

Temperature Inversions: Their Impact On Pesticide Applications



Vern Hofman, Former Ext. Ag. Engineer, Andrew Thostensen,
Pesticide Coordinator and John Enz, Former State Climatologist
North Dakota State University
Fargo, North Dakota

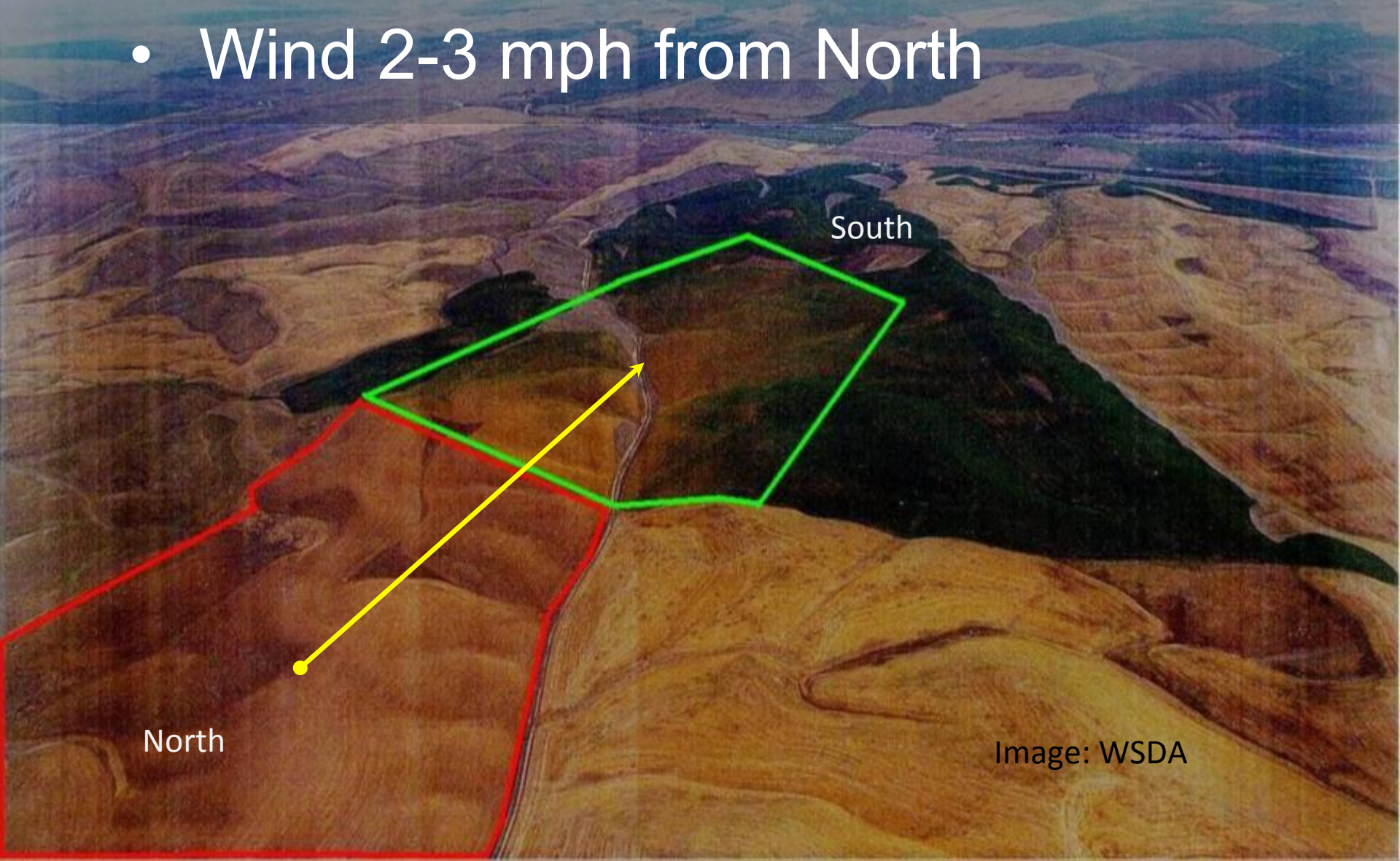
NDSU Extension Service
**PESTICIDE
PROGRAM**



NDSU
Extension Service

Helicopter application of glyphosate

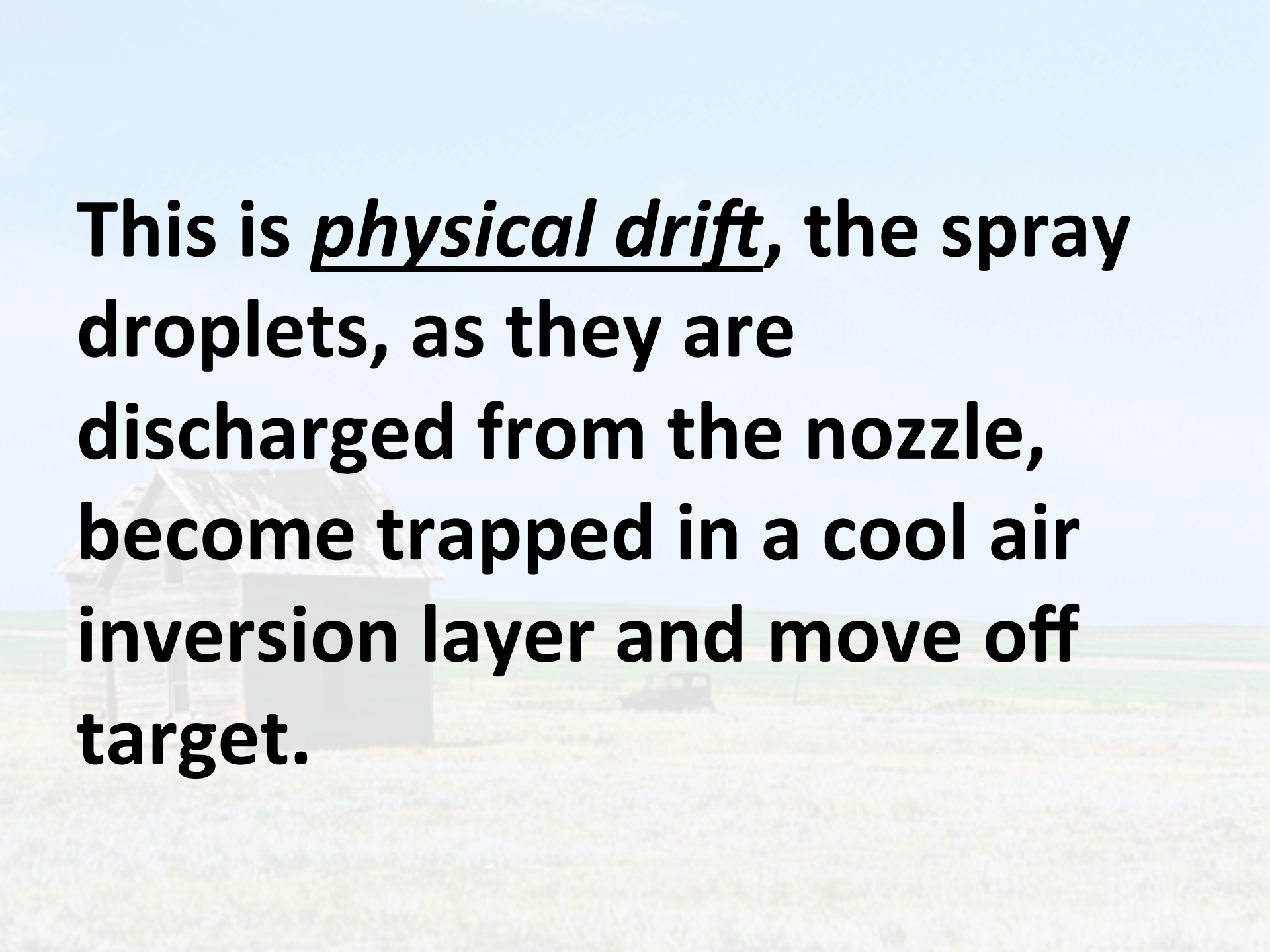
- Application from 2:00 pm to 5:00 pm
- Wind 2-3 mph from North



North

South

Image: WSDA



This is *physical drift*, the spray droplets, as they are discharged from the nozzle, become trapped in a cool air inversion layer and move off target.

2,4-D herbicide drift damage stuns east Arkansas cotton

David Bennett

Aug. 11, 2006 4:00pm

RSS  Comments  0

PRINT

SAVE

EMAIL

SHARE

The young, east Arkansas cotton farmer turns in a slow circle trying to find a plant within his line of sight that isn't "smoked" by herbicide drift. There isn't one — leaves in the top third of every plant are off-color, curling and blistered.

