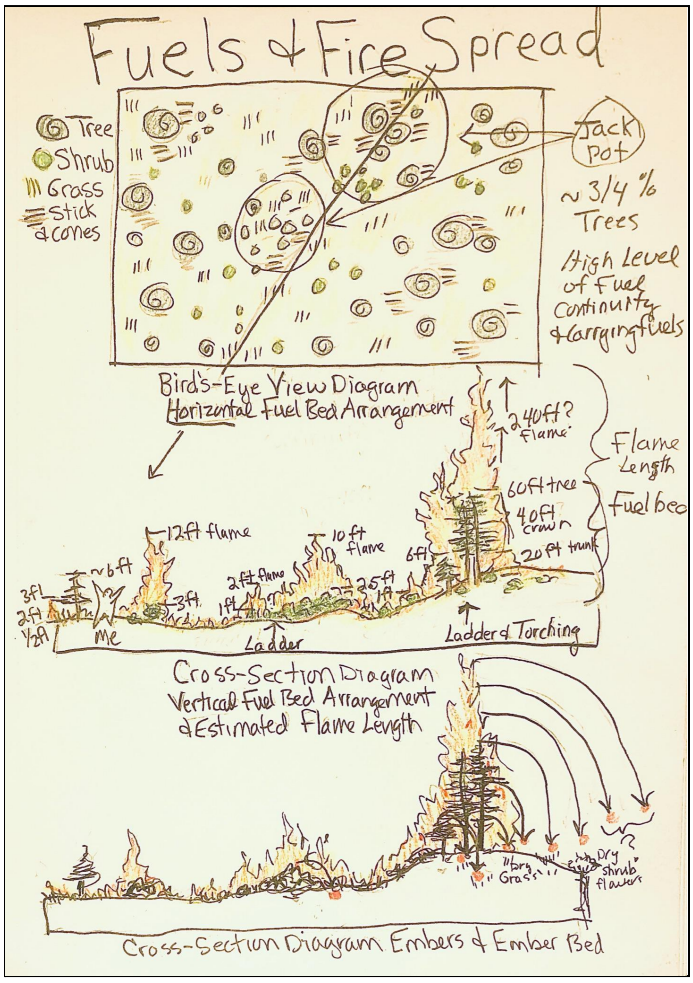
7- VEGETATION ARRANGEMENT & FIRE BEHAVIOR

INTRODUCTION



Students review key fire and fuels terminology and what that means for fire behavior and spread over the landscape. Students will assess horizontal fuels and surface fire types like creeping, backing, advancing by creating a bird's-eye view diagram and vertical fuels and transitional fire types like torching and embers with a cross-section diagram. Students will learn how to use symbolized human figures (star people) in journaling practices and apply biometrics (body measurements) and quick mathematical calculations to estimate fuel levels and potential flame lengths and fire types.

LESSON OVERVIEW & ESTIMATED TIME (60 MINUTES- Optional Extra Exercise 10 to 20 Minutes Added)

- Student lesson introduction and safety talk **(2 minutes)**
- Biometrics measurements and journaling people technique **(10 minutes)**
    - Optional extra exercise- pacing measurements exercise (10- 20 minutes)
- Overview of basic fuels terminology and horizontal fuels diagram exercise **(13 minutes)** which can be indoors or outdoors.
- Vertical fuels measurements and diagrams **(25 minutes)**
- Fuel and fire type data additions to diagrams **(10 minutes)**

MATERIALS & RESOURCES

- Journal or notebook

- Student story zine
- Cardstock or cardboard rectangle viewfinder (**can buy or create but necessary to create prior to the lesson**). Small rectangle opening with four marks along frame edges for halfway points and estimating percent area.
- Graphite pencil, eraser, and a few color supplies such as crayons colored pencils and or watercolors.
- Measuring tape (several, if possible)
- Optional ruler
- Printed Illustrations for lesson including fuel model journal page examples (end of lesson)

LOCATION

This lesson can be carried out anywhere with natural elements mixed in with human infrastructure (backyard, school field or local park) and or partially indoors. It is ideal to do the entire lesson outdoors in an area with mixed vegetation height elements such as trees, shrubs and grass.

BACKGROUND & NATURAL PHENOMENA INVESTIGATED

Most people have heard that our western forests are overcrowded and at risk to insect infestation and catastrophic wildfire, but the issue is far more complex to understand and relate to the local environment. One of the key aspects to understanding fire behavior on the landscape is fuels (vegetation and burnable materials). Fuel is one of three parts of the fire behavior triangle (topography, fuel, and weather). The term fuel feels very detached from the environment and relates fire as a machine or an engine using vegetation as the fuel to run. The fire environment is an interactive and living thing so in the content of nature journaling fire, it is recommended that the terms be learned to connect with traditional fire education and practitioner approaches but also how to connect the interactive and living environment. Fuels, plants and vegetation can be used interchangeably.

