WILDFIRE BEHAVIOR

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ABOUT ZB

- Lyons Code Compliance Official since April 2022
- Lyons Hazard Mitigation Program Coordinator February 2023
- Volunteer Firefighter – Four Mile Fire Department- Wildland, Structure, Hazmat Operations
- Former Police Officer – Mountain View (CA)
- Former Sheriff's Volunteer Team Member/Supervisor – Santa Barbara County

PURPOSE OF PRESENTATION

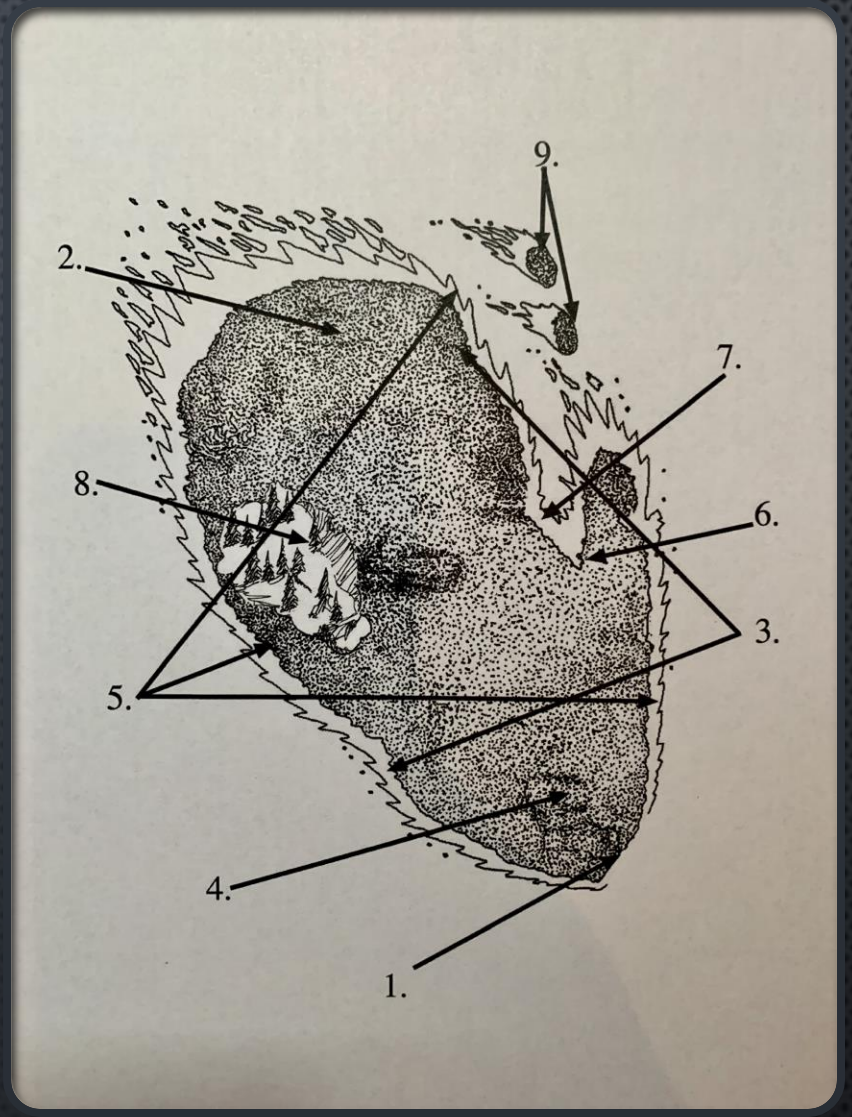
This presentation is designed to provide the basics of the wildland fire environment and fire behavior.

Wildfire is directly influenced by fuels, weather, and topography. However, this presentation mostly focuses on fuels.

