Modeling the survival times of forest fires

Alisha Albert-Green[1], Charmaine Dean[1], Douglas Woolford[2], John Braun[3], David Martell[4] & Steven Cumming[5]

Harlan Campbell[1], Charmaine Dean[1], Steve Taylor[6] & Ken Lertzman[7]

1. Statistics & Actuarial Science, Simon Fraser U • 2. Mathematics, Wilfrid Laurier U. • 3. Statistical & Actuarial Sciences, U. of Western Ontario
4. Forestry, U. of Toronto • 5. Forestry, U. Laval • 6. Canadian Forest Service • 7. REM, Simon Fraser U.

MOTIVATION

- The lifetime of a forest fire, from ignition to extinguishment, is dependent on many variables such as cause (lightning or human), weather, fuel and suppression resources.
- Understanding how these variables affect the lifetime of a fire will allow for improved prediction ability and subsequently better fire suppression.
- The goal of this collaborative project is to construct statistical models for forecasting forest fire behavior over a two week period. Accurate forecasts are essential for effective fire suppression as they inform management decisions and short term resource allocation.
- Effective fire suppression will be increasingly challenging as climate change alters forest dynamics and weather patterns.
- With over 40 years of data accumulated for Alberta and British Columbia forest fires, this work is informed by a long and detailed history. Statistical methods will allow us to use this information to provide important tools for effective fire suppression in an uncertain future.

ALBERTA DATA AND STUDY AREA

- Data are available from 1961-2003 with records of all fires in Alberta including variables such as: report, attack and control dates, cause, fuel type, attack size, final size, longitude and latitude.
- Survival is defined as the time between attack and control.

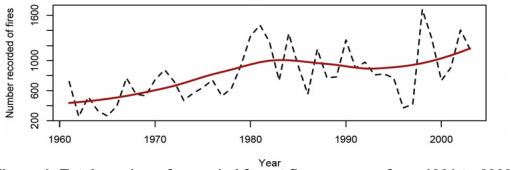

Figure 1: Total number of recorded forest fires per year from 1961 to 2003 for the province of Alberta.

BRITISH COLUMBIA DATA AND STUDY AREA

- Data are available from 1950-2002 for all fires, including variables such as: discovery and control dates, cause, fuel type, final size, longitude and latitude. We also have relevant historical weather data, as well as data on lightning occurrence.
- Survival is defined as the time between discovery and control.

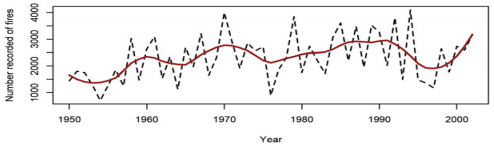

Figure 2: Total number of recorded forest fires per year from 1950 to 2002 for the province of British Columbia.

CHALLENGES

- The data provide many challenges for analysis:
  - Zero heavy data: A higher then expected number of short-lived fires.
  - Digit preference: Fire size arises as a mixed distribution. For fires under 1 ha., area burned is recorded as a few discrete values with a digit preference.
  - Inconsistencies: Management and policy changes (e.g. Alberta, 1983, British Columbia, 1980) result in different requirements for fire recording.
  - Historical weather data: The weather values for each fire in British Columbia were interpolated to a 5 km grid from primary weather station data (point locations) using inverse distance weighting with a temperature correction for elevation. The weather files were generated previously in Flannigan and Wotton (1989).

EXPLORATORY ANALYSIS

- Exploratory analysis was performed in order to shed light on the relationship between survival time and variables such as cause (lightning or human), weather, fuel, suppression resources and month of fire.

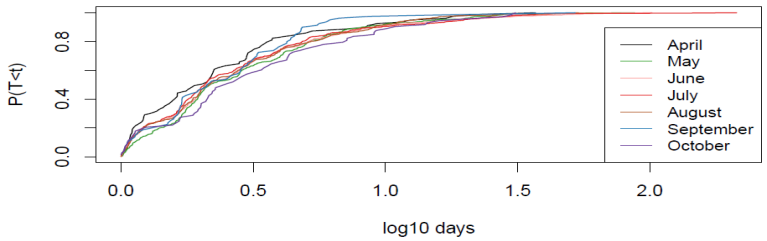

Figure 3: Monthly Survival for Alberta Fires: Cumulative empirical distribution of survival times (attack to control) in days (*x-axis*) by month of attack. Survival probability (*y-axis*) varies according to month of year. Fires in April and September have the shortest lifetimes.