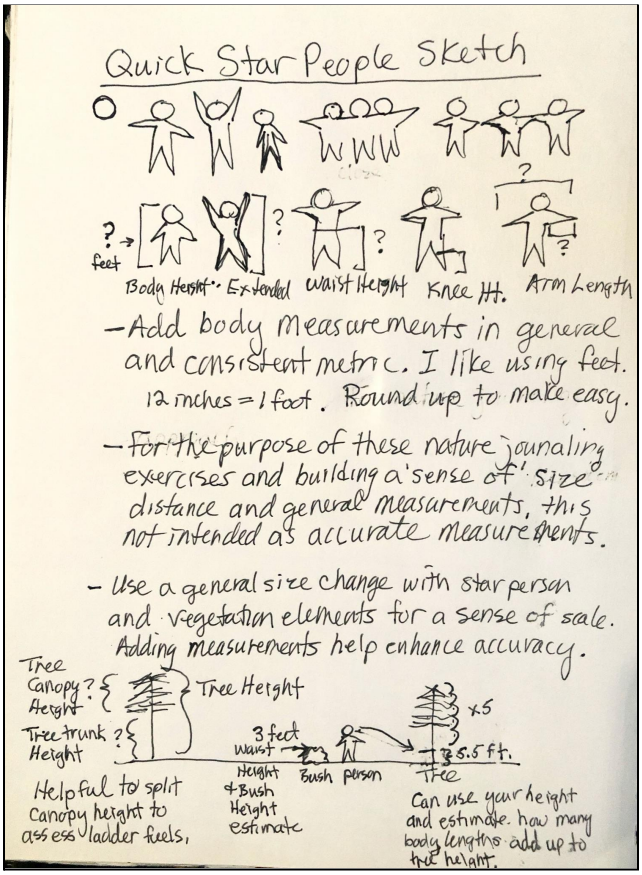
The previous lesson emphasized the relationship between plants (fuels) and moisture and how that influences fire ignition. Fire spread is closely tied to how vegetation is spread out and organized across the landscape. The primary focus in this lesson is understanding how vegetation arrangement influences fire behavior and how to observe and estimate those changing conditions on the landscape and estimate potential fire behavior. This information is key to understanding community and agency fire mitigation goals such as mechanical and prescribed fire treatments.

LESSON INTRODUCTION & SAFETY TALK FOR STUDENTS

This lesson is focused on assessing, estimating and diagraming vegetation conditions that influence fire behavior. This information is very important in understanding and supporting home defensible space and community fuel treatment projects. We may be walking in areas where you can trip or branches could fall from trees. Always have your eyes and ears open to these hazards.

BIOMETRICS JOURNALING (10 Minutes)

For the purposes of this guide, exact measurements are not strongly emphasized. They can be used if teachers and journalers want to integrate them, but the approaches provided are focused on building motor-sensory skills and a general sense of scale without added tools and equipment in the field.



- Let's start with a review, discussion and practice in creating star-people sketches in your journal. See the journal page insert example. It's surprising how our brains interpret very simple and sometimes sloppy shapes as people. These star people characters are used by professional sketchers and graphic facilitators to quickly integrate people into simple sketches. Once we indicate how tall our star people are in feet and inches, the star person can help us show the estimated height or width of vegetation and flames. We are using these measurements to estimate vegetation heights and estimate if flames can move from the surface of the ground into tree tops through what is known as ladder fuels.
    - A tip for using biometrics and comparison measurements in journaling is to sketch elements at a very generalized size scale and use measurement estimates to provide a bit more accuracy. For instance, you may measure a bush as waist height and sketch the star person next to a bush and on the same sketch have a much larger tree that is not proportionally

accurate in the sketch but the metrics help make the clarifications. See the example at the bottom of the sketch page inserted.

- Work with students and a measuring tape to add body measurements to their representative star people. Keep the same metric for all measurements and recommend using feet to relate better to tree height measurements.
    - foot to knee,
    - foot to waist
    - foot to head
    - foot to fingers with raised arms
    - Fingertip to fingertip with arms stretched outward from body at 90 degree angle

OPTIONAL EXTRA BIOMETRIC EXERCISE (10 to 20 minutes above 60 minutes lesson):

If the students are older or more advanced and an additional 10 to 20 minutes can be allocated to this lesson, consider integrating pace measurements to estimate distance between vegetation elements. This can be estimated, but is best when done in the field.

