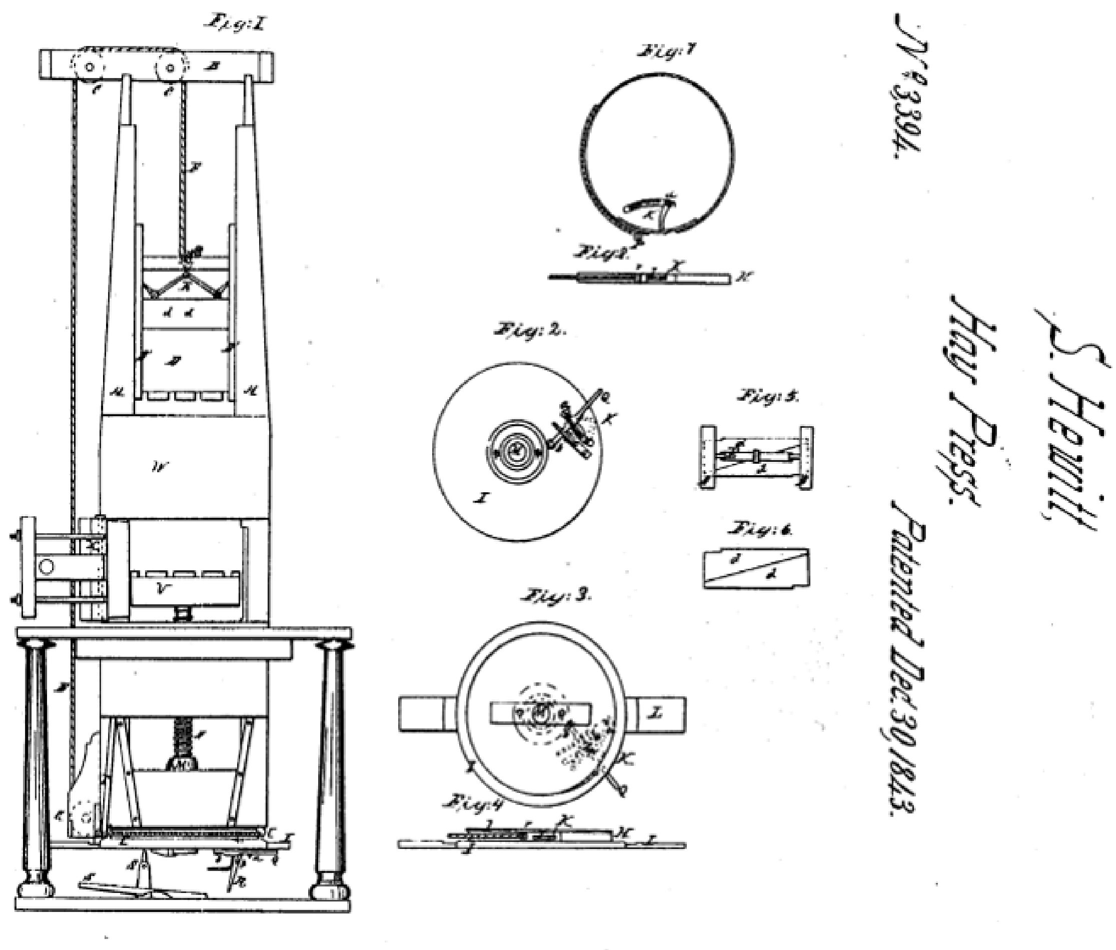

Figure 1. Improvement in Hay-Presses. U.S. Patent No. 3,394, issued December 30, 1843 to Samuel Hewitt of Allensville, Indiana.

Hewitt's machine produced .6 m × .9 m × 1.2 m, 180 kg bales (2 × 3 × 4 foot, 400 pound) that simplified the handling, storage, and transportation of hay. His invention appealed to the region's farmers because it maximized the pressing power of a metal screw with horsepower and incorporated a beater to replace the time consuming process of tramping in. More importantly, the machine made it possible to load twice as much hay onto boats than bales made with other presses. Even though urban demand for hay extended into the early decades of the 20th century, farmers profited from the regional system until the late 1870s (McShane and Tarr 2007; Vevay Reveille 1878). The oversupply of hay and the resulting drop in market prices, the expansion of railroads as a rival to river travel, the opening of interior lands for hay export, and the depletion of soil fertility are all potential reasons for a drop in hay profits and the viability of the system in southeast Indiana and northern Kentucky (Baas and Rubino 2013a, Owen 1862:53).

Figure 2. Leavenworth-Lang-Cole Barn showing Mormon beater hay press. The barn is located at O'Bannon Woods State Park, Harrison County, Indiana. (Photo by Christopher Baas)

Documentation of hay presses, press barns, and the region's commercial hay production system is rare. Local historical publications provide accounts of Hewitt's ingenuity and the "Hay King" Ulysses Schenck's hay production and shipping enterprise (Beach 1987:19; Dufour 1925). Folklorist Warren E. Roberts documented a Crawford County, Indiana, barn and press using field work and oral history (1993). That press and barn was moved to O'Bannon Woods State Park and restored in 2004; the barn and press are available for public view (Figure 2). The Thiebaud Farmstead press barn in Craig Township, Switzerland County, Indiana is described in an archaeological report examining the site's potential as an agricultural museum (Baas 2004a, 2004b; Strezewski and McCullough 2004). Hay press operations, the timber species used for their construction, and the metal parts of Mormon presses are described in detail by Baas and Rubino (2013a); Baas and Rubino (2012) also used tree-ring samples to assign an 1866 date to the John Wycoff Barn in Allensville, Indiana. Establishing a construction date for the Wycoff Barn allowed the authors to determine that it was not directly connected to the press's inventor Samuel Hewitt. However, the date demonstrated that the barn's urban location and association with the entrepreneurial salesman John Wycoff, rather than a farmer, was unique.

This article is the first to define the extent of the system in Kentucky, and it will hopefully lead to the identification and preservation of additional press barn resources in the Commonwealth. It reports field work performed in 2010 and 2011 that collected barn layout and tree-ring data from twelve hay press barns in southeast Indiana and northern Kentucky. The Gridley and Pollard barns reported here are the only known existing press barns in Kentucky (Kentucky Heritage Council 2008; Figure 3). A third barn located in Owen County was advertised for sale in 1866, but its exact location is unknown (Cincinnati Daily Enquirer 1866). Knowing the construction dates of hay press barns helps identify evolutions of form and clarify the landscape distribution patterns of this rare agricultural resource. For the authors, the dendroarchaeology (tree-ring dating) of barns is approached within a framework of interpretive archaeology (Wilkie 2009). We are working closely with local museums and individuals to interpret historic hay production in public history settings and for university and public school students (Baas 2004a, 2004b; Rubino and Hanson 2009; Strezewski and McCullough 2004).

The Beater Hay Press Barn as a Vernacular Barn Type

The Gridley and Pollard Press Barns display character-defining features established through field study of existing press barn resources. As a vernacular architecture barn type, the structure's description is categorized into the fundamental components of construction, use, and form (Baas 2012; Baas and Rubino 2013a; Glassie 1968:8).

Construction- Press barns are constructed with timber frames that rest on rock cellar walls or footings. The exterior is clad in vertical siding. Barns and presses display timber species distinct to the region: tulip poplar, red and white oak species, and beech are commonly used.

Use-Press barns were specifically constructed to house a beater hay press and to facilitate the operations of pressing and baling hay (as opposed to curing tobacco, threshing wheat, housing livestock, or dairying operations). The baling floor was used for storing and pressing hay. The cellar space housed the horse-related operations of the press. A three-story space was allotted for the storage and curing of the season's hay harvest. Ramps, bridges, and aisles accommodated wagon traffic in and through the barn.

Exterior Form-Press barns are three stories in height, but they might also be described as two stories over a cellar. They have gable roofs. Since they are located on farmsteads with both flat and rolling topography, they are either constructed into a hillside, like a bank barn, or are freestanding. The barn accommodates wagon traffic on the baling floor level, so hillside barns utilize topography for access, and barns on flat terrain use earthen ramps and wood bridges.

