SECTION 7 - FUELS, FIRE BEHAVIOR, AND TACTICS BY GEOGRAPHIC AREAS OF THE UNITED STATES

The purpose of this section is to identify by geographic areas of the United States:

- important fuel, topographic, and fire weather conditions that produce critical fire behavior situations.
- appropriate safety, strategies, and tactics for fire suppression.

The following geographic areas are covered:

NORTHWEST AND NORTHERN ROCKY MOUNTAINS

I. NORTHWEST

The Northwest area includes the Coast and Cascade Mountain Ranges of Western Washington and Oregon, and Del Norte and Humboldt counties of Northern California.

A. Topography.

Water, volcanic, and glacial events in this area have created a great variety of land forms ranging from coastal dunes to rolling hills and steep, highly dissected hillsides.

The major geological features are the Coast and Cascade Mountain Ranges. The Coast Range includes lower elevation mountains close to the coastline. The Cascade Range runs parallel to the Pacific coastline about 100 miles inland.

Other important land features are the Willamette Valley, Puget Trough and the Columbia Gorge which is a water gap through the Cascade Range. One active volcano, Mount St. Helens, is located on the Gifford Pinchot National Forest.

Unstable, or potentially unstable soils are extensive on all forested lands west of the Cascades.

Elevations range from sea level to 12,000 feet.

B. Climate.

Because of the maritime influence, coastal areas are comparatively warm throughout the winter. Rainfall is mostly concentrated in the winter months. Summer rainfall is usually very light.

Annual rainfall varies from 60 to 150 inches along the coast. The valley systems to the east of the Coast Ranges receive 30 to 50 inches in Washington and Oregon, and 15 to 20 inches in northern California.

The combination of high rainfall and moderate temperatures results in a buildup of extremely heavy fuel volumes. The maritime influence, particularly along the immediate coast, usually holds the fire danger to moderate levels during most seasons.

However, some summers are very dry and warm with high fire danger. During these periods, fires are characterized by high intensities. firewhirls, and long-distance spotting.

The fire season usually runs from June through September. Lightning fires increase in number and severity from the coast inland.

C. Fire Weather.

In northern California and in western Oregon and Washington, strong dry north to east winds may produce extreme fire danger in late summer and early fall. Two major weather patterns produce this critical fire weather.

1. One is a cold front passage followed by a Pacific high pressure system extending inland over the coast. The northeasterly winds blowing downslope produce a warning and drying foehn wind effect.

2. The second occurs when higher pressure develops east of the Cascades at the time lower pressure lies along the coast. The resulting dry easterly winds will cause high fire danger west of the Cascades. Northeast wind not only keeps the marine air offshore, but also results in adiabatic warming as the air flows from higher elevations down to sea level.

Critical Fire Weather - East Wind.

East wind in fire control means an exceptionally dry wind from an easterly quadrant that may blow continuously for 24 to 48 hours or longer. East wind often reaches maximum strength during night and early morning hours. Surface wind of 60 mph is not uncommon. It is accompanied by relative humidities that remain extremely low around the clock with relief only at night in some of the deeper ravines.

East wind frequencies over northwest Oregon and southwest Washington vary by month, and the pattern of monthly variation differs with elevation. September bears the greatest impact of easterly winds as they affect wildland fire control.

D. Major Fuel Types and Fire Behavior.

1. Douglas-fir/Hardwood

   Natural fuel loading 3 to 33 tons/acre
   Average duff depth 2 inches
   Spread rate 2 to 10 chains/hour
   Flame length 2 to 7 feet
   Resistance to suppression 2 chains/person hour

2. Douglas-fir/hemlock

   Natural fuel loading 14 to 330 tons/acre
   Average duff depth 4 inches
   Spread rate 1 to 17 chains/hour
   Flame length 1 to 13 feet
   Resistance to suppression 1 chain/person hour

3. Subalpine Fir

   Natural fuel loading 3 to 36 tons/acre
   Average duff depth 6 inches
   Spread rate 1 to 6 chains/hour
   Flame length 1 to 6 feet
   Resistance to suppression 1.5 chains/person hour

