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**Supplementary Material**

# Mesoscale spatio-temporal predictive models of daily human and lightning-caused wildland fire occurrence in British Columbia

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## Supplement 1. List of Abbreviations

| | | | |
|---|---|---|---|
| AL | Aleutian Low | NCEP | National Centre for Environmental Prediction |
| AUC | Area Under Curve | NDVI | Normalized Difference Vegetation Index |
| AVHR | Advanced Very High Resolution Radiometer | NOAA | National Oceanographic and Atmospheric Agency |
| BUI | Buildup Index | NPH | North Pacific High |
| CLDN | Canadian Lightning Detection System | NWS | National Weather Service |
| CWFIS | Canadian Wildland Fire Information System | OLCF | Observed Lighting Caused Fire |
| DC | Drought Code | OLR | Ordinary Logistic Regression |
| DMC | Duff Moisture Code | $p_{drop}$ | proportion of times the $i^{th}$ covariate is dropped from $M$ model fits |
| DSR | Daily Severity Rating | | |
| FFMC | Fine Fuel Moisture Code | PLCF | Predicted Lighting Caused Fire |
| FWI | Fire Weather Index | PSUF | Probability of Sustained Flaming |
| HCF | Human Caused Fire | RMSPE | Root Mean Squared Percentage Error |
| ISI | Initial Spread Index | RAWS | Remote Automatic Weather Station |
| MODIS | Moderate Resolution Imaging Spectroradiometer | ROC | Receiver Operator Characteristic |
| MSC | Meteorological Service of Canada | SDMC | Sheltered Duff Moisture Code |
| NAEFS | North American Ensemble Forecast System | TPS | Thin Plate Spline |
| NARR | North American Regional Reanalysis | WII | Wildland Industrial Interface |
| | | WUI | Wildland Urban Interface |

## Supplement 2. Procedure for Ranking Covariate Importance from M Regression Model Fits

Where fire occurrences are rare events in a large set of voxels, subsampling can be used to obtain M balanced datasets, and a model fit to each dataset where the variable coefficients ${\beta^{\Delta}}_i$ and variable ranking are unique to each model fit. While the set of coefficients from each fit can be averaged in an ensemble model as ${\overline{\beta}^{\Delta}}_i = \sum_{j=1}^{M} {\beta^{\Delta}}_{i,j} / M$, the estimation of variable importance in the ensemble is less obvious. We developed a general procedure to rank the covariates from M model fits that can be applied to any ensemble regression, and a particular application for lasso logistic regression where coefficients can be zero. A summary of this procedure is as follows.

1. Compute the standardized coefficients. For regression covariates $\boldsymbol{x} = (x_1, x_2, \dots, x_P)^t$, let us notate $\boldsymbol{\beta}_j = (\beta_{1,j}, \beta_{1,j}, \dots, \beta_{P,j})^t$ be the vector of coefficients resulting from the $j^{\text{th}}$ fit of the Lasso logistic model, $j = 1, 2, \dots, M$. These coefficients correspond to covariates on the original scale of measurement. We compute a corresponding vector of *standardized coefficients*, notated as $\boldsymbol{\beta^{\Delta}}_j = (\beta^{\Delta}{}_{1,j}, \beta^{\Delta}{}_{1,j}, \dots, \beta^{\Delta}{}_{P,j})^t$, with ${\beta^{\Delta}}_{i,j}$ defined as:

$$ {\beta^{\Delta}}_{i,j} = \text{s.d}(x_i)\beta_{i,j} $$

where $\text{s.d}(x_i)$ is the standard deviation of observations for the $i^{th}$ covariate. These standardized coefficients correspond to transformed covariates: $z_k = \frac{x_k - \bar{x}_k}{\text{s.d}(x_k)}$.

2. Sort and rank the standardized coefficients. Let $(R_{1,j}, R_{2,j}, \dots, R_{P,j})$ be the ranks assigned to absolute values of ${\beta^{\Delta}}_{i,j}$: $\left(\left|\beta^{\Delta}{}_{1,j}\right|, \left|\beta^{\Delta}{}_{2,j}\right|, \dots, \left|\beta^{\Delta}{}_{P,j}\right|\right)$; where $1 \le R_{i,j} \le P$. Note that the covariates

ranked at $P$ and 1 have the highest and lowest values of the absolute standardized coefficients, respectively. The resulting *sorted* $\boldsymbol{\beta}^{\Delta}{}_{j}$ vector is denoted as $\widetilde{\boldsymbol{\beta}}_{j} = \left(\left|\beta^{\Delta}{}_{i^{(1)},j}\right|, \left|\beta^{\Delta}{}_{i^{(2)},j}\right|, \ldots, \left|\beta^{\Delta}{}_{i^{(P-1)},j}\right|, \left|\beta^{\Delta}{}_{i^{(P)},j}\right|\right)$, such that $\left|\beta^{\Delta}{}_{i^{(h)},j}\right| \leq \left|\beta^{\Delta}{}_{i^{(h+1)},j}\right|$ and $X_{i^{(h)}}$ is the covariate whose assigned rank value is $h$. For instance, if $X_5$ gets assigned a rank value of 10, we have $i^{(10)} = 5$. Note also that for a given rank position $h$, $X_{i^{(h)}}$ can differ between model fits for $j = 1, 2, \ldots, M$.

3. A combined rank based on $M$ fits of the model is given by the following formula:

$$Rank(X_i) = M^{-1} \sum_{h=1}^{P} \sum_{j=1}^{M} h I_{R_{i,j}=h}, \quad (1)$$

where $I_A$ is an indicator function of event *A* and $h$ indicates the rank positon.

4. Lasso logistic application. For a given Lasso logistic fit with a large number of covariates, normally several of them are forced to zero values at convergence as a consequence of the L1 regularization penalty. When displaying a ranking of estimated coefficients based on Lasso logistic fit, these *zeroed-out* coefficients need not be included in the ranking as they have no effect on the estimated response. Therefore the covariates dropped from selection in that $j^{\text{th}}$ fit should be penalized. This is achieved by restructuring (1) as follows: A modified version of ranking algorithm (1) is therefore presented as follows

$$Rank(X_i) = M^{-1} \sum_{j=1}^{M} \sum_{h=1}^{P} h I_{R_{i,j}=h} I_{\left|\beta^{\Delta}{}_{i,j}\right|>0}, \quad (2)$$

where $Rank(X_i) \leq P$, and ii) $\sum_{i=1}^{P} Rank(X_i) \leq \sum_{h=1}^{P} h$.

5. Lasso logistic with many zero covariates. A scenario can arise when several of the covariates are repeatedly zeroed-out in almost all of the $M$ model fits, causing all the regression coefficients

falling within a certain rank position to become zero. Therefore, the effective maximum rank is given as:

$$P_{EF} = max\left\{h \in (1, 2, \dots, P) : \sum_{j=1}^{M} \sum_{i=1}^{P} \left|\beta^{\Delta}{}_{i,j}\right| I_{R_{i,j}=h} > 0\right\},$$

where $\sum_{i=1}^{P} \left|\beta^{\Delta}{}_{i,j}\right| I_{R_{i,j}=h} = \left|\beta^{\Delta}{}_{i^{(h)},j}\right|$ for a given value of $h$, and $P_{EF} \leq P$.