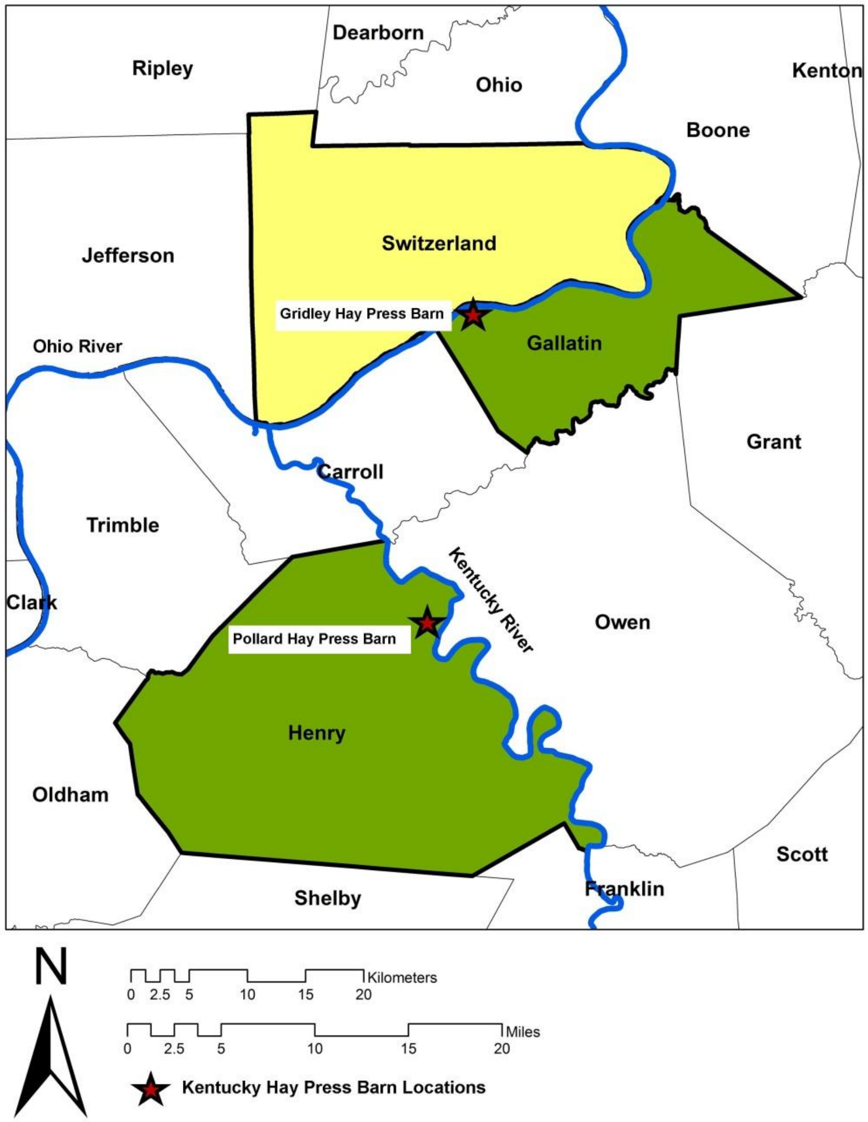

Figure 3. County map of Indiana (northwest of Ohio River) and Kentucky showing the location of the two known extant press barns in the Commonwealth.

Interior form-In section, the barn interior displays two distinct spaces for pressing hay. The first is a cellar that houses hay storage and the press's sweep and screw. Some press barns display provisions for stabling horses. The second space is the baling floor that is located over the cellar; it facilitates the feeding of hay into the press and extracting the bale.

A barn bent is an assemblage of timbers that ties a barn's sidewalls together and frames interior spaces. Bents in press barns are perpendicular to the roof ridge, and are typically assembled on the ground and raised into place. Press barns contain two bent forms specific to the barn type. The first is a set of twin *press bents* constructed to carry the weight of the machine, and accommodate the torque and pounding of its operation. Because the base of the press is a pulley that hovers over the cellar floor, the machine hangs from these bents. In true vernacular fashion, the design of these bents varies among barns. The second is a *hay bent* located between the baling floor and the barn's hay storage bay. It is assembled with a large portal to facilitate the movement of cured hay from storage to the baling floor. Like the press bents, farmers and barn builders chose a variety of methods to frame this opening.

It is unclear if regional farmers transformed an existing barn type to accommodate the beater press and its operations. The raised version of the three-bay barn type—widely known as an English Barn—displays similar exterior forms to the region's beater press barns, and several scholars have documented how English Barns are common to the Mid-Ohio River Valley (Glassie 1968; Hutslar 1981; Noble and Cleek 1995). However, further research is needed to support this hypothesis.

Dendroarchaeology

During each annual growing season in temperate regions, trees deposit a layer of cells or a tree ring around their circumference. Dendrochronology is the science of assigning individual growth rings to the calendar year in which they were formed. The size of individual tree rings is dependent upon various environmental conditions; large rings are indicative of favorable growing season conditions (e.g., abundant precipitation), while smaller rings indicate less favorable conditions (hot and droughty). By accurately measuring individual ring widths and noting the patterns of large and small rings, an investigator can deduce much information about a tree such as its age, when it began growing, when it died, and what its response was to particular climatic events such as droughts.

Dendroarchaeology is a sub-field of dendrochronology that deals specifically with the sampling of historically constructed buildings (and other wooden objects) to tap the tree-ring information found within their timbers. Dendroarchaeological studies are often performed to determine when a structure was built. Dendroarchaeological analysis of timber provides an accurate and reliable means of determining the construction date of a building. In dendroarchaeological studies, the date of formation of individual tree rings in building timbers is unknown. These dates can, however, be determined through a process called crossdating (Stokes and Smiley 1968). Crossdating is performed by matching (both visually and with computer assistance) the pattern of small and large rings in samples with known dates to a sample with rings of unknown age (Figure 4). Crossdating is a highly reliable method for dating wood of unknown age, and dendroarchaeological techniques have proven to be powerful and effective research tools. Dendroarchaeological techniques and crossdating have been successfully used to determine and/or verify the date of construction (and/or subsequent modification) of buildings by numerous researchers throughout the United States (Bortolot et al. 2001; Grissino-Mayer and van de Gevel 2007; Stahle 1979; Therrell 2000; Towner et al. 2001; Wight and Grissino-Mayer 2004).

Construction dates for buildings can be suggested by accurately crossdating the outermost ring of an individual timber. The outermost ring will be the year in which an individual tree died. For hypothesized construction dates to be accurate, the outermost ring of a timber must represent the last year of growth for the tree; the outermost ring must either be adjacent to bark or be associated with the wane of the piece of lumber. Wane can be identified by noting a uniform, rounded outer surface of a timber that is free of any tool marks (e.g., those created by hatchet, ax, adze, chisel, or saw). If wane is present but bark is not, the outermost ring of the timber represents the last ring formed by a tree, and the bark most likely fell off or was removed. When a number of timbers from a structure have similar (or comparable) death dates, one can infer a likely construction date.

A major goal of this study was to use tree-ring data, in association with supporting historical evidence, to establish the year of construction of the Gridley and Pollard Barns. Tree rings offer an objective method of dating the construction of historically erected structures when other lines of evidence are nonexistent or unreliable.

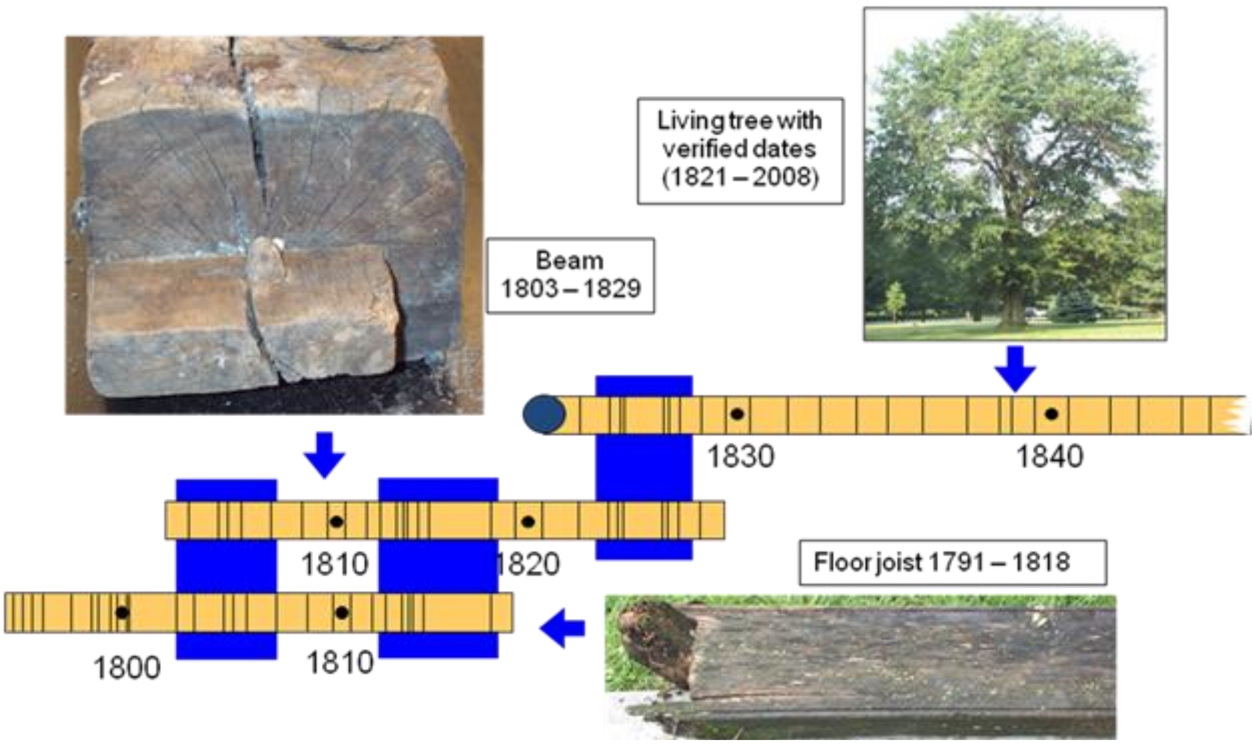

Figure 4. A. Crossdating is performed by identifying the tree-ring patterns in samples with verified dates (upper right) and by comparing and locating the same patterns in samples with unknown dates. Blue areas represent growth patterns that enable crossdating to be performed. Note: the sample lengths used in this demonstration are much shorter than those that are used in actual analyses

Figure 4. B. Drilling a floor joist to obtain a sample. Note the borer chucked into the drill and the bore guide attached to the joist. (Photo by Christopher Baas).

