

5- WEATHER (WIND) & FIRE BEHAVIOR

INTRODUCTION

Students observe and journal temperature, humidity and wind and learn how these observations relate to fire behavior. Students will use a diagram to journal vertical atmospheric gradients (temperature/moisture) and horizontal air movements (high and low winds) observed outdoors. Students will use nature journaling prompts to discuss mixed sensory observations associated with a relative wind speed scale. A sketch will be added to a story zine that captures key weather observations.



No grounding exercise will be used in this lesson since the fire discussions and observations themselves are grounding. This lesson could be expanded or include homework that focuses on cloud identification and cloud painting and sketching techniques. Visit the UCAR Center for Science Education (UCAR SciEd) website for [resources and lesson plans on clouds](#). A recorded workshop by Rosann Hanson on nature [journaling clouds](#) is available on the Field Arts website.

LESSON OVERVIEW & ESTIMATED TIME (70 MINUTES)

- Teacher discusses field safety and session Intro **(5 minutes)**
- Teacher demos and facilitates vertical and horizontal weather observations using a diagram with words, numbers and pictures **(15 minutes)**
- Teacher demos and facilitates student journaling current winds using a relative scale and the multiple sense **(15 minutes)**
- Teacher discusses, demos and facilitates journaling key past and place-based wind observations in their journal **(25 minutes)**
- Teacher demos and facilitates students putting highlights from the above exercises on to their story zine **(10 minutes)**

MATERIALS & RESOURCES

- Journal or notebook
- Printed formatted story zine and a piece of tracing paper
- Graphite pencils, erasers, crayons or colored pencils. Watercolors are best for sky and cloud sketches but don't need to buy anything special for this exercise.
- Printed weather cue table and illustration of Vertical and Horizontal Sky Observations
- Weather forecast for the period of observations
- Ruler optional to help with making vertical and horizontal lines for the diagram

LOCATION

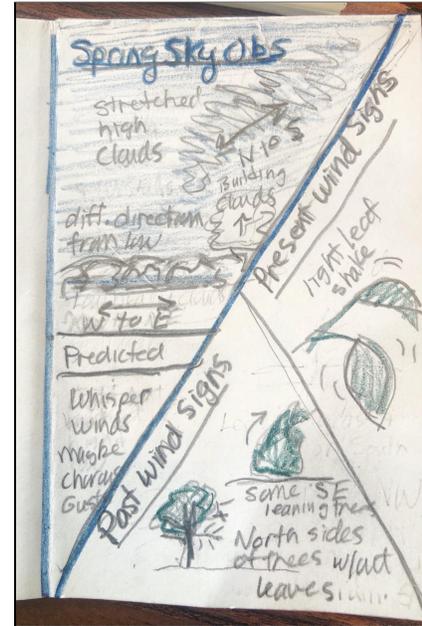
This exercise can be anywhere outdoors but should be far enough away from buildings and large barriers to allow for better sense of wind and other weather conditions.

BACKGROUND & NATURAL PHENOMENA INVESTIGATED

Weather phenomena are natural events and patterns that occur as a result of one or a combination of the water cycle, atmospheric pressure systems, and the Coriolis effect. The primary focus in this lesson is observing and sensing the phenomena of meteorological convection and the aggregate buoyant force or what is called static stability. In fire management, atmospheric instability is a primary situational awareness consideration along with increasing winds. This lesson emphasizes skills and observations intended to enhance the personal situational awareness of changing conditions that influence fire risk.

Other key weather elements influencing fire are temperature, humidity, wind and drought. These may be referenced but do not go into detailed explanation. Weather elements that may be referenced and observed in this lesson include:

- Wind (air and air pressure), Gusts and Gales
- Dust Whirls
- Clouds, Condensation Trails and Fog
- Thunderstorms and Lightning
- Thermals and Inversions
- Fire Weather (hot, dry, windy)



Our observed and experienced sense of weather and especially wind is strongly influenced by gravity and friction. Gravity is what holds the layers of atmosphere in place and friction opposes the direction of the wind and slows the speed.