- A pace is equal to an adult's natural step which is about 30 inches long. The pace is determined by counting the number of steps it takes between two known measure points (everyone has different pace measurements). This is often counted as 100 meters. In western forestry practices, a pace is equal to two normal steps beginning with your dominant foot and is measured to 66 feet. Since most fire related metrics integrate forestry data, it's recommended to use the two-step pace to 66 feet.

- If this exercise is added, build the time into the first exercise for the horizontal fuels diagram.

HORIZONTAL FUELS DIAGRAM & FUELS ESTIMATES (13 Minutes)

This exercise can be done indoors using Google Earth and a projector with a bird's-eye view of the area where the follow up cross-section exercise will be conducted. This can be an easier way to visualize but learning to see and journal a landscape from an imagined bird's-eye view from ground level is a skill that takes development. You will need a nature journal and the story line. Use of a purchased or precut paper viewfinder is also recommended but time and supplies to create the viewfinder has not been integrated into the exercise. Create these before the lesson! Using fingers to frame the scene is also helpful if the viewfinder is not available.

- Gather students into a group (indoors or outdoors) and ask if they can define fuels.
  Discussion: Fuels are burnable materials and mostly focused on vegetation, although buildings and materials can also be included.

- Invite students to open their journals and write down their thoughts and comments from others on the discussion topics.

- Ask students how they would describe fuels to better relate to fire behavior.
  Discussion: Have they ever observed a fireplace or campfire and noticed what is important for starting a fire and what is important for a long-lasting and hotter fire. Small sized vegetation like dried grass, leaves, and twigs are needed for the fire to start, but larger woody materials are needed for fire to burn for longer periods. It's also important to think about the amount of fuels and how they are arranged and how that influences fire spread across a landscape.
    - A key term used in fuels and fire behavior is called "**carrying fuels**". This is the vegetation that most often spreads the fire across the surface of the land. Do you remember in the early lesson about terrain, how we used the speed of a tortoise and of a sea turtle to visualize the fire rate of spread?

    - There are topography, fuels, and weather scenarios that can intensify the fire rate of spread and cause the fire to move from the surface carrying fuels up into the treetops (**crown fire**) and where the crown fire can move with or differently from the main surface fire pattern. The carrying fuels are distributed along the surface of the ground and usually includes grasses, leaves, sticks and bushes but can also include fallen logs, fences and other materials touching the ground. Fire practitioners define these horizontal surfaces and carrying fuels as **light, heavy, uniform and patchy**.

