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:

ALASKA

I. FIRE BEHAVIOR ENVIRONMENT

A. Fuels.

Boreal forest fuel types present suppression and management situations very different from those found anywhere in the lower 48 states.

You must be familiar with these differences to accurately assess the situations. In addition to the fuel type/fire behavior differences, there are logistical problems which necessitate longer time lines. Therefore, a knowledge of fuels, suppression options, and logistical considerations is required prior to mobilization.

The fuel you need to be aware of can be grouped into four types: Tussock tundra, black spruce, hardwoods, and white spruce. Ninety percent of the problem fires in Alaska occur in the tussock tundra or black spruce type. The Hardwood type is usually not a problem and will be discussed as a target of opportunity in making your decisions. White spruce is generally only a problem during extended drought.

1. Tussock Tundra

a. Description.

Tussock tundra can best be described as a bunchgrass prairie in which all of the space between the bunches have been filled in with a thick cushion of other plants. Tussock tundra is found on extensive areas of gently rolling land in western Alaska, and on shallow slopes on many mountain valleys in the interior. Permafrost (permanently frozen ground) occurs beneath, and a thick organic layer is present unless the tundra has been severely burned fairly recently.

b. Fire Behavior in Tussock tundra

Tussock tundra can be a dangerous fuel because of its flashy nature. Fifty-five percent is approximately the relative humidity (RH) at which "moisture of extinction" occurs. A 30 percent relative humidity with a moderate wind leads to a three foot flame length.

This is, of course, approaching the limit of successful handtool work without the aid of water or retardant. With 15 percent relative humidity and wind speeds of 15 mph, 10 foot flame lengths can result. Obviously, this condition is too hot to handle with conventional handtools. For the fire behavior analyst, the fire behavior fuel models fit very nicely and do not present the variable problems that some fuels do.

Tussock tundra is similar to Grassland Models 1 and 3 depending upon the height. If tussocks are less than one foot, use Fuel Model #1 (short grass). If they are more than 1 foot, use Fuel Model #3 (tall grass). The terrain simplicity of tussock tundra is a major advantage in suppression considerations. Tussock tundra is usually found on flat ground or on the lower 113 of gentle slopes.

The depth of tundra burning is dependent upon the dryness of the fuel and the organic layer beneath.

Great variation in depth of bum is to be expected depending on the time of year or drought condition, and relative humidity/wind conditions at the time of burn. Normally, once active flame is removed in tussock tundra, it does not present a mopup problem. Cold trail of the line 24 hours after the flame is extinguished usually suffices to assure the perimeter is secure.

2. Black Spruce - Feather Moss.

   a. Description.

      Black spruce stands are widespread on moist, poorly drained sites and typically underlain with permafrost. Generally, they are in relatively flat valley bottoms, or flat to gentle rolling land, and on cold slopes having a northern exposure. These trees are small. Maximum heights in mature stands seldom exceed 30 feet, but can grow to 50-60 feet in height. They are slow growing and seldom exceed 8 inches in diameter and usually are much smaller. A tree 2 inches in diameter is over 70 years old. Characteristically, mature trees "bunch out" at the top.

This effect is taken advantage of by firefighters as it's common practice to use a black spruce top (spruce bough) to beat out the fire. Spruce often occurs in clusters and/or clumps of trees or can form a continuous, solid stand uninterrupted for miles.

Fires are intense in black spruce, usually killing all trees and consuming all needles during crown fires. Black spruce has adapted to fire primarily through its abundant seed production in semi-serotinous cones. Approximately 75 percent of Alaska's problem wildfires occur in the Black Spruce - Feather Moss types. It is in this fuel type that fire conditions and suppression situations are very different from those of the lower 48 states.

b. Fire Behavior in Black Spruce/Feather Moss.

