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Terry L. Mader

Leslie J. Johnson

Tami Brown-Brandl

John Gaughan

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Climate Conditions in Bedded Confinement Buildings

T. L. Mader, University of Nebraska
L. J. Johnson, University of Nebraska
T. M. Brown-Brandl, U. S. Meat Animal Research Center
J. B. Gaughan, University of Queensland

Abstract. *Confinement buildings are utilized for finishing cattle to allow more efficient collection of animal waste and to buffer animals against adverse climatic conditions. Environmental data were obtained from a 29 m wide x 318 m long, solid floor, bedded confinement building with the long axis oriented east to west. The south side (front) was approximately 8.5 m high and the north (back) side is approximately 5.0 m high with 3.7 m being open (at the top). The opening was closed to within 1.0 m of the top in the winter. In general, low wind speed and/or decreased air movement associated with the building tends to allow for greater relative humidity (RH) especially at the front of the building (south facing) in the summer and winter. The use of the buildings did not lessen heat stress in the summer, as measured by the temperature humidity index (THI) but acted as a shade to decrease the solar heat load on the animal. During the summer season, temperatures were generally greatest at the front of the building. However, in the winter, 2 to 4ºC greater temperatures were maintained in the building when compared to outside conditions, by decreasing air flow through the building and from heat generated by the cattle. Bedded barn facilities appear to be useful for buffering cattle against the adverse effects of the environment under hot and cold conditions even though less airflow and greater RH can be found inside the barn when compared to outside conditions.*

Keywords. *Beef Cattle, Building, Feedlot, Season,*

Introduction

Adverse climatic conditions are known to suppress productivity and contribute to discomfort of confined beef cattle (Mader, 2003). In particular, adverse winter weather in the United States has influenced where and what type of facilities cattle may be reared in (Eng and Peters, 2008). In colder climates, shelter has been shown to be beneficial, depending on time of year (Mader, 1997). Previous research has evaluated various types of confined feedlot facilities that are used for fattening cattle in the north-central portion of the United States (Pusillo et al., 1991; Meiske, 1992). In general, the performance data would support fattening cattle in a facility that is partially enclosed and is covered. Confinement buildings buffer animals against adverse climatic conditions and allow for more efficient collection of animal waste. Most buildings are typically naturally ventilated and positioned to take advantage of seasonal climatic conditions. However, building and maintenance costs have generally limited the use and viability of some units (Lawrence et al., 2001). However, more recent structures are less expensive to build than traditional slatted-floor structures and are designed with solid floors to which bedding is applied. The bedding absorbs moisture and provides insulation as well as a softer surface for cattle to walk and lay on. Typically bedding is added to barns once or twice weekly at a rate that averages 1 kg of bedding/head/day. The objective of this study was to assess climatic conditions in bedded feedlot facilities during summer, fall, and winter seasons.

Materials and Methods

Data were obtained from a 318 m long bedded confinement building with the long axis oriented east to west. The facility is located at latitude 42º28'N and longitude 96º52'W. The south side (front) is 8.5 m high and the north (back) side is 5.0 m high with 3.7 m being open (at the top). The opening was closed to within 1.0 m of the top during winter using a curtain. The building is 29.3 m wide with a 4.6 m alley on the north side. Within the building, there are eight pens that hold approximately 250 cattle each. Feed bunks are located on both north and south sides of the pen.

HOBO datalogger Procedure

Summer Trial - HOBO dataloggers (Onset, Pocasset, MA) were placed at the front and back sides of two bedded confinement pens located in the middle of the unit (Figure 1). In addition, dataloggers were also placed on support columns in the middle of the pen and at the waterers, which are located mid-way between support columns and the front of the pen. Two dataloggers were also placed outside the building approximately 25 m from the building.

Dataloggers were set to record ambient temperature (Ta) and relative humidity (RH) data starting at noon on June 20, 2006. They were removed on the morning of August 10, 2006.

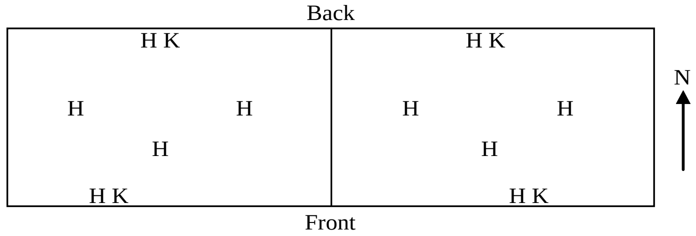

Figure 1. Location of HOBO (H) dataloggers and Kestrel (K) weather monitors in confinement pens. In the summer only H dataloggers were utilized. In the winter, H dataloggers were utilized inside pens only while K weather monitors were utilized at the front and back of the pens. Only K weather monitors were utilized in the fall.