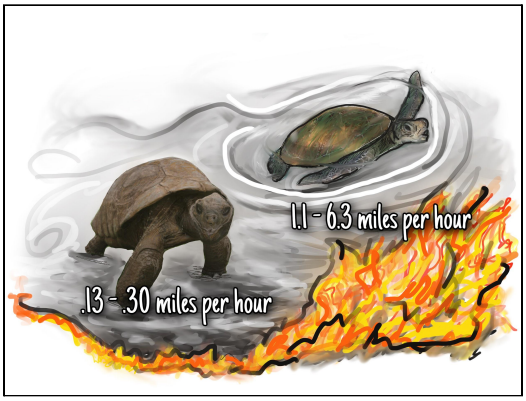


Figure 1—Light Fuels

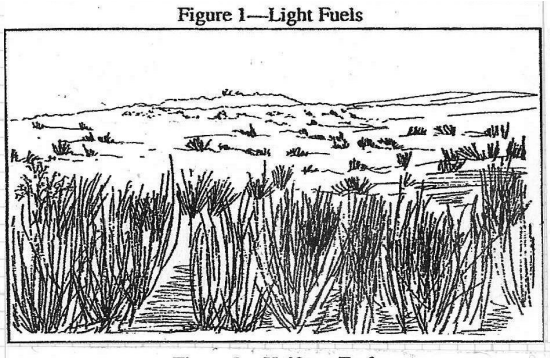


Figure 2—Heavy Fuels

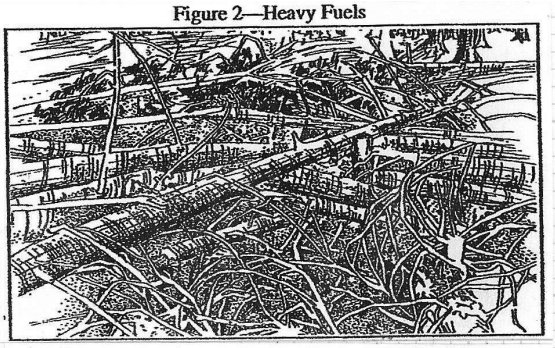


Figure 3—Uniform Fuels

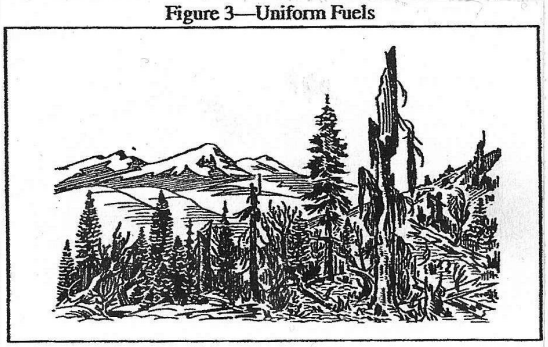
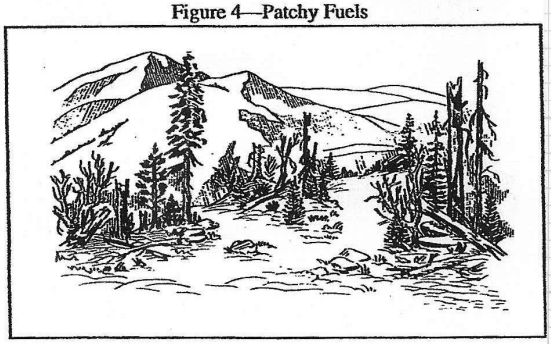


Figure 4—Patchy Fuels



- Discussion: Fire scientists and specialists have many ways to define fuels based on the different types of vegetation communities, concentrations and arrangements (fuel models) and how they will burn, but what is most important for basic nature journaling observations is to think about fuels within the basic vegetation types. There are several examples of fuel models at the end of the lesson:
    - **Agriculture**- different crops like corn, vineyards, etc.
    - **Grass** - mostly natural grass areas but could include lawns if defining whether it is watered or not. There may be occasional trees and shrubs but the area is dominated by grass.
    - **Shrubs/Chaparral**- small to large bushes covering dominating an area. There may be a few trees or grassy patches.
    - **Forest**- mostly trees of similar or different age groups. There can be grass and or shrubs in these areas but should be under trees or in smaller open areas.
- If not yet outdoors, head out to an area with the best mix of vegetation. Students can break out into different groups but it will be easier to demonstrate and discuss as a group.
- The journal visual will be created on the story zine but students are welcome to create an initial draft in their journal. It is a simple visual so should be easy to

create on the small story zine space.

- Put a small rectangle in the top 1/3 of the page/zine. To the left of the rectangle box on the page, discuss and create a legend with students using different symbols for the core vegetation types (grass, shrubs and trees) and other fuels as desired.

- Use the viewfinder or fingers to frame the scene to a reasonable size (can see all vegetation elements) that you will be estimating the vegetation types and arrangement within that space. Reassure students that this is just a general estimate so don't worry about capturing all vegetation or exactly where they are located.

- Quickly fill in the vegetation symbols within the box/diagram on the page that most closely estimates the location and arrangement of vegetation types.

- Ask students if they have questions and let them know how much time they have for the diagram (5 minutes).

- At about five minutes into the diagramming, discuss the area within the diagram where the most variety of vegetation elements are located and circle. Have them also label or put questions where they think concentrated pockets of vegetation are.

- Next, have students create a cross-section line across the diagram for the area with the most horizontal and vertical diversity, which will be used for the next exercise.

- Ask students to look at their diagram and discuss what percentage of the area is covered by trees, shrubs, and grass and to write, to the right of the diagram, what the primary fuels/vegetation type characterizes the area and what percent the dominant vegetation types sare. For instance, if trees cover 1/2 or more of the area, put 50% trees and forest dominant fuels.

VERTICAL FUELS & CROSS-SECTION DIAGRAM (25 Minutes)

In this exercise, students will use the cross-section line from the previous exercise to diagram in a new way and to walk along making a few key biometric measurements for a few different vegetation types along the line. The students are looking for areas with concentrated vegetation pockets (jackpots) and vertically connecting vegetation levels from the ground to the tree branches (ladder fuels). If splitting up the measurement

estimates between students, some can measure while shouting out the data for everyone to add to their diagram.

- In the middle and lower 1/3 of the journal or story zine page, put the same horizontal line that somewhat characterizes the shape of the land along the line. You will add the same vegetation elements on both lines but the middle line will be used for estimably ladder fuels, torching and crown fire spread, while the bottom will be used for adding ember materials and ember beds.
    - For the cross-section ground/surface line, if there is a small dip or a moderate hill, the line will estimate that shape. This can be discussed as a group and the teacher can demonstrate or students can all do on their own and then discuss how and why they shaped the line a certain way. It's not critical for the line to be accurate but a good practice to give a sense of space.

    - Emphasize adding vegetation elements along the line where you see potential ladder fuels and a fire might be carried from the surface into bushes and or trees (torching or crown fire) on both the middle and bottom cross-section lines.
        - Use different representational sketches for the vegetation elements than in the first horizontal fuels diagram. These vegetation sketches may be something like stick figure trees, blob bushes, and star people. A legend is not required for this diagram but can be added, if desired.