Fires in Alaska black spruce are most often crown fires, yet they are rarely running independent crown fires. That is, the fire is carried by surface fuels, with a crown fire often following some distance behind the Fie front, giving the impression of a full-blown running independent, crown fire. The tendency of fires to crown is related to the distribution of the fuels within the stand, the flashy carrier fuel, and the dry black spruce needles. In most black spruce stands, the carrier fuels can carry flames three feet above the surface. The black spruce branches (often with dead lichen covering the lower branches) will ignite from the carrier fuel and carry flames directly into the crown. The layering of the lower branches provides nearly continuous fuel from the forest floor to the tree crowns (ladder effect). The Cladonia, or caribou moss, is an excellent indication of fuel moisture as it crumbles when dry and is resilient when the RH and fuel moisture is increased. A significant change can be observed in a 20 minute period of drying.

The key to black spruce crowning is the carrier fuel and the low moisture content of black spruce needles. The carrier fuel is feather moss and a lichen layer that has a tremendous surface-to-volume ratio with immediate responses to changes in relative humidity.

Although feather moss is a live fuel, it responds like a dead fuel to changes in weather conditions. When free of surface moisture, the response to change in RH would class feather moss as a 20 minute timelag fuel. With RH of 45 percent or less it will usually bum even if temperatures are cool.

Exhaustive studies have concluded that black spruce is always ready to burn at anytime. Even in a wet summer the spruce needles remain dry (70 and 80 percent live fuel moisture). Studies explain the problem faced by Alaska fire managers of having a crowning spruce fire at anytime, including the day after a good, soaking rain. Besides the 20 minute timelag for carrier fuels to dry and bum, we have the spruce with branches to the ground and needles with a live fuel moisture (70 to 80 percent) that is ready to burn. Within minutes, an individual tree or a cluster can be torching out. Added to this is nearly 24-hours of daylight, which minimizes the normal nocturnal effect. Don't expect a fire in black spruce to necessarily lay down at night.

Fuel Model #9, multiplied by a factor of 1.21, is used for the rate-of-spread. This fuel model exhibits one of the slowest rates-of-spread, and should help explain the earlier statement that labels spruce crown fires are seldom running crown fires, but are surface fires with the crown fire following a few feet behind. Fuel Model #5 is used for fireline intensity. This fuel model exhibits one of the highest fireline intensities.

These fuel models pretty well fit the type. The homogeneous fuel which is extensive and continuous presents an opportunity for the fire behavior analyst to make reliable calculations with a high degree of accuracy for entire days.

Again, the black spruce fire is carried by surface fuels with a crown fire following a few feet behind the fire front.

This is why retardant is effective in what appears to be a timber crown fire; the retardant stops the surface fire in the moss/lichen layer and the dependent crown fire dies.

Rate-of-spread is slow and predictable, while intensity is high. It is common to have spotting by aerial firebrands in a crowning spruce fire. This can occur regardless of the previous weather.

Wind is the crucial factor, with spotting occurring over 1/2 mile ahead of the fire and even up to 2 miles. With the right conditions the Yukon River can and has been jumped by aerial firebrands. Spot fires are often difficult to detect until they take off and start running. Fire breaks then are a matter of condition. If conditions are right for long range spotting your fire break must be burned out with enough separation to hold. Spotting distance determines the usefulness of firebreaks.

In summary, black spruce will exhibit extreme fire behavior when temperatures exceed 80 ^{o}F and RH's fall below 30 percent. Remember, that in this fuel type, it is not uncommon to have an extended rainy period followed by clear skies, a little wind, RH to 25 percent, and have spruce trees crowning out by mid afternoon

EXAMPLE: A fire that is lying down and appears to be no problem can be off and running within a few hours. This scenario has ruined the day for many firefighters in Alaska.

3. Hardwoods.

   a. Description.

      Birch and aspen are the primary hardwood species forming this Alaska fuel type. Found on better drained sites, they are generally an indicator of better soils and less permafrost.

   b. Fire Behavior in Hardwoods.

      Although this is a major fuel type, it is primarily useful for the fire manager as a target of opportunity and not a problem fuel. It is very similar to a western aspen stand. For fire behavior calculations we use Fuel Model #9, timber litter understory.

Hardwoods normally serve as a natural barrier and offer a firebreak in all but rare periods of extended drought. A crowning spruce fire will normally drop to the forest floor when encountering a stand of hardwoods.

