This readme file describes the study and shared datasets for the journal article:

Ager AA, Evers CR, Day MA, Preisler HK, Barros AM, Nielsen-Pincus M. 2017. Network analysis of wildfire transmission and implications for risk governance. PLoS ONE. 12(3): e0172867. doi: 10.1371/journal.pone.0172867

This study includes data concerning simulated wildfire data (ignition locations, simulated fire perimeters, wildfire likelihood and intensity, wildfire transmission networks and firesheds).

\*Abstract\*

We characterized wildfire transmission and exposure within a matrix of large land tenures (federal, state, and private) surrounding 56 communities within a 3.3 million ha fire prone region of central Oregon US. Wildfire simulation and network analysis were used to quantify the exchange of fire among land tenures and communities and analyze the relative contributions of human versus natural ignitions to wildfire exposure. Community firesheds, the area where ignitions can spawn fires that can burn into the wildland urban interface, were also quantified. The results provide a first multi-scale characterization of wildfire networks within a large, mixed tenure and fire prone landscape, and illustrate the connectivity of risk between communities and the surrounding wildlands.

\*Study Area and Design\*

The study area was part of the “Forests, People, Fire” project (<http://fpf.forestry.oregonstate.edu/>) and spans 3.3 million ha in central Oregon, along the east slope of the Cascade range.

\*Land Tenure Data\*

The major land ownerships in the study area are the federal government (66%), Warm Springs tribal council (8%), and private industrial (7%). The Bureau of Land Management (BLM) and non-industrial private owners own roughly 6% and 4% of the area respectively. The latter are relatively small tracks of land ranging from 5 to 100 ha. Oregon state forested lands account for 1% of the study area. Federal land includes the Deschutes and Fremont-Winema National Forests, Crater Lake National Park, BLM and areas managed by the US Fish and Wildlife Service. A small portion (1%) of the landscape includes minor federal owners such as the Department of Energy and Department of Defense. The ownership data were combined with federal land management data to create a land tenure dataset using data sources from the “Forest, People, Fire” study. National forest lands were partitioned based on land and resource management plans into protected areas (various conservation and biodiversity reserves) versus those available for mechanical fuel treatments. All other federal land with the exception of national park land was considered available for mechanical fuel treatment. The separation of managed versus non-managed was then incorporated into the land tenure classification.

In addition to the land tenures listed above, we created a community class based on core communities and surrounding sparsely populated wildland urban interface (WUI) areas. We defined core communities within the study area according to the US Census data on community boundaries (<http://www.arcgis.com/home/item.html?id=4e75a4f7daaa4dfa8b9399ea7464189>). Fifty-six communities were identified in these data. We then attached surrounding SILVIS wildland urban interface (WUI) (<http://silvis.forest.wisc.edu/maps/wui/2010/download>) polygons outside the core community boundary based on distance to the closest community core. We removed SILVIS polygons that were: (1) classified as uninhabited, (2) classified as water, or (3) < 0.1 ha in size. All other WUI polygons were assigned to a community and each WUI polygon was attributed with housing unit density (hereafter referred to as structures) and area (ha). The resulting community layer consisted of both the core area defined in the US Census and the adjacent WUI (56 communities). Note one community did not receive wildfire from any adjacent land tenure (fire transmission = 0).

\*Wildfire Simulation\*

Fire simulations used a spatiotemporal fire prediction system and are described in detail Ager et al. (2017) and supplementary files. The spatiotemporal ignition prediction model was built in R using 18 years of ignition data (<http://dx.doi.org/10.2737/RDS-2013-0009.2>) to calculate: (1) the probability of a fire in a given pixel as a function of daily energy release component (ERC), location (X,Y coordinate) and day-of-year; and (2) the expected fire size for locations where the above-mentioned probability equals one as a function of daily ERC and location. We separated human-caused ignitions and fires from natural-caused ignitions and fires. We executed the spatiotemporal ignition model to generate 3000 fire seasons for a total of 63,736 simulated fires. The fire lists generated contained ignition location, day-of-year, year, cause, ERC, wind speed, wind direction, fuel moisture file, burn period and expected fire size of each simulated fire.