Winter Trial - HOBO Pro Series[1] dataloggers were placed in two bedded confinement pens (same pens as summer trial). Dataloggers were set to record T_a and RH starting at 1500 January 9, 2007. They were removed on January 17, 2007.

Kestrel Procedure

Fall and Winter Trials - Four Kestrel 4000 weather monitors (Nielsen-Kellerman Co., Boothwyn, PA) were placed in bedded confinement pens (Figure 1). Two monitors were placed on the front (high side) of the pen and two on the back (low) side of the pen. Monitors measured T_a, RH, and wind speed starting on October 2, 2006 for the fall trial and January 9 for the winter trial; monitors were removed on October 5, 2006, and January 17, 2007, respectively.

General Procedures

For all seasons, dataloggers and monitors were approximately 2 m above floor level at hourly intervals. Weather data were also obtained from an automated weather station near Concord, Nebraska, approximately 10 km from the confinement buildings at a height of 2 m above ground level.

The temperature humidity index (THI) was calculated for the summer and fall periods using the following equation:

1) $$THI = (0.8 \times T_a) + \left[(RH \times 100^{-1}) \times (T_a - 14.4)\right] + 46.4$$

where Ta = air temperature (ºC) and RH = relative humidity (%). A THI value of less than 74 is considered normal. Threshold levels above 74 are defined as follows: 75-78 Alert; 79-83 Danger; 84+ Emergency (LCI, 1970). Also, the windchill index (WCI) was calculated for the fall and winter periods using the following equation:

2) $$WCI = 13.12 + (0.6215 \times T_a) - \left[13.96 \times (WS)^{0.16}\right] + \left[0.487 \times T_a \times (WS)^{0.16}\right]$$

where T_a = ambient temperature (°C) and WS = wind speed (m/s).

In addition to weather data, pen surface temperatures were measured using an infrared gun (Model Raynger 3i, Raytek, Santa Cruz, CA, USA) at approximately 1500 during the fall trial in two confinement building pens and five outside feedlot pens in which no building was present.

Data were analyzed using PROCMIXED of SAS (SAS Inst., Inc., Cary, NC) for repeated measures. The model included for each period effects of location, day, and time of day. Time of day was included in the repeated statement.

Results and Discussion

Air temperatures, RH, wind speeds, and indices from all trials are shown in Table 1.

Summer Trial

A period of high wind speed, primarily from the south, and a period of low wind speed, primarily from the east-southeast, were identified. During the period of high wind speed, the average T_a was similar in all locations except at the front of the building. The T_a at the front of the building was greater than the T_a at the

[1] Reference to commercial products is for informational purposes only.

back of the building. This is probably due to the height of the front of the building, which allows for more direct exposure to sunlight as compared to the back of the building. Temperatures at the front of the building were greater during the day, but lower at night, and were actually cooler than the back of the building at 06:00 hour (Figure 2). The average RH at the front of the building was greater than the RH at the middle of the pen. Accumulation of moisture from cattle defecating and urinating while eating may create this difference. Hourly differences in RH between the front and back of the building indicate RH was greater in the back of the building during daylight hours, but then an opposite trend occurs at night. The average THI was similar across all locations during this period. In contrast to average data, hourly data shows that the THI was greater at the front of the building, when compared to the back of the building, during daylight hours only (Figure 3).