4. Mixed Conifer

   Natural fuel loading 7 to 56 tons/acre
   Average duff depth 2 inches
   Spread rate 1 to 7 chains/hour
   Flame length 2 to 7 feet
   Resistance to suppression 1.5 chains/person hour

5. Spruce-Cedar

6. Oak-Madrone

7. Activity Fuels

   Douglas-fir/Hardwood - Clear-cut 50 to 250 tons/acre
   Douglas-fir/Hemlock - Partial cut 10 to 100 tons/acre
   Douglas-fu/Hemlock - Precommercial thinning 1 to 10 tons/acre

E. Strategy and Tactics.

Direct attack is used on most small fires and spot fires that are a result of a large fire caused by east wind conditions. Fires influenced by the east winds have numerous spots and a fingered fire edge.

Parallel attack is the method most commonly used on medium and large size fires. The average wildland fire bums intensely because fuel types and dense smoke prohibit direct attack. The key to success is anchor points and a well timed burnout.

Indirect attack is not commonly used unless needed to stop the spread of crown fire.

1. Tactical Considerations.

Dozers. In heavy fuels, such as in the Douglas-fir type or in lodgepole, larger bulldozers are particularly effective. Very little advanced clearing is necessary except bucking large logs. It is sometimes advantageous to work two heavy units in tandem so the forward movement is continuous. The first dozer pushes over standing material and the second pushes the debris aside and builds a wide fireline to mineral soil.

Snag Falling. In heavy snag areas, especially in Douglas-fir, a special safety problem is encountered. Many of these snags contain rotten wood and are prone to shedding bark in long sheets, with tops and limbs breaking off. These hazards are compounded when the snag is burning. As a result, local professional fallers should be hired and assigned a local falling boss who knows the local snag policy. Snags are a sensitive issue in the northwest. Most land management agencies have a protection policy.

Helitorch. Adequate planning and timing are critical to success. The helitorch may not be effective in old-growth stands due to a closed canopy in the timber.

Water. It is plentiful and commonly used. Engines, water tenders, hose lays with accessories are used throughout the area. All agencies have water handling specialists that can assist in the installation of progressive hose lays in the most adverse terrain. Heavy fuels in this smoke sensitive area

require an aggressive mopup policy built on the ability to move water regardless of the terrain. Firefighters and incident management teams should assess the water handling needs early and place a balanced order for equipment and personnel.

Air Operations. Air tanker drops are valuable in slash models, young plantations and for protecting high resource values. Old-growth canopies break up the drop patterns, usually making them ineffective.

Light helicopters are useful for scouting, air tactical safety lookouts and logistic operations. Because of the density altitude, and heavy fuels, water bucket loads on light helicopters are generally not effective.

Large and medium size helicopters with water buckets are effective in the various fuel types provided there is less than a 5 minute turnaround time from a water source. These bucket operations can be supported with fold-a-tanks for shorter turnaround times, thus reducing flight costs.

Many helicopter companies have buckets set up to utilize foam. Foam is very effective in light to moderate fuels with an open canopy.

Consider rappellers as an option for initial attack and/or construction of remote helispots. Keep in mind, the host unit may need to retain rappellers for initial attack.

Consider use of camps rather than daily movement of a large number of crews via helicopters.

2. Safety Concerns.

   a. Snags and large trees - use professional fallers.

   b. Heavy fuels - create dense smoke.

   c. Cable logging - cables across canyons.

   d. Blowdown from east winds - feet never touch the ground, rolling logs.

   e. Giardia lamblia - "Beaver Fever," water-borne parasite.

   f. Reburn after a ground fire goes through stand.

g. Usually no night operation period on the Olympic Mountains because of **60** percent plus slopes, snags and heavy fuels.

h. Fuels and terrain make LCES difficult to implement.

i. Hypothermia - high elevations and rain.

j. Logging trucks on single-lane, full bench roads.

k. Power lines crisscross major drainages.