Advertisement

[Herbicide Application](#)

Review Tank Mixing and Application Instructions for Everest® Here www.flushafterflush.com

He says excuses won't cut it. He wants those responsible for the 2,4-D drift that's harmed more than half his crop held liable. After that, he suggests banning or restricting 2,4-D might be a good idea.

"This is beyond ugly and has got to stop," he says throwing up his hands in frustration. "We're trying to make a living and this bush-league (stuff) starts happening. It's the same story up and down the road here. It's on everyone's cotton.

This is easily seen in east Arkansas where multiple counties have been affected by the recent drift. After visiting with Extension agents and consultants, Bill Robertson says there's easily upwards of **200,000 to 250,000 acres** of damaged cotton in Craighead, Greene, Poinsett, Mississippi and Cross counties.

Recognizing and dealing with an inversion is a label requirement

“Temperature Inversions

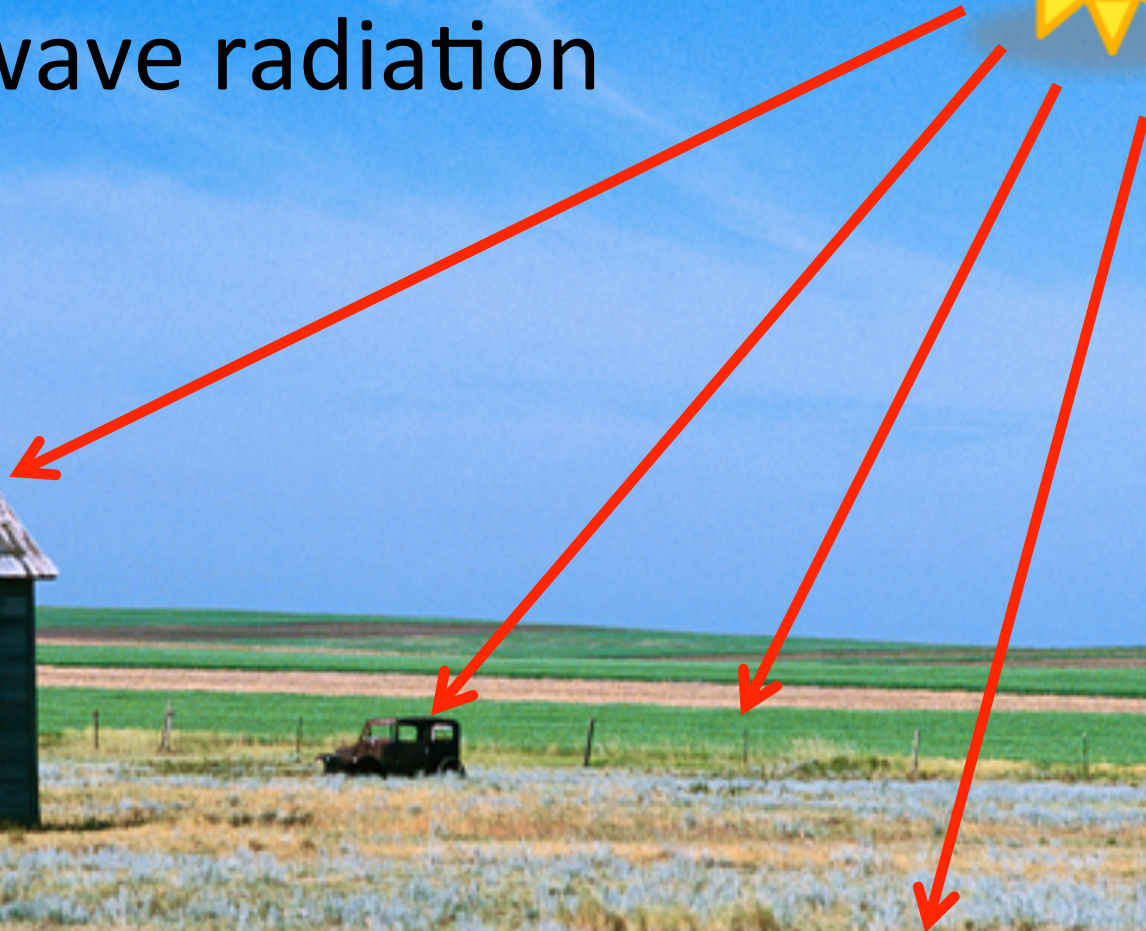
If applying at wind speeds less than 3 mph, the applicator must determine if:

- a) conditions of temperature inversion exist,
- or
- b) stable atmospheric conditions exist at or below nozzle height.

Do not make applications into areas of temperature inversions or stable atmospheric conditions ”



Short wave radiation



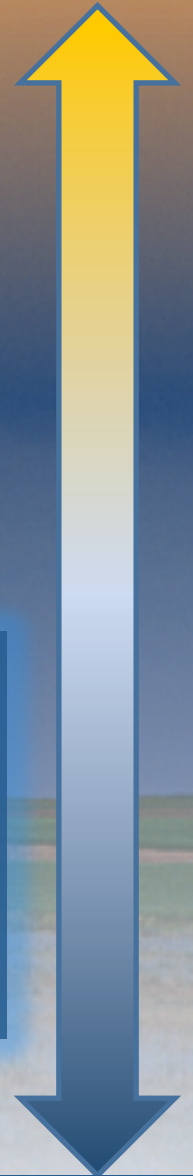
Long wave radiation



Radiation waves from objects
move in all directions into the air



Warmer

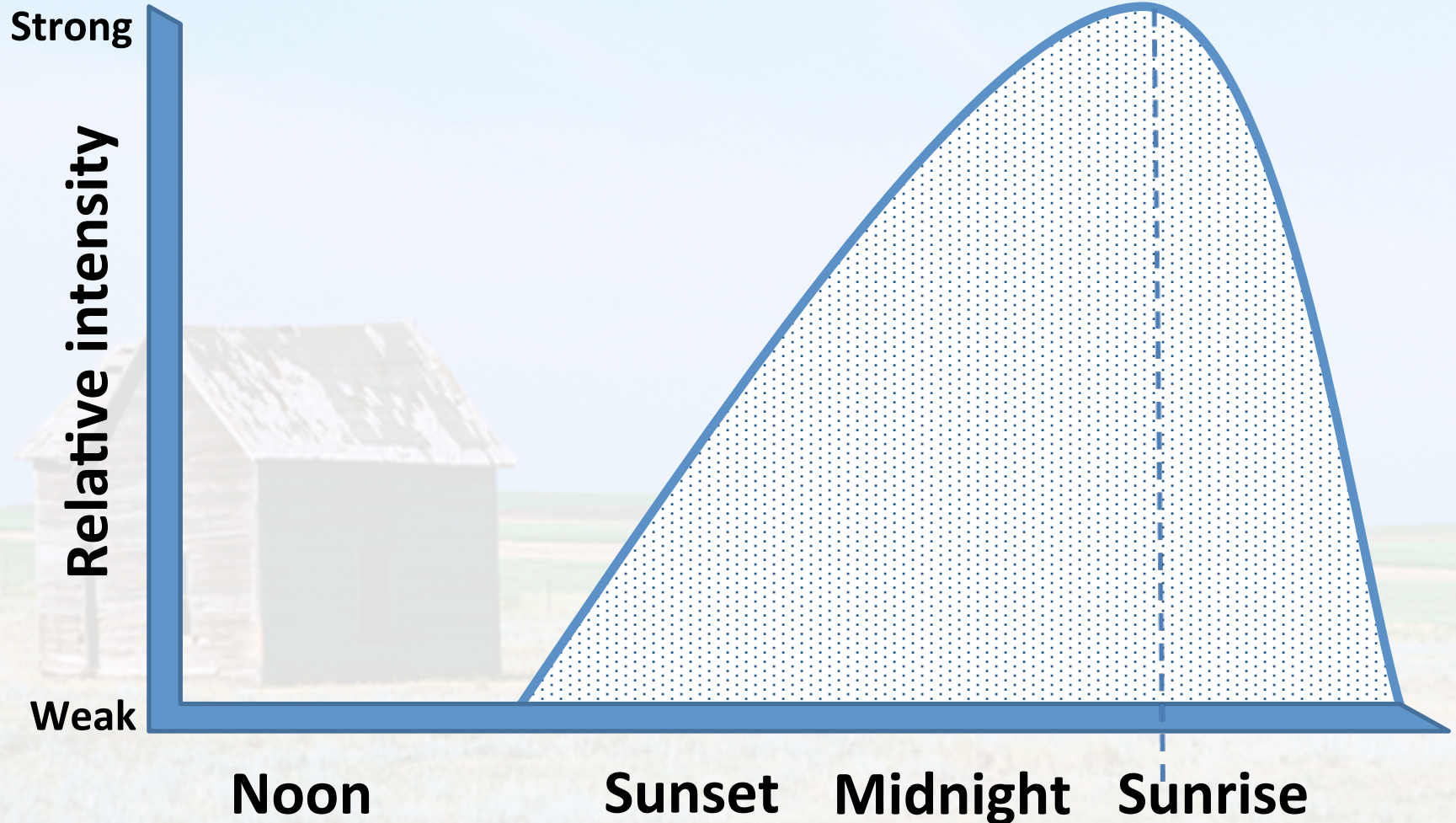


Objects lose heat,
cool the air near the
earth's surface

Coldest



On a clear & calm 24 hour day, when will inversions begin and end?