SAFETY TALK & INTRODUCTION (5 minutes)

- Give safety talk appropriate to location and conditions. See guide introduction section with Safety Discussion overview.
 - When it's windy enough to rattle and wave large tree branches and small trees, you should avoid being near dead trees or being under trees where branches can fall.
- In this lesson, we are learning about the weather that can influence fire behavior and techniques to help us observe and journal seen and unseen elements of weather.

- We will also learn how to build our sensory observation skills to better identify weather conditions.

VERTICAL & HORIZONTAL WEATHER OBSERVATIONS EXERCISE (15 minutes)

Vertical & Horizontal Sky Observations

Thin high clouds
like stretched
cotton candy
in stretch
bending line
was this a
contrail?
some light
thin patchy clouds

Far distance
viewed at
angle hard
to tell if
middle or
low clouds

1/16 to no wind sensed at
ground/surface level

Ridgefield, WA
June 7
2021
M. Morrill

7:50 am

Temp.	50°F
Moist.	80%
Wind	NNW 3 MPH

WX station
sensed level
Surface wind

Vertical Gradients (Moisture/Temp)
Lower heavy clouds
building up - cooler
some low & middle lighter
clouds. - warming?
moisture in high clouds - cool

Horizontal Movements
Cirrus/high clouds
or contrails widely
stretched & pulled
clouds in high, mid & low
levels lined out
different - winds
different directions?

I wonder...
will the surface
winds pick up in
as low clouds build up
or when clouds
break up
some in
the later
afternoon?

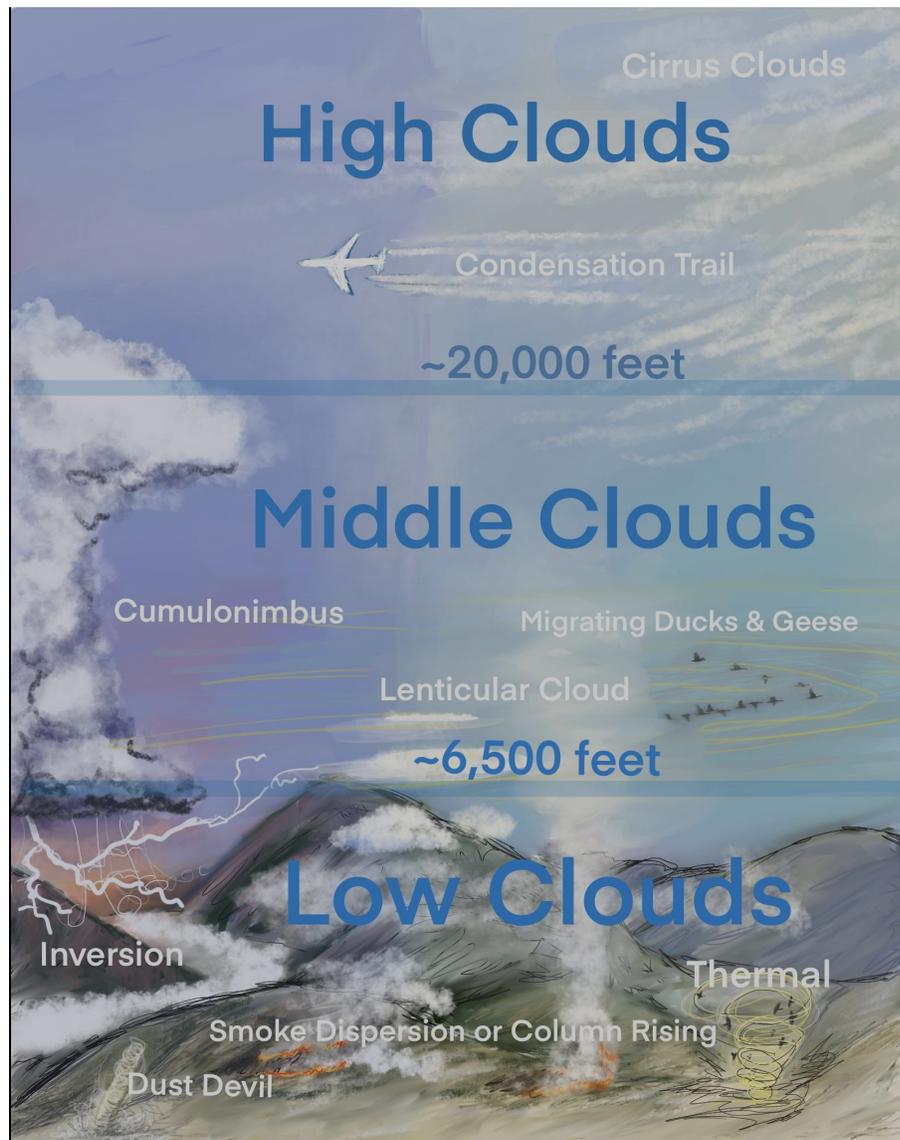
Afternoon & Evening forecast trends
warming gradual
partly cloudy → cloudy → partly cloudy