We used a version of the minimum travel time (MTT) algorithm encapsulated in FConstMTT, a command line version of FlamMap to simulate fires based on the predicted ignitions. Surface and canopy fuel were obtained from the national LANDFIRE dataset (<https://www.landfire.gov/>). FConstMTT simulations were performed at 9m resolution and generated: (1) fire perimeters, (2) annual burn probabilities, and (3) conditional burn probabilities for 20 0.5 m flame length categories. The burn probability (BP) for a given intensity class is the ratio of the number of times a pixel burned to the total number of fires simulated and estimates the annual burn probability at each pixel. The conditional burn probabilities are output as a gridded point file and estimate the probability of a fire at a given intensity. A probability weighted average conditional flame length (CFL) was calculated from the conditional burn probabilities to measure the expected flame length given a pixel burns.

\*Wildfire Transmission\*

We calculated wildfire transmission among land tenures by intersecting the fire perimeter outputs and ignition locations with the land tenure and community map. We then cross-tabulated total area burned in each land class and community by ignition source to derive the amount of incoming (TF-IN), outgoing (TF-OUT), and non-transmitted fire (NonTF). The resulting data were then used to build transmission networks to analyze the connectivity among specific land tenures and into communities. Networks are comprised of nodes and edges with nodes representing land tenures or communities, while edges represent the directional transmission of wildfire. Nodes represented multiple polygons for a given land designation; hence the edges measure the aggregate transmission of all the polygons of one land tenure to the polygons of other land tenures. Network construction and analysis were done in R using the igraph package. Two networks were generated at two scales: (1) large land tenures, and (2) individual communities.

\*Community Firesheds\*

We intersected fire perimeters generated from the fire simulations with community polygons and then calculated the number of structures in each community potentially affected. The structure estimates were calculated as the product of the proportion of area of each community polygon burned and the structure count for that polygon. Structures were grouped by community (n=56) allowing a single ignition point to create wildfire exposure in multiple communities. We define community firesheds as the areas that are likely to transmit wildfire to communities. Using the simulation outputs described above we created a continuous smoothed surface of structure exposure for each community using the logistic kriging algorithm in the R gstat package in R. Kriging is based on a semi-variogram that captures observed spatial dependence between points. Since the kriging algorithm is generalizable we used it to capture occurrence data as a binary logit function. The kriging surface describes the predicted likelihood that an ignition occurring at a given point would expose structures to wildfire within that community (i.e. values varied between 0 and 1). To convert the kriging surface to a discrete boundary (i.e. the fireshed) we used a threshold of 0.1 meant to capture ignition locations where there was at least a nominal (10%) chance of exposure. To account for areas in the fireshed where ignitions were rare or absent we removed areas where the ignition point density was very low (i.e. less than 1.5e-4 km-2). Finally, community firesheds were intersected with the land tenure map to calculate the fireshed area by land tenure, and the proportion of the study area that transmits fire to the WUI.

\*File List and Attributes\*

FPF\_input\_firelist.csv

Comma delimited ASCII text file containing ignition information for 3000 fire seasons in the “Forest, People, Fire” study area output from the spatiotemporal fire prediction model used as an input file to simulate fire spread with FConstMTT. These data contain the following information for each ignition:

Yr = fire year

Prob = probability of ignition [always 1]

Julian = day-of-year [1-365]

BurnPer = burn period (min), number of minutes a fire spreads, correlated to fire size

WindSpeed = wind gust speed (mph)

Azimuth = wind gust direction

FMfile = fuel moisture filename, identifies the fuel moisture input file that describes fuel moisture for dead and live fuels

IgnitionX = X coordinate of ignition [NAD\_1983\_Albers]

IgnitionY = Y coordinate of ignition [NAD\_1983\_Albers]

Original\_Size = fire size (ha)

ERC = Energy Release Component ; National Fire Danger Rating System Index that tracks daily and seasonal moisture of dead and live fuels and relates to the available energy per unit area within the flaming front at the head of a fire

Cause = ignition cause [1 = lightning; 2 = human]

listID = unique fire by firelist ID concatenating firelist #, fire year and day-of-year

ignitionID = unique long integer fire ID

FPF\_output\_firelist.csv

Comma delimited ASCII text file containing ignition information for 3000 fire seasons in the “Forest, People, Fire” study area output from FConstMTT. File contains fields generated from the spatiotemporal ignition prediction model and additional fields created from FConstMTT. These data contain the following information for each ignition:

XCoord = X coordinate of ignition (NAD\_1983\_Albers)

YCoord = Y coordinate of ignition (NAD\_1983\_Albers)