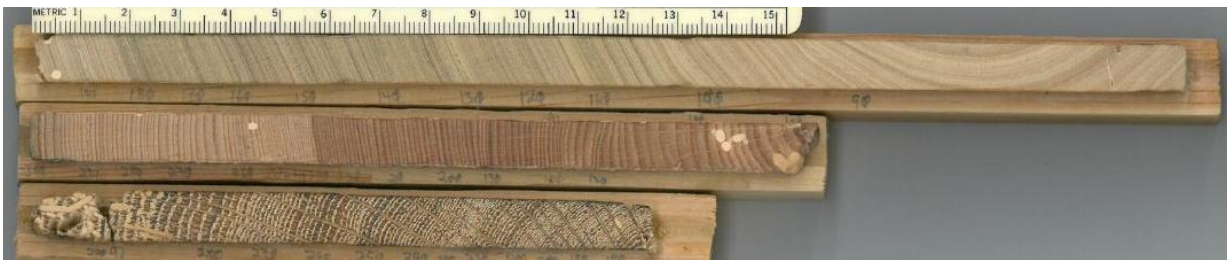

Figure 4. C. Mounted cores POL09A (tulip poplar; top), GRI07A (beech; middle), GRI02A (white oak; bottom) obtained from the press barns. The outermost (wane) end of the cores is to the left. The round, pale-colored holes in the cores are a result of insect damage. (Photo by Darrin Rubino)

Methods and Materials

Field Methods.

The Leavenworth-Lang-Cole Hay Press Barn was the first hay-related resource to be documented and restored. Although the press and barn were preserved, little is known about the history or expanse of the region's agricultural system of exporting hay. Field work documenting thirteen known press barns located in southeast Indiana and northern Kentucky began in 2010. Field work involved measuring and photographing each barn, illustrating each structure in plan and elevation, recording timber species and metal part of hay presses, and collecting dendroarchaeological samples. Combined with the field work, our understanding of this agricultural system comes from a scattering of period documents such as Hewitt's patent, the nineteenth century agricultural census, and news articles published in local and regional newspapers.

The evaluation of the barns revealed distinct patterns of spaces, use, and construction that define the Mormon hay press barns as a specific vernacular building type. Slight variations in these patterns, such as the barn or bent forms, reveal local cultural expressions typical of vernacular structures. For barns that were later expanded, original plans were identified through dendroarchaeology along with an examination of the structure. Examining the structure revealed clues indicating change such as modifications to the roof pitch, hewn versus sawn lumber, nail types, and unusual locations of mortises and tenons that might indicate alterations or the use of timbers from recycled barns. Each barn demonstrates a use that post dates pressing hay. Most all are converted to tobacco curing, and many have housed beef cattle and dairy operations.

Determining construction dates of the press barns was a major goal of this investigation, so sampling focused on wane-bearing and bark-bearing timbers. Samples were obtained from throughout each barn to ensure that an accurate construction date could be determined. For each timber analyzed, the location and provenience were recorded. Each timber in the barns was carefully inspected to make certain that either bark or wane was present.

Sample cores were obtained using a battery-powered drill (1.27 cm chuck) and a dry wood boring bit (Forest Research Tools, Knoxville, Tennessee). Prior to coring the timber, a permanent marker was used to color the outermost surface of the wood or bark to ensure that it was kept intact during the coring process. The bit was drilled into the timber until it passed the approximate center or pith (the oldest portion of the timber) or until a void in the timber was reached. Since repair and renovation are common in barns (especially when focus changes from crop to crop or livestock to crop), sampling was performed throughout a structure so that an accurate date of initial construction could be determined (Figure 4).

For several timbers, two cores were extracted to increase sample size, to provide a better opportunity for dating if one core was undatable (e.g., extensive insect damage or wounds), and to ensure that the outermost ring did in fact represent wane. Replicate sampling of an individual timber is especially beneficial when working with beech and tulip poplar because these species are prone to the formation of "missing rings." A missing ring results from a tree not forming a complete ring around its entire circumference or any ring at all in a given year due to injury or stressful growing conditions. Replicate samples increase the likelihood of obtaining a sample without a missing ring.

Each sample or core was assigned a unique identification containing three portions: a three-letter structure identification (GRI), a two digit provenience (individual timber) identification, and a letter indicating the individual series sampled from a provenience. For example sample GRI02C identifies a replicate series (C) obtained from the second provenience (02) sampled from the structure (Gridley Barn). Cores were placed in a labeled PVC tube to avoid mechanical damage during transport.

Laboratory Procedures.

For each sample, the timber type was identified to the lowest possible taxonomic rank (species or subgenus) using macroscopic and microscopic wood anatomy features and the identification keys prepared by Panshin and de Zeeuw (1980). Subsamples for wood identification were obtained by removing paper-thin sections of wood with a double-edged razor blade. Identification was performed at 100 and 400× magnification with a compound microscope.

Cores were glued into individually labeled mounting boards (Figure 4) so that the vessels (i.e., cells) were aligned vertically for later surface preparation, ring measurement, and dating. Each core was sanded with progressively finer grits of sandpaper (Stokes and Smiley 1968) to expose the tree-ring structure. Each core was sanded with a belt sander with ANSI 80-, 120-, 180-, and 220-grit sanding belts. A palm sander was then used with ANSI 220-, 320-, and 400-grit sandpaper (Orvis and Grissino-Mayer 2002). Each core was then hand sanded/polished with 30 micron sanding film.

Starting with the innermost (oldest) tree ring, years—not dates—were assigned to each ring using a boom dissection microscope at 40× magnification. The innermost ring would be assigned year 1, the next year 2, and so on until the outermost ring was numbered. The resulting tree-ring series were then considered to be "floating" since individual rings were assigned arbitrary years and not calendar dates (Grissino-Mayer 2001).

For each floating series, a skeleton plot was manually created. Skeleton plots are prepared to graphically highlight the pattern of small and large rings in the samples (Stokes and Smiley 1968). The skeleton plots of each series were compared to each other to identify common growth patterns and potential marker years (e.g., abnormally small rings). The skeleton plots were also used to crossdate or compare and match the tree-ring patterns in the timbers to those in samples with known, verified dates from regional tree-ring studies (Baas and Rubino 2012, 2013b; Rubino 2013; Rubino and Baas 2013).

The ring widths of each sample were measured to the nearest .01 mm with a boom dissecting scope (45× magnification), VELMEX unislide measuring device (VELMEX Inc., Bloomfield, NY), ACU-RITE linear encoder (ACU-RITE Inc., Jamestown, NY), and Quick-Check digital readout device (Metronics Inc., Bedford, NH) connected to a computer. The program MEDIR (Version 1.13; Krusic et al. 1997) was used during the measurement process to create computerized ring-width series consisting of years and measurements for each sample.

The outermost ring in each series with wane was not measured since it is not possible to know if the ring was fully formed (i.e., the tree could have been harvested during the growing season). The innermost ring of most samples could not be measured since sawing, hewing, cracking, or decay does not follow a ring boundary, and the ring would be incomplete. The innermost ring of a series can be measured only if pith is present since the innermost ring would be fully present and adjacent to the pith. Measurement of an entire series is not always possible if the sample has an irregular growth pattern due to scar tissue or growth anomalies associated with branching. When such patterns were encountered, measuring was performed only in the region where normal growth was observed. Inclusion of incomplete rings and abnormally-formed rings in the ring-width series is avoided since the true ring width is not determinable and subsequent inclusion of such measurements would likely bias growth pattern analyses.

Calendar date assignment to individual rings in the floating series was achieved by crossdating the samples against local chronologies with known dates. Chronologies are series of dated and measured tree rings created by studying numerous trees in an area. These local chronologies consist of living trees and crossdated timbers from other regional structures (e.g., Rubino 2013). Crossdating was performed by using skeleton plots and by using ring-width measurements via the computer program COFECHA (Holmes 1997). COFECHA utilizes a correlation procedure to enhance time-series characteristics (the pattern of small and large rings) in the samples. COFECHA assists in date assignment of floating tree-ring series by comparing the measured floating series to measured series with known, verified dates. Following a run of COFECHA, a list of possible calendar dates for dating each of the floating series is provided (Grissino-Mayer 2001; Holmes 1997). These tentative dates were then compared to the growth patterns observed in the skeleton plots and in each sample to assist in final calendar date assignment. Crossdating was performed separately for each of the barns analyzed and for different species since response to climate varies among species.

COFECHA was also used to verify date assignments (i.e., quality control). COFECHA breaks each series into consecutive 50-year segments overlapping by 25 years (Grissino-Mayer 2001; Holmes 1997). The correlation of each of the segments is then checked against all other series. If a correlation coefficient for a 50 year segment has an r-value > .33 (associated probability of .01) the crossdating is verified, and date assignment is most likely successful.

Historical background.