BASIC CONCEPTS OF WILDLAND FIRE

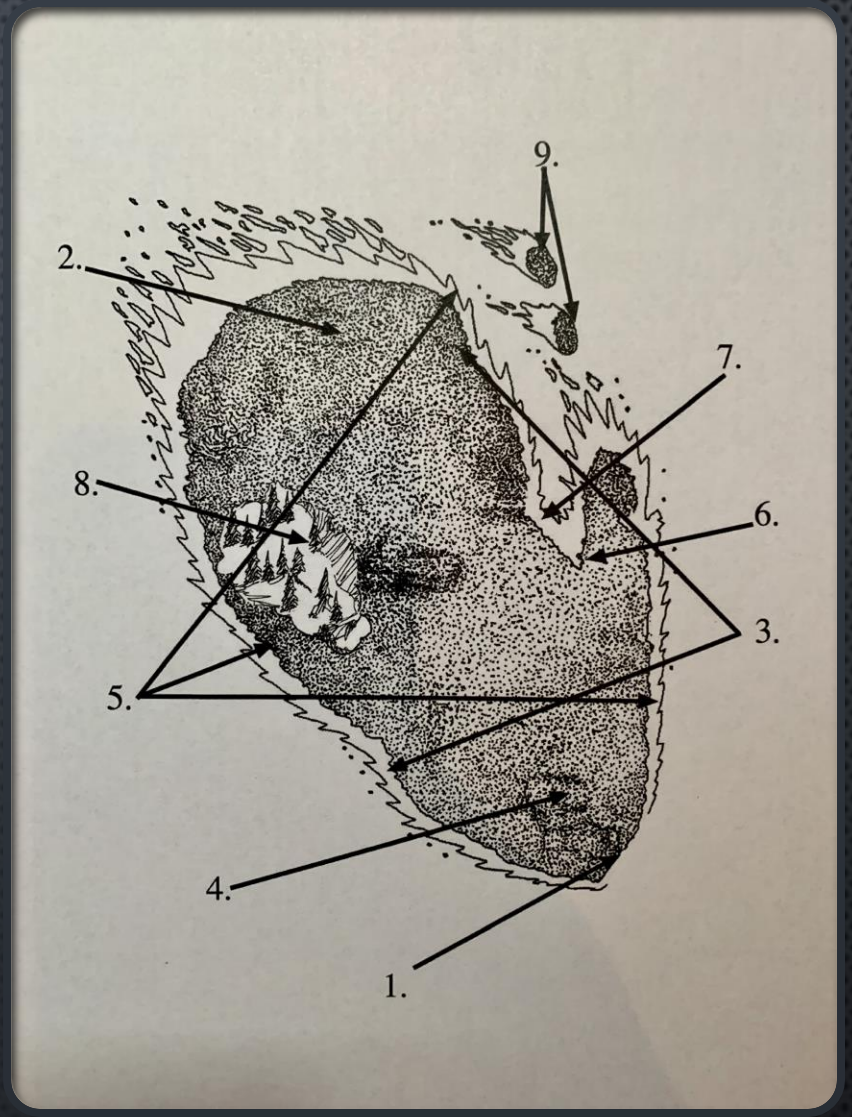
- **Basic Terminology:**

1. **Point of Origin**
2. **Head of fire**
3. **Flank of fire**
4. **Rear of fire (heel)**
5. **Fire Perimeter**
6. **Fingers of a fire**
7. **Pockets of a fire**
8. **Island**
9. **Spot fire**



