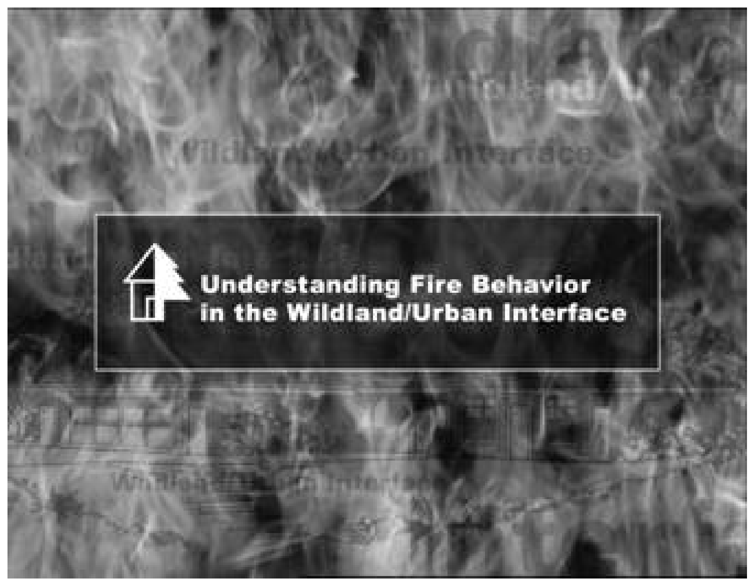
F I R E F I G H T E R   S A F E T Y   S E R I E S

FIRE BEHAVIOR

IN THE WILDLAND/URBAN INTERFACE



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An instructional presentation to accompany the video series from the National Wildland/Urban Interface Fire Program

For use with the Fire Behavior Instructor Guide

Video 1

Overview of the fire behavior video

Methods of heat transfer

Fuel types

Weather effects

Topography

Fire spotting

Extreme fire behavior

Structural vs. wildland fire operations

- Different FF agencies have different missions in the interface
  - Wildland firefighters
    - Protect natural resources
    - Often work from perimeter & clear fuel
  - Structural firefighters
    - Protect homes and other structures
    - Usually have water supplies
- All need training to be aware of fire behavior effects

Discussion:

At large wildland/urban interface fires, many different agencies must learn to work together efficiently and safely. How can interagency cooperation be improved?

Methods of heat transfer

- Heat transfer defined:
  - Movement of heat from one location to another often involving more than 1 object
  - Heat naturally moves from a warmer area to a cooler area
- Radiation
  - Heat is transferred from one object to the second object through the air
  - Without direct contact of the objects
  - Allows fuels to be preheated for ignition

Discussion:

The Second Law of Thermodynamics says that heat normally moves from a warmer area to a cooler area.

Relate this to heat transfer methods at a wildland fire.

Methods of heat transfer

- Convection
  - Heat transfers when it flows in a current, as from a hotter area to a cooler area
  - Or: heat moving up a chimney
  - On slope, effect is to preheat fuels ahead of the heat current
- Conduction
  - Transfer through from direct contact of two solids or within a solid object

Discussion:

How are convection heating and fire spotting related?

What is another factor that contributes to fire spotting?

Fuel types and effects

- Fine fuels
  - – Any fuel with a diameter of less than 1/4 inch
  - – Easy to ignite; burns rapidly
    - But also burns out quickly
    - Generally easy to extinguish
  - – Serves as kindling for heavy fuels
  - – Examples: grasses, dead leaves, pine needles, and dead twigs

Discussion:

What methods of heat transfer are occurring when fine fuels are burning rapidly?

Will fine fuels be as “easy to extinguish” during drought conditions?

Fuel types and effects

- Coarse fuels
  - Thicker mass of fuel than fine fuels
  - Slow to ignite
    - Thicker diameters can absorb more heat
  - When heated, subject to intense and long-lasting burning
  - Examples:
    - Tree trunks, limbs, stumps, logs, large fallen branches

Discussion:

Why does conductive heating have more impact on burning coarse fuels than does thermal radiation heating?