Early afternoon temperature profile on a hot day with 4 mph or less wind



90 degrees F at 60 inches or 5 feet

92.5 degrees F at 39 inches or 3.25 feet

95.5 degrees F at 24 inches or 2 feet

99.4 degrees F at 12 inches or 1 foot

105 degrees F at 4 inches

NDSU Weather Data—Courtesy of John Enz, Professor Emeritus

Early morning temperature profile with a strong inversion (calm & clear)



50 degrees F at 60 inches or 5 feet

48 degrees F at 39 inches or 3.25 feet

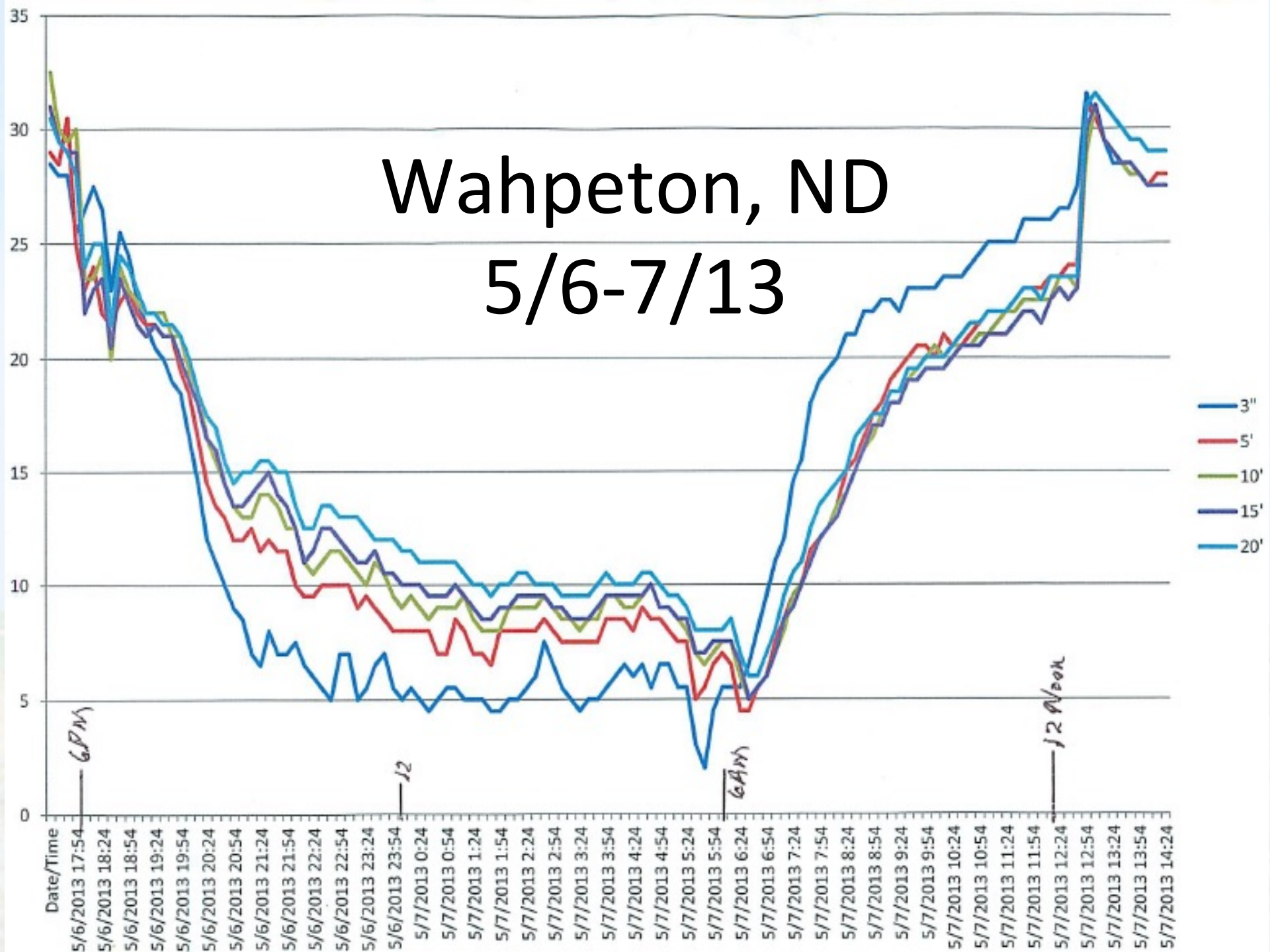
46 degrees F at 24 inches or 2 feet

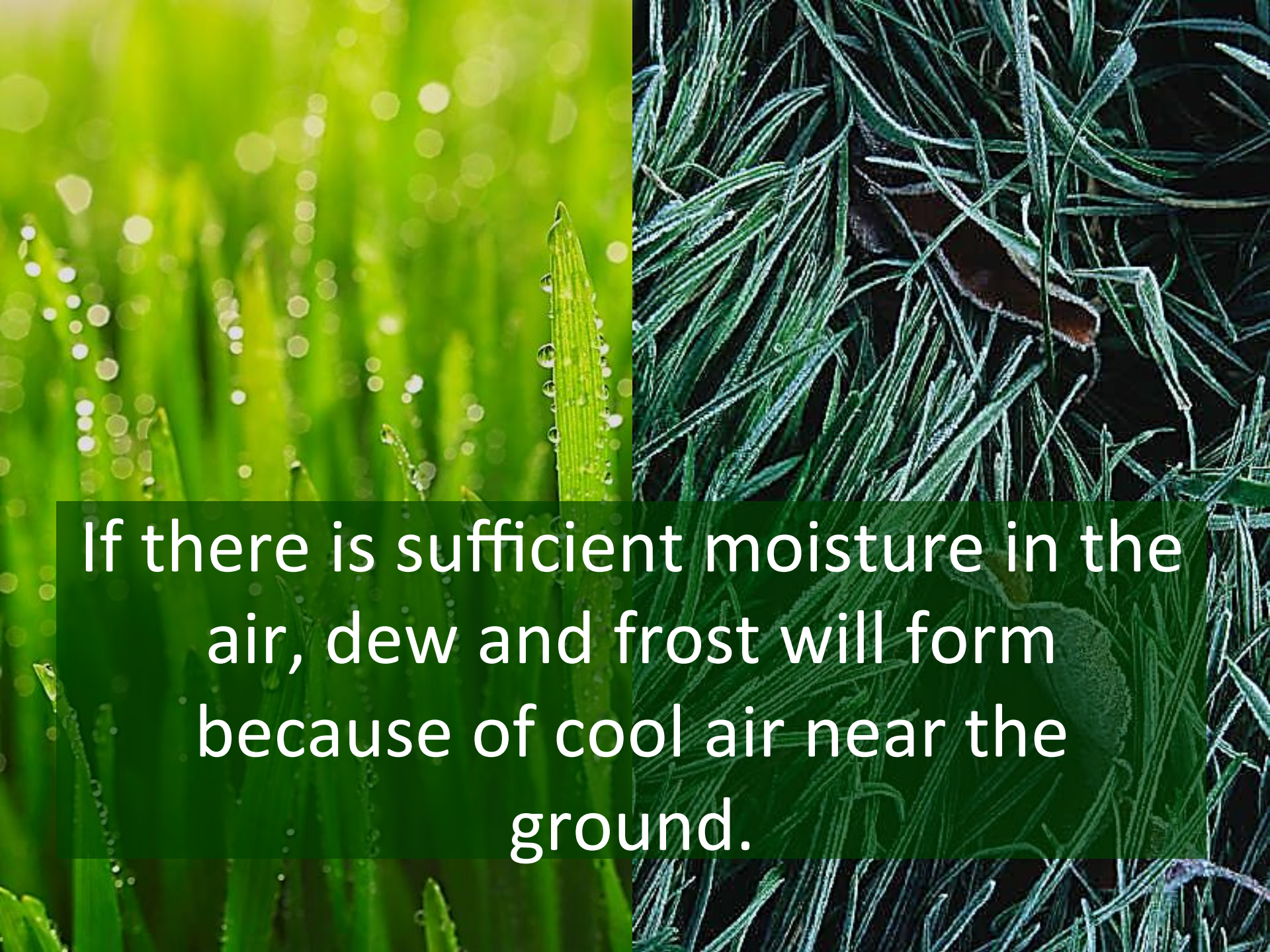
45 degrees F at 12 inches or 1 foot

44 degrees F at 4 inches

Estimated!

