FUEL MOISTURE MONITORING PROGRAM
Grand Teton National Park

(Program initiated 1992. Revised 1995, Lynn Emerick & Ron Steffens. Updated RS, July 25, 2009.)

Background

Since the fire season of 1988, there has been renewed and continuing focus on the tracking of fuel moisture levels to assist in the prediction of fire behavior. On a daily basis, the computed moisture content of live herbaceous, live woody, and cured fuels (1, 10, and 100 hour fuels) is provided through the WIMS system. In Grand Teton National Park, the Fire Management Office has determined that a program of physical fuel moisture sampling, at various locations throughout the park will support more accurate and local information about our fire danger and long term trends in fuel moisture changes.

Program Description

Seven sampling locations have been selected for the program. The North District sites are Flagg Ranch, Moran, Signal Mountain, and RKO Road. The South District sites are Timbered Island, Whitegrass Ranch, and Lost Creek. All sites are easily accessible by road and located where the chance of human or wildlife disturbance is minimal. These sites were selected to represent fuel moistures on a wide range of aspects and elevations. The sampling program will focus primarily on the moisture contents of live herbaceous and woody fuels, 1 hour dead and 1000 hour dead/down fuels. All of the sites will also have a set of standard 10 hour fuel moisture time lag sticks, which will be weighed and recorded as well.

Sampling Procedures

The sampling sites are representative of the fuel models we are most concerned about, T1P3 (sagebrush/grass) and G2P3 (timber). Samples should always be taken from the same aspect and elevation with each visit, so that the sampling program and collection of field data will maintain statistical validity. This will only occur if all personnel follow the procedures outlined below, carefully and consistently.

Upon arrival at each site, the individual collecting the samples should record his or her name, the date, time of day, and weather observations in the appropriate blanks on the date sheet. Weather observations should include approximate temperature, relative humidity, wind-speed and direction and any other significant data such as recent precipitation or high winds.

Sample cans should be clean and completely air dry before any samples are placed inside. Use the appropriately labeled can and lid for that particular site and sample type. For example, can W-1 will contain a 1000-hour sample from Whitegrass Ranch sampling site, while the M-2 will be used for a live herbaceous sample from the Moran site. Once samples are placed inside the can, the lid should be securely sealed around its lip with electrical tape to prevent any moisture from escaping the can during transport.

One-hour dead fuels may be collected from the ground or surface litter or in the case of sagebrush, from a dead stem attached to the plant. Do not collect samples from any part of the duff layer beneath the surface since duff may retain significantly more moisture and because there is a separate procedure for measuring duff moisture content. Cut fuels into short pieces so they can lie flat and neatly in the bottom of the can. Fill cans about ¾ full of sample material, but do not pack or compress fuels inside. Samples from various species may be placed in the same can as long as they are all dead and all less than ¼” in diameter. Quickly apply the tape as soon as you’ve decided you have enough sample material inside. Remember the key to accurate fuel moisture sampling is allowing no moisture to evaporate or escape from the sample during collection and transport.

Live herbaceous fuels may be sampled and collected using many of the same principles and procedures as described in the previous paragraph. Do not collect live fuels if water drops are present on the sample. Such free surface water will cause large errors in calculated values of moisture content. Shaking the samples to

remove excess water is not adequate because enough free water can remain to bias the sample. Collect samples only if rain has not fallen for several hours.

To maintain consistency in the live woody sampling, insure that the same species are collected within the guidelines for type of material whether it is a tree or shrub.

10-hour fuel moisture can be measured using the standard 10-Hour Fuel Moisture Time Lag Sticks (FMTL), which are placed at each sampling site. 10-hour sticks should be situated 10" above a natural duff surface on wire racks, with the hooked end facing north and the stapled side face down. The 10-hour sticks need to acclimatize for 7 days before moisture content can be measured.

The 1000-hour fuels are the primary focus of the sampling program. Logs may be between 3"-8" in diameter, though preferred diameter is 5"-7". The logs should be free of bark, and not yet rotted out. The logs should also be at least six to eight feet long. Logs that are off of the ground will show the driest conditions that 1000-hour fuels can obtain, a worst case scenario.