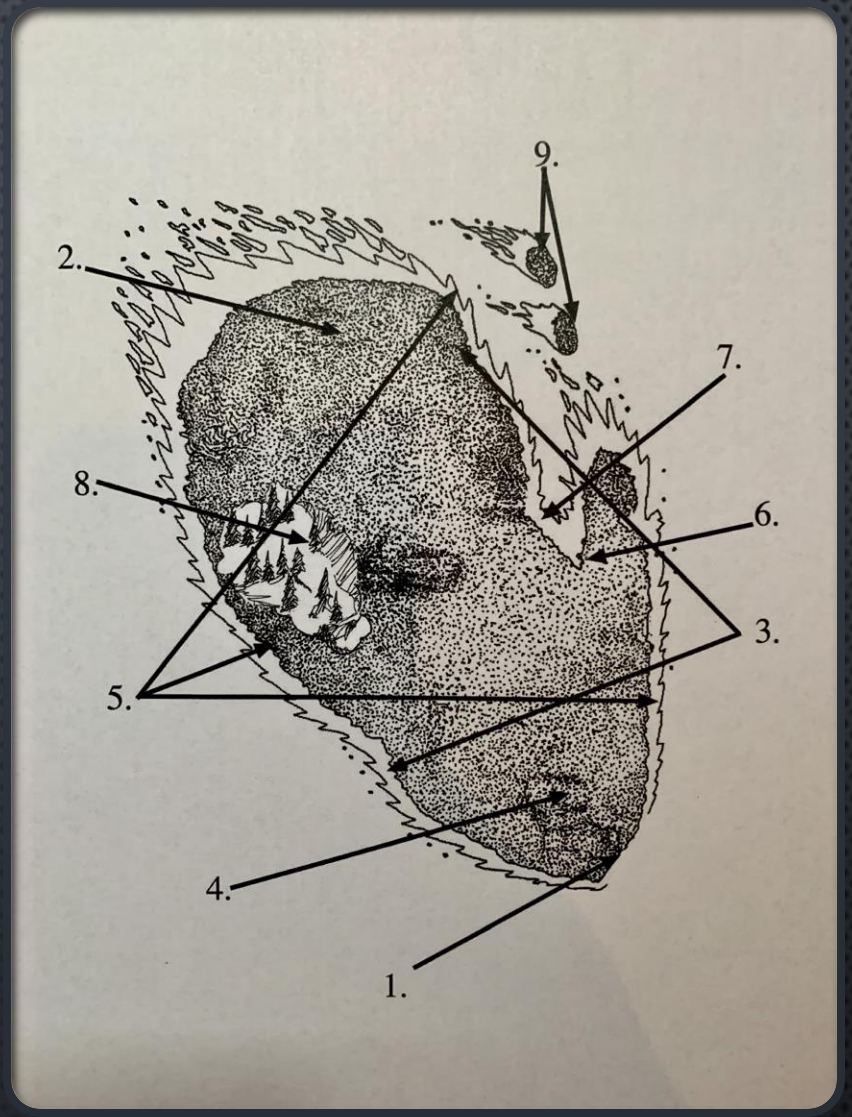
BASIC CONCEPTS OF WILDLAND FIRE

- Fire Behavior Terms:
  - Smoldering
  - Creeping fire
  - Running fire - video
  - Spotting
  - Torching - single tree, bottom up
  - Crown fire – Top to Top
  - Flare up
  - Firewhirl
  - Backing fire – heel fire
  - Flaming front - video