Now, assuming $\boldsymbol{B} = \left[\left|\widetilde{\boldsymbol{\beta}}_1\right|, \left|\widetilde{\boldsymbol{\beta}}_2\right|, \dots, \left|\widetilde{\boldsymbol{\beta}}_M\right|\right]^t$ be the $M \times P$ matrix whose entries $(j, h)$ are given as $\left|\beta^{\Delta}{}_{i^{(h)},j}\right|$. A modified version of $Rank(X_i)$ for a maximum effective rank $P_{EF}$, is then defined as:

$$Rank(X_i) = M^{-1} \sum_{j=1}^{M} \sum_{h=1}^{P_{EF}} h I_{i=i^{(h)}} I_{\left|\beta^{\Delta}{}_{i^{(h)},j}\right|>0}, \tag{3}$$

where $X_i \in \boldsymbol{\chi}$, and the second summation on the right is taken over the first $P_{EF}$ columns of $\boldsymbol{B}$. Here, (3) now satisfies the properties:

i) $0 < Rank(X_i) \leq P_{EF}$ and,

ii) ii) $\sum_{i=1}^{P} Rank(X_i) \leq \sum_{h=1}^{P_{EF}} h$, where $Rank(X_i) = 0$ for $X_i \in \boldsymbol{\chi}^{c}$.

We use (3) as a basis for ranking covariates arising from the *M* model fits. We report the results in Tables 3-4 and Tables S1-S3. A paper with a formal proof of this procedure and examples for other applications is in preparation.

## Supplement 3. Supplementary Figures and Tables

**Table S1. Complete OLCF Model (with lightning strikes).** Variable ranking based on rank scores computed via Eq. (3), where $P_{EF} = 39$. Variable type colours: purple – baseline risk; red – lightning quantities; black - geographic, periodic; green – vegetation; blue – meteorology . Variables in bold were selected as the most influential covariates as per $p_{Drop}$ criterion depicted in Fig. 7. Variables dropped out in all model fits: ELEVATION, DC, FWI, DSR, ACCUM PRECIPITATION, DMC..TEMPERATURE, ISI..TEMPERATURE, BUI..TEMPERATURE, FWI..TEMPERATURE, SDMC..TEMPERATE, ISI..ACCUM PRECIP, FWI..ACCUM PRECIP, RELATIVE HUMIDITY$^2$ and FFMC$^2$.

| Rank | Covariate | Rank Score | $\check{\beta}^{\Delta}{}_i$ | $p_{Drop}$ | Rank | Covariate | Rank Score | $\check{\beta}^{\Delta}{}_i$ | $p_{Drop}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **LIGHTNING RISK RANK** | 38.586 | 1.330114 | 0.000 | 28 | BUI$^2$ | 8.752 | -0.072891 | 0.498 |
| 2 | **LIGHTNING STRIKES** | 37.720 | 1.282861 | 0.000 | 29 | BUI..ACCUM PRECIP | 8.360 | -0.076215 | 0.546 |
| 3 | **LIGHTNING INDICATOR** | 37.038 | 1.164104 | 0.000 | 30 | PRECIPITATION LAG3 | 8.008 | -0.018876 | 0.422 |
| 4 | **SDMC** | 35.970 | 1.057826 | 0.000 | 31 | FWI$^2$ | 7.720 | -0.038296 | 0.510 |
| 5 | **TEMPERATURE** | 35.684 | 1.063949 | 0.000 | 32 | DECIDUOUS COVER | 5.800 | -0.028688 | 0.610 |
| 6 | **RELATIVE HUMIDITY** | 31.978 | 0.284032 | 0.000 | 33 | LIGHTNING STRIKES LAG | 3.414 | 0.010404 | 0.714 |
| 7 | **SDMC$^2$** | 31.526 | -0.338001 | 0.022 | 34 | TEMPERATURE$^2$ | 2.224 | 0.056534 | 0.870 |
| 8 | **LONGITUDE** | 30.952 | -0.259260 | 0.000 | 35 | % DECIDUOUS$^2$ | 2.176 | 0.018985 | 0.814 |
| 9 | **VEGETATION COVER** | 30.636 | -0.252251 | 0.000 | 36 | DMC..ACCUM PRECIP | 2.158 | -0.049385 | 0.868 |
| 10 | **PSUF** | 30.120 | 0.242519 | 0.000 | 37 | DMC | 1.952 | 0.061082 | 0.880 |
| 11 | **BUI** | 29.676 | 0.259579 | 0.008 | 38 | MONTANE CORDILLERA | 1.914 | -0.022526 | 0.852 |
| 12 | **DC..ACCUM PRECIP** | 27.802 | -0.182046 | 0.000 | 39 | % CONIFER | 1.820 | 0.019625 | 0.876 |
| 13 | **PACIFIC MARITIME** | 27.640 | 0.176857 | 0.000 | 40 | PRECIPITATION LAG2 | 1.226 | -0.004405 | 0.894 |
| 14 | **PRECIPITATION LAG1** | 24.092 | -0.106730 | 0.000 | 41 | WIND SPEED | 1.094 | -0.001507 | 0.904 |
| 15 | **ROUGHNESS** | 22.808 | 0.093095 | 0.000 | 42 | FFMC..TEMPERATURE | 0.712 | 0.048778 | 0.948 |
| 16 | **PRECIPITATION** | 21.112 | 0.073241 | 0.002 | 43 | DC..TEMPERATIRE | 0.698 | 0.041140 | 0.948 |
| 17 | **DMC$^2$** | 20.334 | -0.125823 | 0.162 | 44 | WIND SPEED$^2$ | 0.466 | -0.008332 | 0.958 |
| 18 | **FFMC..ACCUM PRECIP** | 19.096 | 0.094724 | 0.132 | 45 | % DECIDUOUS | 0.454 | 0.024804 | 0.962 |
| 19 | **LIGHTNING STRIKES LAG2** | 18.080 | -0.049013 | 0.002 | 46 | % CONIFER2 | 0.330 | -0.024999 | 0.968 |
| 20 | **ELEVATION$^2$** | 17.874 | 0.063310 | 0.080 | 47 | ISI$^2$ | 0.206 | -0.029491 | 0.984 |
| 21 | **BOREAL PLAIN** | 16.834 | 0.045933 | 0.040 | 48 | SDMC..ACCUM PRECIP | 0.176 | -0.074948 | 0.988 |
| 22 | **DC$^2$** | 15.302 | -0.046904 | 0.122 | 49 | FFMC | 0.140 | 0.015843 | 0.984 |
| 23 | **AVERAGE NDVI** | 14.640 | 0.038505 | 0.106 | 50 | ISI | 0.058 | 0.026699 | 0.994 |
| 24 | CONIFER COVER | 12.960 | 0.057565 | 0.286 | 51 | BOREAL CORDILLERA | 0.044 | -0.025778 | 0.996 |
| 25 | LATITUDE | 12.808 | 0.058650 | 0.302 | 52 | TREE COVER | 0.032 | 0.034944 | 0.998 |
| 26 | TAIGA PLAIN | 11.584 | -0.032591 | 0.254 | 53 | AVERAGE NDVI$^2$ | 0.028 | 0.007826 | 0.998 |
| 27 | % MIXEDWOOD | 10.386 | -0.032352 | 0.344 | | | | | |

**Table S2. Complete PLCF Model (without lightning strikes).** Variable ranking based on rank scores computed via Eq. (3), where $P_{EF} = 47$. Variable type colours: purple – baseline risk; black - geographic, periodic; green – vegetation; blue – meteorology.Variables in bold were the most influential covariates as per $p_{Drop}$ criterion depicted in Fig. 7. Variables dropped out in all model fits: DSR, ACCUM PRECIPITATION, ISI..TEMP, FWI..ACCUM and FFMC$^2$.