II. NORTHERN ROCKY MOUNTAINS

The Northern Rocky Mountain area includes:

- Eastern Washington and Oregon, and Northern California.
- Idaho (area north of line from Boise to Yellowstone National Park), Montana, North and South Dakota

A. Eastern Washington and Oregon and Northern California.

1. Topography and Climate

In eastern Washington and Oregon and northern California, elements of the continental Rocky Mountain forests meld with some of those from coastal areas. In addition, forest species mix with species steppe and shrub-steppe communities. The area is typical ponderosa pine forests. The area includes the Klamath Mountains in northern California which are characterized by rugged, deep dissected terrain and knife-like ridges. The Blue Mountains of northeast Oregon and southeast Washington have variable relief, ranging from moderate to steep with Hells Canyon comprising the eastern boundary of the province.

Central Oregon and northeastern California have high lava plains characterized by young lava flows of moderate relief, interrupted by scattered cinder cones and lava buttes. The surface layer of pumice varies from a few inches to 20 feet deep in places, and was deposited by air currents during the last major volcanic eruptions. This is a land where rocks float, wood sinks and soil burns.

The vegetation of northern California consists of grass in the lowlands, brush at intermediate levels, and extensive coniferous stands in the higher mountains.

The annual precipitation is generally light, around 10 to 20 inches at lower elevations. Precipitation in the mountains ranges up to 60 inches or more locally. Summers are usually rainless with persistent droughts common in southernmost sections. Widespread summer thunderstorms with little precipitation reaching the ground, particularly in the mountains of the northern half, occasionally result in several hundred fires within a two or three day period.

The fire season usually starts in June and lasts through September.

2. Fire Weather.

Several weather patterns produce high fire danger.

a. One is the cold front passage followed by northeast winds, the same as was described above for the coastal region farther north.

b. Foehn winds are created by the airflow around a high pressure system in mountainous areas. The airflow spills over the mountain range and downhill at a phenomenal rate of speed. This causes fuels to dry out. As the temperature increases, wind speed may reach 50 to 70 mph.

In Oregon, a foehn wind is referred to as an east wind. In northern California it is a north wind and in central California it is known as a Mono. In southern California the foehn wind is the famous Santa Ana.

Many of the largest, most damaging and most costly fires in Oregon, Washington, and California have been caused by foehn winds.

c. A third pattern occurs when a ridge or closed high pressure system aloft persists over the western portion of the United States. At the surface this pattern produces very high temperatures, low humidities, and air mass instability.

Never assume general principles are absolute; on the Fremont NF in Lake County, Oregon, the Summers Lake/Winters Rim area has reverse diurnal winds. This rim on the West side of the basin has upslope winds at night and downslope winds during the day.

3. Forest Fuels and Fire Behavior of Eastern Washington and Oregon, and Northern California.

Following are the major natural fuel types. The fire behavior descriptions listed do not reflect the erratic fire behavior that may occur as a result of multiple years of drought and dying forests caused by insect infestations.

a. Lodgepole Pine.

Natural fuel loading 3 to 35 tons/acre
Average duff depth 0.6 inches (OR, WA, CA) 4.5 inches (N. Rockies)
Spread rate 1 to 12 chains/hour
Flame length 1 to 10 feet
Resistance to suppression 2 chains/person hour

b. Ponderosa Pine

Natural fuel loading 1 to 48 tons/acre
Average duff depth 1.5 inches
Spread rate 3 to 10 chains/hour
(Needle drape bitterbrush 40 to 50 chains/hour)
Flame length 2 to 6 feet
Resistance to suppression 2 chains/person hour

c. Activity Fuels

Lodgepole pine clear cut 16 to 40 tons/acre
Lodgepole pine partial cut 3 to 35 tons/acre
Ponderosa pine clear cut 22 to 46 tons/acre
Ponderosa pine partial cut 3 to 29 tons/acre
Ponderosa pine precommercial thinning 7 to 28 tons/acre

d. Brush Fields

Natural fuel loading 5 to 37 tons/acre
Average duff depth 20 inches
Spread rate 7 to 13 chains/hour
Flame length 5 to 7 feet
Resistance to suppression 1 chain/person hour
Generally not a fire problem. Brush fields are a result of old burns.