- Exercise Introduction:** We are starting our observations by looking up into the sky high in the atmosphere and down to the ground (vertical and horizontal). Our primary goal in this first exercise is to look for vertical temperature and moisture gradients and horizontal winds. There are three main levels or zones in the sky we'll be looking at (High, Middle and Low Cloud Zones). From a fire behavior perspective we want to know and observe:

Discussion: Is the atmosphere stable or unstable (static stability or aggregated buoyant force created by temperature gradients)? We can often observe whether the atmosphere is unstable when there are dark and bright blue skies. The lighter whiter and or smokier skies is considered more stable, like having a lid on a pot of water. This means that fire behavior is less intense when the skies are smokier and clear skies can create worse fire conditions.

- Is the air moist or dry? Clouds are a good indication of moisture in the air and using weather data for relative humidity is very helpful. The smaller the humidity number the drier it is. A 15% RH number is often a red flag fire condition.
- Is the air warm or cool?

- Are there light or strong winds that you can see and feel? You cannot always feel the wind. Some winds are moving at higher levels of the atmosphere and are easiest observed when clouds are pushed, pulled and stretched.
- There is a table below with clues to help you determine vertical and horizontal weather.



- To highlight observations at different levels, we will use a tall vertical line for height and horizontal line along the bottom to indicate time and/or to spread out the different weather observations. You could instead, create a box to add the observations, with the same height principle.

- Before starting the teacher demo, ask students if they know what the atmosphere is or other questions about terminology used.

Discussion: An atmosphere is a layer or set of layers of gases surrounding a planet and held in place by gravity. There are five layers of atmosphere around the earth based on different temperature zones. The earth's atmosphere is made up of oxygen, carbon dioxide, water vapor and several other gases.

- Let students know that any sketches in this lesson should be simple and quick. This is not about creating art but documenting observations which often need to happen quickly such as changing weather conditions.
 - Some quick drawing tips: Start with a light pencil sketch of the main shape of the element. Clouds can be challenging to draw, but the key for this exercise is to indicate whether the clouds are thin, flat, stretched, and broken or if they are fluffy and building upward. Are they an individual element or covering a broad area? You can use a simple outline for a cloud and light smeared pencil lines for a larger blanketed area. Use color sparingly and only to highlight key points. I used a sloppy blue colored pencil to help differentiate the sky from the clouds. The color of blue is not important.
 - Share with students the tips for differentiating high, middle and low cloud zones within the atmosphere along with the illustration.

Discussion:

High Cloud Zone- commercial airplanes and military jets cruise in the bottom portion of the high cloud zone. Clouds at the same level or higher than airplanes are likely in the high cloud zone.

Middle Cloud Zone- migrating ducks and geese often fly at the low end of the middle cloud zone. Clouds below the airplane zone and equal to or above migrating geese are in the middle zone.