| Rank | Covariate | Rank Score | $\check{\beta}^{\Delta}{}_i$ | $p_{Drop}$ | Rank | Covariate | Rank Score | $\check{\beta}^{\Delta}{}_i$ | $p_{Drop}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **LIGHTNING RISK RANK** | 46.4 | 1.551 | 0.000 | 33 | FFMC..ACCUM PRECIP | 13.88 | 0.052 | 0.256 |
| 2 | **TEMPERATURE** | 46.3 | 1.547 | 0.000 | 34 | ISI | 12.81 | 0.077 | 0.396 |
| 3 | **SDMC** | 45.3 | 1.462 | 0.000 | 35 | BOREAL PLAIN | 11.31 | 0.017 | 0.090 |
| 4 | **RELATIVE HUMIDITY** | 44.0 | 0.952 | 0.000 | 36 | WIND SPEED | 9.98 | -0.023 | 0.238 |
| 5 | **SDMC$^2$** | 42.4 | -0.502 | 0.000 | 37 | % MIXEDWOOD | 8.90 | -0.019 | 0.294 |
| 6 | **SHOWALTER INDEX** | 42.2 | -0.490 | 0.000 | 38 | DMC..TEMPERATURE | 7.35 | -0.069 | 0.636 |
| 7 | **DC..ACCUM PRECIP** | 38.6 | -0.241 | 0.000 | 39 | BUI$^2$ | 6.95 | -0.045 | 0.586 |
| 8 | **VEGETATED** | 38.5 | -0.235 | 0.000 | 40 | BUI..ACCUM PRECIP | 5.85 | -0.064 | 0.706 |
| 9 | **C-HAINES INDEX** | 37.9 | -0.222 | 0.000 | 41 | TOTALS INDEX | 4.69 | 0.022 | 0.616 |
| 10 | **LATITUDE** | 37.7 | 0.219 | 0.000 | 42 | DC$^2$ | 4.30 | 0.027 | 0.664 |
| 11 | **PRECIPITATION** | 36.7 | 0.205 | 0.000 | 43 | % DECIDUOUS$^2$ | 4.28 | 0.011 | 0.590 |
| 12 | **BUI** | 33.3 | 0.171 | 0.004 | 44 | AVERAGE NDVI$^2$ | 3.41 | -0.033 | 0.742 |
| 13 | **RELATIVE HUMIDITY$^2$** | 32.9 | -0.338 | 0.124 | 45 | WIND SPEED$^2$ | 3.16 | -0.019 | 0.730 |
| 14 | **DC..TEMPERATURE** | 31.2 | -0.139 | 0.008 | 46 | % DECIDUOUS | 2.47 | 0.012 | 0.752 |
| 15 | **ROUGHNESS** | 30.4 | 0.115 | 0.000 | 47 | BOREAL CORDILLERA | 2.24 | -0.008 | 0.770 |
| 16 | **PACIFIC MARITIME** | 29.1 | 0.108 | 0.002 | 48 | TREE COVER | 1.22 | 0.018 | 0.908 |
| 17 | **DMC..ACCUM PRECIP** | 28.5 | -0.134 | 0.050 | 49 | FWI..TEMPERATURE | 1.14 | -0.039 | 0.922 |
| 18 | **PRECIPITATION LAG3** | 28.5 | -0.102 | 0.000 | 50 | ISI$^2$ | 0.62 | 0.003 | 0.940 |
| 19 | **K INDEX** | 28.1 | -0.103 | 0.006 | 51 | DECIDUOUS COVER | 0.36 | -0.011 | 0.968 |
| 20 | **PSUF** | 27.5 | 0.106 | 0.014 | 52 | LONGITUDE | 0.33 | 0.008 | 0.968 |
| 21 | **PRECIPITATION LAG2** | 26.7 | -0.092 | 0.000 | 53 | DMC | 0.31 | 0.021 | 0.972 |
| 22 | **CONIFER COVER** | 24.9 | 0.087 | 0.018 | 54 | FFMC..TEMP | 0.25 | 0.017 | 0.976 |
| 23 | **FWI$^2$** | 24.8 | -0.091 | 0.024 | 55 | MONTANE CORDILLERA | 0.15 | -0.015 | 0.984 |
| 24 | **PRECIPITATION LAG1** | 22.9 | -0.072 | 0.000 | 56 | SDMC..ACCUM PRECIP | 0.14 | -0.109 | 0.994 |
| 25 | **FFMC** | 22.7 | 0.083 | 0.066 | 57 | ELEVATION | 0.14 | -0.033 | 0.988 |
| 26 | **TAIGA PLAIN** | 21.7 | -0.065 | 0.000 | 58 | BUI..TEMP | 0.09 | -0.028 | 0.992 |
| 27 | **500 MB ANOMALY** | 20.9 | -0.061 | 0.000 | 59 | SDMC..TEMP | 0.04 | -0.017 | 0.996 |
| 28 | **ELEVATION$^2$** | 19.5 | 0.056 | 0.012 | 60 | TEMPERATURE$^2$ | 0.03 | 0.032 | 0.998 |
| 29 | **500MB TENDENCY** | 18.8 | -0.051 | 0.000 | 61 | ISI..ACCUM PRECIP | 0.03 | 0.013 | 0.996 |
| 30 | **AVERAGE NDVI** | 18.4 | 0.052 | 0.020 | 62 | DC | 0.02 | -0.001 | 0.998 |
| 31 | **% CONIFER** | 15.7 | 0.039 | 0.048 | 63 | % CONIFER$^2$ | 0.01 | -0.007 | 0.998 |
| 32 | DMC$^2$ | 15.1 | -0.062 | 0.272 | 64 | FWI | 0.01 | 0.000 | 0.998 |

**Table S3. Complete HCF Model.** Variable ranking based on rank scores computed via Eq. (3), where $P_{EF} = 48$. Variable type colours: purple – baseline risk; black - geographic, periodic; green – vegetation; blue – meteorology ; orange – ecumene. Variables in bold are the most influential covariates as per $p_{Drop}$ criterion depicted in Fig. 7. Variables dropped out in all model fits (i.e. $X_i \in \boldsymbol{\chi}^c$): TREE COVER, FWI, FFMC..TEMPERATURE, DMC..TEMPERATURE, ISI..TEMPERATURE, BUI..TEMPERATURE, SDMC..TEMPERATURE, ISI..ACCUM PRECIP, RELATIVE HUMIDITY$^2$ and % CONIFER$^2$.