Wahpeton, ND 5/6-7/13



The image is a vertical composition of two photographs. The left half shows a close-up of green grass blades with numerous small, clear dew droplets clinging to their surfaces. The right half shows a brown spider on its web, which is stretched across a dense thicket of green grass. The background of the right half is dark, making the spider and the dew on the grass blades stand out.

If there is sufficient moisture in the air, dew and frost will form because of cool air near the ground.

If there is sufficient moisture in the air,
fog will also form.



Dew point
Temperature



Temperature =

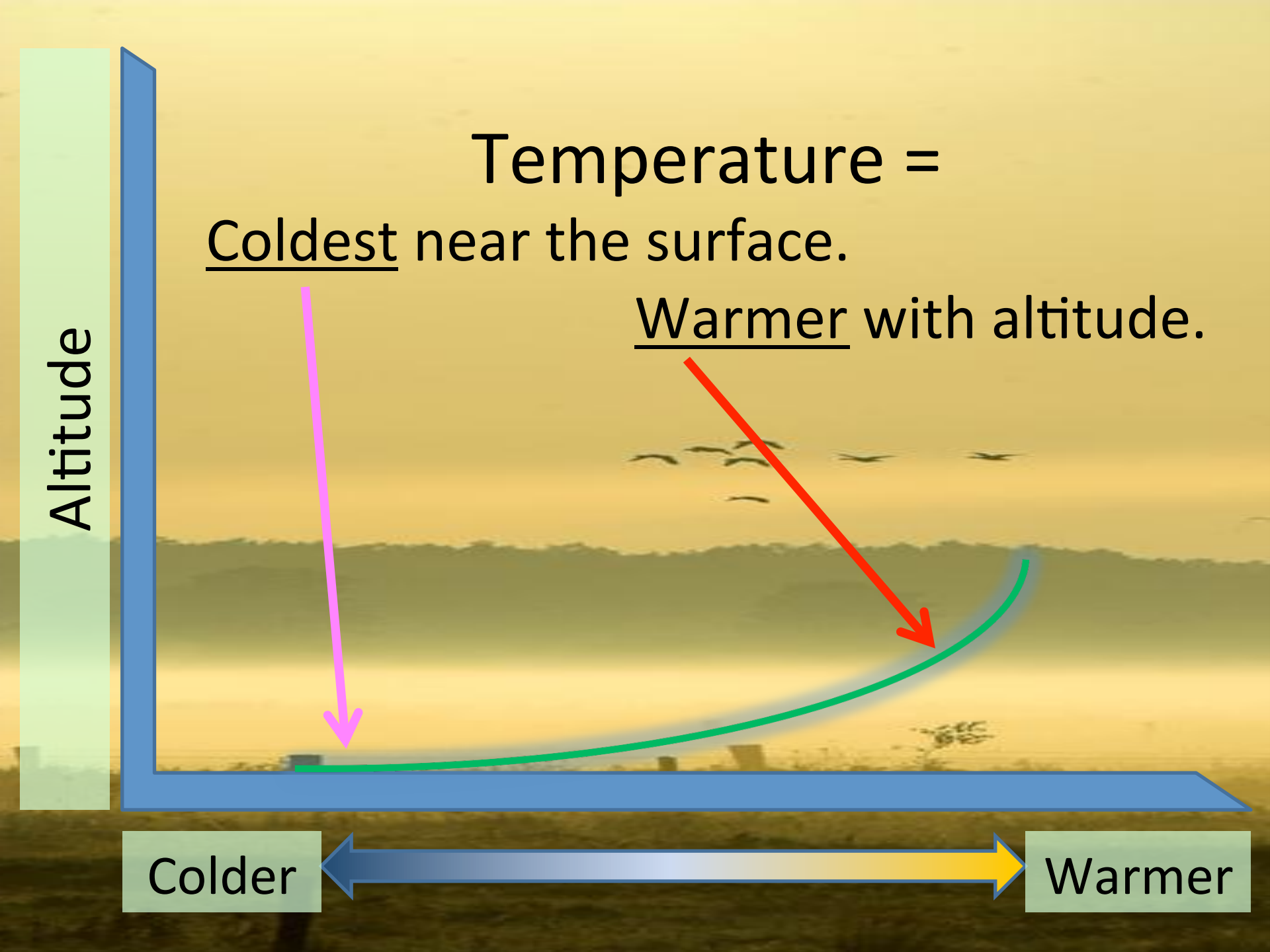
Coldest near the surface.

Warmer with altitude.

Altitude

Colder

Warmer

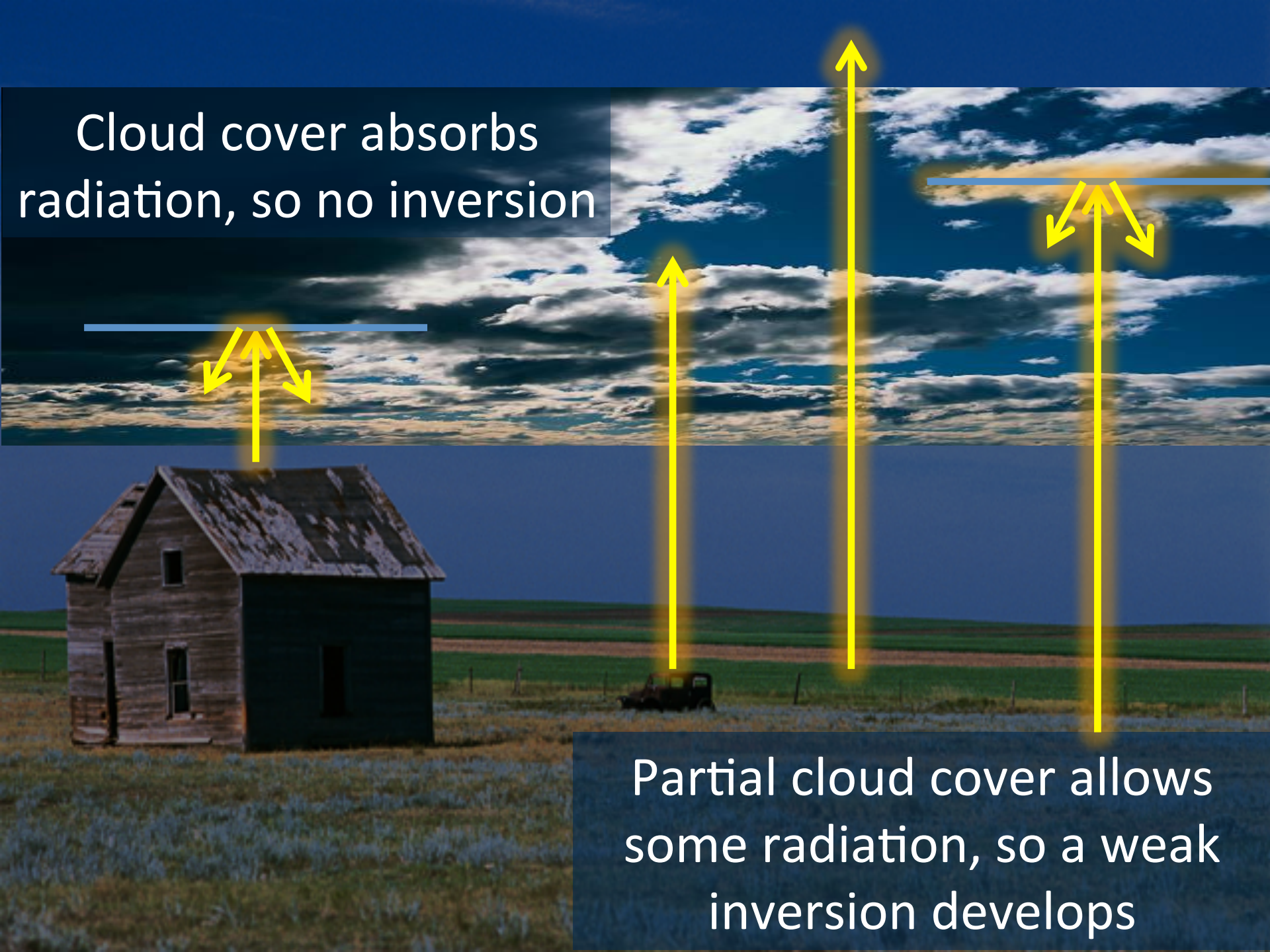


All the conditions we've talked about
assumes very little wind.