The preferred sampling method is by a manual drill (though other methods, such as sawing a wafer, may also be used). Material should be loosely placed in a sampling can until the can is about ¾ full. Special care should be taken to insure that the can is immediately sealed with the tape when no additional material is to be added to that can.

If moisture does leave the sample and condense inside the can, then the weight of that moisture should be included as part of the wet fuel weight when performing the calculations to determine percent moisture content. It is important to weigh the samples inside the cans, as soon as possible, after being collected in the field. However, remove the tape from the outside of the can first. Weigh each can with its lid and contents in place. Weights should be recorded to the nearest 1/10 gram.

Be sure to remove the lids and place them underneath the can when putting them into the oven. The cans should be placed at least an inch apart in the oven. The normal drying time for fuels is 8 hours. After the appropriate drying time has elapsed, remove the sample cans from the oven. Weigh each can again, lids and sample materials in place. Record these weights on the date sheet. Empty the material inside the can into a wastebasket. Weigh the empty can again for the tare weight.

To calculate the percent moisture content of each sample first determine the dry sample weight by subtracting the given empty canister weight from the gross dry weight (wt. of canister, lid and contents). Then calculate the percentage of moisture content using the following formula:

% Moisture content = (wet wt.-dry wt.)/(dry wt.-empty can wt.) X 100
(Note: This formula is in the data entry spreadsheet.)

After samples and empty cans are re-weighed all data should be entered into a Fuel Sampling spreadsheet (filed by year in W:\FMO\Weather & Fuels\Fuel Moisture).

Samples should be done on a regular basis (a minimum of twice monthly) in order to accurately track changes in fuel moisture levels from May through September. Canisters and lids should be thoroughly cleaned and air-dried prior to the next sample collection.

Summary

The sampling program outlined above can be completed after a short orientation and training. The statistical validity of the program, however, depends on whether the individual collecting and weighing the samples follows these instructions carefully, and performs the calculations correctly. For example, transporting canisters from the field with lids sealed with tape, and re-weighing the canisters immediately upon removal from the oven, are two things which will greatly enhance the accuracy of the measured weights and the results of the calculations.

Fuel Moisture Sampling Sites

Site	*Description*	*Fuels*
Whitegrass Ranch	43.63962650,-110.76681026 Elevation 6500 Aspect: Flat/SE Slope: 0%	1. 10 Hour FMTL Fuel Sticks 2. 1000 Hour 3. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*) 4. Live Woody, Snowberry 5. Live Woody, Lodgepole Pine
Timbered Island	43.70712161,-110.71975895 Elevation: 6570 Aspect: SE Slope: 10-30%	1. 1 Hour, Litter and Rotten Logs 2. 10 Hour FMTL Fuel Sticks 3. 1000 Hour 4. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*) 5. Live Woody, Lodgepole Pine 6. Live Woody, Douglas Fir 7. Live Woody, Mountain Big Sagebrush
Lost Creek	43.74858856,-110.62400945 Elevation: 6770 Aspect: Flat Slope: 0%	1. 1 Hour, Litter/Branches 2. 10 Hour FMTL Fuel Sticks 3. Live Herbaceous, Idaho Fescue (*Festuca idahoensis*) 4. Live Woody, Mountain Big Sagebrush
Moran	43.83855136,-110.50226441 Elevation: 6800 Aspect: S & SW Slope: 10-30%	1. 10 Hour FMTL Fuel Sticks 2. 1000 Hour 3. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*) 4. Live Woody, Silver Buffaloberry 5. Live Woody, Lodgepole Pine
RKO Road	43.82067025,-110.59124895 Elevation: 6960 Aspect: Flat Slope: 0%	1. 1 Hour, Litter/Branches 2. 10 Hour FMTL Fuel Sticks 3. Live Herbaceous, Idaho Fescue (*Festuca idahoensis*) 4. Live Woody, Mountain Big Sagebrush
Signal Mountain	43.85133862,-110.56485065 Elevation: 7600 Aspect: N Slope: 30%	1. 10 Hour FMTL Fuel Sticks 2. 1000 Hour 3. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*) 4. Live Woody, Thinleaf Huckleberry 5. Live Woody, Lodgepole Pine 6. Live Woody, Douglas Fir
Flagg Ranch	44.10996258,-110.68558224 Elevation: 6850 Aspect: Flat Slope: 0%	1. 1 Hour , Litter 2. 10 Hour FMTL Fuel Sticks 3. 1000 Hour 4. Live Herbaceous, Geyer's Sedge (*Carex geyeri*) 5. Live Woody, Lodgepole Pine