| Rank | Covariate | Rank Score | $\check{\beta}^{\Delta}{}_i$ | $p_{Drop}$ | Covariate | Rank Score | $\check{\beta}^{\Delta}{}_i$ | $p_{Drop}$ | Covariate |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **LOGIT HUMAN RISK$^2$** | 48.00 | -1.634 | 0.000 | 37 | WII DISTANCE | 7.386 | -0.012 | 0.642 |
| **2** | **RELATIVE HUMIDITY** | 45.36 | -0.279 | 0.000 | 38 | WEDNESDAY | 7.220 | -0.008 | 0.616 |
| **3** | **CHANGE POINT** | 45.31 | -0.278 | 0.000 | 39 | LONGITUDE | 6.418 | -0.009 | 0.716 |
| **4** | **ISI** | 44.78 | 0.269 | 0.000 | 40 | WII AREA | 5.956 | 0.009 | 0.694 |
| **5** | **FFMC.ACCUM.PRECIP** | 43.55 | 0.235 | 0.000 | 41 | ROAD LENGTH | 4.712 | 0.019 | 0.776 |
| **6** | **LOGIT HUMAN RISK** | 41.86 | 0.284 | 0.032 | 42 | TEMPERATURE | 4.650 | 0.012 | 0.762 |
| **7** | **PSUF** | 40.88 | 0.179 | 0.000 | 43 | SATURDAY | 4.518 | 0.007 | 0.748 |
| **8** | **ACCUM PRECIPITATION** | 39.62 | -0.153 | 0.000 | 44 | FWI..TEMPERATURE | 4.456 | -0.032 | 0.806 |
| **9** | **DC$^2$** | 39.17 | 0.141 | 0.000 | 45 | THURSDAY | 4.364 | -0.006 | 0.750 |
| **10** | ELEVATION | 39.12 | -0.138 | 0.000 | 46 | POPULATION | 4.096 | -0.016 | 0.786 |
| **11** | **FWI$^2$** | 38.06 | -0.152 | 0.040 | 47 | PRECIPITATION | 2.586 | -0.008 | 0.844 |
| **12** | **SDMC** | 34.79 | 0.130 | 0.084 | 48 | PRECIPITATION LAG3 | 2.460 | -0.008 | 0.864 |
| **13** | **VEGETATION COVER** | 34.01 | -0.094 | 0.050 | 49 | % MIXEDWOOD | 2.410 | -0.008 | 0.874 |
| **14** | **PACIFIC MARITIME** | 32.50 | 0.054 | 0.012 | 50 | BUI$^2$ | 2.398 | -0.040 | 0.902 |
| **15** | **ROUGHNESS** | 30.09 | 0.038 | 0.028 | 51 | SDMC.ACCUM PRECIP | 2.246 | -0.043 | 0.904 |
| **16** | **BOREAL PLAIN** | 27.61 | -0.027 | 0.012 | 52 | FRIDAY | 1.792 | 0.001 | 0.880 |
| **17** | **WIND SPEED** | 27.08 | 0.027 | 0.040 | 53 | FWI..ACCUM PRECIP | 1.562 | -0.041 | 0.918 |
| **18** | **AVERAGE NDVI** | 25.70 | -0.024 | 0.058 | 54 | WIND SPEED$^2$ | 1.344 | 0.014 | 0.936 |
| 19 | **CONIFER COVER** | 24.30 | 0.053 | 0.222 | 55 | % DECIDUOUS$^2$ | 1.126 | 0.001 | 0.928 |
| **20** | **PRECIPITATION LAG1** | 23.31 | -0.023 | 0.122 | 56 | WII DISTANCE$^2$ | 0.958 | -0.009 | 0.940 |
| 21 | BUI..ACCUM PRECIP | 21.90 | -0.074 | 0.338 | 57 | FFMC | 0.464 | 0.003 | 0.976 |
| **22** | **WUI DISTANCE$^2$** | 20.92 | -0.019 | 0.156 | 58 | DSR | 0.450 | -0.016 | 0.964 |
| 23 | POPULATION$^{0.5}$ | 19.59 | 0.024 | 0.248 | 59 | ELEVATION$^2$ | 0.386 | 0.050 | 0.984 |
| 24 | DMC$^2$ | 18.18 | -0.038 | 0.368 | 60 | TAIGA PLAIN | 0.344 | -0.003 | 0.974 |
| 25 | TUESDAY | 17.56 | -0.013 | 0.228 | 61 | SDMC$^2$ | 0.338 | -0.029 | 0.982 |
| 26 | % CONIFER | 16.05 | 0.020 | 0.348 | 62 | BUI | 0.324 | 0.007 | 0.980 |
| 27 | DC..ACCUM PRECIP | 12.38 | -0.035 | 0.538 | 63 | DMC..ACCUM PRECIP | 0.258 | -0.023 | 0.990 |
| 28 | WUI AREA | 12.01 | 0.016 | 0.478 | 64 | PRECIPITATION LAG2 | 0.180 | -0.011 | 0.988 |
| 29 | SUNDAY | 11.97 | 0.010 | 0.416 | 65 | BOREAL CORDILLERA | 0.118 | 0.005 | 0.992 |
| 30 | LATITUDE | 11.18 | 0.029 | 0.558 | 66 | DC | 0.076 | -0.028 | 0.996 |
| 31 | FFMC$^2$ | 10.46 | 0.028 | 0.624 | 67 | MONTANE CORDILLERA | 0.068 | -0.005 | 0.994 |
| 32 | DECIDUOUS COVER | 10.07 | -0.015 | 0.594 | 68 | TEMPERATURE$^2$ | 0.028 | -0.001 | 0.998 |
| 33 | % DECIDUOUS | 9.446 | -0.014 | 0.626 | 69 | ROAD LENGTH$^{0.5}$ | 0.016 | -0.008 | 0.998 |
| 34 | MONDAY | 8.604 | 0.008 | 0.558 | 70 | DC..TEMPERATURE | 0.010 | 0.000 | 0.998 |
| 35 | DMC | 8.382 | 0.061 | 0.702 | 71 | AVERAGE NDVI $^2$ | 0.006 | 0.002 | 0.998 |
| 36 | ISI$^2$ | 8.004 | 0.035 | 0.690 | 72 | WUI DISTANCE | 0.006 | 0.002 | 0.998 |

**Table S4.** OLCF Model with an Ordinary Logistic Regression fit using the Stepwise model selection algorithm. Variable type colours: black - geographic, periodic; green – vegetation; blue – meteorology. The dropped covariates are: WIND SPEED, PRECIPITATION LAG1, PRECIPITATION LAG2, PRECIPITATION LAG3, ELEVATION, % DECIDUOUS, LATITUDE, DC, TEMPRATURE$^2$, % DECIDUOUS$^2$, ISI$^2$, BUI$^2$, BOREAL CORDILLERA, PSUF.