e. Mixed Conifer - Pine

Natural fuel loading 2 to 31 tons/acre
Average duff depth 1.5 inches
Spread rate 1 to 13 chains/hour
Flame length 1 to 7 feet
Resistance to suppression 1.5 chains/person hour

B. Idaho (area North of a line from Boise to Yellowstone National Park), Montana, North and South Dakota

1. Topography of Idaho.

Idaho - Includes portions of four major physiographic areas, the Northern Rocky Mountains; the Middle Rocky Mountains, Basin and Range, and the Columbia Plateau. Our area of concern is the Northern Rocky Mountains that occupy almost half of the state's area lying mostly north of a line from Boise to Yellowstone National Park. Within this area are some of the most inaccessible mountains in the United States. The Continental Divide is the boundary line between Idaho and Montana from Yellowstone National Park northwesterly to Lost Trail Pass. Fuels are heavier on the west side of the Continental Divide. Elevations range from 720 feet to 12,655 feet. Two major drainages, the Salmon River and the Snake River, both exceptionally deep canyons, flow through this region. Both of the canyons exhibit hazardous fire suppression conditions because of steep slopes, side canyons and inaccessibility and a local fire behavior analyst should be requested.

The Snake River in Hells Canyon is the border between Oregon and Idaho. Elevation varies between 550 feet and 7,900 feet with heavy fuels on the Idaho side and light, flashy fuels on the Oregon side. Most of the area is wilderness inside the Hells Canyon National Recreation Area.

2. Topography of Montana.

Montana - Topographically, the state is divided into two regions: east and west. The eastern portion is composed of rolling hills interspersed with low mountains, deep gorges, and unusual rock formations. These little pockets of mountains produce downslope winds all night, especially at the mouth of the canyons. Fires bum rapidly into the wind. West winds

come off the east slope of the Rockies and blow constantly. Fuels dry out quickly in June. Aspect can be used to your advantage when planning control tactics. Because of the extreme breadth of the state, 560 miles, it can be light in western Montana and dark in eastern Montana.

Western Montana is heavily forested. The mountains consist mostly of north-south ranges and are separated by broad, deep valleys and basins. All of the mountains were glaciated. Elevations in the state range from 1,820 feet to 12,799 feet. The Continental Divide runs north and south through the western section.

3. Climate of Idaho and Montana.

   Winter temperatures are quite low, and summer temperatures are moderate.

   Annual precipitation ranges from 10 to 20 inches in the valleys to 40 to 60 inches locally in the mountains. Most of the precipitation falls in the winter and spring in the southern portion of this area, while in the northern portion it is fairly well distributed throughout the year. Winter precipitation is in the form of snow. In the southern portion there often is widespread rainfall until June, followed by generally light precipitation during the summer.

4. Fire Weather of Montana and Idaho.

   There is a gradual drying out of forest fuels during July and August with frequent thunderstorms producing lightning and starting fires. Extremely low humidities can result from large scale subsidence of air from very high levels in the atmosphere.

   Occasional chinook winds on the east slope of the Rockies produce moderate temperatures and are effective in bringing subsiding air to the surface, which usually occurs in winter. The fire season usually extends from June or July through September. Catastrophic fire seasons usually begin with long term drought conditions for months before the outbreak itself.

   This is an area of extreme weather conditions, especially east of the Continental Divide. Eastern Montana has an early fire season until greenup. The winds blow every day, 15 to 30 mph, until sundown.

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5. Major Natural Fuel Types and Fire Behavior - Idaho and Montana.

The overall fire potential ratings of nil to extreme are for an "average bad" fire weather situation defined as 80 to 90 degree F temperature (27 to 32 degree C), 15 to 20 percent relative humidity, 10 to 15 mi/h windspeed (16 to 24 km/h), and 4 weeks since a significant rain (0.10 inch (0.25 cm} or greater).

Overall Fire Potential Ratings

Nil - fire will not sustain itself.

Low - fire can be easily controlled by several firefighters with handtools.

Medium - aggressive initial attack required (6 to 10 persons) for successful control.

High - aggressive crew-size initial attack (25 persons) with substantial reinforcement required for successful control; 10 percent chance that initial control will fail.