Low Cloud Zone- Clouds below the other zones often appear closer, bigger and fluffier. Inversions are often in this zone based on the height of the mountains where it functions as a lid/cloud cover over a lower valley area.

- Draw the vertical and horizontal lines or a rectangle box in your journal and add lines with labels for high, middle and low cloud zones. Tell students they have 10 minutes for this exercise and have them follow along.
- Ask students what they see in the sky. Is the sky color bright blue or more white and grey? Can they see any clouds and can they differentiate how high. Demonstrate how to use words, numbers and pictures in the box in their journal describing what they observe. If they want to use an entire journal page, that is great too. Discussion: In most weather visualizations, the opacity (thickness) of white indicates how much water vapor is in the sky - places that look whiter in the visualization have high water vapor. You can use this technique when sketching

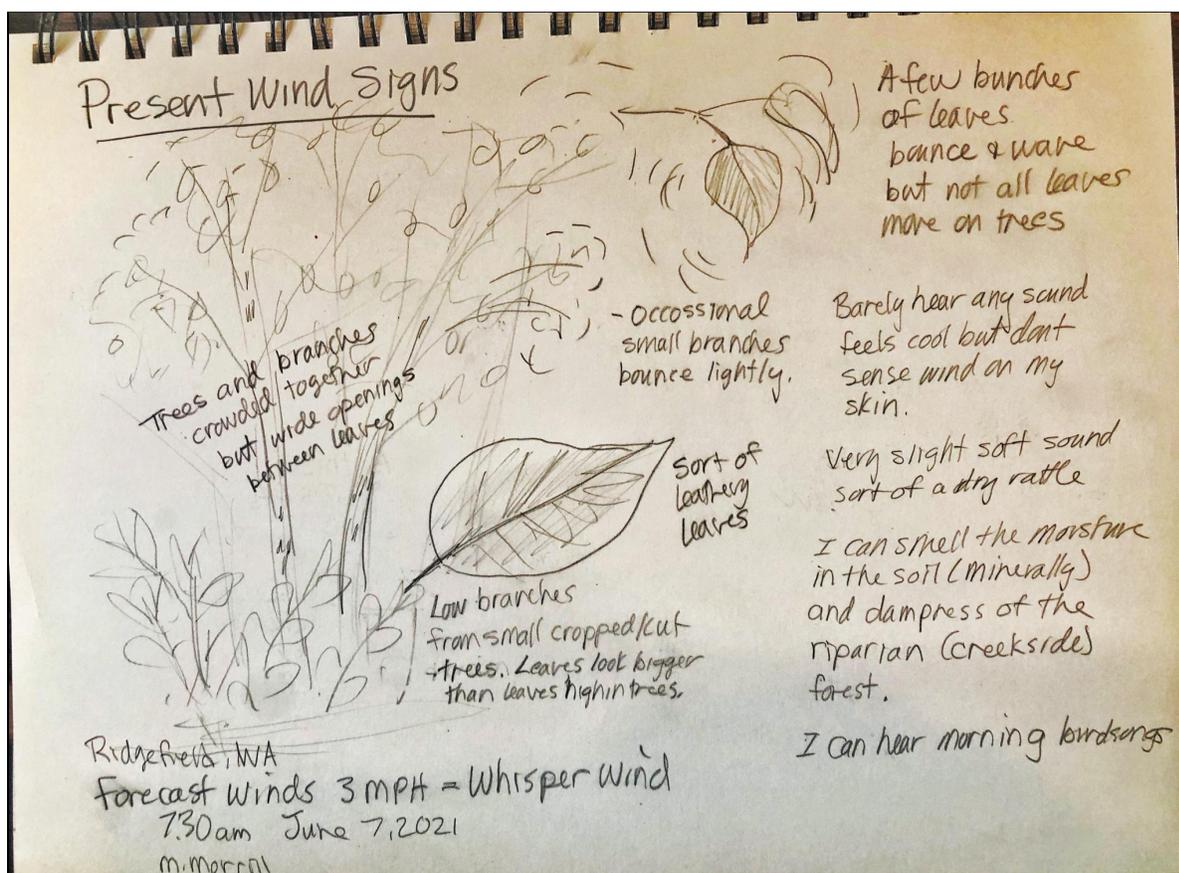
or painting your sky and clouds.