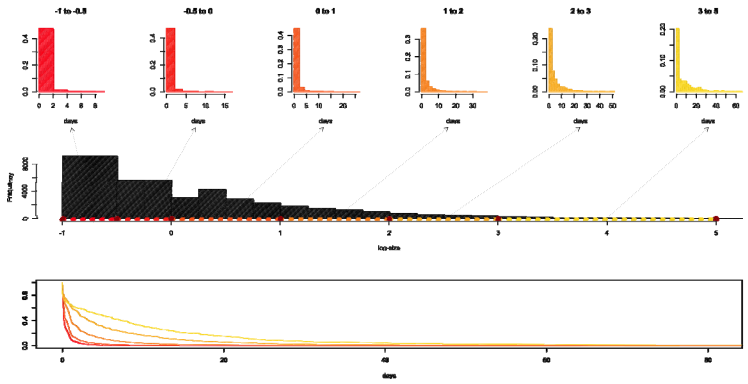

Figure 4: Survival vs. Size for B.C Fires. Top: Histograms display survival distribution of fires of a given log-10-size in ha. Mid: Histogram displays log-size distribution of fires. Bottom: Kaplan-Meier survival curves for fires of different log-size illustrate that, as the log-size of fires increases, the probability of extinguishment at any time decreases.

DATA VISUALIZATION

- The data is both spatial and longitudinal. Creative visualization illustrates factors that effect the survival times. In the plots below, we see the summer of 1982 in both British Columbia (Figure 5) and Alberta (Figure 6). Factors that initiate fires (e.g. lightning) and factors which terminate fires (e.g. rain events) are easily identifiable.

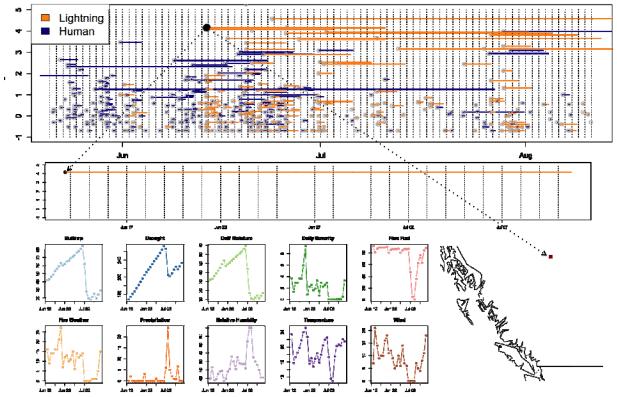

Figure 5: Top panel shows British Columbia fires during the summer of 1982 represented by horizontal lines (length = duration, height = size on the log-10 scale, colour = cause). The fire of interest (identified by the black circle), was ignited by lightning on June 13th and extinguished 27 days later on July 10th. Lower panel shows weather information collected during the 27 days (left) as well as location of the fire (right).

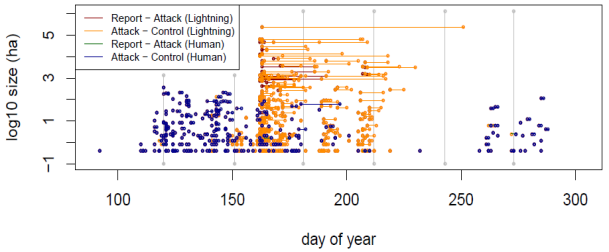

Figure 6: Alberta forest fires during 1982 are represented by horizontal lines (length = duration, height = size on the log-10 scale, colour = cause). Early June is hit by a barrage of lightning caused fires. Digit preference can be seen as fires with final size less than 1 ha are recorded to one decimal place.

REFERENCES

Flannigan, M.D. and Wotton B.M. 1989. A study of interpolation methods for forest fire danger rating in Canada. Canadian Journal of Forest Research, 19:1059-1066.

ACKNOWLEDGEMENTS

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