| Coefficients: | Estimate | Std. Error | z value | Pr(>\|z\|) | |
|---|---|---|---|---|---|
| (INTERCEPT) | -4.131e-01 | 1.647e+00 | -0.251 | 0.801960 | |
| TEMPERATURE | 1.727e-01 | 7.952e-03 | 21.720 | < 2e-16 | *** |
| PRECIPITATION | 6.625e-02 | 1.097e-02 | 6.039 | 1.56e-09 | *** |
| RELATIVE HUMIDITY | 7.801e-02 | 1.208e-02 | 6.457 | 1.06e-10 | *** |
| AVERAGE NDVI | 5.843e+00 | 1.188e+00 | 4.919 | 8.68e-07 | *** |
| LIGHTNING STRIKES | 2.704e-01 | 9.679e-03 | 27.938 | < 2e-16 | *** |
| LIGHTNING STRIKES LAG1 | 4.988e-02 | 5.828e-03 | 8.559 | < 2e-16 | *** |
| LIGHTNING STRIKES LAG2 | 1.480e-02 | 5.182e-03 | 2.857 | 0.004281 | ** |
| ELEVATION | 1.504e-03 | 2.288e-04 | 6.571 | 4.99e-11 | *** |
| TREE COVER | -3.037e-02 | 6.949e-03 | -4.371 | 1.24e-05 | *** |
| VEGETATION COVER | -2.006e-02 | 4.346e-03 | -4.616 | 3.92e-06 | *** |
| DECIDUOUS COVER | 4.765e-02 | 9.184e-03 | 5.188 | 2.12e-07 | *** |
| CONIFER COVER | 4.288e-02 | 8.714e-03 | 4.920 | 8.63e-07 | *** |
| % CONIFER | 4.210e-02 | 6.365e-03 | 6.614 | 3.75e-11 | *** |
| LONGITUDE | 9.324e-02 | 1.091e-02 | 8.546 | < 2e-16 | *** |
| ISI | 3.092e-01 | 3.959e-02 | 7.810 | 5.73e-15 | *** |
| BUI | 7.971e-03 | 2.580e-03 | 3.089 | 0.00200 | ** |
| FWI | -1.536e-01 | 3.847e-02 | -3.994 | 6.49e-05 | *** |
| DSR | 4.896e-01 | 3.245e-01 | 1.509 | 0.131356 | |
| SDMC | 4.652e-02 | 2.982e-03 | 15.601 | < 2e-16 | *** |
| RELATIVE HUMIDITY$^2$ | -5.217e-04 | 1.030e-04 | -5.067 | 4.04e-07 | *** |
| WIND SPEED$^2$ | -2.686e-03 | 4.713e-04 | -5.699 | 1.20e-08 | *** |
| AVERAGE NDVI$^2$ | -8.415e+00 | 2.184e+00 | -3.853 | 0.00011 | *** |
| ELEVATION$^2$ | -2.616e-07 | 5.459e-08 | -4.792 | 1.65e-06 | *** |
| % CONIFER$^2$ | -2.348e-04 | 4.880e-05 | -4.812 | 1.50e-06 | *** |
| DC$^2$ | -2.581e-06 | 3.014e-07 | -8.565 | < 2e-16 | *** |
| FWI$^2$ | -4.849e-03 | 3.071e-03 | -1.579 | 0.114338 | |
| SDMC$^2$ | -9.853e-05 | 7.330e-06 | -13.441 | < 2e-16 | *** |
| BOREAL PLAIN | 4.562e-01 | 1.598e-01 | 2.855 | 0.004300 | ** |
| MONTANE CORDILLERA | 5.922e-01 | 1.013e-01 | 5.844 | 5.10e-09 | *** |
| PACIFIC MARITIME | 5.820e-01 | 1.466e-01 | 3.971 | 7.15e-05 | *** |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

**Table S5.** PLCF Model with an Ordinary Logistic Regression fit using the Stepwise model selection algorithm. Variable type colours:black - geographic, periodic; green – vegetation; blue – surface weather, cyan – atmospheric stability . The dropped covariates are: PRECIPITATION LAG3, % DECIDUOUS, 500MB ANOM, % DECIDUOUS$^2$, DC$^2$, ISI$^2$ AND PSUF.

| Coefficients: | Estimate | Std. Error | z value | Pr(>\|z\|) | |
|---|---|---|---|---|---|
| (INTERCEPT) | 1.702e+00 | 1.199e+00 | 1.420 | 0.155536 | |
| TEMPERATURE | 2.843e-01 | 1.925e-02 | 14.765 | < 2e-16 | *** |
| PRECIPITATION | 9.364e-02 | 7.059e-03 | 13.266 | < 2e-16 | *** |
| RELATIVE HUMIDITY | 1.311e-01 | 7.167e-03 | 18.286 | < 2e-16 | *** |
| WIND SPEED | -2.569e-02 | 1.167e-02 | -2.201 | 0.027752 | * |
| PRECIPITATION LAG1 | -2.808e-02 | 8.095e-03 | -3.469 | 0.000522 | *** |
| PRECIPITATION LAG2 | -1.815e-02 | 7.798e-03 | -2.328 | 0.019922 | * |
| AVERAGE NDVI | 5.672e+00 | 6.667e-01 | 8.508 | < 2e-16 | *** |
| ELEVATION | 6.677e-04 | 1.976e-04 | 3.379 | 0.000727 | *** |
| ROUGHNESS | 1.828e-03 | 1.486e-04 | 12.303 | < 2e-16 | *** |
| TREE COVER | -2.418e-02 | 4.009e-03 | -6.032 | 1.62e-09 | *** |
| VEGEATATION COVER | -1.305e-02 | 2.540e-03 | -5.137 | 2.79e-07 | *** |
| DECIDUOUS COVER | 4.540e-02 | 5.221e-03 | 8.697 | < 2e-16 | *** |
| CONIFER COVER | 3.031e-02 | 5.042e-03 | 6.011 | 1.84e-09 | *** |
| % CONIFER | 4.051e-02 | 3.683e-03 | 11.001 | < 2e-16 | *** |
| LONGITUDE | 1.723e-01 | 8.592e-03 | 20.051 | < 2e-16 | *** |
| LATITUDE | 5.585e-02 | 1.211e-02 | 4.612 | 3.98e-06 | *** |
| DC | -1.745e-03 | 1.318e-04 | -13.234 | < 2e-16 | *** |
| ISI | 2.511e-01 | 2.428e-02 | 10.342 | < 2e-16 | *** |
| BUI | 1.695e-02 | 3.033e-03 | 5.588 | 2.29e-08 | *** |
| FWI | -1.503e-01 | 2.180e-02 | -6.893 | 5.46e-12 | *** |
| DSR | 7.790e-01 | 1.665e-01 | 4.678 | 2.90e-06 | *** |
| SDMC | 3.320e-02 | 2.648e-03 | 12.535 | < 2e-16 | *** |
| C HAINES INDEX | -3.980e-01 | 4.464e-02 | -8.918 | < 2e-16 | *** |
| K INDEX | -1.211e-02 | 4.584e-03 | -2.642 | 0.008237 | ** |
| TOTALS INDEX | 1.224e-01 | 8.942e-03 | 13.691 | < 2e-16 | *** |
| TEMPERATURE$^2$ | -7.167e-04 | 5.068e-04 | -1.414 | 0.157347 | |
| RELATIVE HUMIDITY$^2$ | -7.865e-04 | 6.002e-05 | -13.105 | < 2e-16 | *** |
| WIND SPEED$^2$ | -7.195e-04 | 5.076e-04 | -1.417 | 0.156374 | |
| AVERAGE NDVI$^2$ | -8.856e+00 | 1.224e+00 | -7.233 | 4.73e-13 | *** |
| ELEVATION$^2$ | -5.481e-07 | 8.145e-08 | -6.729 | 1.70e-11 | *** |
| % CONIFER$^2$ | -1.947e-04 | 2.810e-05 | -6.930 | 4.22e-12 | *** |
| BUI$^2$ | -4.348e-05 | 9.992e-06 | -4.351 | 1.35e-05 | *** |
| FWI$^2$ | -7.763e-03 | 1.542e-03 | -5.033 | 4.83e-07 | *** |
| SDMC$^2$ | -5.730e-05 | 8.239e-06 | -6.954 | 3.54e-12 | *** |
| BOREAL PLAIN | 2.283e-02 | 1.203e-01 | 0.190 | 0.849535 | |
| MONTANE CORDILLERA | 1.005e+00 | 8.357e-02 | 12.024 | < 2e-16 | *** |
| PACIFIC MARITIME | 7.764e-01 | 1.143e-01 | 6.790 | 1.12e-11 | *** |
| TAIGA PLAIN | -6.370e-02 | 1.053e-01 | -0.605 | 0.545162 | |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

**Table S6.** HCF Model with an Ordinary Logistic Regression fit using the Stepwise selection algorithm. Variable type colours: black - geographic, periodic; green – vegetation; blue – surface weather; orange – ecumene. The dropped covariates are: TEMPERATURE, PRECIPITATION , WIND SPEED, CONIFER COVER, FWI, WII AREA, RELATIVE HUMIDITY$^2$, ELEVATION$^2$, SDMC$^2$, MONDAY, SATURDAY, SUNDAY, THURSDAY, TUESDAY and WEDNESDAY.