Profiles of Fuel Moisture Sampling Sites

Whitegrass Ranch

Directions: From Park Headquarters, drive straight through the stop sign (west) onto the Moose Wilson Road. Follow the MW Road for 3.1 miles to the Death Canyon Road. Park in a small grassy turnout south of the Death Canyon Rd, on the west side of the MW Rd. Cross the MW Rd and walk east 100 ft. to the site.

Fuel Samples:

1. 10 Hour FMTL Fuel Sticks
2. 1000 Hour
3. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*)
4. Live Woody, Snowberry
5. Live Woody, Lodgepole Pine

Description: This is a mostly shaded, riparian site with 0% slope. Shrubs, grass and dead and down logs are common. The overstory consists of mixed conifer and deciduous trees. Small meadows nearby were artificially created by clearing for a former cabin site. This site typically has the highest RH of the collection areas, and samples from here usually have the highest fuel moistures. Fires here would probably be carried by dead and down litter and 1000 hour logs, and additionally by shrubs and grass if those fuels were sufficiently dry. Potential for torching and crown fire is high, with dry windy conditions. Litter and 10 to 100 hour fuels are common. Ladder fuels exist that could carry a fire into the canopy.

Timbered Island

Directions: From Park Headquarters at Moose, turn north (right) and drive 4.0 miles on the inside road. Park on the east side of the road in a gravel pullout just south of the turnoff for Highlands. Walk east for approximately ¼ mile to the southern tip of Timbered Island. Turn north and the site will be visible on the eastern edge.

Fuel Samples:

1. 1 Hour, Litter and Rotten Logs
2. 10 Hour FMTL Fuel Sticks
3. 1000 Hour
4. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*)
5. Live Woody, Lodgepole Pine
6. Live Woody, Douglas Fir
7. Live Woody, Mountain Big Sagebrush

Description: This east facing site is located where the sagebrush flats meet an old glacial moraine, now forested with Douglas fir and lodgepole pine. The slope varies from 0% at the site of the fuel sticks and the 1000 hour weighing logs to 0-15% on top of the bench where forest fuels are collected. The hillside is partially shaded by mature Douglas firs, while the fuel stick area is unshaded except for afternoon canopy cover. The site's position on the east side of Timbered Island protects it from the prevailing southwest winds. Grass in the sagebrush area around the fuel stick site is non-continuous, growing in small tufts, while grass on the hillside is long and continuous, retaining moisture and green color long after the grass below is cured and brown. The sagebrush is also not continuous and would require wind to carry a fire. The cover on Timbered Island moraine above and to the west of the fuel collection site is mainly mature trees with significant fuel loading. Fire in this area would be carried by dead and down logs and grass, if cured.

Lost Creek Ranch

Directions: From park Headquarters, turn east (left) and drive 0.4 mi to Moose Junction. Turn north (left) and drive 8.3 mi to Lost Creek Road. Turn east onto the Lost Creek Road and drive 0.15 mi to a faint turnout on the south side of the road. Park and walk SE for 150 feet to the site. The stands for the 10 hour sticks are visible and may be marked with flagging nearby.