Sufficient wind will mix the air, thus
preventing or destroying the inversion.

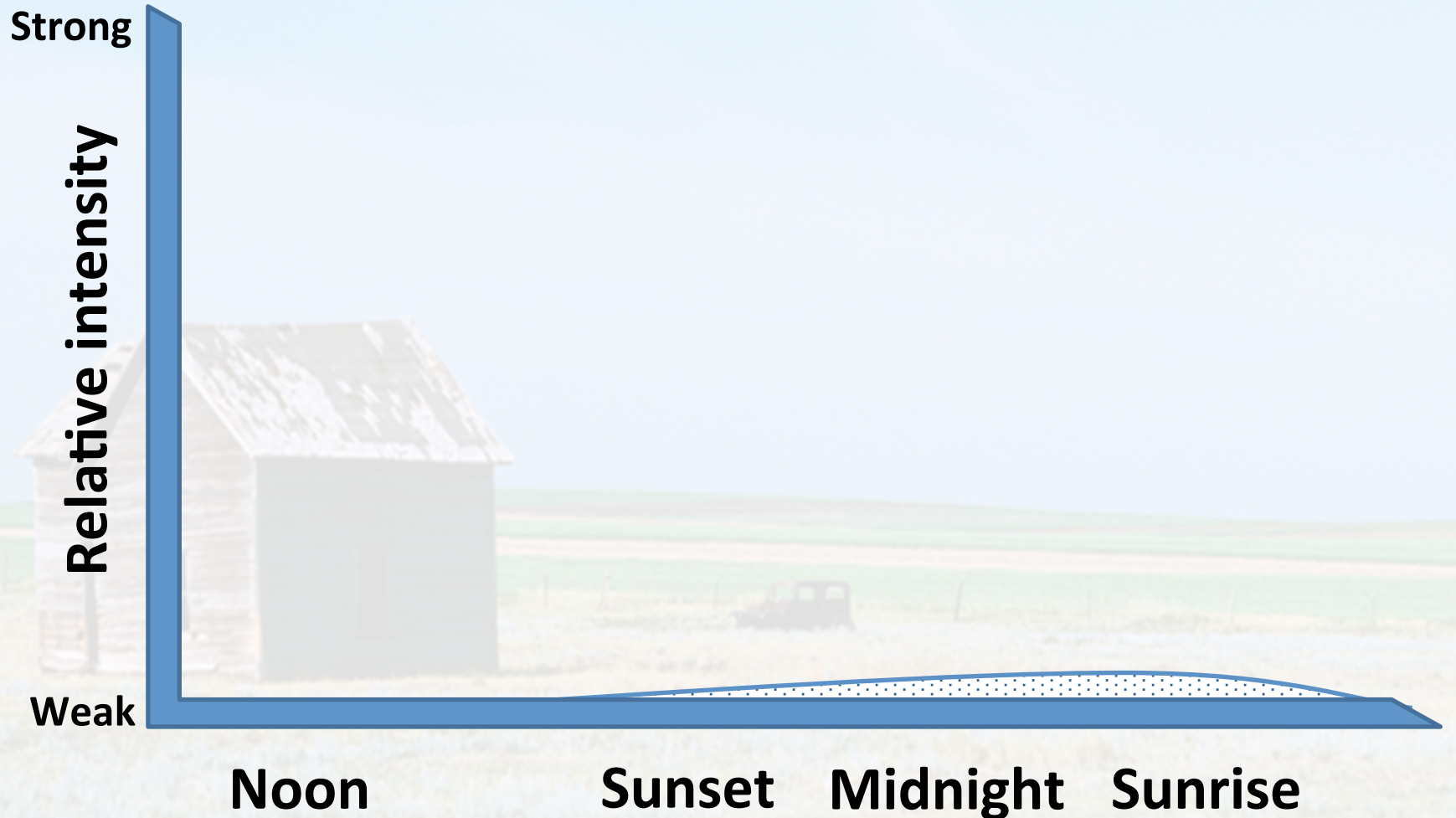


Cloud cover absorbs radiation, so no inversion



Partial cloud cover allows some radiation, so a weak inversion develops

On a cloudy and/or windy 24 hour day, when will inversions begin and end?



Early afternoon temperature profile on a hot & windy day

18th Hole

92.5 degrees F at 60 inches or 5 feet

93.4 degrees F at 39 inches or 3.25 feet

94.3 degrees F at 24 inches or 2 feet

95 degrees F at 12 inches or 1 foot

95.8 degrees F at 4 inches

NDSU Weather Data—Courtesy of John Enz, Professor Emeritus

Early morning temperature profile with little or no inversion (windy & cloudy)

18th Hole

40.7 degrees F at 60 inches or 5 feet

40.4 degrees F at 39 inches or 3.25 feet

40.3 degrees F at 24 inches or 2 feet

40.1 degrees F at 12 inches or 1 foot

40 degrees F at 4 inches

Estimated!



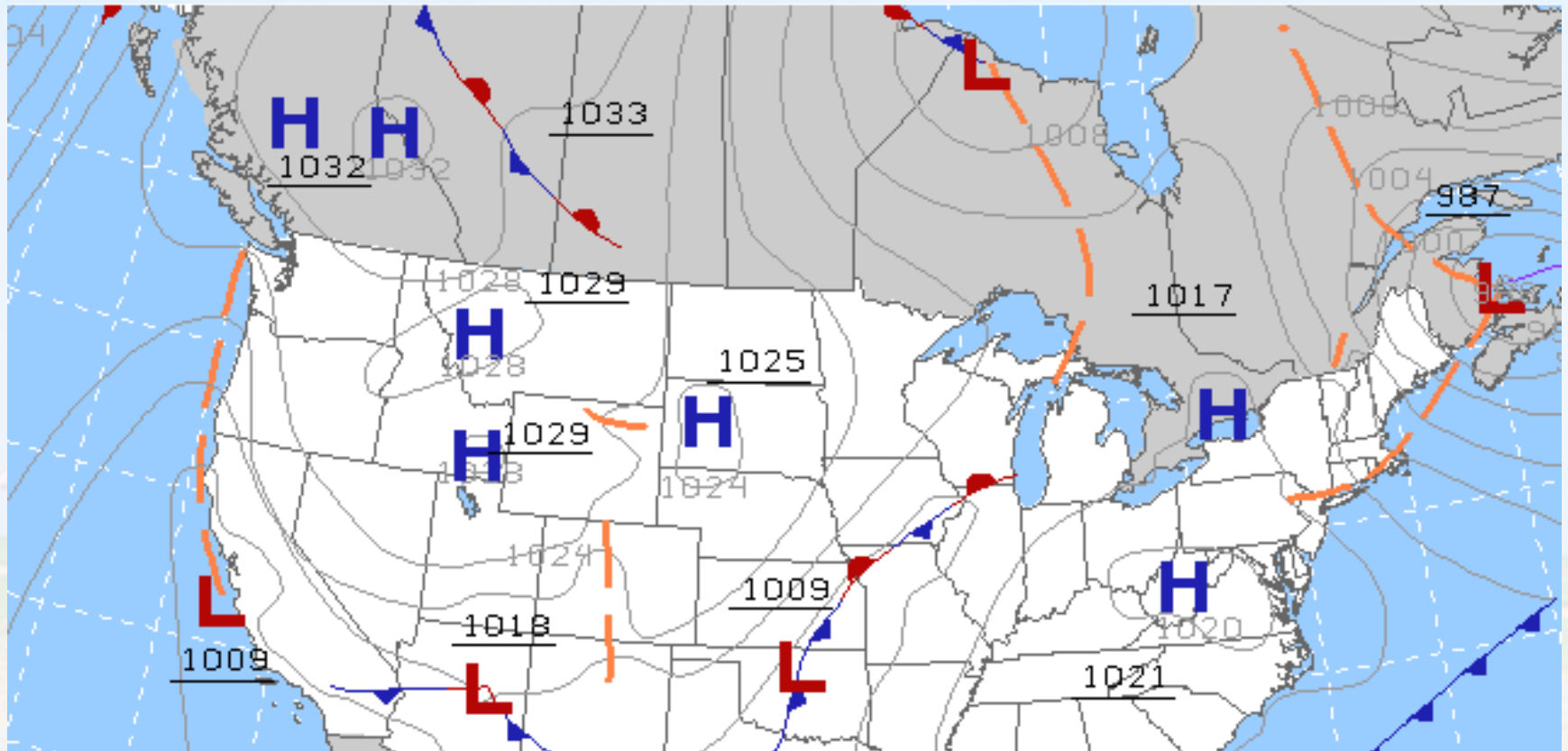
Cold air flows like water and
will move down into
valleys and basins

Cold air moves into a low lying pasture



Moisture in the air condenses and creates fog.