William H. Gridley Press Barn: Gallatin County, Kentucky.

William H. Gridley (1831-1919) was a native of Gallatin County and had roots extending to Connecticut and New Jersey (Garland 2013). Gridley's farm was a substantial land holding of 160 hectares (397 acres) of rolling ridge top terrain, 800 m (.5 miles) inland from the Ohio River. The farm is reached by a steep and winding road that ascends the riverside bluff and bisects the property into east and west sections (Figure 5). The family's home is located east of the road, and the press barn is to the west.

Gridley's advertisement in the 1883 *J.D. Lake's Atlas of Gallatin County* identifies him as a dealer and breeder of horses, sheep, and cattle (Figure 6). The Gallatin County section of the blue-grass region was well suited for meadows of timothy, orchard grass, bluegrass, and clover for stock raising (Davie 1878:359). As an example of the scale of Gridley's farming operation, he reported in the 1880 agricultural census the following hay-dependent animals: 155 sheep, 50 head of cattle, nine horses, and four mules.

The farm was managed to support the raising of livestock. According to the 1880 agricultural census, Gridley allotted 123 hectares (305 acres) to meadow, and tilled 21 hectares (52 acres) for crops. The balance of the farm, 16 ha (40 acres) of woodland, was likely located on bluff slopes and ravines too steep to farm or pasture. Gridley had 30 ha (75 acres) of the farm dedicated to hay production, presumably leaving the remaining acres of meadows for grazing his livestock. He reports 82 metric tons (75 tons) of hay, for a yield of 2.7 metric tons per hectare (1 ton per acre). If his entire harvest were pressed it would equal three hundred seventy-five, 180 kg (400 pound) bales.

The original size of Gridley's Press Barn was 11 m x 17 m (38 × 58 feet). It is three stories in height, has a gable roof, and its timber-framed structure rests on stone cellar walls. (Figures 7 and 8). The cellar was constructed within the excavations of a slight hill. This location permitted the use of topography and exterior ramps to access the two aisles flanking the press.

The barn was expanded to 20 m x 23 m (67 x 78 feet) with 4 m wide (14 feet) side sheds that enclosed the ramps, and a 6 meter (20 foot) extension of the structure's south end. The barn remains in the family, and is currently used to cure tobacco and house beef cattle.

In comparison to other press barns, the Gridley press bent is distinctive as the only example where the press's weight is carried out to the foundation walls through long timber diagonals (Figure 9). All other presses, for example the Pollard press, incorporate a rectangular timber truss to transfer weight to vertical posts, and then to a foundation. The Gridley hay bent (Figure 9) is a simple post-and-beam opening of 11.5 meters (38 feet).

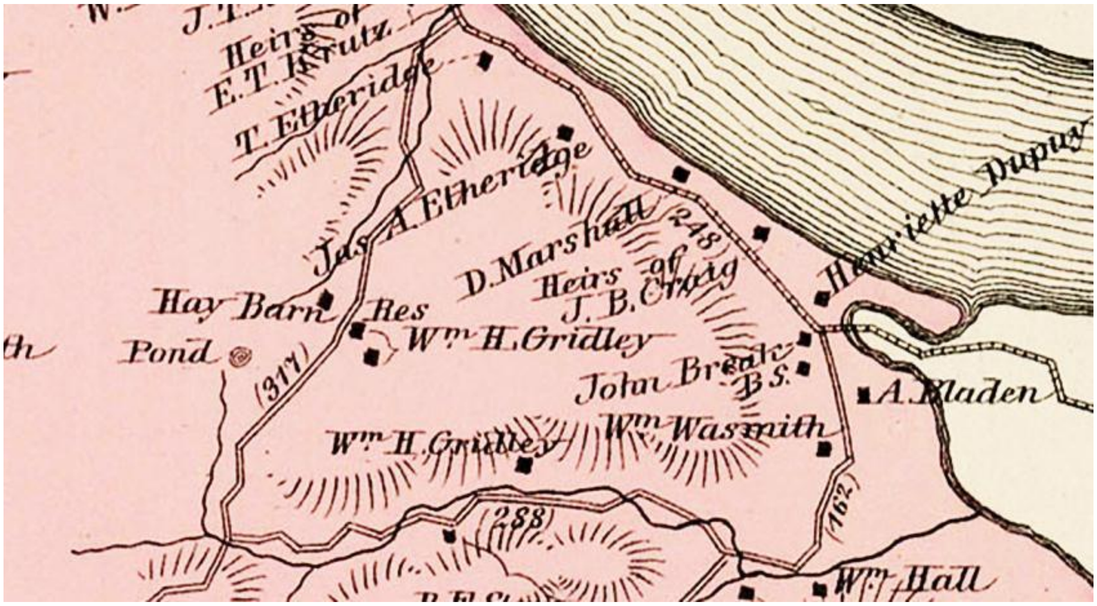

Figure 5. W.H. Gridley farmstead, 1883 (Lake 1883:33). The press barn is located across the road from the residence.

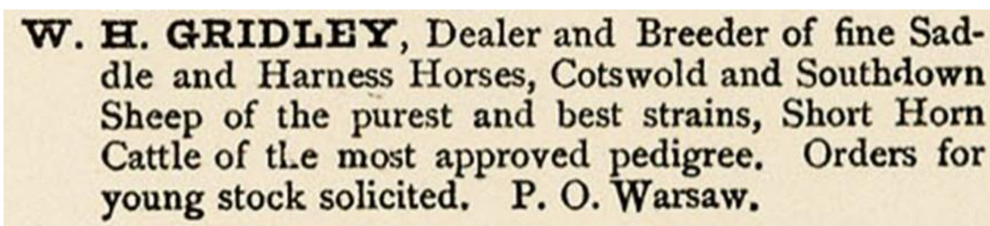
W. H. GRIDLEY, Dealer and Breeder of fine Saddle and Harness Horses, Cotswold and Southdown Sheep of the purest and best strains, Short Horn Cattle of tLe most approved pedigree. Orders for young stock solicited. P. O. Warsaw.

Figure 6. W. H. Gridley advertisement, 1883 (Lake 1883: 33).

Figure 7. A. W. H. Gridley Press Barn: Looking northwest at east (ramp and aisle entry doors) and south (gable end) facades. The barn is constructed into a small hill that allows the baling floor to be accessed without the need of a constructed ramp or barn bridge.

Figure 7. B. W. H. Gridley Press Barn: Looking east at west façade. (Photos by Christopher Baas)

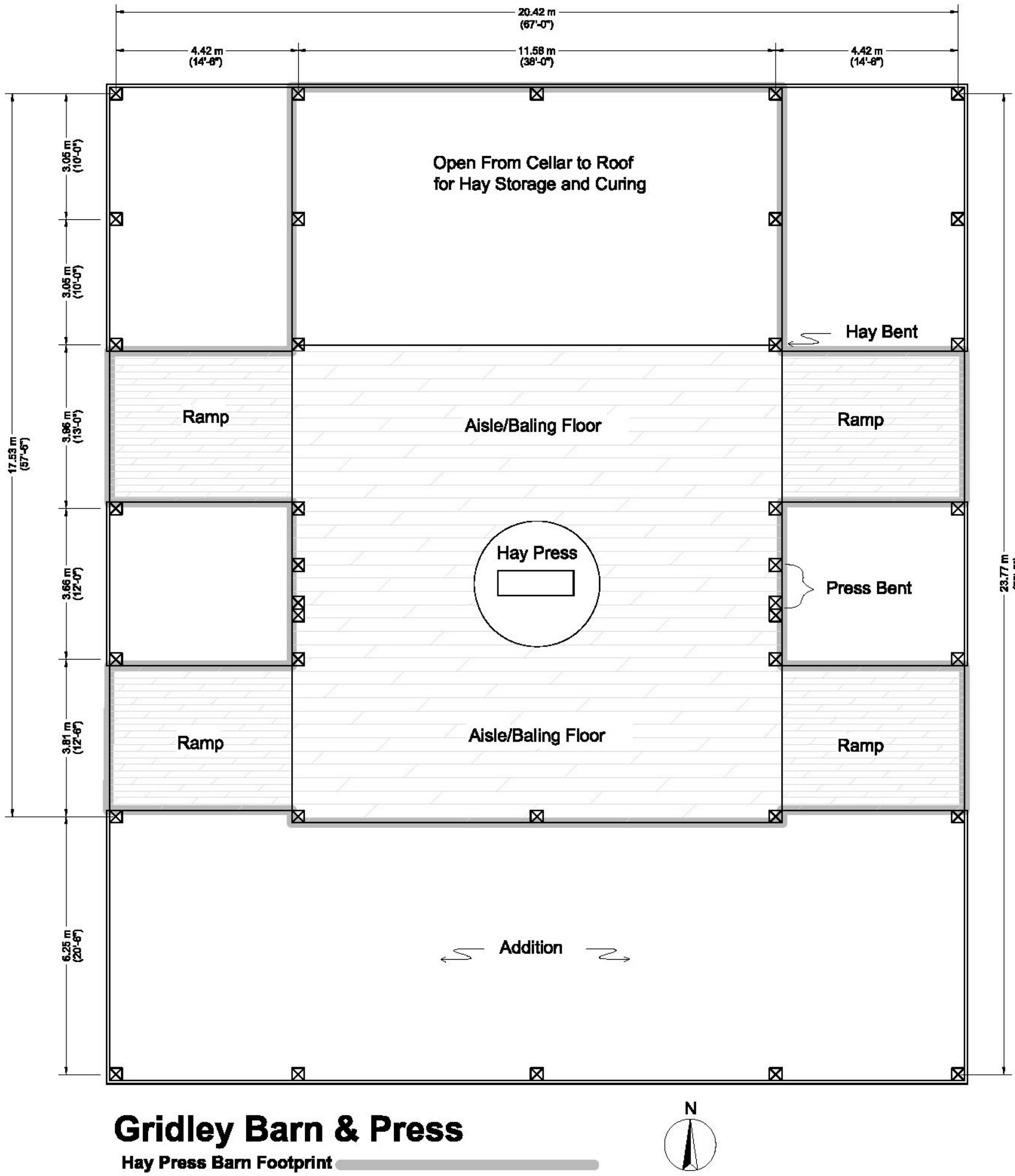

Figure 8. W. H. Gridley Press Barn plan.