| Coefficients: | Estimate. | StdError z | value | Pr(>\|z\|) |
|---|---|---|---|---|
| (INTERCEPT) | -4.040e+00 | 9.128e-01 | -4.426 | 9.61e-06 |
| RELATIVE HUMIDITY | -1.732e-02 | 1.607e-03 | -10.777 | <2e-16 |
| PRECIPITATION LAG1 | -2.703e-02 | 8.209e-03 | -3.292 | 0.000993 |
| PRECIPITATION LAG2 | -1.127e-02 | 7.505e-03 | -1.502 | 0.133183 |
| PRECIPITATION LAG3 | -3.317e-02 | 6.853e-03 | -4.840 | 1.30e-06 |
| AVERAGE NDVI | 9.321e-01 | 5.567e-01 | 1.674 | 0.094090 |
| ELEVATION | -8.379e-04 | 7.599e-05 | -11.027 | <2e-16 |
| ROUGHNESS | 1.321e-03 | 1.357e-04 | 9.735 | <2e-16 |
| ROAD LENGTH | -2.729e-03 | 3.159e-04 | -8.641 | <2e-16 |
| POPULATION | -1.017e-05 | 1.500e-06 | -6.781 | 1.19e-11 |
| TREE COVER | 1.107e-02 | 1.723e-03 | 6.425 | 1.32e-10 |
| VEGETATION COVER | -8.874e-03 | 2.273e-03 | -3.905 | 9.43e-05 |
| DECIDUOUS COVER | 9.968e-03 | 3.562e-03 | 2.799 | 0.005129 |
| % DECIDUOUS | 4.088e-02 | 6.931e-03 | 5.898 | 3.68e-09 |
| % CONIFER | 1.272e-02 | 3.407e-03 | 3.735 | 0.000188 |
| LONGITUDE | -4.486e-02 | 7.874e-03 | -5.697 | 1.22e-08 |
| LATITUDE | -5.932e-02 | 1.263e-02 | -4.696 | 2.65e-06 |
| DC | -1.804e-03 | 2.818e-04 | -6.403 | 1.53e-10 |
| ISI | 3.519e-01 | 2.856e-02 | 12.320 | <2e-16 |
| BUI | 1.285e-02 | 2.087e-03 | 6.157 | 7.40e-10 |
| DSR | -7.773e-01 | 1.103e-01 | -7.046 | 1.84e-12 |
| SDMC | 8.776e-03 | 1.331e-03 | 6.594 | 4.27e-11 |
| WUI DISTANCE | -4.317e-05 | 5.167e-06 | -8.354 | <2e-16 |
| WII DISTANCE | -2.002e-05 | 1.912e-06 | -10.472 | <2e-16 |
| WUI AREA | 1.924e-09 | 4.657e-10 | 4.131 | 3.62e-05 |
| TEMPERATURE$^2$ | -5.228e-04 | 1.137e-04 | -4.599 | 4.24e-06 |
| WIND SPEED$^2$ | -6.774e-04 | 1.736e-04 | -3.903 | 9.50e-05 |
| AVERAGE NDVI$^2$ | -2.247e+00 | 1.015e+00 | -2.214 | 0.026842 |
| % CONIFER$^2$ | -4.460e-05 | 2.738e-05 | -1.629 | 0.103371 |
| % DECIDUOUS$^2$ | -3.690e-04 | 7.159e-05 | -5.155 | 2.54e-07 |
| DC$^2$ | 3.011e-06 | 3.380e-07 | 8.908 | <2e-16 |
| ISI$^2$ | -4.513e-03 | 1.122e-03 | -4.024 | 5.72e-05 |
| BUI$^2$ | -6.044e-05 | 5.432e-06 | -11.128 | <2e-16 |
| FWI$^2$ | 7.197e-03 | 1.190e-03 | 6.050 | 1.45e-09 |
| ROAD LENGTH$^{0.5}$ | 1.373e-01 | 8.243e-03 | 16.652 | <2e-16 |
| POPULATION$^{0.5}$ | 6.949e-03 | 6.862e-04 | 10.127 | <2e-16 |
| TIME INDICATOR | -5.904e-01 | 2.685e-02 | -21.991 | <2e-16 |
| WII DISTANCE$^2$ | 1.102e-10 | 1.650e-11 | 6.677 | 2.43e-11 |
| WUI DISTANCE$^2$ | 3.826e-10 | 1.203e-10 | 3.180 | 0.001472 |
| PSUF | 5.305e-01 | 1.991e-01 | 2.665 | 0.007708 |
| BOREAL PLAIN | -4.554e-01 | 1.385e-01 | -3.287 | 0.001012 |
| MONTANE CORDILLERA | 3.472e-01 | 8.470e-02 | 4.099 | 4.14e-05 |
| PACIFIC MARITIME | -2.173e-02 | 1.100e-01 | -0.198 | 0.843428 |
| TAIGA PLAIN | -4.928e-01 | 1.246e-01 | -3.954 | 7.67e-05 |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

doi: 10.1071/WF19058_AC

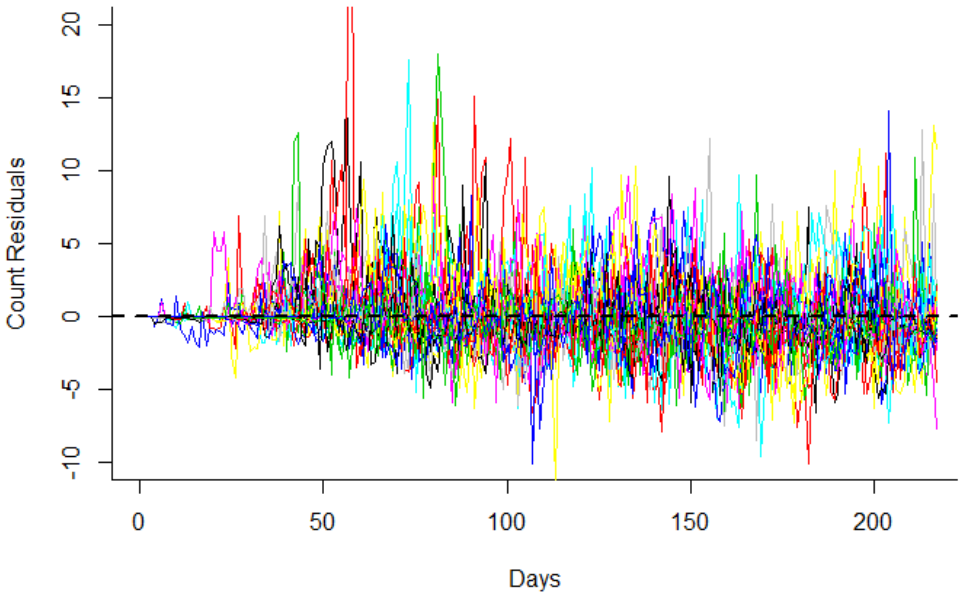




Fig. S1. Temporal residuals computed for the 28 fire seasons (1981-2008) under the HCF model. Each line represents a season and the residual value corresponds to a specific day in that season.