    - The teacher should demonstrate the first additions of vegetation elements added to the cross-section diagram and discuss how there should be some size differentiation between smaller and larger elements but that there is not enough space to create more accurate differences. The added measurement data will help clarify size differences.
        - For the first vegetation element sketch, add the start person somewhat proportional to the vegetation element. For instance a super tiny person near a tree or a larger star person next to a small bush at waist height.

- When the students come to the first potential ladder fuels, measure the height from the top of the lower vegetation (usefully a bush or small tree) to the bottom of the larger tree branches (bottom of the tree crown). These areas do not need to be touched because flame-lengths can be up to four times higher than the vegetation height so add the vegetation elements measurements and then the following exercise will add possible flame-lengths.
    - In the areas with ladder fuels, stop and look for vegetation elements that can become fire embers or fire brands and ember beds. On the bottom

diagram, add a dot in the bush or tree where there are some potential ember materials and create an arch to the ground to see if an ember bed is there. If there is an ember bed, create a circle at that place on the diagram.

- Fire embers/brands are usually small woody materials blown and carried on the wind like acorns, pine cones, thick leaves, small branches, etc.

- Ember beds are areas with small dry vegetation materials that can quickly ignite. These may be patches of dry grass, dry flowers on a bush, or the crooks and crannies of a tree or building. Depending on the height of the flames, smoke column and speed of winds, embers can be carried a 1/2 mile or more, but more frequently they will drop down directly below the tree or be blown a shorter arched distance. This shorter distance is what we are looking at in this exercise.

- When students come to the tallest tree, work as a group to estimate the height. This will be used to measure the area's overall fuel bed.

- Once the core of vertical vegetation elements have been added along the cross-section diagram with key measurements, stop and go to a comfortable area to work on the diagram and additional journaling exercise

FUEL BED, FIRE TYPES, FLAME LENGTH & EMBER CARRY (10 Minutes)

In this exercise, students will be adding fire elements to their diagrams. To reduce potential traumatic memories and emotions, move away from the actual landscape view of the area and assess responses to the exercise, which can be dropped if needed. Ideally, the simplified sketchy diagrams with simplified fire visualizations and information will be less traumatic. There is a full-sized illustration with key fuel and fire type visuals below.

- In the new and comfortable location for follow up journaling (could be indoors), pull out a few additional color marking materials like colored pencils and go back to the two vertical diagrams on the page to add more information.

- Review the Fuels and Fire Types Illustration below and definitions with students and consider how all of the fire types and behavior are influenced by vegetation conditions.
  Discussion: Fire specialists have defined several different 'fire types' that

differentiate the location and mode of fire movement and associated fire intensities. The primary fire types are:

- **Ground fire**- fire type that is located under the surface fuels and or soil. Ground fire is often in the pyrolysis phase of fire before flame combustion due to lack or limited oxygen.

- **Smoldering**- is a fire behavior that occurs when the fire is not moving and growing and is typically at the start and end phase of a fire/flame combustion, which can vary around the overall fire area based on various conditions like moisture and wind.

- **Creeping**- fire behavior that occurs on the ground and surface fuels that is expanding very slowly with light fire effects and typically less combustion (less of fuels burned).

- **Surface fire-** fire located along the top of the ground and exposed to the elements and can be influenced by weather, topography/terrain, and changing fuel conditions (moisture, arrangement, etc.).

- **Backing-** a surface fire behavior that is moving against the direction of the wind and without strong influences of weather and topography. This fire behavior is slower moving and has lighter fire intensity and effects. At the very start of a fire ignition, the fire often moves in a circular backing pattern until the influence of weather, topography and change in fuel occurs.

- **Advancing/Running**- a surface fire behavior that is moving in the direction of the wind and influenced strongly by weather and topography. This is a faster growing and faster paced fire behavior and can have more intense flames, but usually results in mixed severity effects.

- **Spot fire**- this is not necessarily a fire type but a new ignition from the main fire movement pattern which is caused by embers/fire brands. A spot fire can start to move under the various fire types or behaviors and move or merge into the main fire or move in a different direction and pattern.

- **Torching**- is still considered a surface fire behavior that is typically influenced by ladder fuels that carry the surface fire into a tree crown. It is part of the surface fire behavior because it is still moving within the primary surface fire.

- **Jackpot-** is a fuels scenario or condition where a concentration of vegetation materials burns at an increased fire intensity. The jackpot can

be a heavy load of fallen branches and logs, a thick bushy area or a concentrated pocket of trees. The increased fire intensity of a jackpot can cause a surface fire to move into the crown with torching or crown fire.