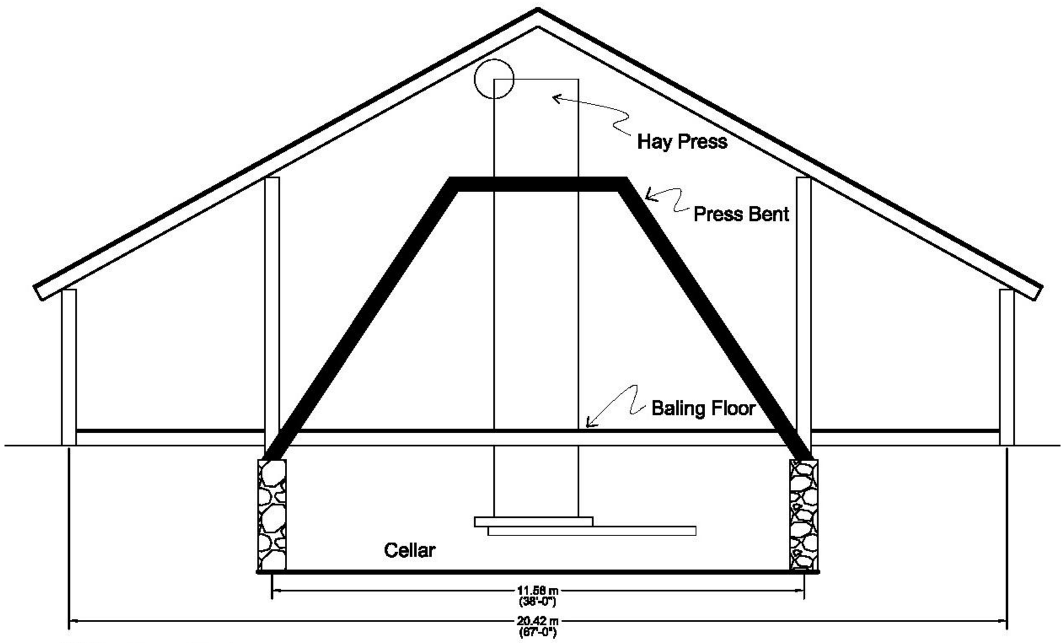

Figure 9**.** A. W. H. Gridley Press Barn section: A.) detail of press bent

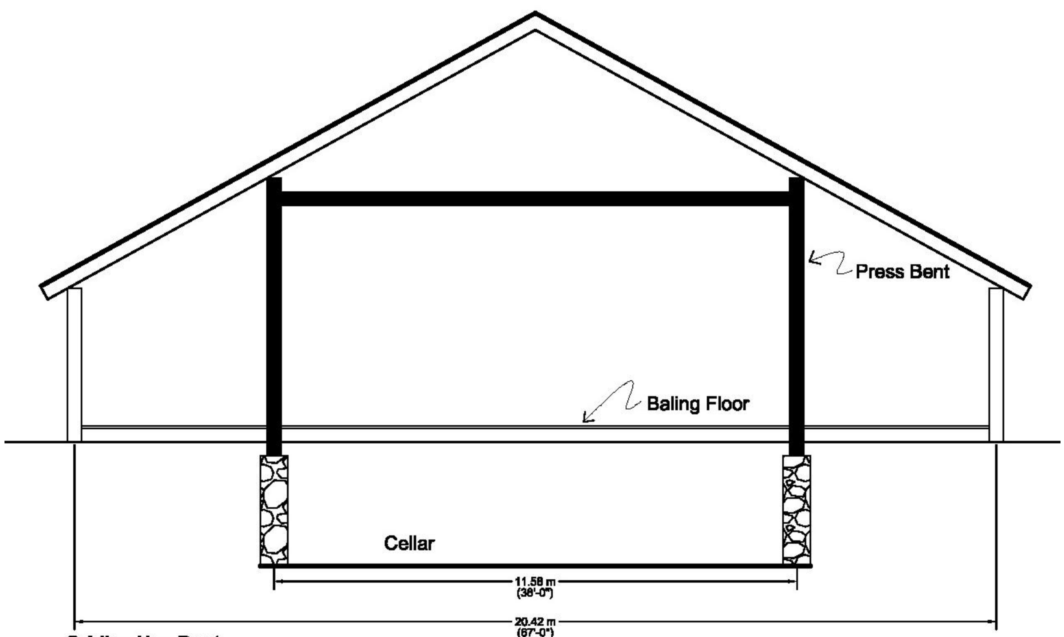

Figure 9**.** B. detail of hay bent.

Frank D. Pollard Press Barn: Henry County, Kentucky.

The Frank D. Pollard Press Barn is located in eastern Henry County, Kentucky on a farm that abuts the Kentucky River. The barn's location on the river afforded easy access to flatboats and barges for shipping baled hay and saved Pollard the labor and costs of hauling hay to the river that was required of inland farmers. The D. J. Lake *Atlas of Henry and Shelby Counties*, Kentucky identifies the farmer's river landing approximately 300 m (1,000 feet) due east of the press barn (Figure 10; Lake 1886:11).

Pollard's farm was 135 ha (335 acres) in size, and the farmer allotted 69 ha (170 acres) to meadow, tilled 26 ha (65 acres), and maintained 40 ha (100 acres) in woodland. In 1879 he mowed 22 ha (55 acres) and reported 35 metric tons (39 tons) of hay for a yield of .63 metric tons per hectare (.7 tons per acre). If his entire harvest was pressed, it would equal approximately two hundred, 180 kg (400 pound) bales.

Pollard's Barn is distinct because it demonstrates the minimum structure required to operate the press: a raised platform used as a baling floor, space below for a horse to pull the press's sweep, and a press and its hay bent support structure. John K. Harris, an agent for the press inventor, promoted this minimal form as an affordable alternative to constructing a complete barn (Harris 1851). Therefore, the barn lacks several character-defining features seen in all other extant barns such as wagon aisles and spaces for storage.

Pollard's Barn was constructed in an 11 m x 11 m (35 x 35 foot) square and was expanded in the twentieth century to 23 m x 23 m (75 x 75 foot) by the construction of shed additions to all four sides (Figure 11). Images of the barn's exterior illustrate how it was constructed piecemeal; it does not represent any known architectural type or follow patterns of form seen in other press barn examples (Figure 12). To press hay, the grass was delivered to the platform by a single ramp on the south side of the structure. The structure would not have stored loose hay or bales.

The barn's hay bent is a rectangular truss with two interior diagonals, and is typical of other press barns. Threaded metal rods were added later, likely to stabilize a deteriorating structure, or to steady the barn during baling operations. Triangular wood blocks sit on top of the press bent and support roof beams (Figure 13). This awkward detail is exclusive to this barn, and suggests the construction of the roof was unplanned and came after the construction of the press.

Figure 10. Frank D. Pollard farmstead, 1886 (Lake 1886: 11). The press barn is located at the base of the bluffs 300 m (1,000 ft) from the Pollard Landing located on the banks of the Kentucky River.

