Carefully examine the information in this handout before making any decisions regarding the losses or damage in wheat caused by cold temperatures. Wheat is remarkably resilient and can withstand sudden drops in temperatures.
The degree of injury is moderated by stage of growth, temperature, moisture, and duration of exposure. Prolonged exposure + 4 hours causes more damage than brief exposure at the same temperature.
Some varieties require less vernalization and thus may be subject to greater injury due to advancing physiological development during warm winter days. The plant may enter into head initiation too early (prior to the onset of spring) and be subjected to below freezing temperatures. In general, the earlier stages of wheat growth are less sensitive temperatures near 28\(^\circ\) degrees than when advanced to the anthesis stage. During flowering, a prolonged frost or air temperature at freezing can cause moderate to severe damage depending on the length of exposure.

During heading, wet soils will improve the chances of survival to a short duration freeze due to the moderating effects of heat capture in the water. High N rates can increase injury via greater lush growth, thinner cell walls and higher moisture content.
Factors Influencing Freeze Injury

- Duration of exposure
  - Time of exposure in one or multiple events
  - Less injury can be expected from shorter periods of exposure times while greater injury might be expected at slightly higher temperatures from longer exposure
- Low point of temperature
  - Wheat at Feekes 5 can withstand colder temperatures than at later stages
- Field variability
  - Low areas vs high areas
  - Clay soils vs sandy soils

There are several factors that influence the susceptibility to low temperature injury: 1) Time of exposure in one or successive events, 2) age of plant, 3) variability’s in the field (dry, wet, residue, heavy or clay soils vs sandy soils)
As you see, wheat in the tillering stage can withstand lower temperatures before severe damage occurs than in the flowering stage. However, these temperatures are guidelines. As you approach the temperature at which damage occurs, other influences sometimes separate fields, i.e. Was the field in a low area, is it surrounded by trees, was the wind blowing, was the soil wet from a recent rain, did a prolonged heavy frost occur, etc?

<table>
<thead>
<tr>
<th>Growth Stage</th>
<th>°F</th>
<th>Symptoms</th>
<th>Yield Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillering</td>
<td>12</td>
<td>Leaf chlorosis and burn</td>
<td>Slight/Moderate</td>
</tr>
<tr>
<td>Jointing</td>
<td>24</td>
<td>Leaf burn/death of growing pt</td>
<td>Moderate/Severe</td>
</tr>
<tr>
<td>Boot</td>
<td>28</td>
<td>Floret sterility/head discolored</td>
<td>Mostly severe</td>
</tr>
<tr>
<td>Heading</td>
<td>30</td>
<td>Floret sterility/head discolored/ Bleached/leaves discolored</td>
<td>Severe</td>
</tr>
<tr>
<td>Flowering</td>
<td>30</td>
<td>Floret sterility/head discolored/ Bleached/leaves discolored</td>
<td>Severe</td>
</tr>
<tr>
<td>Milk</td>
<td>28</td>
<td>Heads bleached/kernels shrunken, discolored, rough</td>
<td>Mostly severe</td>
</tr>
<tr>
<td>Dough</td>
<td>28</td>
<td>Seeds shriveled and discolored</td>
<td>Slight/Moderate</td>
</tr>
</tbody>
</table>
In any case, it usually takes 3 to 4 days for the eye to pick up or separate damage symptoms. Allow a couple of extra days to pass before attempting to make any type of damage and yield assessment. When making yield assessment, wheat damaged earlier in its growth stage has greater yield compensating abilities. Severe freezes during flowering or heading do not always mean a complete loss. Late (surviving) tillers will begin to grow through the damage, flower and set seed. Before making a decision, give the crop at least two weeks to demonstrate new growth and potential yield ability.
Depending on the growth stage, injury includes many symptoms. Listed in the slide are some of the symptoms expected 5 to 7 days after a freezing event.

- Emerging leaf in whorl turns yellow or is brown
- Stems are flaccid, rough and collapse
- Areas below or above nodes begin to show a brown discoloration
- Head located in boot becomes milky in color, water-soaked or begins to turn tan-brown
- Exposed head turns light tan to bleach
- Developing kernels begin shriveling, turn brown.
An example of different symptomatic responses due to growth stage difference in wheat varieties with different maturities.
Remember when examining a stem or head, an uninjured plant continues to develop normally. Several days of growth will make a significant difference. Once the tissue of the developing head is killed, the spike will continue to be pushed up by internode lengthening.
Use a razor blade or sharp knife to cut or split the head just above the upper most node. Examine several stems to determine the extent of injury.
An injured head will ultimately turn colors with time from a yellow-green, to opaque or white, then tan to brown. It will lose its turgor, become flaccid and ultimately shrivel.
An item of importance to remember is that for some reason, the area below the upper two nodes may freeze without any damage to the head. The stem will appear uninjured for 7 to 10 days and then collapse. In fact, the head will continue to develop until the stem collapses, shutting off the flow of water/nutrients to the head.
This slide shows different damage symptoms compared undamaged heads. Notice the glumes have been removed from the grains heads on the right. The caryopsis or kernels that were damaged have stopped developing compared to the kernels in the grain head on the right.
Sometimes, there are very slight differences in growth and susceptibility. Notice the kernels at the top of the head were uninjured and continued to develop vs. the kernels at the bottom of the head which were killed in the early caryopsis development phase. Usually a head flowers in the middle first. It is likely that the flowers in the injured spikelets had flowered earlier and were slightly ahead of those at the top or bottom of the head.
This slide shows wheat head about 5 to 6 days after a freeze.
A comparison of a healthy floret and an injured floret.
Damage at the early kernel development phases. Notice the differences in stage of growth at the time of the freeze vs a healthy caryopsis. Notice how the kernels are beginning to show signs of deterioration and shriveling.
Assessing the Damage

- Wait at least four days before making determination.
- Carefully cut into the stems or flowers. Look at the developing heads or caryopsis for symptoms.
- Check nodes below the head.
- Check multiple areas of the field.
- Usually wheat can compensate when damage occurs at earlier growth stages.

Be patient.