- **Crown fire**- is a fire that occurs in the tree crowns and can move independently of the surface fire. This fire type has more fire intensity, severity and adverse fire effects.

- **Smoke Column**- is not a fire type but the result of more severe fire combustion and an organized large concentration of smoke which can carry fire embers higher and farther away. Smoke columns can also be blown by winds and lean up steep slopes igniting an entire hillside.

- Ask if there are any questions related to the fire types and behavior.

- Create a mark at the right or left side of the middle diagram at the height of the tallest tree/vegetation and pull down to the ground and label it as the fuel bed. The fuel bed is the entire vegetation height in the area.

- Go back to the potential ladder fuel areas on the middle diagram and calculate what the flame length could be for the lowest vegetation first. A very generalized formula for determining flame length is that for every 1-foot of vegetation height, there will be a 4-foot flame-length. Does the flame length reach the lower branches of the taller bush or tree? If yes, create the outline shape of a flame behind the lower vegetation and the taller vegetation (tree) and add the potential flame lengths of those vegetation elements since there is a possibility the surface fire could be carried into the tree.

- Underneath the horizontal vegetation diagram line near the ladder fuels, add the label ladder fuel.

- Look at the ladder fuels and see if there is a single tree that could catch fire. If so, label that as torching. Do the ladder fuels connect to multiple trees that are close to each other and where fire could move from tree top to tree top? If yes, label that as crown fire.

- Look back at the top diagram for horizontal fuels and consider if there are continuous surface fuels? Add labels or notes to relate that observation.

- If desired, go back to the flame areas and embers and color in.