There is little understory vegetation of dead fuels and normally higher humidity and lower temperatures due to the canopy cover. Fire in hardwoods will usually creep along the surface doing little damage and offering little danger to the firefighter. Difficulty may be encountered however, when grubbing the fire out from among the maze of roots. As more spruce appear in those closed stands, the behavior of a fire may become more erratic. The peat and moss in some hardwood areas can be quite deep burning. This presents a difficult mopup situation. Frequently, with deep burning in peat moss and hardwood roots, a hotspot can smolder undetected for days. Infrared for mopup is especially effective in these conditions.

4. White Spruce.

White spruce stands often meet black spruce stands near lakes or streams, and form a very different fuel situation than may be burning in the black spruce. Under most usual burning conditions, the white spruce stands are on wetter sites and fire often does not pass through, although there is often a large loading of down dead fuels in the white spruce stands. It should be noted however, that under very dry conditions and especially with steep slopes and strong winds aiding it, fire of extreme intensity in mature white spruce stands can occur. (Rosie Creek fire on the Bonanza Creek Experimental Forest, and parts of the Bear Creek Fire around Farewell.) When extended drought has occurred, white spruce stands should not be considered a fuel break or a safe refuge for firefighters. Also, resistance to control in such stands is extremely high, usually dictating some form of indirect attack if at all possible. Alaska does grow some very large trees on good sites! They usually do not burn, but when they do, they pose a very dangerous situation.

B. Topography.

Generally speaking, topography/terrain is not a major determinant of fire behavior in Alaska.

1. Fire prone areas are in flat and rolling terrain between sea level and 3,500 feet elevation. Above 3,500 feet there are no fire problem fuels. (Density altitude is not a problem for aircraft operations.)

2. As a rule, north facing slopes are poorly drained and underlain by permafrost, resulting in black spruce stands and south facing slopes are fairy well drained (especially the upper 3/4) resulting in more deciduous (hardwood) stands of birch and aspen.

3. River bottoms are characteristically meandering with stringers of taller white spruce that normally do not burn as a crown fire, but often have large amounts of heavy down and dead wood.

C. Weather.

There is no "typical" weather pattern for Alaska. A strong high pressure system can dominate for days with clear skies, warm temperatures and low humidities. Daily thunderstorm activity during these periods leads to multiple fire occurrence and fire blowups. The high pressure system can break down rapidly and cool, moist Arctic air can move in followed abruptly by a return of high pressure and good burning conditions. Weather prediction in Alaska is difficult and should be used with contingency for change.

1. Relative humidity is the primary weather factor that determines fire behavior. Below 50 percent RH, fires will burn in most heavier fuels and at 30 percent, fire behavior becomes extreme at warmer temperatures. RH rarely drops below 20 percent in Alaska.

2. Temperatures in summer normally range from 65 to 85 ^{o}F with occasional readings in the 90's. Extreme burning conditions occur in black spruce with temperatures 80 ^{o}F or higher when coupled with RH's below 30 percent.

3. Winds are generally varying depending on local terrain with no predominant wind flow pattern except near mountain ranges where glaciers and permanent snow fields on mountains can cool air masses causing down-slope flows. Afternoon and evening thunderstorms produce significant winds which adversely affect fire behavior.

4. The 24 hour daylight ("midnight sun") for most of June and July greatly decreases the nocturnal temperature and humidity differentials enjoyed in the lower 48.

II. STRATEGIES AND TACTICS

A. Strategies.

1. The most common strategy used for effectively containing large project fires in Alaska is indirect attack. Mechanized equipment, such as engines and dozers, is not readily available in large quantities in Alaska and due to terrain difficulties usually cannot be used effectively on most fire perimeters. Likewise, large numbers of hand crew personnel cannot be transported and easily supported along fire perimeters, requiring most perimeter to be covered on foot. These situations combine to make it infeasible to keep up with a running fire.

2. Direct attack strategy can be implemented when weather conditions reduce fire behavior to a level where black lining can be rapidly and thoroughly accomplished or when the fire perimeter has road access.