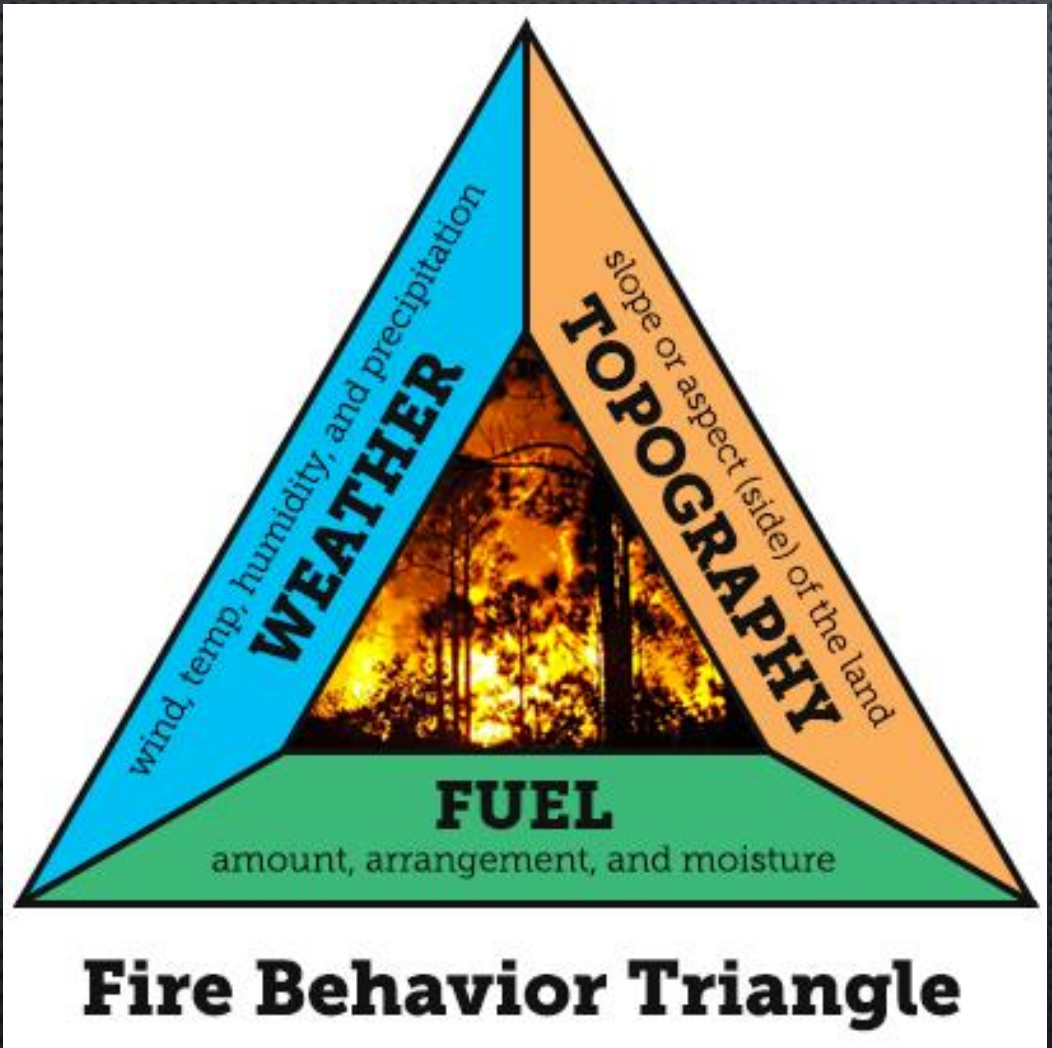
BASIC CONCEPTS OF WILDLAND FIRE

- Other useful terms:
  - Anchor point – point to start a fireline
  - Control line – barriers, edges, etc.
  - Fireline – scrape/dig line
  - Mop-up – removing material
  - Contained
  - Controlled
  - Chain (66 ft., 80 chains equal 1 mile, 10 square chains equal 1 acre)



ELEMENTS OF THE FIRE TRIANGLE

- THREE ELEMENTS MUST BE PRESENT AND COMBINED BEFORE COMBUSTION CAN OCCUR AND CONTINUE:
  - FUEL TO BURN
  - AIR TO SUPPLY OXYGEN TO THE FLAME
  - HEAT (TO START AND CONTINUE COMBUSTION PROCESS)
- REMOVE ANY SINGLE ONE AND THERE CAN BE NO FIRE.



ELEMENTS OF FIRE BEHAVIOR

- THREE COMPONENTS DICTATE FIRE BEHAVIOR

  - WEATHER (CURRENT + FORECASTED)
  - TOPOGRAPHY
  - FUEL

THREE METHODS OF HEAT TRANSFER

1. RADIATION (THERMAL): RAY OR WAVE. RADIANT HEAT WARMS YOU AS YOU STAND CLOSE TO A CAMPFIRE OR STAND IN SUNLIGHT

2. CONVECTION: SMOKE COLUMN ABOVE THE FIRE. OCCURS WHEN LIGHTER WARM AIR MOVES UPWARD. THE HOT GASES AND EMBERS WHICH COMPOSE THE SMOKE COLUMN CAN DRY AND IGNITE OTHER FUELS

3. CONDUCTION: SPOON IN A HOT DRINK. HEAT IS CONDUCTED FROM ONE PARTICLE TO ANOTHER VIA DIRECT CONTACT. SINCE WOOD IS A POOR CONDUCTOR, THIS PROCESS IS THE LEAST IMPORTANT

Topography: The configuration of the earth's surface including its relief and the position of its natural and man-made features

Aspect:

- Aspect is the direction a slope is facing (its exposure in relation to the sun)

- The aspect of a slope determines the amount of heating it gets from the sun; therefore, determines the amount, condition, and types of fuels present

- South and southwest slopes are normally more exposed to sunlight and generally have:
  - Lighter and sparser fuels
  - Higher temperatures
  - Lower humidity
  - Lower fuel moisture

  They are the most critical in terms of start and spread of wildland fires.