Fuel Samples:

1. 1 Hour, Litter/Branches
2. 10 Hour FMTL Fuel Sticks
3. Live Herbaceous, Idaho Fescue (*Festuca idahoensis*)
4. Live Woody, Mountain Big Sagebrush

Description: The site is covered with mature sagebrush, mixed with scattered tufts of short grass. There is very little 1 hour fuel on the site, except for dead sage branches. The sage and grass is not continuous, and large fires here would be primarily wind driven. There are no 1000 fuels in the vicinity of the site. The slope here is 0% and shading is also 0%, unless clouds are present. This site is similar to the previous South District sagebrush fuel collection site in Antelope Flats, which was burned over by the Row Fire in August 1994. The Row Fire was ignited on 8/28/94 by lightning and eventually burned 2250 acres in the park. At 1200 on the day of ignition, a temperature of 77, RH of 34% and windspeeds of 4-8mph were recorded at the Antelope Flats site. Live woody fuel moisture was 63%, 1 hr fuel moisture was 10%, live herb was 30% and the 10 hour FMTL sticks were 7%. The Row fire was primarily wind driven, with flame lengths of 15 feet recorded, and the sagebrush flats were burned completely.

Moran

Directions: From Park Headquarters turn east (left) and drive 0.4 mi to Moose Junction. Turn north (left) and drive 18.8 miles to a gravel pullout on the east side of the road. This pullout is 0.3 miles north of Moran Junction. Cross the road and walk north 150 ft into the wooded area adjacent to the “Approaching Moran Junction” sign. The site is at the base of the small hill to the east/northeast.

Fuel Samples:

1. 10 Hour FMTL Fuel Sticks
2. 1000 Hour
3. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*)
4. Live Woody, Silver Buffaloberry
5. Live Woody, Lodgepole Pine

Description: The site is located at the base of a south facing hill and had 0% slope. It is partially shaded by an overstory of mixed conifers. Grass exists in patched but is not continuous. Shrubs, primarily buffaloberry, grow in clumps. Dead and down 1000 hour logs are common, most of them rotten. The predominant southwesterly winds could send a start in this area uphill into more heavily forested and steeper terrain. Ladder fuels are also abundant. Shrubs and grass would be the main understory fire carriers.

RKO Road

Directions: From Park Headquarters at Moose, turn north (right) and drive 16.0 miles on the inside park road. Turn east onto the RKO road (may need to be unlocked early in the season) and continue for 1.1 miles to a pullout on the north side of the road. The pullout is across from where a small forested hill comes close to the road on the south side. On foot, follow an old road on a bearing of 65^{o} for 3.5 chains (about 225 feet). The site is about 20 feet north of the old road and visible from it.

Fuel Samples:

1. 1 Hour, Litter/Branches
2. 10 Hour FMTL Fuel Sticks
3. Live Herbaceous, Idaho Fescue (*Festuca idahoensis*)
4. Live Woody, Mountain Big Sagebrush

Description: This sire is very similar to the Lost Creek Ranch Site, except for the presence of forested hills within ¼ mile to the north. It is unshaded except for cloud cover, with 0% slope. There are no 1000 hour fuels occurring naturally on the site, but dead and down logs are common in the forest nearby. The area consists primarily of mature sagebrush with occasional clumps of short grass. One hour fuels mainly as sage branches, and wind would be required to carry fire from one sage plant to the next. If a wind event did occur, fire originating in this area could easily spread into the timber to the north.

Signal Mountain

Directions: From Park Headquarters at Moose, turn north (right) and drive 16.3 miles to the Signal Mountain Road. Turn east and drive up the road for 4.6 miles to the last hairpin turn before the summit. There are barrier logs around the turn and almost enough space to pull off the road. There is a faint trail that goes steeply downhill to the north for 20 feet and then bends west-northwest to contour along the slope for 60 feet to the sampling site.

Fuel Samples:

1. 10 Hour FMTL Fuel Sticks
2. 1000 Hour
3. Live Herbaceous, Pinegrass (*Calamagrostis rubescens*)
4. Live Woody, Thinleaf Huckleberry
5. Live Woody, Lodgepole Pine
6. Live Woody, Douglas Fir

Description: This mostly shaded, north facing site is located on an approximately 30% slope. The dominant shrub is huckleberry, growing in patches. The overstory consists mainly of spruce, lodgepole and subalpine fir (with some Douglas fir). Litter and dead and down fuel are abundant, with all size classes present in significant amounts. Ladder fuels are common. An understory fire would be carried by dead and down fuels as well as shrubs, and aided by the steepness of the slope. The entire Signal Mountain area is characterized by large amounts of dead and down fuels and a shrub understory.