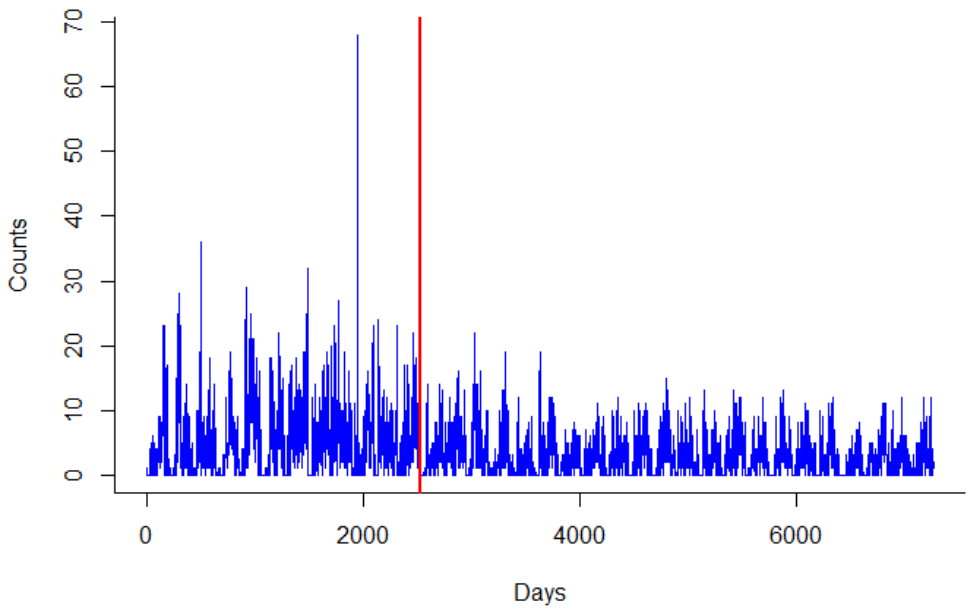



Fig. S2. Daily number of human caused fire occurrences in 34 fire seasons (1981-2014). Vertical red line is a cut-off point for the top ranking CHANGE POINT covariate (Table A3): CHANGE POINT=1 for days after the 1992 fire season, and 0 otherwise.

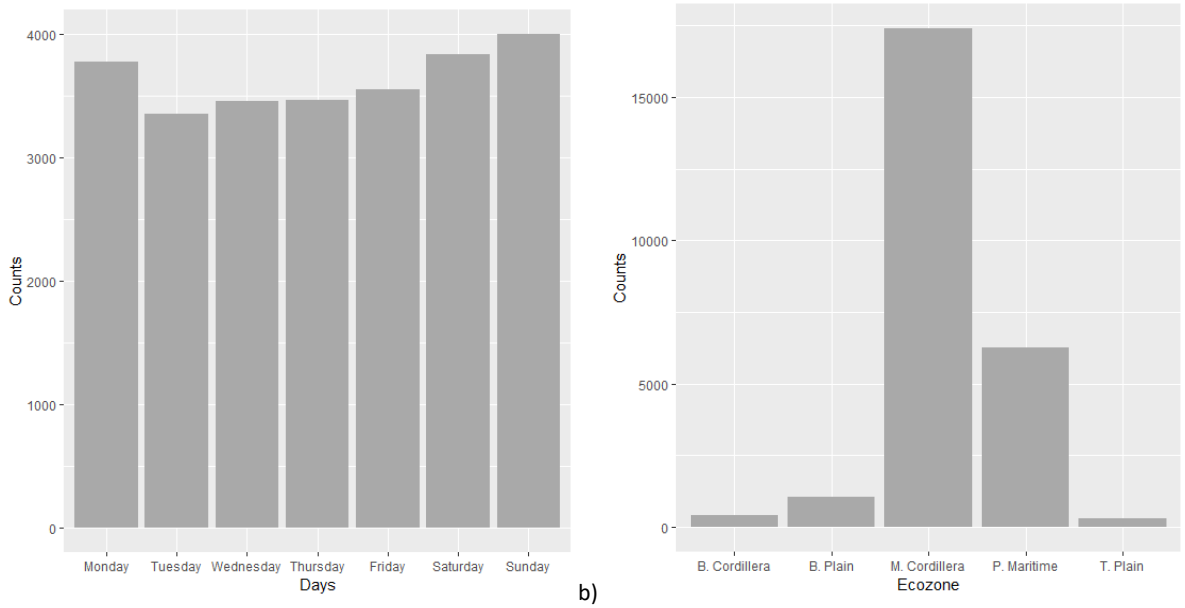



Fig S3. Human caused fire occurrence counts within a) day and b) ecozone categories aggregated over 34 fire seasons (1981-2014).

doi: 10.1071/WF19058_AC

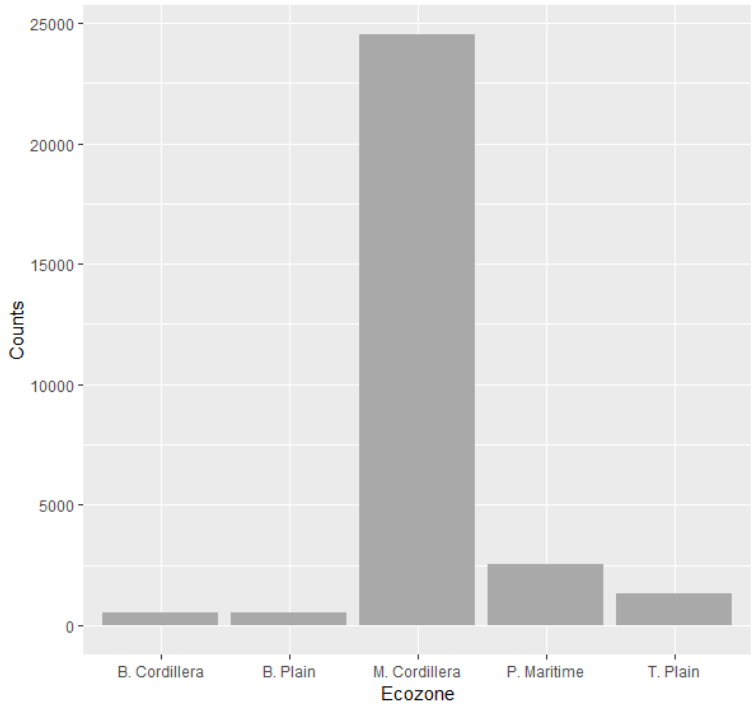
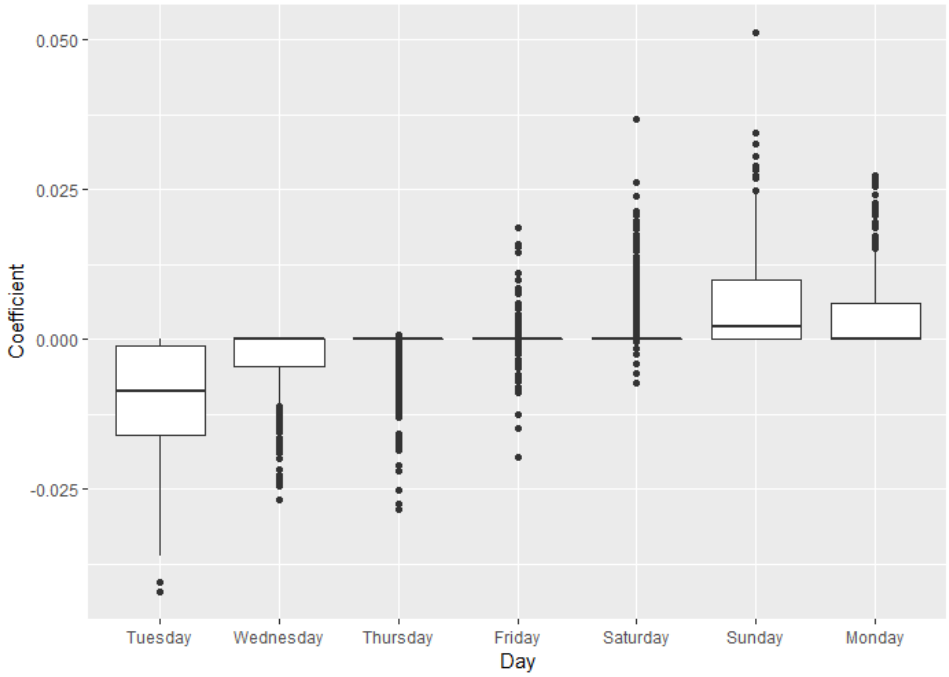