- North facing slopes have more shade which causes:
  - Heavier fuels
  - Lower temperatures
  - Higher humidity
  - Higher fuel moistures

  A north facing aspect will have less fire activity than a south facing slope

Topography: The configuration of the earth's surface including its relief and the position of its natural and man-made features

Slope:

- the amount or degree of incline of a hillside (a steep slope)

Fires burn more rapidly uphill than downhill. The steeper the slope, the faster the fire burns. This is because the fuels above the fires are brought into closer contact with the updward moving flames.

Convection and radiant heat help the fuel catch fire more easily.

Another concern about steep slopes is the possibility of burning material rolling down the hill and igniting fuel below the main fire.

The position of the fire in relation to the topography is a major factor in the resulting fire behavior.

A fire on ground level is primarily influenced by fuels and wind.

A fire which starts near the bottom of a slope during normal upslope daytime wind conditions will normally spread faster and has more area to spread upslope than a fire that starts near the top of a slope.

- The aspect of a slope determines the amount of heating it gets from the sun; therefore, determines the amount, condition, and types of fuels present

- North facing slopes have more shade which causes:
  - Heavier fuels
  - Lower temperatures
  - Higher humidity
  - Higher fuel moistures

TOPOGRAPHY: THE CONFIGURATION OF THE EARTH'S SURFACE INCLUDING ITS RELIEF AND THE POSITION OF ITS NATURAL AND MAN-MADE FEATURES

SHAPE OF THE COUNTRY - TERRAIN

- Certain topographic features can influence the wind speed and direction for small areas, independent of general weather conditions for an area.
- The shape of the country can also influence the direction of the fire spread, rate of spread, and the intensity

BOX CANYONS

- Fires starting near the base of box canyons and narrow canyons may react similar to a fire in a wood burning stove or fireplace
- Air will be drawn in from the canyon bottom creating very strong upslope drafts. These upslope drafts create rapid fire spread up the canyon, also referred to as the chimney affect. This affect can result in extreme fire behavior and can be very dangerous. (Only the Brave, Amazon)

TOPOGRAPHY: THE CONFIGURATION OF THE EARTH'S SURFACE INCLUDING ITS RELIEF AND THE POSITION OF ITS NATURAL AND MAN-MADE FEATURES

NARROW CANYONS

- Fire in a steep narrow canyon can easily spread to fuels on the opposite side by radiation and spotting. Wind eddies and strong upslope air movement may be expected at sharp bends in the canyon

WIDE CANYONS

- Prevailing wind direction can be altered by the direction of the canyon. Cross-canyon spotting of fires is not common except in high winds. Strong differences in fire behavior will occur on north and south aspects.

TOPOGRAPHY: THE CONFIGURATION OF THE EARTH'S SURFACE INCLUDING ITS RELIEF AND THE POSITION OF ITS NATURAL AND MAN-MADE FEATURES

RIDGES

- Fire burning along lateral ridges may change direction when they reach a point where the ridge drops off into a canyon. This change of direction is caused by the flow of air in the canyon

SADDLE

- Wind blowing through a saddle or pass in a mountain range can increase in speed as it passes through the constricted area and spreads out on the downwind side with possibly eddy action

TOPOGRAPHY: THE CONFIGURATION OF THE EARTH'S SURFACE INCLUDING ITS RELIEF AND THE POSITION OF ITS NATURAL AND MAN-MADE FEATURES

ELEVATION

- The height of the terrain above mean sea level, usually expressed in feet (ASL – Above Sea Level)
- Elevation plays a large role in determining the conditions and amount of fuel
- Because of higher temperatures, fuels at lower elevations dry out earlier in the year than those at higher elevations
- In extremely high elevations there may be no fuel
- Elevation affects fire behavior in several other ways like the amount of precipitation received, wind exposure, and its relationship to the surrounding terrain

TOPOGRAPHY: THE CONFIGURATION OF THE EARTH'S SURFACE INCLUDING ITS RELIEF AND THE POSITION OF ITS NATURAL AND MAN-MADE FEATURES

BARRIERS

- Any obstruction to the spread of fire, typically an area or strip lacking any flammable fuel
- Barriers to fire include many things, both natural and man-made.