Extreme - 90 percent chance that initial control action will fail. (Usually a two week period in a normal year).

a. Interior Ponderosa Pine

Natural fuel loading 1 to 11 tons/acre
Average duff depth 0.4 to 1.7 inches
Overall fire potential low to high

b. Ponderosa Pine-Larch-Douglas-fir

Natural fuel loading 2.5 to 38 tons/acre
Average duff depth 1.0 to 1.9 inches
Overall fire potential low to medium

c. Larch-Douglas-fir

Natural fuel loading 1.4 to 74 tons/acre
Average duff depth 0.5 to 4.6 inches
Overall fire potential low to high

d. Lodgepole Pine

Natural fuel loading 3.5 to 35 tons/acre
Average duff depth 0.7 to 2.8 inches
Overall fire potential low to medium

e. Engelmann Spruce-Subalpine Fir (The overall fire potential rating does not illustrate the erratic fire behavior caused by the change in fuel profiles as a result of the mountain pine beetle and spruce budworm).

Natural fuel loading 1.3 to 77 tons/acre
Average duff depth 1.0 to 5.0 inches
Overall fire potential low to high

f. Grand Fir-Larch-Douglas-fir

Natural fuel loading 16 to 38 tons/acre
Average duff depth 2 to 4 inches
Overall fire potential low to high

g. Western Hemlock-Western Red Cedar (Old-growth stands have **a** high percent of cull material).

Natural fuel loading 9 to 58 tons/acre
Average duff depth 2 to 5 inches
Overall fire potential low to medium

h. Interior Douglas-fir

Natural fuel loading 2.5 to 53 tons/acre
Average duff depth 0.3 to 3.0 inches
Overall fire potential low to medium

6. Strategy and Tactics.

a. Methods of Attack.

Direct attack (one foot in the black) is the preferred strategy. Cold trail when possible to avoid reburns escaping. Direct attack reinforced by a hose lay with laterals every 200 feet is very effective in most fuel types. Night work is very effective.

A guideline to remember concerning eastern Montana and the Dakotas is that sagebrush cannot be burned out when the relative humidity is over 30 percent.

When direct attack is not possible, parallel attack is usually successful. Position control lines as close to the fire's edge as possible. Fuels should be burned out as line progresses or as quickly as favorable conditions exist.

Indirect attack is used when erratic, severe, or extreme fire behavior occurs and displays one or more of the following conditions.

- Presence of fire whirls.
- Prolific crowning and/or spotting.
- Very high to extreme rates of spread.
- A tall, well-developed convection column.

b. Principles of Burnout/Backfiring

Aggressive direct attack and burning out as necessary is preferred, Conducting backfiring operations requires great care in timing. All the conditions must be right and all safety precautions must be in place.

Except in ponderosa pine/grass fuel types, constructing fireline in timber fuels several hundred feet or farther from the main fire and burning out or backfiring, generally results in spotty burn out/backfire and escaped fires.

Indirect attack and backfiring should be the last strategy used and must be approved in the Escaped Fire Situation Analysis (EFSA).

c. Tactical Considerations. Building fireline from the top down.

Sometimes it is necessary to construct a fireline downhill. This is a hazardous practice when done in fast burning fuels and steep topography, because of the danger that the fire may cross the slope below the crew and sweep uphill to trap them. A fireline should not be built downhill in steep terrain and fast burning fuels, unless there is no suitable alternative for controlling the fire; and then only when all safety requirements are

adhered to for downhill fireline construction (See also NWCG Fireline Handbook, Chapter 4, page 46.):

d. Air Operations. In addition to the aviation considerations listed for the Northwest area, the following should be considered for the Northern Rocky Mountain area.

Nighttime inversion will hold smoke in valleys until mid or late morning and make air operations doubtful.

Air tankers have a low priority on large fires. In appropriate situations, aerial retardant can be effectively used for:

1. Holding action on small fires or spot fires.

2. Tactical support to line crews.

3. Pretreatment or indirect attack.

Paracargo for camp resupply is an option (24 hr notice required.)