Fig S4. Lightning caused fire occurrence counts within ecozone categories aggregated over 34 fire seasons (1981-2014).

a)




b)

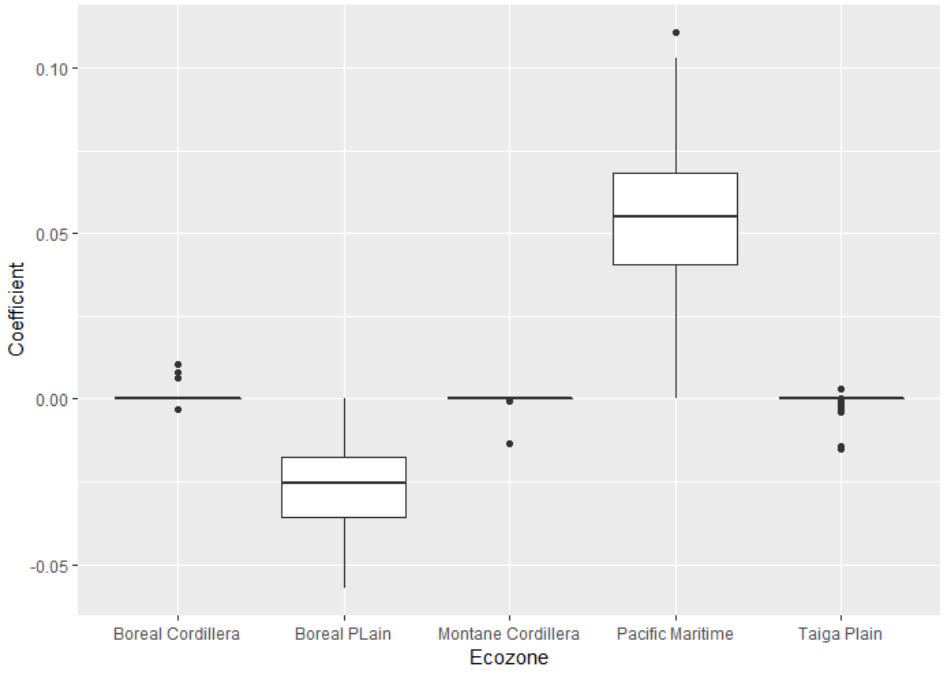
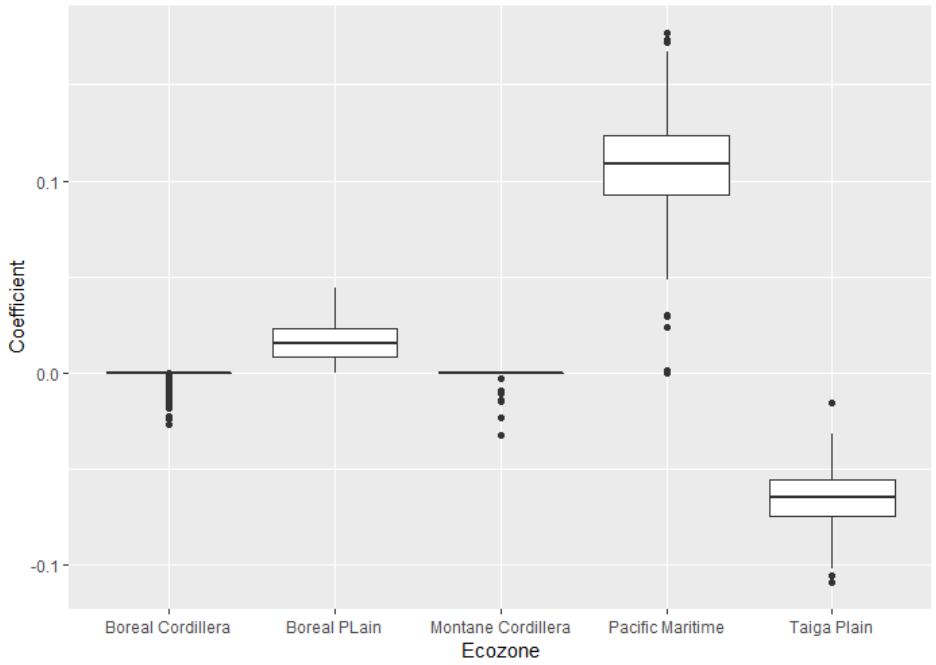



Fig. S5. (HCF Model). Distribution of standardized coefficients for (a) days of week and (b) ecozones over 500 fits of the lasso logistic model.

a)




b)

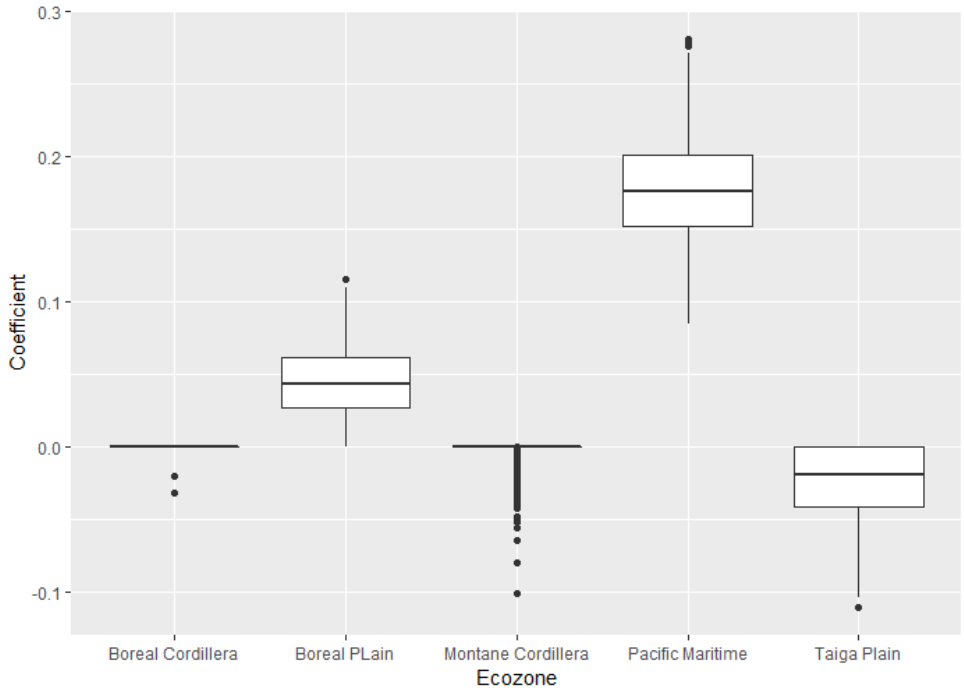



Fig. S6. (LCF Models). Distribution of standardized coefficients for ecozones over 500 fits of the lasso logistic model for a) PLCF and b) OLCF models.