3. Often extreme fire behavior and/or limited suppression resources may require a strategy of defense of critical sites vs. offensive containment of the fire. Both direct and indirect attack can be applied in a defense strategy.

B. Tactics.

1. Direct Attack.

The most common method of direct attack consists of beating out the flame front with a "spruce bough" or wet gunny sack. Conventional back pack pumps and/or portable pumps are used but less extensively. Use of shovels is minimal and the pulaski is used primarily to cut spruce boughs or for mopup. Seldom is a line cut using a pulaski. Cold trailing is the most reasonable method of securing the line.

2. Indirect Attack.

Burning out from natural barriers or built line is most common. Smokejumpers on initial attack carry fusees and often use burnout on small fires to minimize hand line construction.

When fireline intensity or size of a fire dictates indirect attack methods, a number of options are available. Aerial ignition from a helicopter is usually a valuable time saving tool. In addition to normal line construction methods, burnout can be accomplished from:

- Fireline explosives built line.
- Retardant line.
- Wet line from FEDCO's or Hoselays.
- Walk down line.
- Brush line (bum and beat).

Common mistakes or problems in indirect attack:

- Not planning enough time or moving far enough ahead of the fire.
- Parallel line to white spruce, hardwoods, or other natural barriers. Line through black spruce instead of hardwoods, or tundra
- Fuels drying out faster than anticipated.
- Tundra not as easy as it looks (especially the difficulty in movement of ground crew).
- Retardant not always effective (especially in tussock tundra when it can burn under the retardant).
- Indirect attack can be a major gamble with weather. It may take a week to build the line and by then weather will permit direct attack on the main fire miles away. Weather can also prevent a clean burnout.
- Timing a transition to direct attack - better late than too soon.

C. Strategy and Tactics for Black Spruce.

Complex fires in black spruce - feather moss call for long range planning, use of natural barriers, and a constant alertness to the weather. Nearly all lines, constructed or natural, require burning out to hold. Patrols are necessary on a fairly continual basis as the exposed moss along trenched line ignites readily and spot fires can smolder for several days before "popping up". The use of natural barriers is the most positive means of control.

III. SPECIAL CONSIDERATIONS UNIQUE TO ALASKA

A. Safety.

1. Bears.

Black bears and grizzly bears are frequent visitors to incidents. Both can be dangerous! The best solution to avoid bear problems is to maintain garbage free, food clean camps and operations areas. If bears become a recurring problem, and therefore, a hazard, weapons and licensed hunters are available upon order.

2. Drinking Water.

Streams and creeks in Alaska are infected with giardia, and therefore, are not suitable for use as drinking water. There are several portable water filtration systems available for order, but if one of those systems cannot be obtained; then drinking water must be hauled to the incident. This may involve costly and scarce aircraft resources, but it must be done.

3. Fire Shelters.

In black spruce and tundra it is nearly impossible to cut a sufficient clearing through the vegetative ground cover to mineral soil for safe, effective deployment of a fire shelter. Escape routes and safety zones, often found in the form of shallow lakes and ponds, are a must.

4. Fatigue.

   Mobility in Alaska terrain is often overestimated by the inexperienced observer. What appears to be a refreshing green meadow when viewed from the air, is usually an ankle, twisting, knee wrenching, muscle torturing obstacle course of tussock wetland covered with ankle to knee deep water. Working and foot travel in this type of terrain is difficult, slow, fatiguing and often hazardous.

5. Camp Supply.

   The supply of camps is primarily by air transportation, and therefore, vulnerable to adverse weather and smoke conditions. Camps often go for several days without the availability of re-supply. A minimum supply level of three days of food and water should be maintained at all camps not accessible by road or boat. The minimum level needs to be confirmed, and if necessary restocked anytime weather or fire behavior forecasts indicate limited air operations.

B. Functional Considerations.

1. 24-Hour Daylight.

   Remember, 24-hour daylight results in little nocturnal fire behavior relief; but, on the other side of the coin, it does allow round-the-clock operations (including air operations) with little concern for darkness limits.