Table 1. Mean climatic conditions for summer, fall, and winter periods

		Location within facility				
	Outside	Front	Waterer	Middle	Back	SE
Summer[1]						
High wind speed (4.9 m/s)						
Air temperature, °C	31.3[ab]	32.1[b]	31.2[ab]	31.2[ab]	30.8[a]	0.5
Relative humidity, %	50.1[ab]	54.4[b]	50.2[ab]	48.8[a]	53.4[ab]	2.4
THI[2] 79.1 80.6	79.3	79.0	79.5	0.9		
Low wind speed (2.3 m/s)						
Air temperature, °C	27.6[a]	29.1[b]	27.9[a]	27.6[a]	27.5[a]	0.5
Relative humidity, %	71.0[ab]	79.6[c]	69.6[a]	68.9[a]	74.6[b]	2.4
THI[2] 77.0[a] 80.0[b]	77.7[a]	77.0[a]	77.5[a]	0.9		
Fall[1]						
Air temperature, °C	15.0[a]	16.2[c]	--	--	15.6[b]	0.2
Relative humidity, %	74.0[c]	68.9[a]	--	--	71.4[b]	0.9
THI[2] 58.8[a] 60.6[b]	--	--	59.8[b]	0.4		
Wind speed, m/s	4.0[c]	1.6[a]	--	--	2.6[b]	0.2
Wind chill index, °C[3]	14.1	16.6	--	--	15.5	2.9
Winter[1]						
Air temperature, °C	-14.4[a]	-11.6[c]	-11.0[c]	-12.3[bc]	-12.4[b]	0.4
Relative humidity, %	79.8[ab]	82.5[c]	81.8[c]	79.1[a]	80.3[b]	0.6
Wind speed, m/s	6.7[b]	0.4[a]	--	--	0.5[a]	0.4
Wind chill index, °C[3]	-24.2[a]	-10.9[c]	--	--	-12.5[b]	0.4

[1]For the summer period, outside data were obtained within 25 m of the bedded facilities. For the fall and winter period, outside data were obtained from an automated weather station located approximately 10 km from the feedlot site.

[2]THI (Temperature Humidity Index) = $(0.8 * T_a) + [(RH/100)* (T_a - 14.4)] + 46.4$, where T_a = ambient temperature, °C and RH = relative humidity, %.

[3]Wind Chill Index = $13.12 + (0.6215* T_a) - [13.96*(WS)^{0.16}] + [0.487* T_a *(WS)^{0.16}]$ where T_a = ambient temperature, °C and WS = wind speed, m/s.

[abc]Means within a row differ ($P < 0.05$).

During periods of lower wind speed, similar T_a (Table 1) were found outside the pen, at the waterer, the back of the pen, and the middle of the pen, but T_a were greater at the front of the pen. Hourly differences between the front and back of the pen followed the same pattern as was found during periods of high wind with T_a at the front of the pen being greater during most of the daylight hours due to the direct exposure to sunlight (Figure 4). Average RH during the low-wind period were similar at the waterer, the middle of the pen and outside the confinement building. The RH at the back and the front of the building were greater than RH at the waterer and middle. Hourly RH data during this period indicated similar trends as found under the higher wind speed period. As discussed previously, the greater RH at the front and back may be due to the wetter manure/bedding accumulated behind the bunks versus the dryer bedding found in the middle of the pen. The THI during the lower wind period was the same in all locations excluding the front of the building. The THI at the front was greater due to elevated temperature and RH (Table 1). The THI at the front of the building was greater during 17 hours during the day, but was similar to THI at the back of the building during the night-time hours from 02:00 to 08:00.

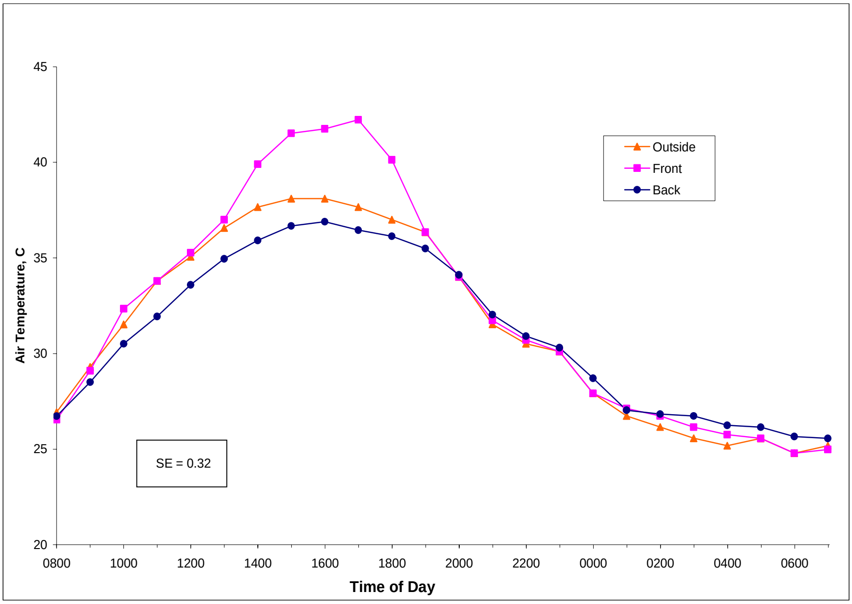

Figure 2. Summer hourly air temperatures during high-wind conditions. Front vs. back were different from 10:00 to 19:00, at 00:00, and at 06:00. Outside vs. front and back were different at 11:00, from 15:00 to 18:00, at 03:00 and at 04:00.