SIZEHA = fire size (ha) simulated by FConstMTT

YEAR = Ignition year

PROB = probability of ignition [always 1]

JULIAN = day-of-year [1-365]

BURNPER = burn period (min), number of minutes a fire spreads, correlated to fire size

WINDSPEED = wind gust speed (mph)

AZIMUTH = wind gust direction

FMFILE = fuel moisture filename, identifies the fuel moisture input file that describes fuel moisture for dead and live fuels

ORIGSIZE = original fire size (ha) predicted by the spatiotemporal ignition prediction model

ERC = Energy Release Component ; National Fire Danger Rating System Index that tracks daily and seasonal moisture of dead and live fuels and relates to the available energy per unit area within the flaming front at the head of a fire

Cause = ignition cause [1 = lightning; 2 = human]

ignitionID = unique long integer fire ID

FPF\_fire\_perimeters.shp

ArcGIS polygon shapefile containing all fire perimeter polygons associated with ignitions predicted by the spatiotemporal ignition prediction model in the “Forest, People, Fire” study area and simulated in FConstMTT. The attribute table includes the following information:

FID = unique feature ID

Shape = feature shape [Polygon]

SizeHa = fire size (ha) simulated by FConstMTT

XCoord = X coordinate of ignition (NAD\_1983\_Albers)

YCoord = Y coordinate of ignition (NAD\_1983\_Albers)

Year = Ignition year

Prob = probability of ignition [always 1]

Julian = day-of-year [1-365]

BurnPer = burn period (min), number of minutes a fire spreads, correlated to fire size

WindSpeed = wind gust speed (mph)

Azimuth = wind gust direction

FMfile = fuel moisture filename, identifies the fuel moisture input file that describes fuel moisture for dead and live fuels

OrigSize = original fire size (ha) predicted by the spatiotemporal ignition prediction model

FPF\_BP\_CFL\_pixellevel.csv

Comma delimited ASCII text file containing the burn probability, conditional flame length and land tenure classification for each 90-m pixel in the “Forest, People, Fire” study area. These data contain the following variables:

Tenure = land tenure [Community, Native, Other Fed, BLM, Private, NF-P, Other, PI, NF-M; see FPF\_LandTenure\_Groups.csv ]

BP = conditional burn probability, the ratio of the number of times a pixel burned to the total number of fires simulated, estimates the annual burn probability [0-1]

CFL = conditional flame length (m), expected flame length given a pixel burns [

FPF\_Network\_FireTransmission.csv

Comma delimited ASCII text file containing the area burned for each of 56 communities in the “Forest, People, Fire” study area by surrounding large land tenures. These data contain the following variables:

tenure\_source = land tenure source, ignition source of transmitted wildfire [see FPF\_LandTenure\_Groups.csv]

tenure\_sink = land tenure sink, recipient of transmitted wildfire; large land tenure or 1 of 56 communities in the study area; community is defined by community core plus wildland urban interface [see FPF\_LandTenure\_Groups.csv]

TF\_human\_ha = area burned annually (transmitted fire) from human-caused wildfire ignited on one land tenure and transmitted to another land tenure or community (hectares)

TF\_natural\_ha = area burned annually (transmitted fire) from lightning-caused wildfire ignited on one land tenure and transmitted to another land tenure or community (hectares)

FPF\_Fireshed\_Community.csv

Comma delimited ASCII text file containing the fireshed surrounding the 56 communities in the “Forest, People, Fire” study area associated with each large land tenure based on both area burned and housing units exposed. These data contain the following variables:

community = community land tenure, recipient of transmitted wildfire; 1 of 56 communities in the study area; community is defined by community core plus wildland urban interface [see FPF\_LandTenure\_Groups.csv]

tenure = large land tenure source, ignition source of transmitted wildfire [see FPF\_LandTenure\_Groups.csv]

fireshed\_area\_ha = area of land tenure within each community fireshed (ha); fireshed is defined as the area where ignitions can spawn fires that burn into communities

exposure\_hu = number of structures annually exposed to transmitted wildfire

FPF\_LandTenure\_Groups\_csv

Comma delimited ASCII text file containing the land tenure codes and names defined in the “Forest, People, Fire” wildfire transmission study and associated description where applicable. These data contain the following variables:

Land\_Tenure\_Code = code indicating land tenure

Land\_Tenure\_Name = full name of land tenure

Network\_Type = land tenure type [large land tenure; community]

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