- As students work, take time to keep track of time, circulate and troubleshoot and engage in discussions. It should be okay to discuss and copy each other as long as they are doing their own work. Remind them that these are quick and simple sketches and for them to only use color if highlighting something important.
- A few minutes before ending the exercise, Say: “Take about two minutes to wrap up and add any final details to your comparison table.

Atmospheric Observations for Fire Behavior Situational Awareness		
Moisture & Temperature	Winds	Transitions & Instability
<p>Moist and Cool:</p> <ul style="list-style-type: none"> ● Cloud buildup (like biscuits rising in the oven) and cloud layers and fog ● Contrails observed and last longer in the sky ● Inversion development (looks like fog from higher in the mountains but like clouds from below in the valley.) ● Some people have headaches, allergies and joint pain when moist and cool. <p>Dry and Warm:</p> <ul style="list-style-type: none"> ● Absence of the above ● Relative humidity 15% or less ● Existing drought conditions ● Thermals (birds use to rise up in the air in a circular pattern) 	<ul style="list-style-type: none"> ● Cirrus (high level) and other clouds appear stretched and torn ● High, middle and low clouds moving in different directions. <i>NOTE:</i> Due to the influence of friction the high level winds have a 30 degree difference in direction from the felt wind at eye-level. ● Contrails pulled and stretched in direction of the wind ● Lenticular clouds (spaceship or disc shaped) and rolled and wave-like clouds over mountainous terrain features. ● Below the three cloud levels, at the ground, eye and or felt level, sustained winds of 10 MPH 	<ul style="list-style-type: none"> ● Low level cumulus clouds (cotton ball looking) build up throughout the day into large cumulonimbus thunder clouds which have a high risk of lightning and erratic and intense winds. ● Cold front passages which can bring Foehn winds (called North winds in northern California and come from NE in Butte County) ● Thermals and dust whirls indicating unstable air current from changes in temperature ● Morning inversions break up with warming and can cause erratic winds ● Smoke columns build and rise straight up into higher cloud levels instead of billowing out along a valley or hillside.

<ul style="list-style-type: none"> • Heat waves along flat surface like a road • Skin feels dry and lips chapped 	<p>or more and gusts of 25 MPH or more are typical fire weather or red flag conditions.</p> <ul style="list-style-type: none"> ○ See the next exercise for a relative sensed wind scale. 	<ul style="list-style-type: none"> • A 5 degree change in temperature.
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PRESENT WIND OBSERVATIONS EXERCISE (15 minutes)



Exercise Introduction: In this exercise, we are going to use our senses to observe eye-level or sensed winds and try to describe differences in wind speed using a simple relative scale based on the concept of the Beaufort Wind Force Scale.

