Combustion Behavior of Fresh Wildland Forest Fuels

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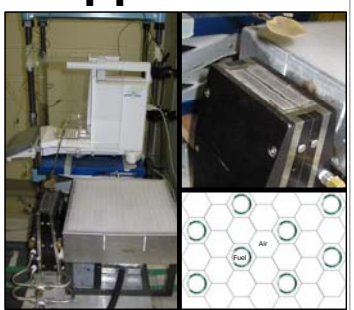
Background

- Fire suppression has caused fuel accumulation in forests
  - High fuel loads cause high intensity fires – damage to property and ecology
  - Prescribed burns are used to reduce fuel accumulation
- Current fire spread models are based on extensive empirical correlations
  - Correlations were performed on dry, dead fuels
  - Spread models do not accurately predict the effects of moisture in live vegetation
- Ground-up samples show similar burning characteristics from EGA analyses
  - Heat and mass transfer effects are important
  - Effects of extractives can be important
- Improve current models with combustion data for live vegetation
- Improve overall understanding of combustion of moist fuels in wildland fires

Experimental Apparatus

Flat Flame Burner

- Gases
  - Fuels (H_2, CH_4)
  - Oxidizer (Air)
  - Inert (N_2)
- Stoichiometry altered to obtain post-flame conditions
  - Temperature ~ 1000°C
  - O_2 Concentration ~ 10 mol%
  - Flame length ~ 1-3 mm
- Repeatable experiment



Data Available from Experiment

- Labview ~ 18-19 Hz
  - Mass balance (mg) reading
  - Thermocouple temperature (0.005 mm – Type K) inserted into sample
  - Video images
- IR Camera ~ 30 Hz
  - Surface temperature on sample
  - Able to obtain array of temperatures – not only one as with thermocouple
- Derived data
  - Ignition time and temperature
  - Mass release rates
  - Maximum flame height and time
  - Leaf geometry – surface area and perimeter

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Experimental Samples

California Species

- Ceanothus
  Ceanothus crassifolius
- Chamise
  Adenostoma fasciculatum Hook. & Am.
- Manzanita
  Arctostaphylos glandulosa
- Scrub Oak
  Quercus berberidifolia

Regional Species

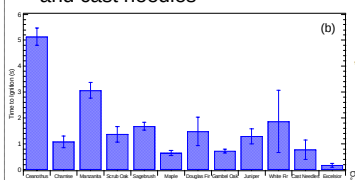
- Canyon Maple
  Acer grandidentatum Nutt.
- Gambel Oak
  Quercus gambelii Nutt.
- Utah Juniper
  Juniperus osteosperma (Torr.) Little
- Big Sagebrush
  Artemisia tridentata Nutt.
- Douglas Fir
  Pseudotsuga menziesii
- White Fir
  Abies concolor

Other Fuel Samples

- Pacific Northwest
  - Ponderosa pine
  - Lodgepole pine
- Southeastern United States
  - Saw palmetto
  - Wax myrtle
  - Large gallberry
- Others Samples
  - Cast pine needles
  - Excelsior

Time to Ignition

- Time to ignition also varies for live species
- Lower ignition time for excelsior and cast needles

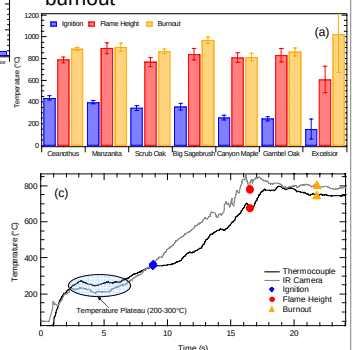


Temperature History

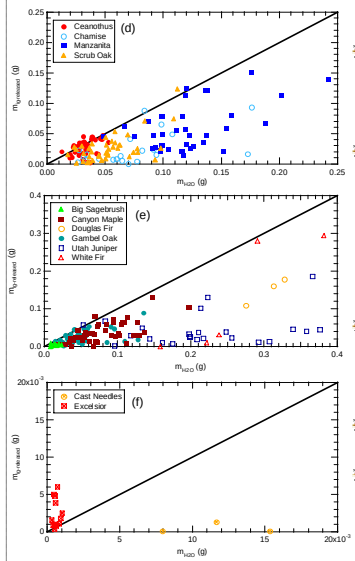
- No observed temperature plateau at 100°C from moisture evaporation
- Some observed plateaus at 200-300°C in thicker species
- Most qualitative information occurs before ignition
  - Color change
  - Bubbling
  - Bursting

Temperature

- Ignition temperature varies according to species
  - Live broadleaf species range from 436°C (Ceanothus) to 247°C (Gambel Oak)
  - Excelsior has a lower ignition temperature (152°C)
- Similar temperatures at maximum flame height and at burnout according to species
- Less variation among species at maximum flame height and burnout

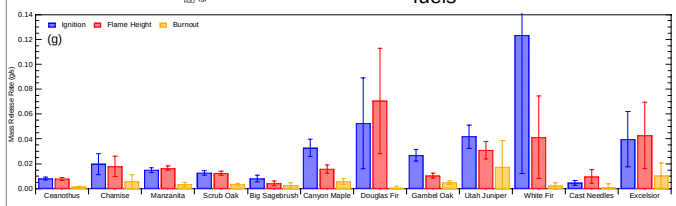


Mass



Moisture Effects

- Plots $m_{ig\text{-}released}$ vs m_{H2O} (d-f)
  - Mass of released matter at ignition
  - Mass of moisture in sample
- Ignition occurs before all moisture is driven off in live fuels
  - Most individual runs below parity line
  - Significantly below line for species
- Flammable species exhibit lower slope
  - Juniper
  - Chamise
- Relatively consistent with time to ignition
- Excelsior
  - Higher than parity line
  - Burns differently from live fuels



Conclusions

- Ignition parameters vary by species
  - Ignition temperature
  - Time to ignition
- No significant evaporation plateau observed at 100°C
- Ignition does not always occur before moisture is driven off
- Live and dead fuel difference
- Mass transfer (geometry) effects are significant
  - Surface area
  - Perimeter
- Moisture evaporation must be altered in models

Mass Release Rates

- Ignition vs flame height
  - Chaparral species similar
  - Regional species different
  - Due to moisture evaporation
- Geometry effects
  - Larger with higher surface area/perimeter
  - Non-broadleaf – high surface area
  - Large perimeter – Maple and Gambel Oak

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