Flagg Ranch

Directions: From Park Headquarters turn north (right) and drive the inside park road for 20.5 miles to Jackson Lake Junction. Turn west (left) and drive for 21.4 miles to turn for Grassy Lake Rd. Turn west (left) and take the first right (about 100ft). Both these turns are marked as Grassy Lake Rd. Drive for 1.2 miles to pullout on north (right) side of road, the trailhead for Huckleberry Hot Springs. Walk north up a small (4 ft.) bank and continue north, across an abandoned gravel pit, for 4.5 chains to the sampling site.

Fuel Samples:

1. 1 Hour , Litter
2. 10 Hour FMTL Fuel Sticks
3. 1000 Hour
4. Live Herbaceous, Geyer's Sedge (*Carex geyeri*)
5. Live Woody, Lodgepole Pine

Description: This site is characteristic of much of the Yellowstone area. It is partially shaded by a few mature lodgepoles; however, most of the standing trees are of moderate age and less than 30 feet tall. The slope is 0%. There is a large amount of dead and down 1000 hour logs, much of it rotten. Litter exists under live trees in the form of dead pine needles. There is a swampy area nearby, but the fuel collection site is dry and hot during the summer. Grass exists in patches, and shrubs are few. An understory fire can spread through litter, grass (if cured), and dead and down logs. As this forest ages, the potential for torching and crown fire increases.

EQUIPMENT LIST: Fuel Moisture Sampling Program

Containers: Sample cans should have tight fitting lids and be labeled with a letter/number that identifies the site and type of sample that the can will be used for.

Tape: Electrical tape to seal the lid onto the canister to prevent any moisture from escaping during transport.

Data Sheets: A prepared form to be sure all proper information about samples, site conditions, and sample weights is recorded for each visit.

Scale: A portable AC/DC digital gram scale (accurate to within 0.1 g) for weighing fuel samples. Also, a manual scale for recording moisture percentages of the 10 hour FMTL sticks. All scales should be periodically checked and/or calibrated for accuracy.

Pruning Shears: For hand cutting both dead and live 1 hour fuels (grasses and sagebrush tops) and for trimming samples to an appropriate size to fit the sample can.

10 hr FMTL sticks: 10 hour FMTL sticks and wire racks to be placed at most of the sampling sites in the manner described in the Fire Weather Observers Handbook.

Drill: A manual drill (a hand brace) for collecting samples from dead and down 1000 hour logs. Drill samples in the center of the log.

Ruler (optional): A go/no go gauge or ruler to measure fuel diameter so proper identification of the correct size class can be assured.

Drying Oven: A mechanical or gravity convection oven set at 95 –100 degrees C. which allows for the free circulation of inside air and the uniform drying of fuel samples.

Gloves: Gloves or hot pads for handling hot sample cans when they are removed from the oven.

Fuel Moisture Site GPS Locations (Datum NAD83)

Whitegrass Ranch	43.63962650,-110.76681026
Timbered Island	43.70712161,-110.71975895
Lost Creek	43.74858856,-110.62400945
Moran	43.83855136,-110.50226441
RKO Road	43.82067025,-110.59124895
Signal Mountain	43.85133862,-110.56485065
Flagg Ranch	44.10996258,-110.68558224

Fuel Moisture Site Maps and Photos

Please note: Photo files may be found on:

- *Fire Effects external photo drive, currently the F: drive, or;*
- *W:/FMO/Weather & Fuels/Fuel Moisture/Site Images.*

Google Earth KML file of Fuel Moisture Sampling Sites:

- *W:/FMO/Weather & Fuels/Fuel Moisture/Site Images/GTNP Fuel Moisture Sites.kmz*