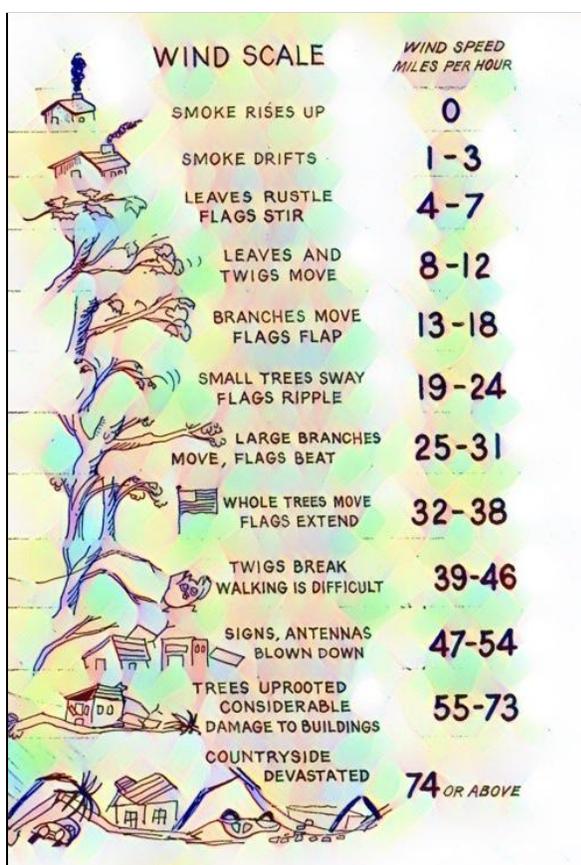
Discussion: The Beaufort Wind Force Scale originated in 1805 by the British Royal Navy to help provide consistent interpretation and guidance on sailing. This scale has been modified and used widely for land wind observations

including use in fire management. Use of a more relative wind scale reduces time spent measuring and interpreting exact wind speeds but is also very subjective.

- For this exercise, we are not going to focus on learning or observing each of the Beaufort wind scales but differentiating at more intuitive levels that are key to fire behavior.

Discussion: Depending on the specific location and terrain characteristics, like steep slopes, the critical wind levels can vary. In general, a 10 mile an hour wind is a threshold where fire behavior becomes more intense and often one of several red flag conditions. As the wind increases from that level the effect becomes more extreme. Students can rename the scale to something more meaningful but differentiate between less than and more than 10 miles per hour winds.

Beaufort Wind Force Scale Graphic Below (Not used in this exercise)



Relative Wind Scale:

- **Whisper Wind (less than 10 MPH)-** barely sensed breeze on the skin and sounds like a whisper from the leaves when close to trees with medium to large leaves.

- **Conversation or Chorus Wind (10-30 MPH)-** Start of fire weather conditions. Winds felt strongly on the skin and in hair, with the leaves of close and more distant trees and shrubs making rustling, rattling, slapping, scraping and scratching sounds like a crowd talking or choral group singing. The wind alone should have a sound caused by friction.

- Fire weather winds: Sustained 10 MPH winds or higher and wind gusts 25 MPH or more

- **Screaming Wind (30-72 MPH)-** Gale level winds makes it difficult to walk and whips large branches and trees back and forth, with some branches and trees

breaking and crashing to the ground. Very loud sounds from the wind that can sound like a rock concert or train coming. Hurricane winds are the next and highest wind level.

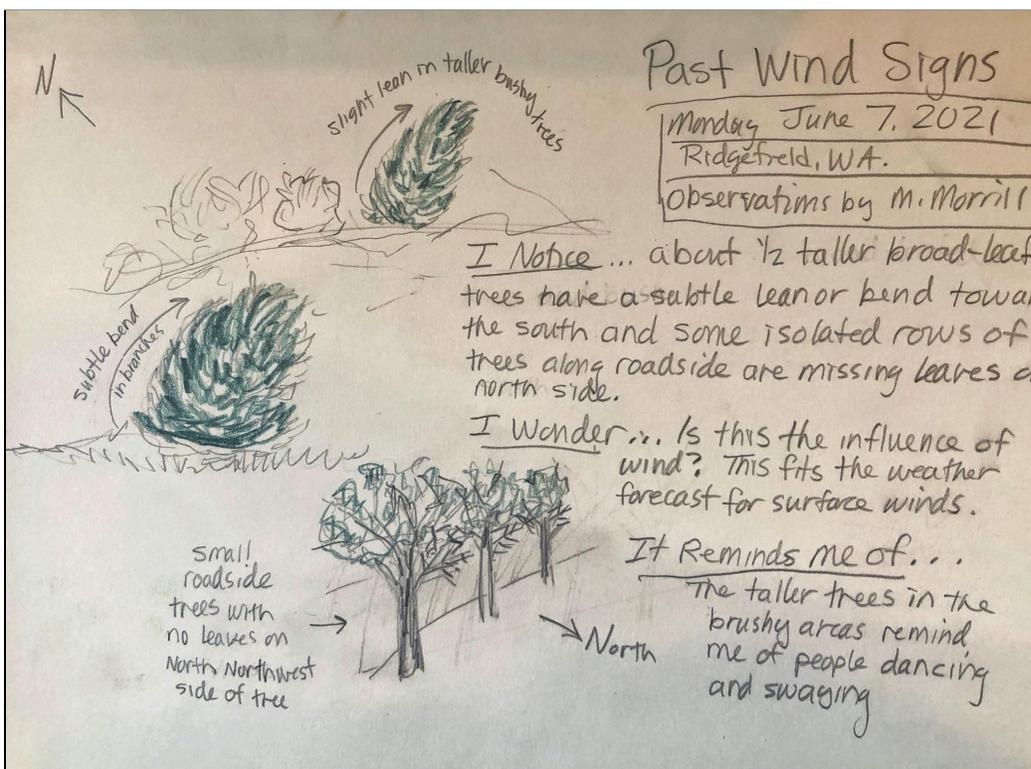
- Describe the relative wind scale we are using in this exercise (above) and that