High Pressure Areas are associated with cool /dry air, clear skies & stable winds



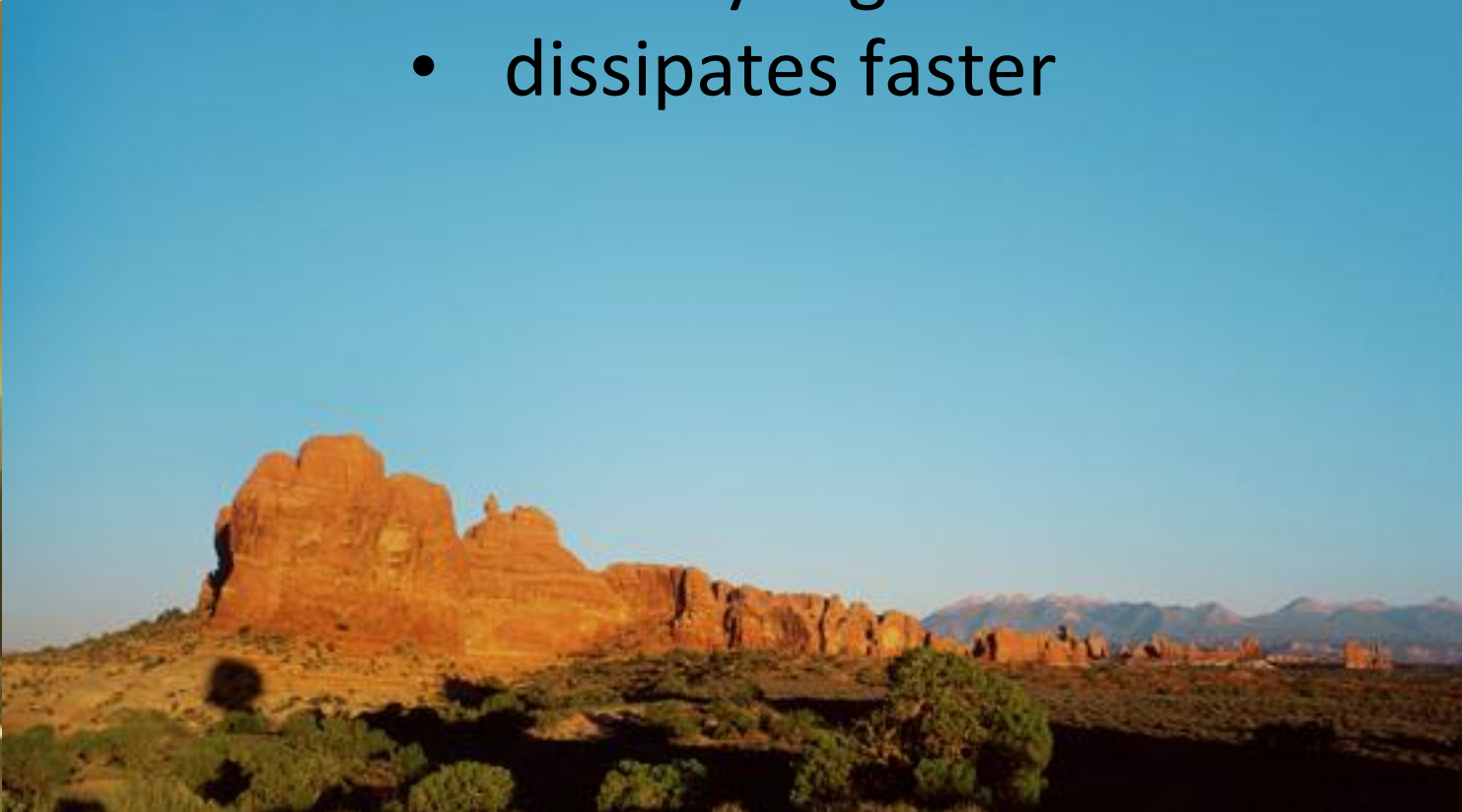
*Excellent ingredients for
inversion formation*

Humidity

High
humidity
rainforest

Low humidity desert

- inversion builds faster
- intensity is greater
- dissipates faster

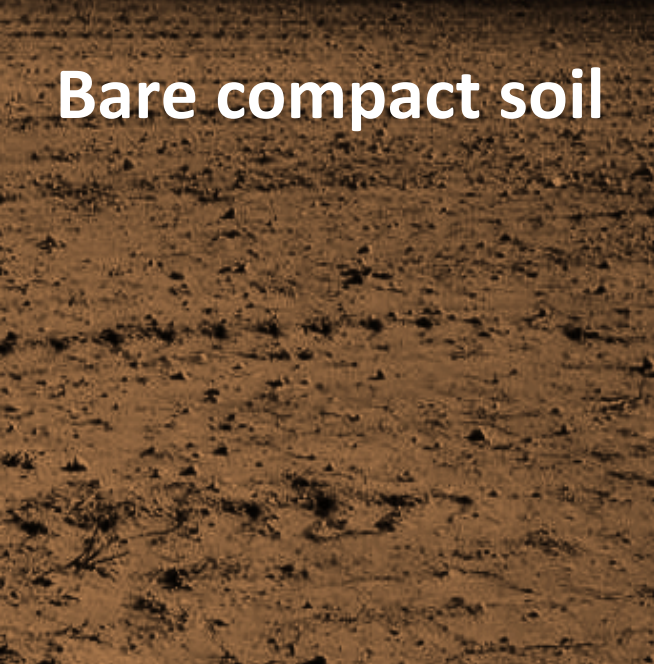


Surface conditions making matters worse



- Exposed soil that:
 - Has a low moisture content
 - Is sandy or coarse textured
 - Has been freshly tilled
- Soil that is heavily mulched and/or covered with heavy crop residue
- Closed crop canopy and or complete vegetative ground cover
- Wind breaks and/or shelter belts

Bare compact soil



Loose tilled soil



Mulched soil



**Warmer
Surface**



**Colder
Surface**

Open row



Partial row closure



Canopy





Open row
surface
temperature
slightly colder than
bare ground

Closed row
surface
temperature
much colder than
bare ground



Wind Breaks



Trees will interfere with wind, inversion builds more quickly and cold air layer becomes trapped



Tree shadow causes inversion earlier in the afternoon and will prevent dissipation longer into the morning