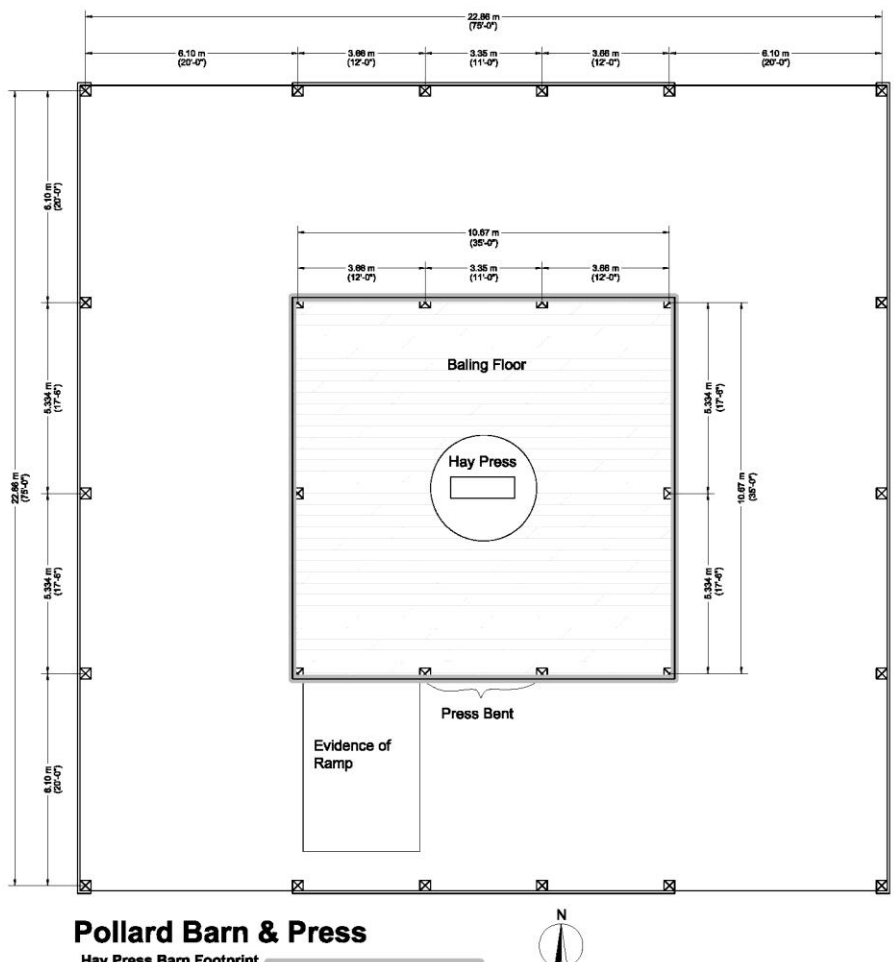

Figure 11 Frank D. Pollard Press Barn plan.

Figure 12**.**A. Frank D. Pollard Press Barn, looking north at south elevation.

Figure 12**.** B. Frank D. Pollard Press Barn, looking south at north elevation (Photos by Christopher Baas)

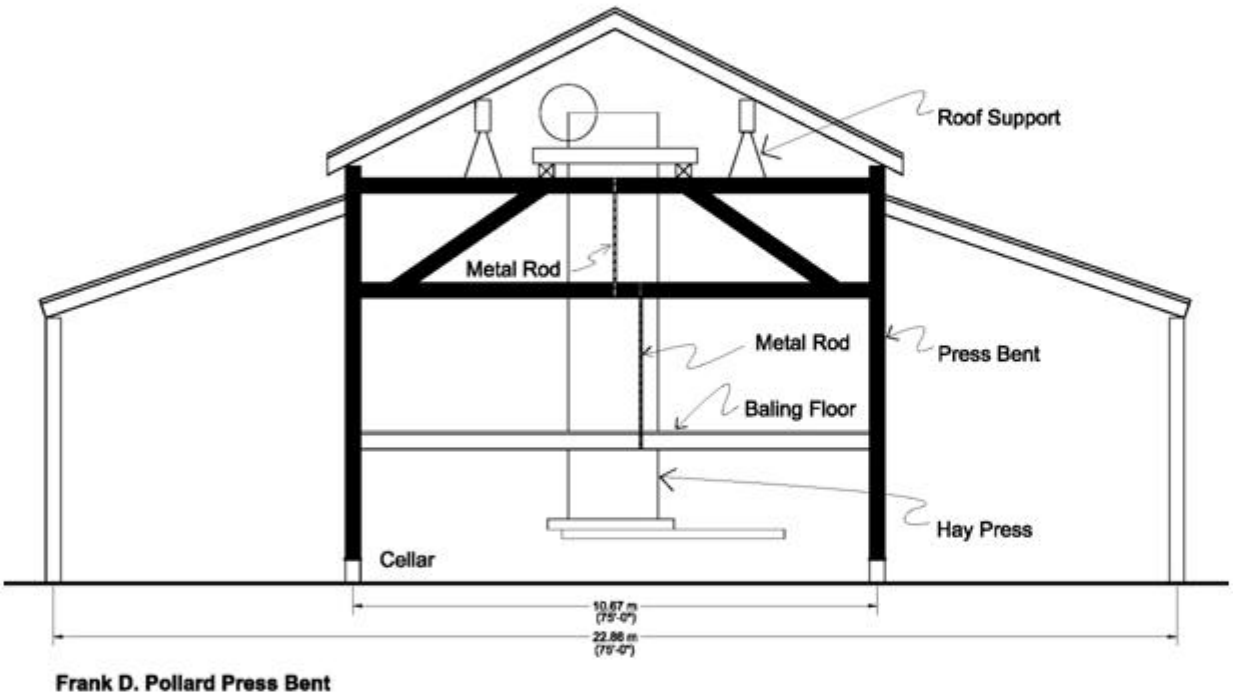

Figure 13. Frank D. Pollard Press Barn section: detail of press bent.

Dendroarchaeology results.

Ten and 13 timbers were sampled from the Gridley and Pollard Barns, respectively (Table 1). Samples represent several different timber types: tulip poplar, white oak (*Quercus* subgenus *Lepidobalanus*), hard maple, and beech (Table 2). Only one sampled timber (POL07) from the Pollard was not dated successfully; two samples from the Gridley Barn (GRI04 and GRI06) were not successfully dated due to growth anomalies (Table 2). Combination of all of the series from the Gridley and Pollard Barns created a 151 year-long (1713 – 1863; 1713 is the first year of growth accurately dated in any of the trees, and 1863 is the last year of recorded growth) and a 239 year-long (1623 – 1861) chronology, respectively (Table 3 and Figure 14). A total of 905 (Gridley) and 1,646 (Pollard) tree rings were successfully crossdated. The ring width mean and standard deviation for each series can be found in Table 1.

For each of the species studied at each of the barns a strong and significant ($P < .01$) species intercorrelation among ring width was found (Table 3; intercorrelation r-values are calculated by finding the correlation of each individual series against all other series present in a species chronology). Additionally, when individual series were broken into 50 year segments and correlated against other series in each species/site chronology, significant correlation coefficients ($r > .33$; $P < .01$) were consistently found (Table 4). The strong correlation results suggest that crossdating between different timbers was successful and accurate. The skeleton plots also confirmed the crossdating between the different series.

When individual series ring widths were correlated against other regional chronologies significant ($P < .01$) correlations were also found (Table 5). These strong correlations suggest proper calendar date assignment to individual tree rings. Using both graphical (skeleton plots) and statistical analyses we infer that date assignment was accurate internally (within each species at each barn) and externally (comparison of the barn chronologies with other regional chronologies).

Based on dendroarchaeological evidence, the Gridley Press Barn was erected from timbers that were harvested after the initiation of the 1864 growing season. In this context, growing season refers to the period of the year when a tree deposits wood around its circumference not when it is in leaf. Wood is deposited around the circumference of a tree for only part of the spring and summer, most likely from April through August (Phipps and Gilbert 1961). During the growing season, trees deposit cells as earlywood (large and less dense cellular structure) and later as latewood (smaller and denser cellular structure). The 1864 growth rings exhibit both earlywood and latewood suggesting that the trees were not harvested until well into the summer of 1864 or after its completion (but prior to April 1865, the initiation of the 1865 growing season).

The Pollard Press Barn was constructed from timbers that were likely harvested during the spring or early summer of 1862. Trees exhibiting an 1862 ring show only earlywood formation (the cells produced at the initiation of annual growth). This means that the trees were alive at the beginning of the 1862 growing season and began producing a ring but died prior to completion of the growing season. Several of the timbers (e.g., POL01, POL02, and POL05; Table 1) show no cells produced for the 1862 growing season but latewood for 1861. We hypothesize that the 1861 rings were complete and that the trees were harvested prior to the initiation of the 1862 growth season. This mix of 1862 and 1861 harvest dates suggests that the structure was erected in the Spring of 1862. Some tulip poplars show an earlier harvest date of 1857. These pieces were likely recycled from another structure.

Table 1. Series Data for Each of the Timbers Sampled from the Pollard and Gridley Barns.