1. Natural Barriers: rivers, lakes, rockslides
   - Fuels which have a high moisture content do not burn as well as others in the same area

2. Man-made barriers: roads, highways, reservoirs, fireline constructed by fire resources

FUEL: ANY BURNABLE MATERIAL

- Wildland fuels are basically live and/or dead plant material
- Houses, sheds, etc., can also be fuels
- Fuels are the source of energy that drives the fire.
- Regardless of the area of the country, fire behavior is dependent on certain fuel characteristics:
  - Fuel Type
  - Fuel Loading
  - Fuel Availability

FUEL TYPES

WILDLAND FUELS ARE GROUPED INTO FUEL TYPES BASED ON THE PRIMARY FUEL THAT CARRIES THE FIRE. THERE ARE 6 MAJOR FUEL TYPES

- GRASS
- GRASS – SHRUB
- SHRUB
- TIMBER – UNDERSTORY
- TIMBER LITTER
- SLASH – BLOWDOWN

•FUELS VARY IN TYPE FROM ONE AREA OF THE COUNTRY TO ANOTHER AND WITHIN THE SAME AREA.

•DIFFERENCES IN THE AMOUNT OF WATER IN THE SOIL IS ONE REASON THAT TYPES OF FUELS VARY, AND ELEVATION CHANGES IS ANOTHER.

- Grass: Burns hottest and fastest
- Grass – Shrub: Plains and high deserts, significant contributor to fire spread due to fine fuels mixed with aerial/shrub fuel
- Shrub: Found throughout most areas, some highly flammable shrub fuels are Palmetto (southeast), Sagebrush (Great Basin), Chaparral (southwest, CA)
- Timber – Understory: Found throughout most area, provides ladder to aerial crown fuels
- Timber litter: Most dominant in mountain topography/Northwest, provides fuel for ground fire
- Slash – Blowdown: Debris left after natural events or human activities:
  - Activities: Logging, road building, pruning, thinning, shrub cutting, wind, fire, snow
  - Debris may include logs, chunks of wood, bark, branches, stumps, broken trees, shrubs
  - Provides fuel for fire spread

FUEL LOADING

•Fuel Loading: The amount of fuel present expressed quantitatively in terms of weight of fuel per unit area (tons per acre).

- This may be available fuel (consumable fuel) or total fuel and is usually dry weight
- The loading of the fuels in any given area does not necessarily mean the fire will burn with great intensity
- What is more important is the quantity of fuels available for combustion

FUEL AVAILIBILITY

Many factors are involved when talking about the availability of a fuel for combustion

- Fuel size classes and shape
  - The physical characteristics of fuels, divided into four categories on the basis of their size:
    - 1-hour fuels: 0-¼ inch in diameter
    - 10-hour fuels: ¼-1 inch in diameter
    - 100-hour fuels: 1-3 inches in diameter
    - 1000-hour fuels: 3-8 inches in diameter

FUEL AVAILIBILITY

MANY FACTORS ARE INVOLVED WHEN TALKING ABOUT THE AVAILABILITY OF A FUEL FOR COMBUSTION

•2. SURFACE ARE TO VOLUME RATIO

- RELATES TO THE AMOUNT OF THE OUTER SURFACE OF THE FUEL THAT IS EXPOSED TO THE AIR
- THE MORE SURFACE EXPOSED, THE MORE EASILY THE FUEL WILL DRY AND BURN
- SMALLER (FINE) FUELS HAVE A HIGHER SURFACE AREA TO VOLUME RATIO THAN LARGER (HEAVY) FUELS

•AN EXAMPLE OF SURFACE-AREA-TO-VOLUME RATIO IS THE PROCESS OF BUILDING A CAMPFIRE:

- START WITH SMALL FUELS (SUCH AS DRY GRASS, PINE NEEDLES AND SMALL TWIGS), THEN ADD LARGER FUELS (LARGER TWIGS AND STICKS), AND FINALLY ADD THE LARGEST FUEL – THE LOGS.

- THE SMALLER FUELS (GRASS, NEEDLES, ETC.) HAVE A LARGER SURFACE AREA TO VOLUME RATIO THAN THE LOGS, AND THEREFORE IGNITE MORE READILY THAN THE LOGS.