Fuel types and effects

- Fuel loading
  - Quantity of fuels in a given area available for combustion
  - Consider both fine and coarse fuels
  - Consider composition and arrangement
  - Consider moisture content
  - Loading range for a fuel can be low, medium, or high

Discussion:

Do you know which local, state, or federal agencies have calculated fuel loading for your local areas?

How can you use this information?

Fuel arrangements and effects

- Horizontal continuity
  - Continuous fuels
    - Fuels that are in contact with each other
    - Evenly distributed
    - Provides a continuous path for spread
  - Patchy fuels
    - Have gaps with no fuels
    - Include bare ground, rock outcroppings
    - Specific fuels much more resistant to fire ignition and spread

Discussion:

What is the advantage, related to fuel arrangement, of creating a defensible space around a home?

Vertical fuel arrangement

Definition: Distribution of fuels in a vertical dimension from bottom to top

- Ground fuels
  - Includes all combustible material beneath surface
    - Examples: roots, rotten buried logs, deep duff, other organic material
  - Slow to ignite
  - But can hide below surface and be hard to extinguish

Discussion:

Why is thermal radiation heating insignificant in ground fuel fires?

Can you describe a local incident where ground fuels were involved?

Vertical fuel arrangement

- Surface fuels
  - All materials resting on the ground or immediately above
    - Examples: pine needles and leaves, grass, and downed woody materials
  - Easy to ignite
  - Usually limited volume
    - Which can limit rate of fire spread

Discussion:

What different heat transfer methods are likely at work with a fire in surface fuels?

Does the indication of “limited volume” generally apply in your local area?

Vertical fuel arrangement

- Aerial fuels
  - Includes all vegetation above ground in the forest canopy
    - Green or dead
  - Extends to the height of the forest
  - Volume of fuel can be great
  - Allows ready access to oxygen
  - Crown fires can spread rapidly

Discussion:

What weather effect has an especially strong impact on burning aerial fuels?

Ladder fuels

- Combustible material on or near the ground that will carry fire to the crown of the tree
  - Operates in a step-by-step manner
  - Light fuels on the surface are easy to ignite and spread fast
  - Burning grass ignites low bush
  - Burning bush ignites lower limbs and leaves
  - Burning lower limbs ignite crown

Discussion:

How do all three heat transfer methods affect a fire in ladder fuels?

Weather effects: Temperature

- Increasing heat combines with other effects to increase fire danger
  - Fuels become preheated by the sun
  - Physical firefighting operations become more difficult
  - Convection currents more active
  - Heat contributes to drying of fuels

Discussion:

How does increasing heat contribute to more active convection currents?

Weather effects: Precipitation

- Precipitation affects fuel moisture
  - Depends on type (rain vs. snow)
  - Depends on amount and duration
    - Large amount of precipitation for a short time has less effect than lower amount over a longer time
    - Heavy fuels slow to absorb water
  - Local fuel moisture conditions
    - Local drought conditions increase fire danger

Discussion:

Why is fuel moisture more important than total precipitation when thinking about interface fires?

Weather effects: Humidity

- Relative humidity
  - Ratio of amount of moisture in air (vapor) compared to amount the air could hold at same temperature and pressure if it were saturated
    - Low relative humidity
      - Moisture moves out of fuels into the air
    - High relative humidity
      - Moisture moves from air into fuels

Discussion:

How is relative humidity affected by the time of day?

Weather effects: Wind

- More wind = faster fire spread
  - Increases fuel preheating for ignition
  - Contributes to drying of fuel
  - Provides oxygen for burning
  - Influences direction of fire
  - Extends fire spotting

Discussion:

Using the Beaufort Scale of Wind, determine what is the wind speed of today.

Weather effects: Wind

- Time-of-day effects on wind
  - Day time: up-slope winds
    - Sun warms the ground
    - Lighter warm air rises
    - Rising air follows any slopes upward
  - Night time: down-slope winds
    - After sun sets, ground cools
    - Night air cools and becomes heavier
    - Heavier air flows downward

Discussion:

Describe some conditions that can offset or overcome the normal time-of-day effects of wind moving up-slope or down-slope.