Figure 1, Whitegrass Ranch Fuel Sampling Site

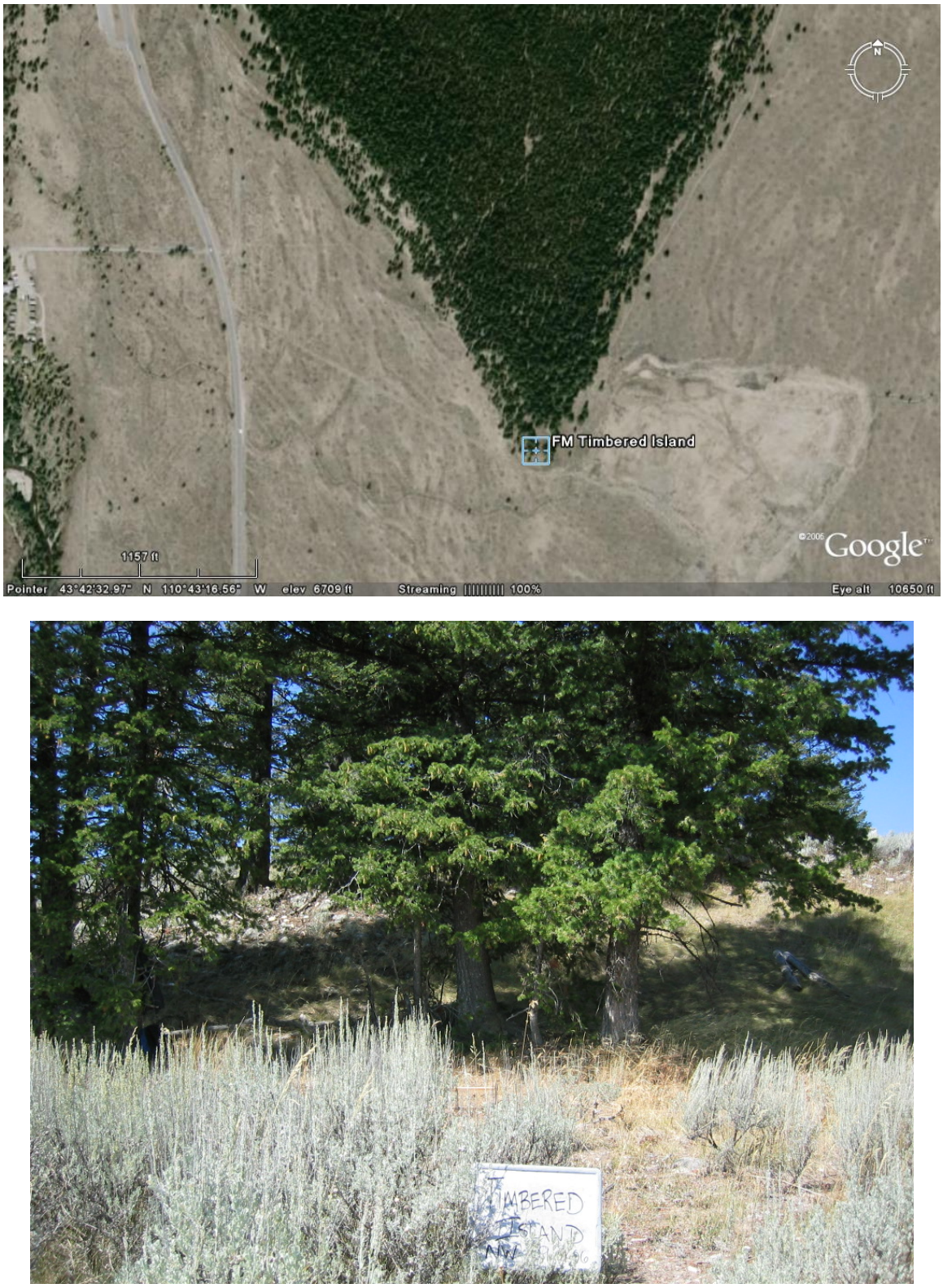

Figure 2, Timbered Island Fuel Sampling Site

Figure 3, Lost Creek Fuel Sampling Site