Fuels & Fire Types

Vegetation

Loading

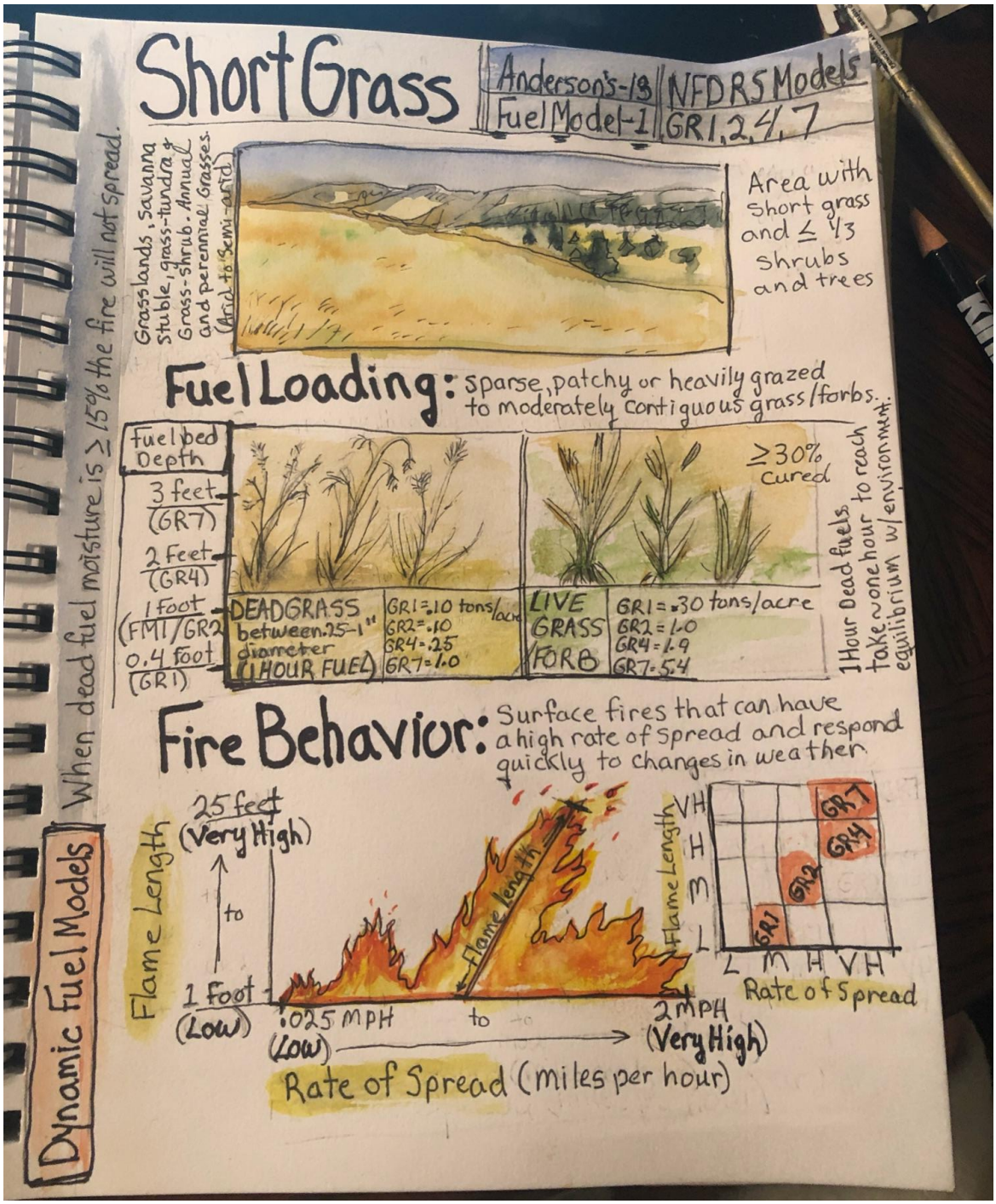
Location

Composition

Arrangement

Illustrations by Miriam Morrill @Pyrosketchology

OTHER FUELS AND FIRE SPREAD VISUAL REFERENCES- Not required for lesson



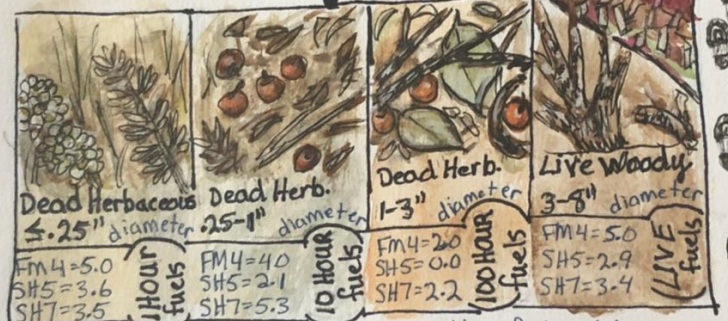
Chaparral

Anderson's-13 Fuel Model-4

Rothermel's SH5 & SH7

Fuel Loading:

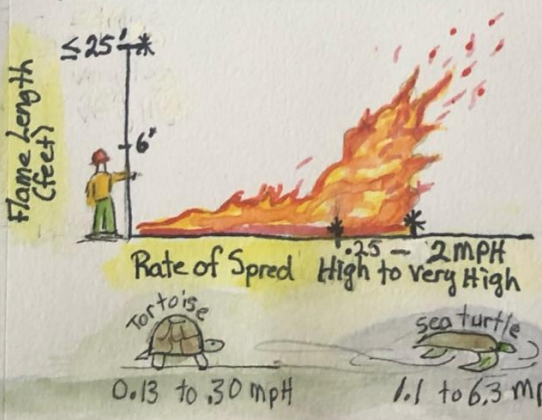
Primary carrier of fire is live and dead woody shrubs- foliage and litter. Heavy fuel loads in mature stands with shrubs six feet or taller.