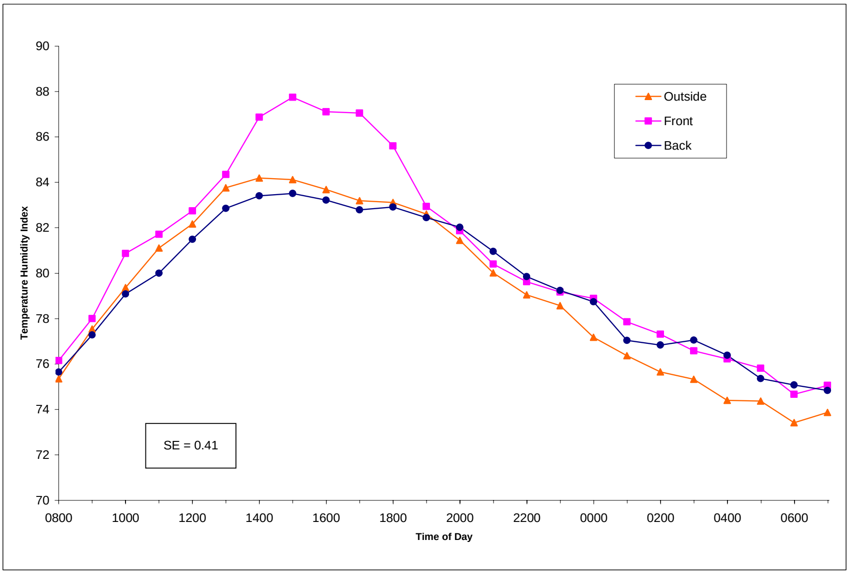

Figure 3. Summer hourly temperature humidity index (THI) during high wind conditions. Front vs. back were different from 10:00 to 18:00. Outside vs. front and back were different from 14:00 to 18:00 and from 00:00 to 07:00.

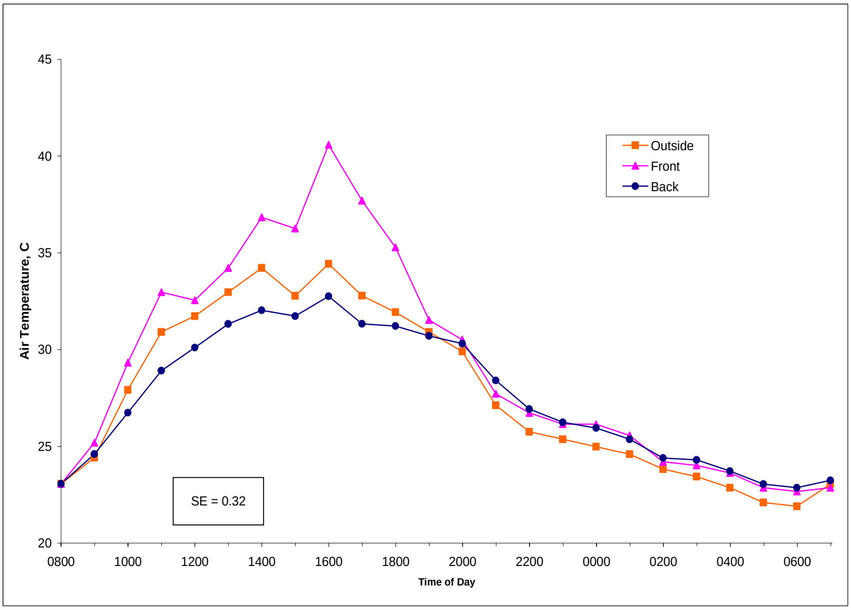

Figure 4. Summer hourly air temperature during low-wind conditions. Front vs. back were different from 10:00 to 19:00. Outside vs. front and back were different from 15:00 to 18:00, from 21:00 to 01:00, and from 04:00 to 06:00.