Fire weather: Cold front

Definition: The line between a cooler air mass as it moves against and replaces a warmer air mass

- Dangerous effects
  - Abrupt change in wind direction
    - Strong southerly wind ahead of front can drive fire rapidly to N or NE
    - Shifting to W or NW after front passes
  - Rapid drop in humidity within 24 hours after front passes

Discussion:

What sources of information are available to keep you informed about local fire weather conditions?

Fire weather: Foehn winds

Definition: Dry winds with a strong downward movement

- Dangerous effects
  - Are warmer than the season
  - They reduce relative humidity
  - Are strong and steady
    - Frequently 40 to 60 mph
    - Can last for days
  - Examples: Chinook, Santa Ana

Discussion:

Is your local area subject to Foehn winds?

If so, what are they called?

Describe how they can affect fire behavior.

Effects of topography

- Topography
  - Refers to the land's surface features
  - Not changing as is wind or weather
  - Can be better predicted
- Barriers
  - Natural or man-made
  - Can slow or stop the spread of fire
    - Examples: rivers, lakes, rock outcroppings, bare ground, roads

Discussion:

Describe the significant topography features in your local area.

Effects of topography: Slope

- The angle of incline on a hillside
  - Steeper slope = faster burning
  - Upper fuels become preheated
    - By radiant and convection heating
  - Remember time-of-day wind effects
- Aspect: Direction slope faces
    - S and SW slopes = higher temps, lower humidity, lower fuel moisture
    - N aspects more shaded = more fuels, higher humidity and fuel moistures

Discussion:

Why do slopes with southern and southwestern aspects tend to have lower fuel moistures than northern and northwestern aspects?

Effects of topography: Shape

- Shape can influence fire behavior
  - Box canyons are ravines that extend to ridge top
    - They keep heat and fires confined
    - Fire can move rapidly upslope
  - Narrow canyons = risk of spotting
- Unusual fire behavior at ridges
  - Air flow causes whirling
  - Remember night down-slope winds

Discussion:

How does the shape of a box canyon contribute to a chimney effect related to smoke and heat from an interface fire?

Do you have box canyons in your local area?

Fire spotting

- Defined
  - When numerous burning embers break away from flaming fuel and are carried by wind and convection currents ahead of the fire to start additional fires on landing
- Multiple ignitions
  - The multiple flying embers can start more new ignitions than firefighters can extinguish
  - New ignitions can rapidly spread

Discussion:

Discuss several factors that can affect fire spotting, including wind speed and direction, topography, fuel moisture conditions, fuel types, fuel loading, and structures downwind of the main fire.

Extreme fire behavior

- Problem fire behavior:
  - Any fire behavior that in some way presents potential hazard to firefighters
- Extreme fire behavior:
  - Rapid fire spread, intense burning, fire spotting, crowning, fire whirls, strong convention column
  - Has greatest potential to put firefighters at risk

Discussion:

Is there a system in place to communicate the development or possible development of extreme fire behavior in the local area?

Extreme fire behavior: Fuel

- Fuel indicators to watch for:
  - Unusally dry fuels
  - Great quantities of continuous fine fuels
  - Fuels exposed to direct sunlight
  - Coarse and live fuels dried by long drought
  - Ladder fuels present to allow surface fire move into crowns
  - Crown foliage dried by surface fire over a large area

Discussion:

Identify the local fuel factors that could contribute to developing extreme fire behavior.

Extreme fire behavior: Weather

- Weather indicators to watch for:
  - Strong wind
  - Sudden changes in wind speed and direction from passing front
  - High clouds moving fast, watch for surface winds to follow
  - Unexpected calm; may indicate wind shift
  - Thunderstorms = downdraft winds
  - High temps early in the morning
  - Dust devils, whirlwinds developing
  - Bent smoke column

Discussion:

Discuss several ways that these weather indicators can affect an interface fire and place firefighters in greater danger.

Extreme fire behavior: Topography

- Topography indicators to watch for:
  - Steep slopes
  - Chutes, saddles, box canyons allow chimney effects
  - Narrow canyons allow spotting

Discussion:

Identify which topography indicators at left are present in your local area.