we are only focusing on the difference between the Whisper Wind and the Chorus Wind since we would not be nature journaling outside if the winds are at the Screaming Wind level.



- Ask students to look and listen quietly for a few minutes. Ask them if they can see or hear or see any wind. If they can see some leaves moving but not hear, have everyone move closer to the trees or vegetation observing.
- Ask students to close their eyes and notice if they can smell, hear and feel the wind on their skin. Tell students they have around ten minutes to use words, numbers and pictures journaling observations about the felt or sensed wind and using the relative wind scale above.
 - If there is no wind, go to a low hanging branch or bush and rattle lightly to mimic a light Whisper Wind.
- After a few minutes, go to a low hanging branch or bush and rattle hard to mimic a more intense wind speed than currently experiencing. Have them describe their sensory observations again.
- After a few more minutes, ask students to write down the nature journaling prompts of 'I wonder' and 'It reminds me of' and then write questions and similarities of things they observed.
- A few minutes before ending the exercise, Say: "Take about two minutes to wrap up and add any final details to your comparison table."

PAST & PLACE-BASED WIND EXERCISE (25 minutes)



Exercise Introduction: In this exercise, we are going to look for signs of past wind and compare with current wind direction and speed. We are also going to use our Landscape Position Map from lesson #2, with tracing paper, and put arrows for potential terrain influenced winds. At the end of this exercise we will use all of our observations from today to make predictions of winds later today and put highlights on our story zine.

PAST WIND CLUES (15 minutes)

- Describe to students some of the past wind observations you might see.
Discussion: For instance, you can sometimes see the tops and or sides of trees sculpted or leaning away from the direction of frequent past winds. You might also see the windy side of trees with less leaves. There are other reasons that trees may lean or have different leaf distribution, so it's important to look for these signs on numerous trees and important to just ask the question, is this a wind clue, rather than assume with certainty that it is from wind. You can also see wind signs on the leeward side of trees and bushes, where the wind has less impact. For instance, you might see more grasses, mosses, plant debris and animal signs like rabbit poop, small mammal burrow openings and bird nests. Again, there are many other reasons for why things look the way they do, so you want to look for these signs in numerous places.
- Demonstrate and have students write as different heading areas in their journals the nature journaling prompts of 'I notice', 'I wonder' and 'It reminds me of'. Tell

them they have about six minutes to first add their observations under the I notice heading using words, numbers and or pictures.

- Ask students to look around for trees and shrubs in the open or on the edge of a forest where they may have more clues of past wind influences. This can be done as a group, in teams or independently.
- After six to ten minutes, tell the students to stop their observations and use two minutes to now add questions about those observations under the I wonder heading. After the two minutes, tell them they have another two minutes to think about what these observations remind them of and put those comments under the It reminds me heading.