Fall Trial

Average T_a were different at each location. Temperatures were lowest outside and greatest at the front of the building (Table 1). Hourly T_a were found to be greater at the front of the building than at the back during the daylight hours, but no differences between front and back were observed during evening and night hours (Figure 5). Average RH were also different at all locations, with the front of the building having the lowest RH and outside being the greatest (Table 1). However, similar trends in hourly RH were found in the fall as those found in the summer with RH being lower at the front of the building during the daylight hours. No differences in RH were observed between the front and back of the building during the night hours. Average THI was similar within the building, but greater than those found outside (Table 1). Average wind speed differed at each location; it was greatest outside and lowest at the front of the building (Table 1). Hourly wind speeds were greater at the back of the building during most of the day (Figure 6).

Winds were most likely greater at the back of the building because of the funneling effect achieved by the design of the building resulting in the compression of air at the back of the building due to less open space when compared to the front. The average wind chill indices (WCI) during the fall trial were similar across all locations.

Infrared temperatures obtained during this time period indicated that pen surface temperatures at the front of the building were warmer than the back of the building, but were not as warm as the surface temperatures in outside pens (Table 2).

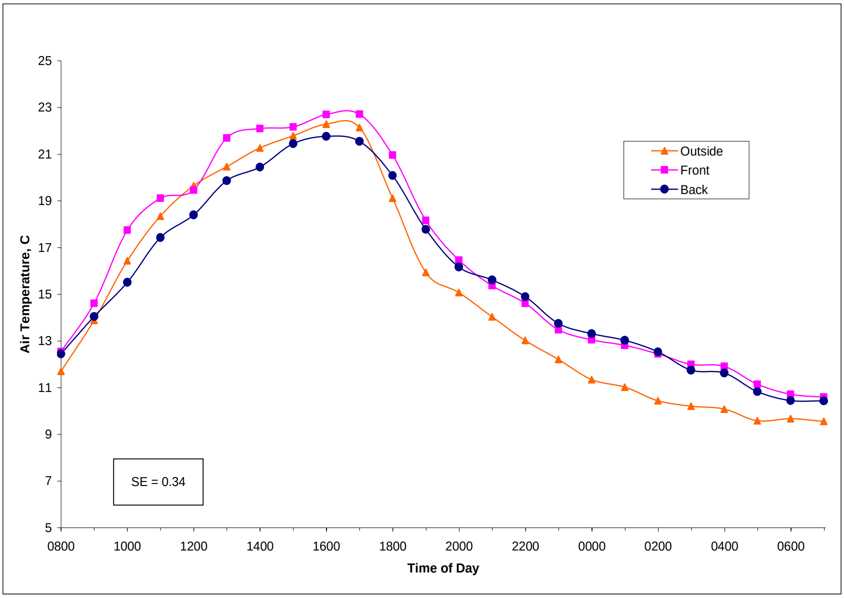

Figure 5. Fall hourly air temperature. Front vs. back were different from 10:00 to 14:00 and from 16:00 to 18:00. Outside vs. front and back were different at 08:00 and from 18:00 to 07:00.

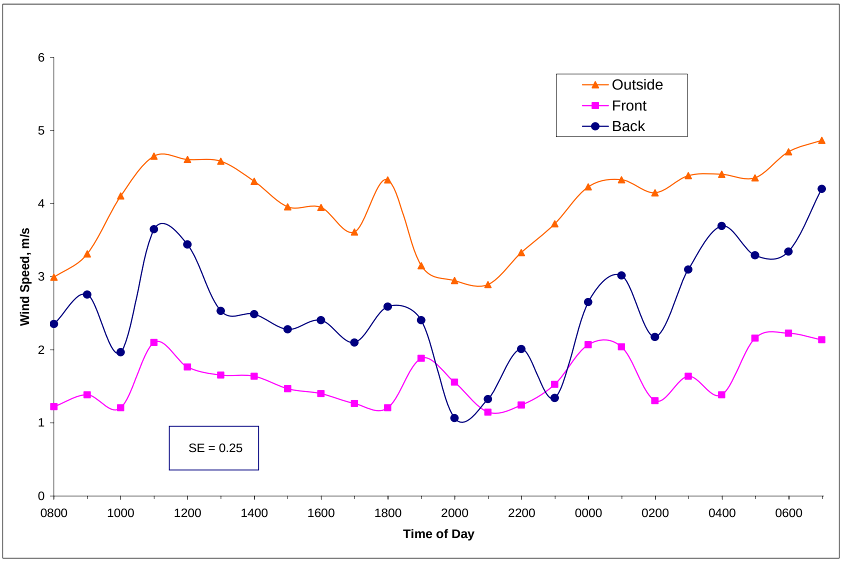

Figure 6. Fall hourly wind speed. Front vs. back were different from 08:00 to 18:00, at 22:00, and from 00:00 to 07:00. Outside vs. front and back were different at all hours.