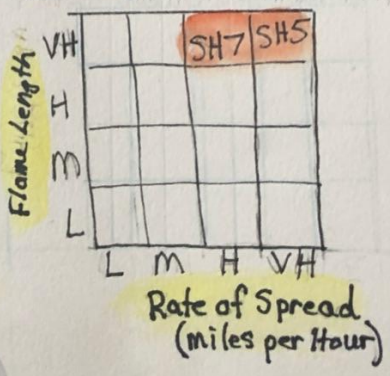


Herbaceous = mostly shrub leaves in this fuel model

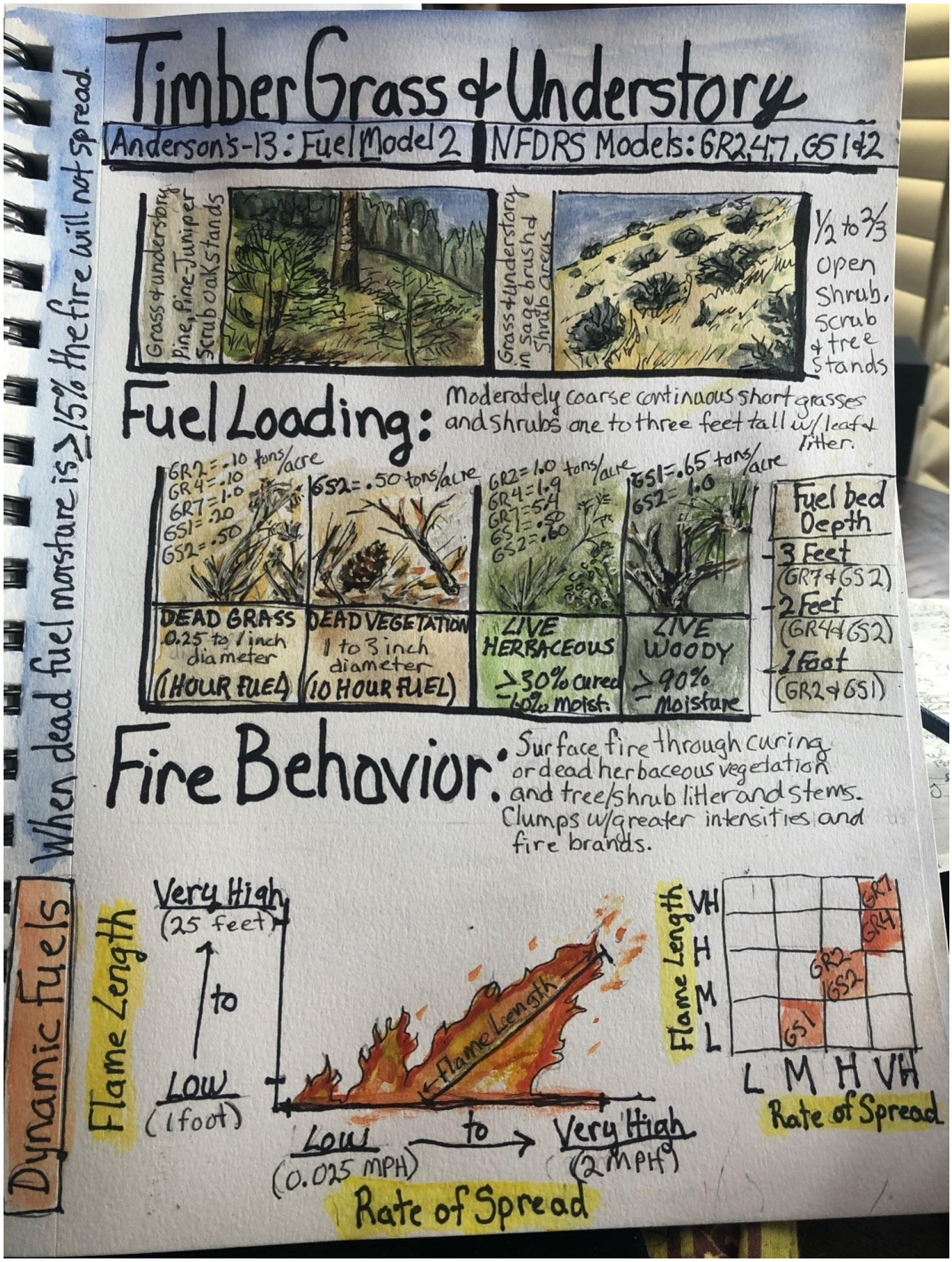
Fire Behavior:

fires intense and fast moving.
Deep litter may hamper suppression efforts.
Dry shrub flowers may increase ember ignition.





When the dead fuel moisture is @ 15% (SH5 + SH7) to 20% (FM4) the fire will not spread


Timber Grass & Understory
Anderson's-13: Fuel Model 2
NFDRS Models: GR2, 4, 7, GS1 & 2
Grass & understory Pine, Pine-Juniper Scrub oak stands
Grass & understory in sagebrush & Shrub areas
1/2 to 3/3 open Shrub, scrub & tree stands
Fuel Loading:
Moderately coarse continuous short grasses and shrubs one to three feet tall w/ leaf & litter.
GR2 = .10 tons/acre
GR4 = .10
GR7 = 1.0
GS1 = .20
GS2 = .50
GS2 = .50 tons/acre
GR2 = 1.0 tons/acre
GR4 = 1.9
GR7 = 5.4
GS1 = .50
GS2 = .60
GS1 = .65 tons/acre
GS2 = 1.0
DEAD GRASS
0.25 to 1 inch diameter
(1 HOUR FUEL)
DEAD VEGETATION
1 to 3 inch diameter
(10 HOUR FUEL)
LIVE HERBACEOUS
≥ 30% cured
= 60% moist.
LIVE WOODY
≥ 90% = Moisture
Fuel bed Depth
3 Feet
(GR7 + GS2)
2 Feet
(GR4 + GS2)
1 Foot
(GR2 + GS1)
Fire Behavior:
Surface fire through curing or dead herbaceous vegetation and tree/shrub litter and stems. Clumps w/ greater intensities and fire brands.
Dynamic Fuels
When dead fuel moisture is ≥ 15% the fire will not spread.
Flame Length
Very High
(25 feet)
to
Low
(1 foot)
Flame Length
Low
(0.025 MPH)
to
Very High
(2 MPH)
Rate of Spread
Flame Length
VH
H
M
L
GR7
GR4
GR2
GS2
GS1
L M H VH
Rate of Spread