FUEL ARRANGEMENT

- Fuel Arrangement: The manner in which fuels are spread over a certain area.
- Horizontal continuity – affects fire's rate of spread
  - Uniform fuels
    - Include all fuels distributed continuously over the area
      - Areas containing a network of fuels which connect with each other to provide a continuous path for a fire to spread are included in this category
  - Patchy fuels
    - Include all fuels distributed unevenly over the area, or areas of fuel with definite breaks or barriers present
      - Examples:
        - Patches of rock outcroppings
        - Bare ground
        - Areas where another dominant type of fuel is much less flammable

FUEL ARRANGEMENT

•Fuel Arrangement: The manner in which fuels are spread over a certain area.

- Vertical arrangements
  - Ground fuels
    - All combustible materials lying beneath the surface:
      - Deep duff
      - Tree roots
      - Rotten buried logs
      - Other organic material

•Ground fire consumes the organic and combustible materials beneath the surface, such as smoldering duff or peat fire.

Fuel Arrangement

- Fuel Arrangement: The manner in which fuels are spread over a certain area.
- Vertical arrangement (continued):

  2. Surface fuels – All combustible materials lying on or immediately above the ground:

    - Needles or leaves
    - Duff
    - Grass
    - Small dead wood
    - Downed logs
    - Stumps
    - Large limbs
    - Low shrubs

  - Surface fire burns surface litter, debris, small shrubs, and other vegetation

FUEL ARRANGEMENT

•Fuel Arrangement: The manner in which fuels are spread over a certain area.

- Vertical arrangement (continued):

3. Ladder fuels – Combustible materials that aid the spread of fire from the surface to the upper canopy

- Ladder fuels can include surface litter, shrubs, and other moderate height vegetation that provides a pathway from the surface to the canopy

FUEL ARRANGEMENT

•Fuel Arrangement: The manner in which fuels are spread over a certain area.

- Vertical arrangement (continued):

4. Aerial fuels – All green and dead materials located in the upper canopy:
   - Tree branches and crowns
   - Snags (standing dead or dying tree)
   - Hanging moss
   - Tall shrubs

•Crown fire burns through the tops of trees and shrubs and can advance in conjunction with or be independent of the surface fire.

FUEL ARRANGEMENT

•Fuel Moisture: The amount of water in a fuel, expressed as a percentage of the oven-dry weight of that fuel.

- Fuel moisture is expressed as a percent of total weight
- How well a fuel will ignite and burn is dependent, mostly, on it's moisture content
- Dry fuels will ignite and burn much more easily than the same fuels when they are wet (You don't use wet wood for a campfire!)
- Before a wet fuel can burn, the moisture it contains must evaporate (This process requires more heat. As fuel moisture increases, the amount of heat required to ignite and burn that fuel also increases).
- Because of the various sizes and characteristics, different fuels in the same area will have various moisture levels
- Likewise a similar type of fuel, across a broad area, will have different moisture levels based on the amount of precipitation received and period of warm, dry weather

- Remember, light (small) fuels take on and lose moisture faster than heavier (larger) fuels

FUEL ARRANGEMENT

- **Wet Fuels – Fuels that have a high moisture content because of the exposure to precipitation or high relative humidity.**

- **Dry Fuels – Fuels that have low moisture content because of prolonged exposure to sunshine, dry winds, drought, or low relative humidity**