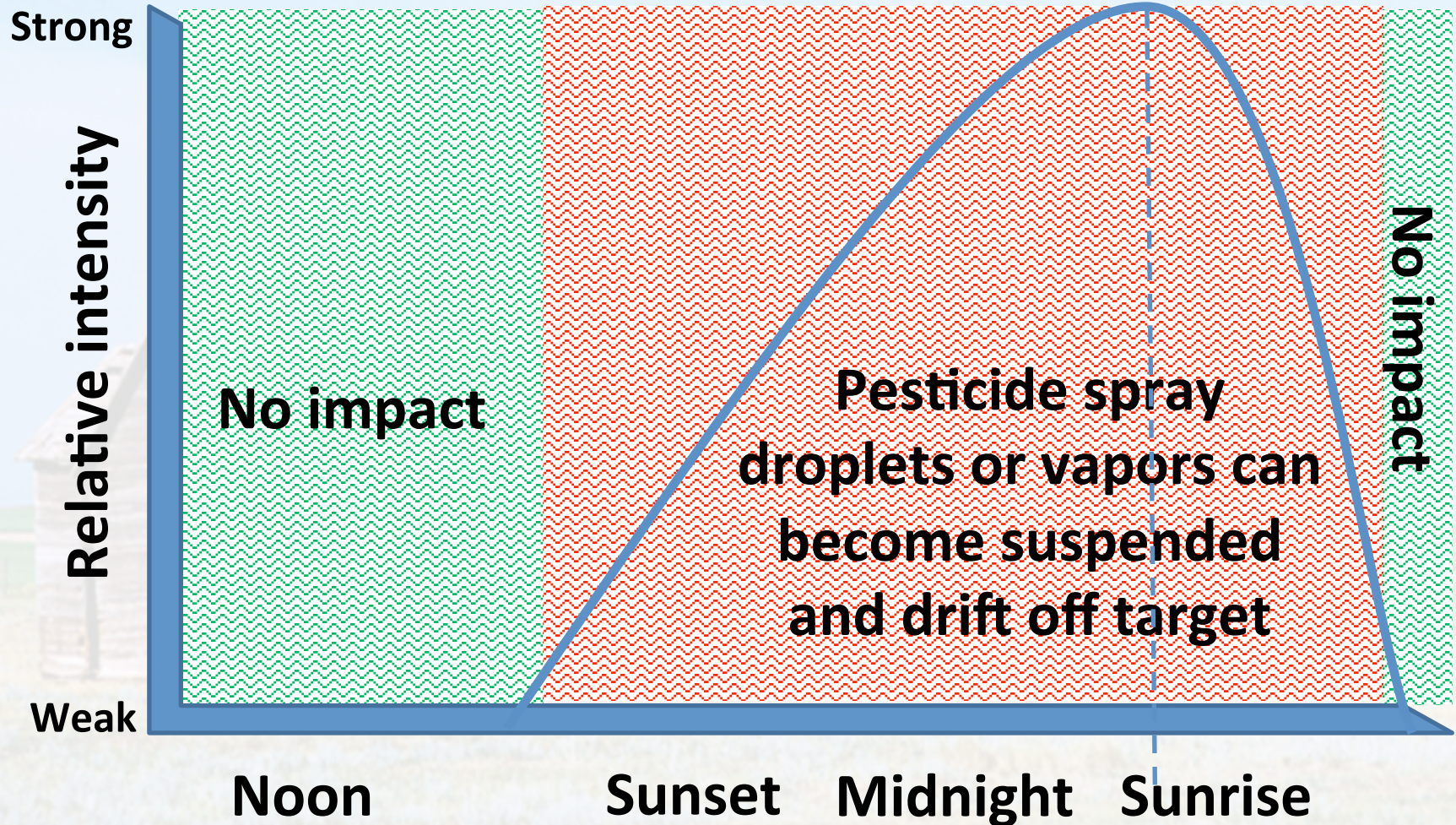
Late Afternoon / Evenings



Mornings



When will an inversion impact my spray operation?



Exceptions

Stagnant air
conditions,
inversions may not
dissipate for days



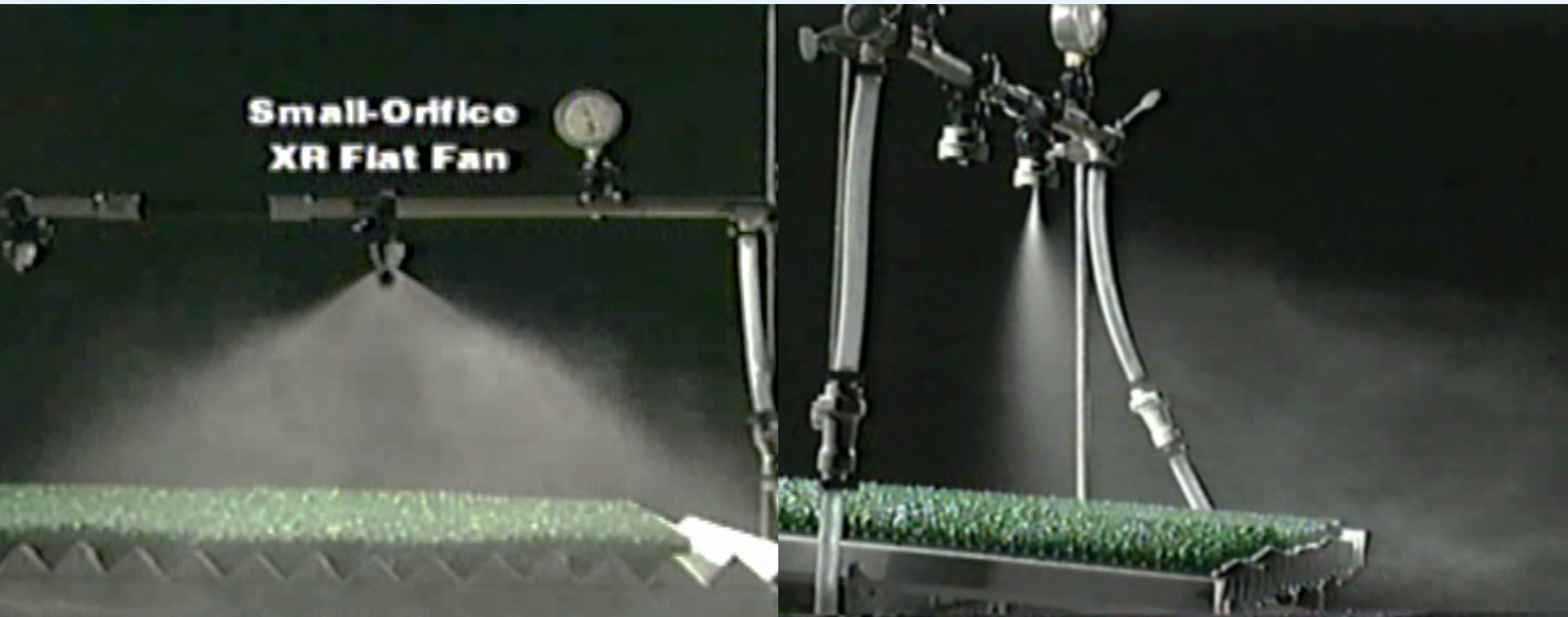


What happens
when I spray
during an
inversion?

It depends on the
type of application
and the inversion
intensity.



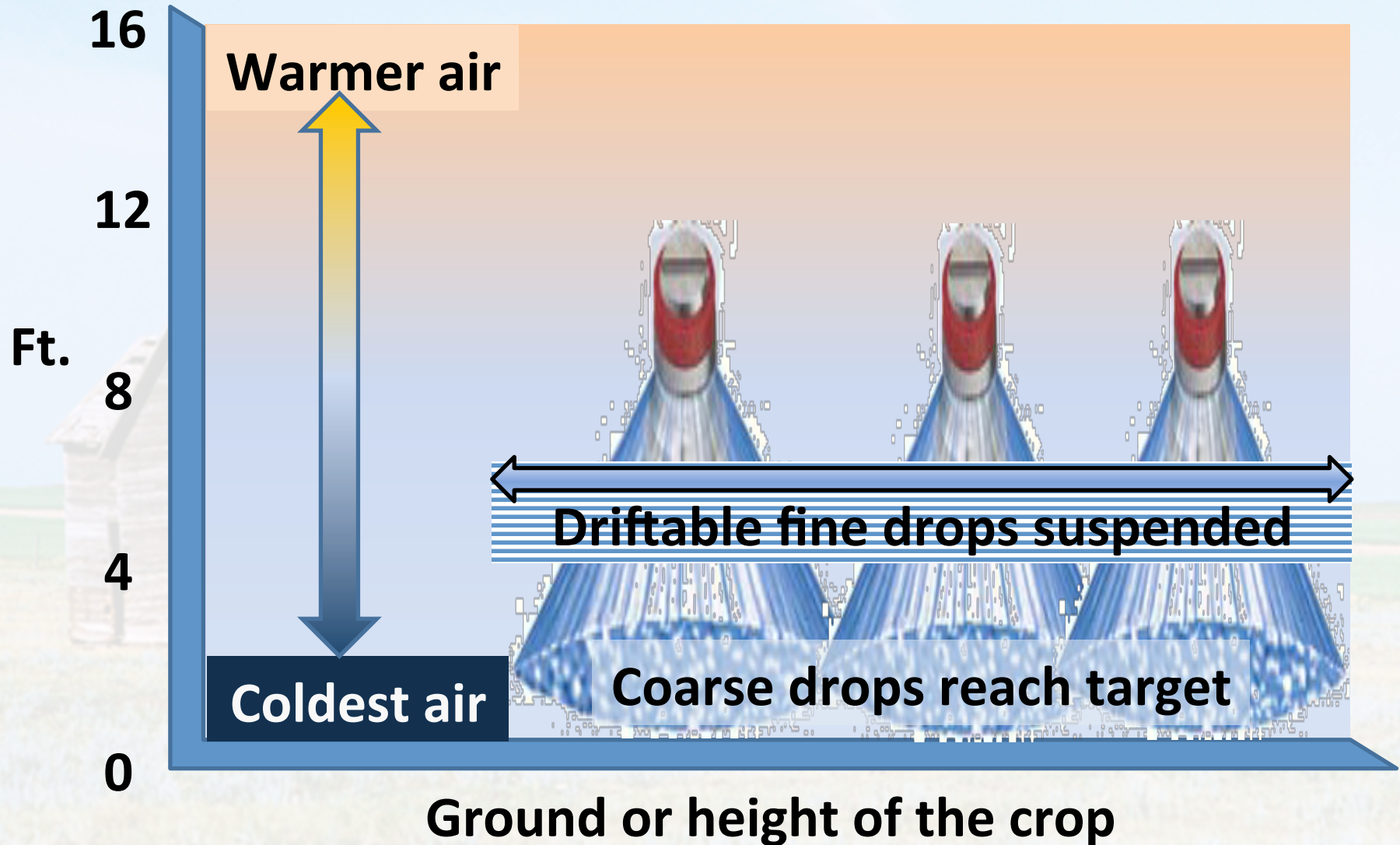
Physical Drift & Fine Drops



High percentage of fine drops is never good, but they are especially bad in an inversion.