PLACE-BASED WINDS (10 minutes)

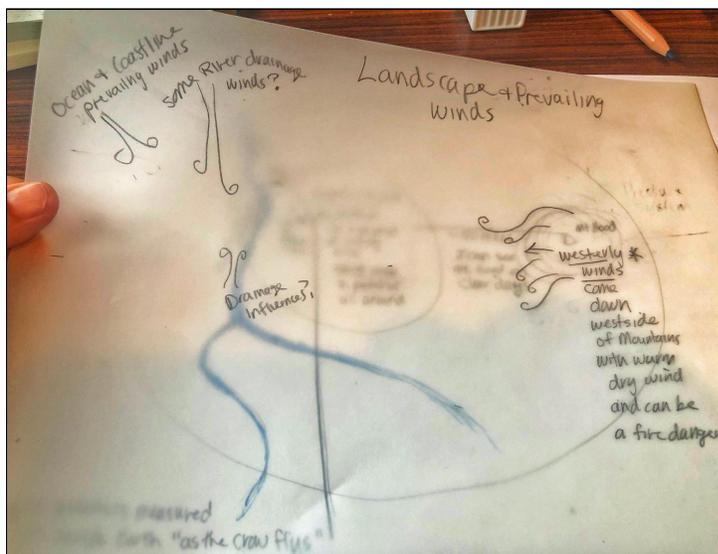
- Now that students have explored current and past wind observations, tell them we are now going to think about where those winds come from and move across the landscape.

Discussion: It is critical to know which direction the wind is coming from and if it is being funneled through landscape elements. *The journaling example below was not done in Butte County so do not use that as a wind reference by visual sketch example.*

- In northern California, the Foehn or North winds (winds pushed over mountains from a high pressure system) are typically warm and dry winds. In Butte County, we see these winds come from the northeast and funnel through areas like the Feather River Canyon. These are high fire risk winds and important to consider in fire awareness.
- Winds are also created and influenced by terrain and sunlight interactions. For instance, in a canyon, late morning and evening periods when the sunlight is moving over a steep slope, the temperature gradients cause winds to move upslope as it warms in the morning and downslope winds as it cools in the evening.
- The most common winds are the prevailing winds which are large landscape scale winds and in Butte County, these are the winds funneled from the coast and up through the mountain gaps in the Bay Area and valley. These come from the southwest.
- Have students take a piece of tracing paper or parchment paper and overlay it on the Position Map created in Lesson #2. If doing these lessons out of order, you'll need to create a simple map with geographic elements laid out in the north, south, east and west directions before starting this exercise. This could be done quickly by printing Google Earth or Google Maps with key landscape features within 50-100 miles of the observation location.
- Demonstrate to the students how to overlay the tracing paper to the map and have them discuss the three types of wind referenced above and where they

might experience on the landscape and on their Position Map. Tell students they have around five minutes to show wind moving over their landscape on the tracing paper. If they have trouble visualizing, you can show the example or demonstrate with arrows, symbols or other visuals like color gradients. Have them use words, numbers and pictures.

- A few minutes before ending the exercise, Say: "Take about two minutes to wrap up and add any final details to your comparison table."



Example place-based winds exercise using tracing paper over the lesson #2 Landscape Position Map (example not in Butte County)

STORY ZINE OBSERVATION SUMMARY EXERCISE (10 minutes)

- **Exercise Introduction:** In this exercise we are going to take the weather observation highlights from the previous weather observations and add them to page #5 on our story zine.
- Demonstrate to students how they can compartmentalize their story zine page to put at least one thing they observed about the sky, felt wind, past wind and place-based wind observations. Tell them they have about eight minutes to complete. This does not need to be artistic but should have at least a picture and some words for each of the observation categories.
- A few minutes before ending the exercise, Say: "Take about two minutes to wrap up and add any final details to your comparison table."