FUEL ARRANGEMENT

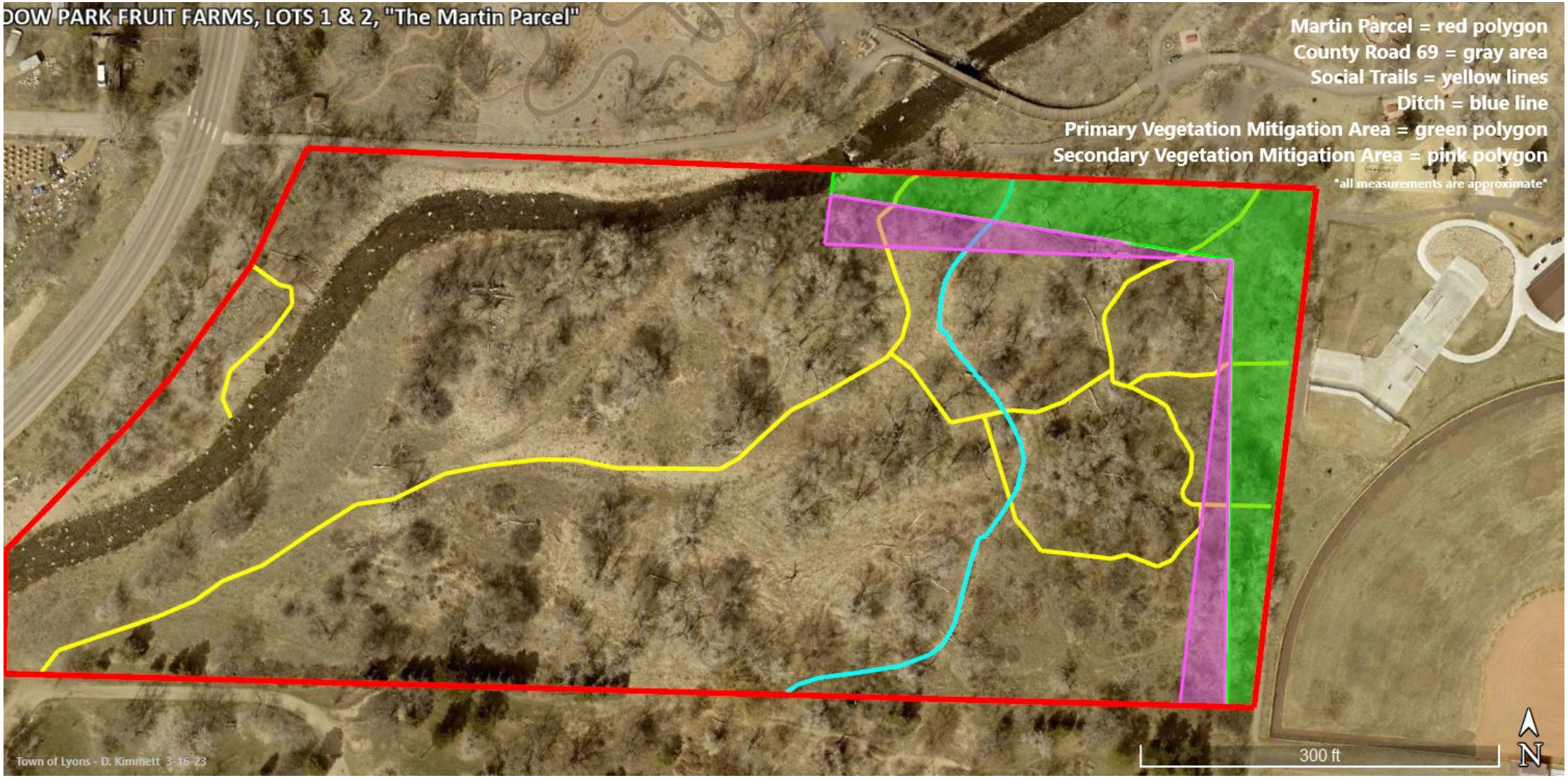
•Timelag – The rate at which dead fuel gains or loses moisture

- Time needed under specified conditions for a fuel particle to lose about 63 percent of the difference between its initial moisture content and its equilibrium moisture content.
- If conditions remain unchanged, a fuel will reach 95 percent of its equilibrium moisture content after four timelag periods.
- Firefighters use a concept of "Timelag" to identify the different sizes of dead fuels as they relate to increasing moisture or drying-out over time
- One-hour timelag fuels react to changes in relative humidity much faster than 100-hour timelag fuels
- The timelag categories are:
  - 1-hour, 0-¼ inch in diameter
  - 10-hour, ¼-1 inch in diameter
  - 100-hour, 1-3 inches in diameter
  - 1000-hour, 3-8 inches in diameter

BOULDER COUNTY: THE 80/20/20 RULE

80+ DEGREE TEMPERATURES
20+ MPH WINDS
RH OF LESS THAN 20%

= PRIME WILDFIRE CONDITIONS


DOW PARK FRUIT FARMS, LOTS 1 & 2, "The Martin Parcel"
Martin Parcel = red polygon
County Road 69 = gray area
Social Trails = yellow lines
Ditch = blue line
Primary Vegetation Mitigation Area = green polygon
Secondary Vegetation Mitigation Area = pink polygon
all measurements are approximate
Town of Lyons - D. Kimmett 3-16-23
300 ft
N

THANK YOU

ZACK BERTGES

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