Figure 4, Moran Fuel Sampling Site

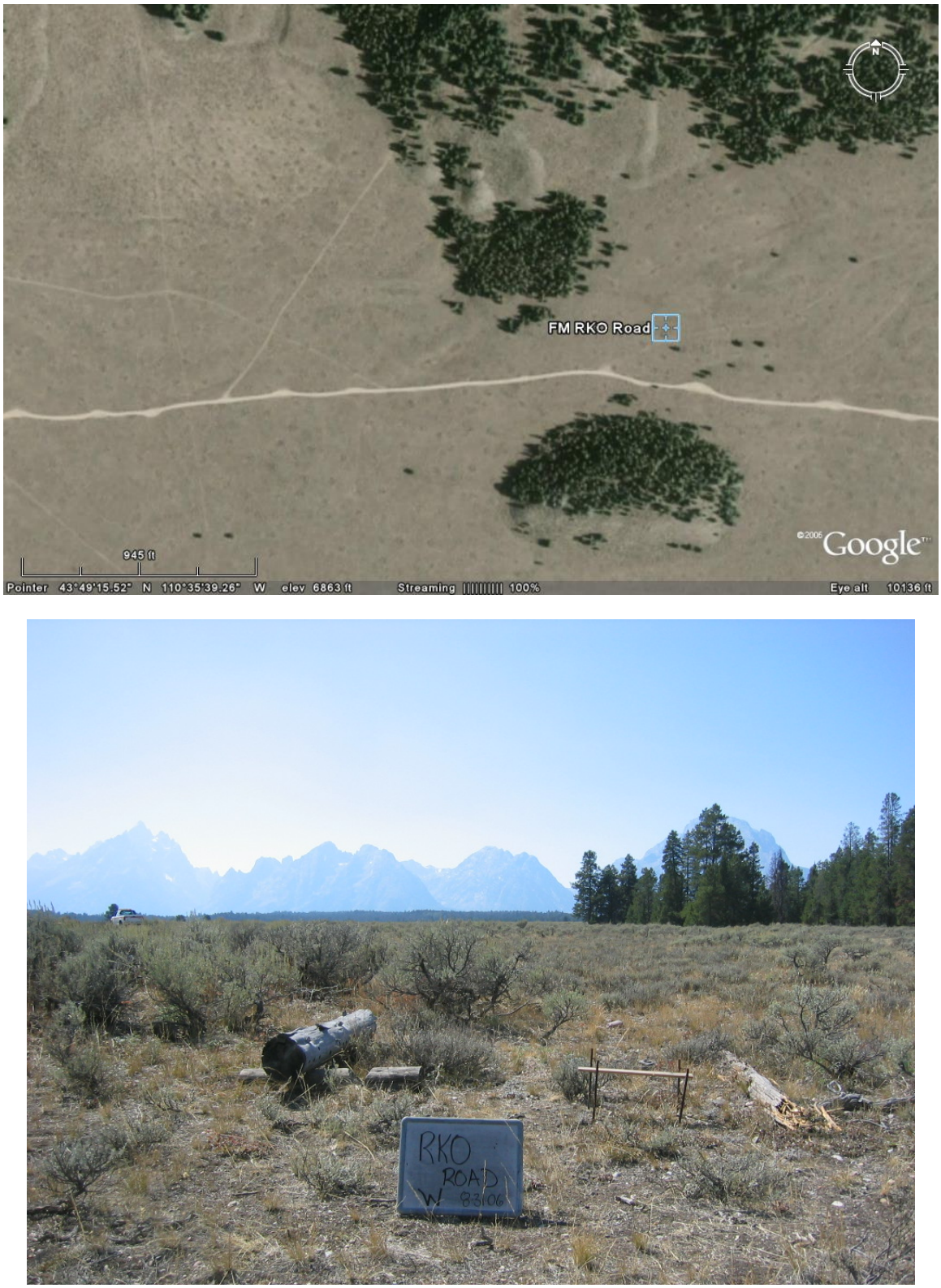

Figure 5, RKO Road Fuel Sampling Site

Figure 6, Signal Mountain Fuel Sampling Site

Figure 7, Flagg Ranch Fuel Sampling Site