Table 2. Infrared temperatures of feedlot surfaces in two confinement building pens and five outside pens with contained cattle

	Temperature, °C	SE
Front of pen (in sun)	36.8[b]	0.7
Back of pen (shaded)	22.2[a]	1.5
Outside pen	42.8[c]	2.1

[abc]Surface temperatures differ ($P < 0.05$).

Winter Trial

Average T_a during the winter trial were lowest outside the confinement pens (Table 1). The average T_a at the middle of the pen were similar to both the back and the front of the pen, but the back T_a was lower than at the waterer and the front of the building. No significant differences were observed between the front and the back of the building at any hour, but differences were found between the building and outside T_a (Figure 7). Average RH were greater at the front of the pen and at the waterer when compared to RH at other locations (Table 1). The greatest difference in RH occurred at 1000. At that time, RH was approximately 8 units greater at the front of the pen than at the back of the pen. Average wind speeds were similar within the building, but the outside wind speed was much greater (Table 1). No differences were found between the front of the building and the back, because the use of a curtain on the back side of the building diminished airflow through the pen when it was closed. The average WCI during the winter trial was different at each location (Table 1). The WCI was much lower outside than in the building, but remained lower at the back of the building than the front. This is probably because of sun exposure elevating air temperatures at the front of the building, thus increasing the WCI.

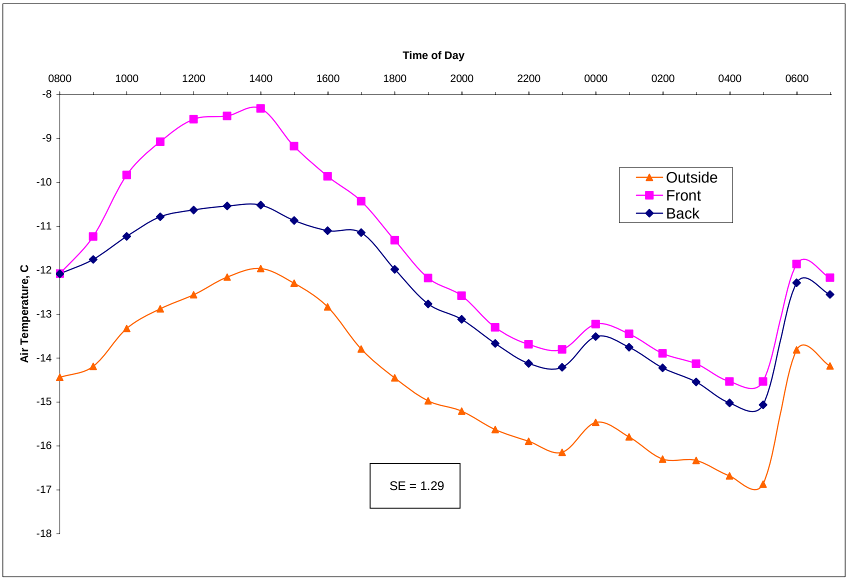

Figure 7. Winter hourly air temperature. Front vs. back were not different. Outside vs. front and back were different at 08:00 and from 18:00 to 07:00.

Conclusion

In warmer climates, fattening cattle in outside, open feedlots is the common practice. However, in colder climates, protection from adverse weather conditions may be warranted. Bedded confinement barns are one type of feedlot facility that can be used to buffer cattle against heat and cold stress, as well as enhance collection of animal waste. However, greater RH were observed at the front of the building (south facing) in the summer and winter due to lower wind speeds and/or decreased air movement associated with buildings. The use of the buildings did not lessen heat stress in the summer, as measured by the THI, but acted as a solar shield (shade) and decreased solar heat load on the animal. In the summer, T_a is elevated approximately 1 °C at the front of the building only. However, in the winter, with the use of a curtain (partially closing north side), T_a can be elevated between 2.0 to 4.0 °C.

Bedded barn facilities are useful for buffering cattle against the adverse effects of the environment under hot and cold conditions. In addition, if properly bedded, bedded barn facilities should virtually eliminate adverse effects that mud can have on cattle welfare and performance.

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