Spraying during an inversion = trapping of fine droplets



Dust particles hang in the air

Visible dust particles are about
200 microns in size

Fine spray drops hang in the air



Tracer dye, late afternoon spray,
conducted in early May



Fine pesticide laden droplets move off target



Create the best droplet pattern possible with the right nozzle



CP-06



CP-01-3



CP-03

Operate them based on the nozzle manufacturer's specifications!

Be wary of pesticides that are sensitive to vaporization

Pesticide hits the target when sprayed



But then vaporizes or gasses off during or after application

Vaporization of pesticide from the soil or foliage during an inversion

Light wind moves pesticide down range

Cold air trapped vapors near surface



While the actual A.I. may not be volatile, solvent odors can be

their direct supervision
Applicator's certificate



Insecticide
®Trademark of Dow Agrosciences

Headline®

fungicide

For use in disease control and plant health in the following crops:

Barley, citrus fruit, corn (all types), cotton, dried shelled peas and beans, edible podded legume vegetables, grass grown for seed, mint, peanut, pecan, rye, soybean, succulent shelled peas and beans, sugar beet, sunflower, tuberous and corm vegetables (includes potato), wheat and triticale

Active Ingredient*:

pyraclostrobin: (carbamic acid, [2-[[[1-(4-chlorophenyl)-1H-pyrazol-3-yl]oxy)methyl]phenyl]methoxy-, methyl ester) 23.6%

Other Ingredients:** 76.4%

Total: 100.0%

* Equivalent to 2.09 pounds of pyraclostrobin per gallon.

** Contains petroleum distillates.

Clues



You can smell them



A blurred landscape at sunset or sunrise. The sky is a gradient of light blue, yellow, and orange. The ground is dark and blurry, suggesting a road or field. The text is overlaid in the lower half of the image.

Dust from vehicles or farm
machinery will hang in the air

You can hear them



Outdoor Sound Propagation in the U.S. Civil War

by Charles D. Ross

Students of military history know that acoustic refraction and unusual audibility have often played significant roles in the outcome of battles. Before electrical and wireless communications became common on the tactical level, the sound of battle was often the quickest and most efficient method

entire war. The unusual acoustics at Seven Pines placed Confederate commander Joseph Johnston in a position of danger when the battle should have been over. Because of Johnston's wound, Robert E. Lee assumed command of the Confederate forces two days later.



A Perfect *Inversion* Storm



1. Requires radiation from surface objects into a cloudless or near cloudless sky
 - 25% or less cloud cover
2. Requires light and variable winds with minimal mixing of the lower atmosphere.
 - Especially 0 to 3 mph
 - Remain cautious with winds of 4 to 6 mph

A Perfect *Inversion* Storm



3. Begins in the mid to late afternoon and intensifies throughout the night until dawn. (The inversion will then dissipate into mid-morning.)
 - Especially 3-5 hours before sunset
 - Especially 2-3 hours after sunrise

A Perfect *Inversion* Storm



4. Includes an unsuspecting applicator who does not recognize there is a problem:
 - Applicator who has been shut down for several days (due to high winds) and is desperately looking for an opportunity to spray
 - Applicator who has been spraying for many hours and loses track of weather conditions, especially in the late afternoon / early evening

Late afternoon / evening spraying



Inversions during this time of the day could have serious consequences

NOAA Tabular Weather Forecast for Sioux, Falls, SD

Date	10/02									10/03										
Hour (CDT)	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10
Temperature (°F)	58	58	57	56	51	48	45	41	39	38	37	36	35	35	34	34	35	37	40	44
Dewpoint (°F)	36	36	35	35	35	35	35	35	34	34	34	33	32	32	31	31	32	33	35	36
Wind (mph)	8	7	6	5	3	2	2	2	2	2	2	2	2	1	1	2	3	5	7	9
Wind Dir	NE	NE	NE	ENE	ENE	E	E	ESE	ESE	SE	SSE	SSE	SE	SE	SE	SE	SE	SE	SSE	SSE
Gust																				
Sky Cover (%)	38	36	30	24	18	12	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Rel. Humidity (%)	44	43	44	46	53	60	69	78	81	85	89	89	88	89	88	88	89	86	82	74

www.weather.gov

The screenshot shows the National Weather Service website. At the top left is the NOAA logo. The main header reads "National Oceanic and Atmospheric Administration's National Weather Service". Below this is a navigation bar with "Site Map", "News", and "Organization". A sidebar on the left contains a search box for "Local forecast by 'City, St'" with a "Go" button, and a "Sign-up for Email Alerts" section with "XML" and "RSS Feeds" options. The main content area features a news article titled "...Flooding continues in tthe East, heavy rains have ended..." with a "Details..." link. Below the article is a row of tabs: "Warnings & Forecasts", "Graphical Forecasts", "National Maps", "Radar", "Water", "Air Quality", "Satellite", and "Climate". Under "Warnings & Forecasts", there is a dropdown menu set to "Warnings By State" and a "Go" button. To the right of the dropdown is the text "Click Below To Zoom In." and "Tabs At A Glance". Below these elements is a map of the United States with various colored regions, and a timestamp "Created: 10/02/10 at 19:41 UTC".

NOAA

National Oceanic and Atmospheric Administration's
National Weather Service

Site Map News Organization

Local forecast by
"City, St"

Sign-up for Email Alerts
XML RSS Feeds

Warnings
Current
By State/County...
UV Alerts

Observations
Radar
Satellite
Snow Cover
Surface Weather...
Observed Precip

Forecasts
Local
Graphical
Aviation
Marine
Hurricanes

...Flooding continues in tthe East, heavy rains have ended...
While the heavy rains of recent days have come to an end across the Eastern Seaboard, flood warnings remain in effect across parts of eastern North Carolina and New England. Across New England, rainfall totals of nearly 6 to 8 inches were reported. In the Mid-Atlantic, rainfall totals of up to almost 18 inches were reported. [Details...](#)

Warnings & Forecasts Graphical Forecasts National Maps Radar Water Air Quality Satellite Climate

Warnings By State Click Below To Zoom In. Tabs At A Glance

Created: 10/02/10 at 19:41 UTC

Scroll Down & Select Tabular Forecast





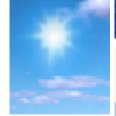
 **Your National Weather Service forecast** 

Cooperstown ND

Enter Your "City, ST" or zip code

NWS Grand Forks, ND [Mobile Weather Information](#) | [En Español](#)
Point Forecast: Cooperstown ND
47.44°N 98.13°W **Last Update:** 10:23 am CDT Oct 2, 2010
Forecast Valid: 3pm CDT Oct 2, 2010-6pm CDT Oct 8, 2010

Forecast at a Glance

This Afternoon	Tonight	Sunday	Sunday Night	Monday	Monday	Tuesday	Tuesday	Wednesday
								
Sunny Hi 57 °F	Mostly Clear Lo 38 °F	Breezy Hi 64 °F	Mostly Clear Lo 46 °F	Sunny Hi 67 °F				

Additional Forecasts & Information

- Zone Area Forecast for Griggs County, ND
- Forecast Discussion
- Printable Forecast
- Hourly Weather Graph
- Quick Forecast
- International System of Units
- Local Climatology
- Outlooks
- Storm Prediction Center
- Fire Weather
- NOAA Weather Radio
- Air Quality Forecasts
- Text Only Forecast
- Tabular Forecast
- About Point Forecasts
- Watches and Warnings
- Hazards Assessment
- AHPS / River Info
- Aviation
- Storm Ready
- Preparedness

Select



Using Weather Station Reports Are NEVER a Substitute for On-site Observations!

- Weather stations are miles away, even 70 to 80 miles
- Radio & television reports are time sensitive
- Wind is measured at 33 ft. for NOAA and 10 ft. for NDAWN (NDSU Stations). Wind speed at application height can be 20 to 25% slower
- Remote instrumentation can fail because of calibration or maintenance errors
- Labels are specifying on-site readings and state law often demands site of application data

Smoke hangs in the air
and does not dissipate or rise



Aerial applicators can apply oil to the engine manifold to generate smoke. Observation of the smoke cloud can indicate inversion conditions.

Need to observe local conditions



Environmental conditions making matters worse



- Topography—low lying area or a protected area shielded from the sun and / or wind.
- Stagnant and / or intense high pressure system
- Relatively low humidity conditions

Surface conditions making matters worse



- Exposed soil that:
 - Has a low moisture content
 - Is sandy or coarse textured
 - Has been freshly tilled
- Soil that is heavily mulched and/or covered with heavy crop residue
- Closed crop canopy and or complete vegetative ground cover
- Wind breaks and/or shelter belts