Series	Species	First	Last	Outer Ring	Species Correlation	Mean	SD
POL01A	Beech	1725	1861	W	.689	1.12	.43
POL02A	Beech	1816	1861	W	.783	1.64	.49
POL02B		1799	1861	W	.566	1.61	.72
POL02I		1704	1771		.538	.71	.34
POL03A	Beech	1848	1862	W(y)	.746	.87	.28
POL03B		1846	1862	W(y)	.686	1.05	.41
POL03C		1709	1862	W(y)	.540	1.03	.53
POL04A	Beech	1708	1862	W(y)	.626	1.13	.54
POL04B		1804	1862	W(y)	.700	1.52	.51
POL05A	Beech	1711	1861	W	.575	1.08	.49
POL06A	Beech	1731	1860	W	.543	1.40	1.06
POL07A	Tulip						
POL08A	Tulip	1659	1719		.587	.90	.62
POL09A	Tulip	1706	1821		.702	1.32	.57
POL09C		1818	1862	W(y)	.522	.94	.33
POL10A	Tulip	1790	1859		.758	.99	.44
POL10B		1793	1858		.767	.93	.35
POL10C		1727	1853		.824	.75	.26
POL11A	Tulip	1652	1736		.849	1.13	.70
POL11B		1628	1736		.864	1.67	1.34
POL12A	Tulip	1829	1857	W	.517	.77	.45
POL12B		1829	1857	W	.706	.74	.43
POL13M	Tulip	1786	1857	W	.469	.96	.41
GRI01A	Beech	1845	1864	W	.575	2.11	.60
GRI01B		1848	1864	W	.643	1.32	.46
GRI02A	Oak	1739	1854	+8	.416	.83	.47
GRI02B		1824	1855	+6	.579	1.39	.63
GRI03A	Beech	1731	1863		.656	1.31	.72
GRI04A	Beech						
GRI05A	Oak	1724	1854		.337	1.12	.53
GRI06A	Hard maple						
GRI07A	Beech	1712	1864	W	.496	1.01	.60
GRI08A	Beech	1738	1864	W	.528	1.22	.52
GRI09A	Beech	1758	1864	W	.582	1.63	.66
GRI10A	Beech	1749	1864	W	.528	1.36	.62

Note: “First” and “last” refer to the first and last years present in a series. See text for an explanation regarding the identification code of individual series obtained from a provenience. If more than one sample (series) was taken from an individual timber (provenience), the species and provenience description are only given once and not for each series. All samples have been archived in the Hanover College botanical collection. A “W” indicates the presence of wane on an individual series; W(y) indicates a young/not fully formed wane year; + indicates the number of additional rings present on the outer portion of the series but undatable due to lack of sample integrity or growth irregularity. Species correlation is the *r*-value obtained by correlating the series ring widths with all other samples of a particular species from an individual structure. Mean and SD of ring widths are in mm.

Table 2. Timber Types Analyzed from the Gridley and Pollard Barns.

Timber Type	Scientific Name	Common Name
Beech	*Fagus grandifolia* Ehrh.	American beech
Hard maple	*Acer saccharum* Marshall	Sugar maple
	Acer nigrum Michx. *f.*	Black maple
Tulip poplar	*Liriodendron tulipifera* L.	Tulip poplar
White oak	*Quercus bicolor* Willd.	Swamp white oak
	Q. lyrata Walter	Overcup-oak
	Q. macrocarpa Michx.	Bur-oak
	Q. muehlenbergii Engelm.	Chinkapin-oak

Note: More than one species of tree may be called by a single timber type because identification of wood is not possible to the species level for timber types such as white oak (i.e., a white oak timber could be a swamp white oak or a bur-oak). A species is considered “possible” if its natural distribution occurs in Henry (Pollard Barn) or Gallatin (Gridley Barn) Counties. Species distributions are based on United States Department of Agriculture, Natural Resources Conservation Service (2012); taxonomy and nomenclature follows Gleason and Cronquist (1991).

Table 3. Chronologies Created from Dendroarchaeological Samples Collected from the Gridley and Pollard Barns.

Timber	Number of Proveniences	Number of Series	Number of Tree Rings	Time Span	Number of Years	Series Intercorrelation
Gridley Barn						
Beech	6	7	638	1713 - 1863	151	.558
White oak	2	3	267	1727 – 1854	128	.419
Pollard Barn						
Tulip poplar	6	11	674	1623 - 1861	239	.708
Beech	6	11	972	1705 - 1861	157	.607

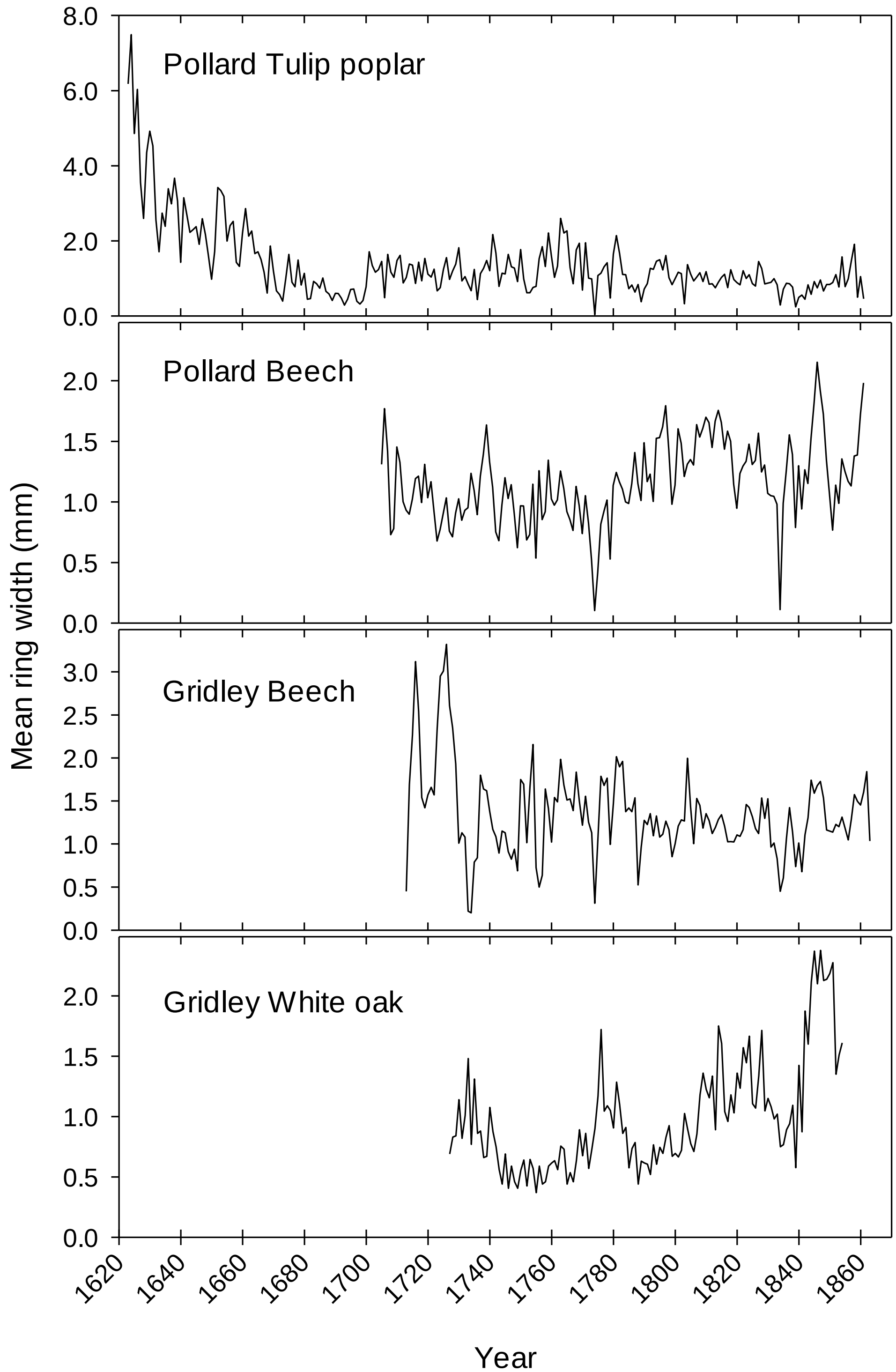

Figure 14. Composite mean chronology for dated Pollard tulip poplar and beech and Gridley beech and white oak.

Table 4. Series Segment (50 Year Segments Overlapping by 25 Years) Correlation Analysis of Each Timber Type from the Pollard and Gridley Barns.

Series	Years Measured	1650 - 1699	1675 - 1724	1700 - 1749	1725 - 1774	1750 - 1799	1775 - 1824	1800 - 1849	1825 - 1874
Pollard beech									
POL01A	1726 - 1860				.75	.73	.63	.72	.69
POL02A	1817 - 1860							.78	
POL02B	1800 - 1860							.55	.65
POL02I	1705 - 1770			.58	.58				
POL03A	1849 - 1860								.75
POL03B	1847 - 1861								.69
POL03C	1710 - 1861			.38	.43	.58	.43	.56	.63
POL04A	1710 - 1861			.59	.72	.63	.53	.79	.78
POL04B	1805 - 1861							.68	.72
POL05A	1712 - 1860			.46	.63	.66	.51	.71	.66
POL06A	1732 - 1860				.68	.56	.56	.54	.52
Pollard tulip poplar									
POL08A	1661 - 1718	.64	.60						
POL09A	1708 - 1819			.68	.92	.87	.68		
POL09C	1824 - 1861							.52	
POL10A	1792 - 1858						.79	.79	.71
POL10B	1794 - 1857						.82	.80	.72
POL10C	1828 - 1852								.82
POL11A	1653 - 1735	.86	.85	.84					
POL11B	1623 - 1735	.88	.88	.86					
POL12A	1837 - 1856								.52
POL12B	1831 - 1856								.71
POL13M	1789 - 1856						.37	.46	.42
Gridley beech									
GRI01A	1846 - 1863								.58
GRI01B	1849 - 1863								.64
GRI03A	1752 - 1862					.77	.64	.55	.54

GRI07A	1713 - 1863	.59	.65	.35	.37	.44
GRI08A	1739 - 1863	.66	.75	.47	.34	.43
GRI09A	1760 - 1863		.60	.36	.50	.58
GRI10A	1750 - 1863		.61	.19	.42	.48
Gridley white oak						
GRI02A	1740 - 1853	.43	.35	.33	.48	.53
GRI02B	1825 - 1854					.69
GRI05A	1727 - 1849	.43	.35	.33	.30	

Note: In each column headed by a set of dates the correlation coefficient found by correlating each of the series' segments against all other series of that species is given. A correlation is significant ($P < .01$) for a 50-year segment if $r > .33$.