When using dirt airstrips for crew/cargo transport, downloading or early morning or late afternoon flights may be necessary due to density altitudes.

e. Critical fire problems are in lodgepole pine and lodgepole pine/subalpine fuel types where 50 percent of the lodgepole pine is dead and "jack strawed."

In these stands, tree moss and dead aerial fuels such as small twigs have the greatest influence on crown fires. Trees loaded with moss and lichens that extend from the tips of the trees to the ground present the worst conditions. Crown fires can start when a sufficient amount of ground fuels is present to carry fire to the aerial fuels. The problem becomes one of direct vs. indirect attack. The final decision is usually a combination of both methods based on safety, cost, values at risk and the ability to implement the decision in a timely manner.

f. Canyon Country. A parallel or flanking strategy tied into good anchor points usually works best.

Tactical considerations:

1. Make sure you use a lead plane with air tankers for best result.

2. Let fire come to the top, rather than build line downhill.

3. Maximum, aggressive effort at night is usually successful.

4. Make sure operation overhead and crew bosses working the night operational period have seen their assigned work area in daylight.

5. Burnout is preferred to backfiring.

6. If you are building line from the ridgetop to the bottom, find a side ridge that goes all the way. Bum out as you go, leaving a good clean edge with a solid black line.

g. Safety Zones. It is essential to have firelines anchored to a safety zone or to create safety zones as work progresses along the flanks. Determining safety zone dimensions based on percent slope, height of adjacent timber and adjacent fuel loading is a critical assessment that must be done in a timely manner.

h. Camps are often necessary to implement a strategy and are effective in reducing the fatigue of crews. Any time travel from the incident base to the fireline exceeds one hour, seriously consider establishing camps. (Camps are recommended, rather than helicopter troop movements.)

i. Coyote tactics are sometimes necessary because of logistics. If coyote tactics are established they are often supplied with helicopter long lines. Timing of load, adequate water, and wash kits are critical.

j. Dozer use. Bulldozers are in constant use for fire suppression in this geographic area because of heavy fuel complexes. Dozers are extensively used on large fires as the main line building method.

They are more likely to be used where fires have escaped initial attack, rather than during initial attack. Bulldozers are often used to reopen logging roads ahead of engines. Preconstruction of firelines around heavy slash concentrations is also a common application.

k. Eastern Montana has large prairie fires from 300 to 1,500 acres that can be controlled with 20 to 30 people at night. Hit and run tactics are applied at the critical points in the fire perimeter. This type of tactic requires personnel and equipment to be highly mobile and have good communications with **all** units on the fire. If air tankers are used, 3 or 4 should be ordered at a time and lined up by a lead plane for trail drops. One air tanker is usually useless. Smoke jumpers are a good suppression force because of their mobility.

A real safety hazard in Eastern Montana and the Dakota's is pockets of surface gas in low areas. Pipelines and coal seams also present unique hazards. A "HAZMAT" specialist should be ordered if you are around any of these operations.

7. Key Areas of Concern.

a. Safety (Helicopter evacuation and fire shelters are not acceptable escape routes).

b. Snags - from old fires, bug kill, and drought conditions.

c. Spot fires in subalpine types - aerial fuels and ladder fuels.

d. Density altitude - helicopter limitation.

e. Communications - difficult to establish in first 48 hours in remote areas.

f. Avoid night work in cliff and heavy snag areas.

g. Rock slides after fuel burns off steep slopes.

h. Location of safety zones in dense timber areas. You cannot build them big enough. Indirect attack can get you in trouble.

i. Wide variation of fuel types and arrangements.

j. Warning signs of long-range spotting or erratic fire behavior:

Relative Humidity, < 15 percent
Flame Lengths, > 8 feet
Live Fuel (foliage) Moisture, < 60 percent
10 Hour F.M. Below 10 percent
Windspeed exceeds 10 mph
1000 Hour F.M. is in 10 to 13 percent range
Watch your relative humidity recovery rate at night. If it is less than 60 percent, expect early, rapid burning.

k. Fire Whirls - E-W drainages.

l. Giardia lamblia

m. Bears are attracted by food, keep firelines clean.

n. Vertical mine shafts in many areas of the west. (Example: Black Hills of S.D.)