2. Retardant Use.

   The philosophy in Alaska is to make a major retardant commitment on initial attack. Due to long hauls and the resulting high cost, heavy air tankers are seldom committed to a single project fire, but are kept working new fires. You may be able to arrange through logistics for a tanker to secure a flank or burn out from retardant line. A helicopter and water bucket may be cost effective.

3. Native Crews.

   The primary sources of Type 2 crews in Alaska are Emergency Fire Fighter (EFF) crews from rural native communities and villages. Village crews are trained to national standards with a crew leader from the village. Crew size is 16 due to limitations of transportation by Twin Otter aircraft,

4. Remote Camps.

   Remote camps are difficult for many lower 48 firefighters to adapt to, but they are a must in order to maximize line production without wasted time moving crews by helicopter. Logistical support demands multiple camps on a large fire. Feeding and camp systems are designed for camp support.

5. Logistics.

   a. A 72-hour lead time is required on resource orders after the first 48-hours.

   b. Problems due to distance from headquarters supply point

   c. Food rations and fresh food boxes with no caterers or camp kitchens

   d. There is limited availability of helicopters.

   e. Radio communications - few telephones

   f. Showers are normally not available.

6. Aircraft Operations.

   Probably no place is more dependent upon aircraft than Alaska. Some considerations:

   a. 24-hour daylight provides round-the-clock air operations. Double crew helicopters.

   b. After initial attack, most aviation work is logistical, not tactical (little bucket work, etc.)

   c. Density altitude is usually not a factor (most operations are below 2,500' M.S.L.).

   d. Distances are great!

e. Supplying jet fuel for helicopters is a significant problem. Due to the remote nature of Alaska all helicopter contracts stipulate fuel to be provided by the government.

f. There are no chase trucks. Fuel can be parachute dropped in 500 gallon rollagons and then sling loaded by helicopter to a fueling area. This is a significant workload and requires planning. There is a short supply of available helicopters.

g. For remote fires and camps paracargo is significantly less expensive and time consuming than helicopter transport from an airstrip 30-50 miles away. All supplies can be delivered by the AFS paracargo unit which is the largest nonmilitary paracargo operation in the world. Consider drop zones removed from people areas and sling supplies from drop zones. Do not fail to allow for the workload of cargo and parachute retrieval.

h. Allow for aircrew fatigue factor in a "bush" environment.

i. The air tactical group supervisor dispatched with airtankers is also the lead or airtanker coordinator.

j. Helpful Hints:

(1) Order an Alaska air support group supervisor, at least for the first 72 hours.

(2) Order a fueling specialist (this is a red-carded AK position).

(3) Zone air service managers are an important resource, especially for lower-48 teams.

(4) Don't fall behind the fueling power curve!!

C. Environmental Considerations.

1. Environmental Area.

Alaska is a very high visibility area for all the traditional environmental concerns and confrontations. Rarely are fire operations exempt from close environmental scrutiny. You are not "out of sight, out of mind"!

2. Dozer Lines.

   Problems caused by dozer lines on permafrost have essentially eliminated their use in either remote or permafrost areas.

   Fire managers must have the agency administrator's approval before use. When dozers are used, special procedures can avoid many problems which have created environmental concerns in the past. Often fire perimeter is inaccessible to heavy equipment.

IV. SUMMARY

Incident management teams and firefighters arriving in Alaska must adapt to many changes besides the mosquito population. They will probably find:

- A large fire size (25,000+ acres) with no natural barriers for many miles.
- Indirect attack with many miles to a natural barrier.
- Poor weather information.
- Extreme fire behavior in seemingly mild weather conditions.
- Many unfamiliar logistic problems.
- Lack of sufficient helicopters.
- Difficult communication to outside world.
- Highly variable burning conditions with minimum timelag for drying.

The most frequent management problem facing incident management teams and firefighters is developing strategy to protect resources from a large fire that is still five or more miles away. Strategic decisions are complicated by factors of inaccessibility, limited force availability, unique logistical concerns, and unpredictable weather.