Discussion

This article is the first effort to document beater hay press barns in Kentucky. It had the goals of describing two markedly different press barns using tree-ring data to establish years of construction for each barn, and placing the structures within a context of a regional culture of commercially exporting hay.

Beater Hay Press Barns as a Vernacular Building Type.

An understanding of the use, form, and construction of Kentucky hay press barns is based on field work where the measurements, layout, materials, and geographic location of thirteen barns were recorded. Dendrochronology samples have been collected for twelve of the barns. Along with the two Kentucky barns presented here, eleven barns located in Switzerland, Ohio, and Harrison counties in Indiana were evaluated. Field work resulted in establishing the character defining features presented at the beginning of this article and establishing the framework for evaluating Commonwealth press barns.

In describing the two Kentucky hay press barns, both structures display the anticipated vernacular characteristics of construction, form, and use the region's farmers followed in building their barns. For instance, each barn is three stories in height, is of timber frame construction, and displays an organization of spaces for storing and pressing hay. The structures also exhibit significant exceptions to these characteristics. For example, the Gridley Barn has all the aisle and hay storage spaces expected in a press barn, while the Pollard Barn contains the minimal spaces and structure to operate a beater press. The Gridley Barn uses the farmstead's rolling topography as an asset to accessing the baling floor, while the Pollard Barn is located on level terrain and requires a ramp to reach the baling floor. The presses are oriented differently within the press bents. The Gridley press hangs with the baling doors parallel to the bents, while the Pollard press hangs perpendicularly. The orientation of the Gridley press is characteristic of double-aisle press barns and was likely positioned to accommodate two wagons operating in the barn at the same time—the first bringing hay to the press, and the second removing finished bales. Finally, the form of the Gridley press bent is unique. While it is not a form seen in any other barn, it is sufficient to support the press.

Table 5. Correlation Results of 50 Year (Overlapping by 25 Years) Segments of Pollard and Gridley Species Chronologies with Regional Species Chronologies.

Chronology comparison	Segment								
Pollard tulip poplar:	1623 - 1672	1648 - 1697	1673 - 1722	1698 - 1747	1723 - 1772	1748 - 1797	1773 - 1822	1798 - 1847	1812 - 1861
Switzerland Co, IN (1613 - 1856)	.41	.75	.68	.54	.57	.67	.63	.66	
Jefferson Co, IN (1457 - 1835)	.63	.77	.70	.60	.58	.61	.55		
Washington County, IN (1637 - 1882)		.46	.63	.65	.49	.52	.62	.70	.69

Chronology comparison	Segment				
Pollard beech:	1705 - 1754	1730 - 1779	1755 - 1804	1780 - 1829	1805 - 1854
Versailles, IN (1684 – 2010)	.35	.68	.61	.49	.65
North Vernon, IN (1681 - 1816)	.37	.54	.46		

Chronology comparison	Segment				
Gridley beech:	1713-1762	1738-1787	1763-1812	1788-1837	1813-1862
Versailles, IN (1684 – 2010)		.75	.61	.40	.55
Hanover, IN (1760 - 2009)			.45	.35	.59
North Vernon, IN (1681 - 1816)	.32	.51	.39		

Chronology comparison	Segment			
Gridley white oak :	1727 - 1776	1752 - 1801	1777 - 1826	1802 - 1851
Jefferson Co, IN (1590 - 1899)		.33	.33	.58
Switzerland Co, IN (1630 - 1875)	.52	.49	.35	.57

Note: Correlations values for 50-year segments are significant ($P < .01$) if the correlation coefficient is greater than .33.

Historical context for producing and shipping hay.

The construction dates for both barns (Gridley Barn: summer 1864 to spring 1865 and the Pollard Barn: summer 1862) coincides with the prosperous time period of the commercial hay system's viability. The dates come between Hewitt's 1843 patent date and the system's economic demise in the late 1870's. The dates suggest that both farmers were likely capitalizing on the high prices and demand for hay caused by the Civil War.

Growing and exporting hay was a regionally-specific commercial system with roots in southeast Indiana counties located adjacent to the Ohio River. It was fueled by demand from east coast cities and made efficient by Samuel Hewitt's beater hay press. Historically, Kentucky would not be considered a hay producing state. Since access to river transportation was essential to participating in the system, an examination of the Ohio River counties in Kentucky, Indiana and Ohio demonstrates how little hay was grown in the Commonwealth. In 1870, Indiana produced two times, and Ohio five times, more hay than Kentucky (Table 6). In a more balanced comparison of hay per improved acre of farm, Indiana and Ohio farmers produced three times more hay than Kentucky farmers.

Conversely, it appears Kentucky farmers living in Ohio River counties chose to grow and export tobacco over timothy. The tobacco production of Commonwealth farmers dwarfed those of its neighbors. In 1870, they produced five times more than Hoosier farmers and four times more than Ohio farmers. In a comparison of pounds of tobacco produced per improved acre of farm, they produced more than four times Indiana farmers, and more than six times Ohio farmers. The local market value for Kentucky tobacco was comparable to Indiana and Ohio hay (Table 7).

Despite Kentucky not being a hay producing state, the system was embraced by a few Ohio River and Kentucky River farmers, and the geographical characteristics of their farmsteads can be used to help identify undiscovered hay resources. The river's primary hay producing counties are clustered around Ohio and Switzerland Counties in Indiana in an area regarded as the heart of the commercial system. Therefore, it is easy to understand how Gridley, being located directly across the Ohio River, was easily exposed to the fortunes of participating in the economic system. As a result, searches for hay resources start with Gallatin and its neighboring counties. Pollard's farm was located 32 k (20 miles) inland from the Ohio River, but the navigable waters of the Kentucky River made participation feasible. Consequently, the Kentucky River counties between Henry to the Ohio River may likely contain historical hay resources.

Both Gridley and Pollard were financially and geographically positioned to successfully participate in the commercial system. Each farmer owned large farms that contained ample hay producing acreage. In 1880, the average size of a farm in Kentucky was 52 ha (129 acre), but only 36 ha (90 acre) in Gallatin County and 44 ha (109 acre) in Henry County. Gridley's Gallatin County ridge top farm was more than four times the local average, and Pollard's Henry County river-bottom farm was more than three times the local average. Their farms were located on navigable rivers leading to major hay markets. This eliminated the need to transport baled hay to the river, which was an act known as hay hauling required of inland farmers and typically performed in December.

In searching for nineteenth century hay resources, several tools can be used. While only two Kentucky press barn examples are known, participation in the system appears to be by prosperous farmers with sizeable farms. Agricultural census data for individual farms might identify farmers growing disproportionate amounts of hay. This is important in Kentucky where participation appears to be rare and where large producers of hay might stand out. The reliance on Ohio and Kentucky River transportation routes limits the search to counties that abut or are near these waterways. Local atlases often identify press barns and river landings. However, they are often published in the 1880s after the commercial system had faded, and potentially miss hay related structures. For hay resources identified in local atlases published in the late nineteenth century, dendroarchaeology is essential to recognizing that the barns are part of an earlier commercial trade of hay. Exact dendroarchaeologically-determined dates provide more information than relative dates drawn from historic documents. For instance, approximately twenty-five years separate the construction of the barns and their publication in the Lake atlases.

The regional production and exportation of hay is a minor, but significant facet of the Commonwealth's agricultural history that has only been recently discovered. The description and dating of the Gridley and Pollard Press Barns are an initial step in telling this intriguing story and sets the stage for further inquiry.

Table 6. Hay Produced in 1870 for Ohio River Counties in Kentucky, Indiana, and Ohio.

	Kentucky	Indiana	Ohio
Number of river counties	28	13	14
Hay produced	50,454 metric tons (55,617 tons)	119,415 metric tons (131,633 tons)	254,116 metric tons (280,115 tons)
180 kg (400 lb) hay bales per improved acre (Ohio River counties)	.6 bales	.59 bales	.19 bales
Local market value of $15 per ton	$.83 million	$1.97 million	$4.2 million
New Orleans market value of $34 per ton	$1.87 million	$4.47 million	$9.52 million

Note: as reported in the 1870 Agricultural Census. Market prices were published in *The Madison Daily Courier, 25 January1870.*

Table 7. Tobacco Production in 1870 for Ohio River Counties in Kentucky, Indiana, and Ohio.

	Kentucky	Indiana	Ohio
Number of River Counties	28	13	14
Metric tons (pounds) of tobacco produced	17,780 (39.2 million)	3,220 (7.1 million)	4,354 (9.6 million)
Pounds per improved acre	7.2	6.1	4.2
Local market value of 10 cents per pound (Medium grade)	$3.92 million	$.71 million	$.96 million

Note: As reported in the 1870 Agricultural Census. Farmers reported tobacco in pounds. Market prices were published in *The Madison Daily Courier, 25 January1870.*

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