Data Article

Dataset of mountain pine beetle outbreak dynamics and direct control in Cypress Hills, SK

Mélodie Kunegel-Lion a, *, Rory L. McIntosh b, Mark A. Lewis a, c

a Department of Biological Sciences, University of Alberta, CW 405 Biological Sciences Bldg, Edmonton, AB, T6G 2E9, Canada
b Forest Service Branch, Saskatchewan Ministry of Environment, Box 3003 McIntosh Mall, Prince Albert, SK, S6V 6G1, Canada
c Mathematical and Statistical Sciences, University of Alberta, 632 CAB, Edmonton, AB, T6G 2G1, Canada

A R T I C L E   I N F O

Article history:
Received 28 January 2020
Accepted 10 February 2020
Available online 17 February 2020

Keywords:
Insect epidemics
Pest management
Direct control
Simulations

A B S T R A C T

The data presented in this article are related to the research article entitled “Mountain pine beetle outbreak duration and pine mortality depend on direct control effort” [1]. This article provides presence of mountain pine beetle infested trees detected by the Saskatchewan Forest Service on a grid covering the spatial extent of the Saskatchewan portion of the Cypress Hills interprovincial park between 2006 and 2018. For each grid cell, associated ecological and environmental covariates, such as topography, weather and vegetation, are also provided. These data cover the spatio-temporal extent of an almost entire mountain pine beetle outbreak and contribute to the understanding of mountain pine beetle outbreak dynamics.

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Specifications Table

| Subject | Ecology |
|---------|---------|
| Specific subject area | Insect outbreak dynamics |
| Type of data | Tables |
| How data were acquired | Aerial and ground surveys, collection of data across literature and databases |
| Data format | Raw |
| Parameters for data collection | Data were collected between 2006 and 2018 in the Saskatchewan portion of Cypress Hills interprovincial park, Canada, which correspond to the spatial and temporal extent of the focus mountain pine beetle outbreak. |
| Description of data collection | Mountain pine beetle infested trees were identified and located by the Saskatchewan Environment Forest Service. We estimated weather variables for each year using the software BioSIM. We obtained topography data through GeoGratis.gc.ca. We interpolated vegetation data from Ref. [2]. |
| Data source location | Cypress Hills Interprovincial Park, Saskatchewan, Canada |
| Data accessibility | Repository name: Dryad |
| Data identification number | 10.5061/dryad.70rxwdbt9 |
| Related research article | Mélodie Kunegel-Lion & Mark A. Lewis, Mountain pine beetle outbreak duration and pine mortality depend on direct control effort, Journal of Environmental Management, DOI: 10.1016/j.jenvman.2020.110167 |

Value of the Data

- These data are useful for understanding the fine-scale dynamics of an almost complete mountain pine beetle outbreak limited in its spatial range.
- Researchers and managers can benefit from these data to understand outbreak dynamics or to inform decision-making processes and management strategies.
- These data can be used to further insight spatial dynamics of dispersal and can be used for modelling.

1. Data description

The data presented in this article are related to the research article entitled “Mountain pine beetle outbreak duration and pine mortality depend on direct control effort” [1]. Data are provided for each year between 2006 and 2018 and for each cell of a grid covering the spatial extent of the study area. Two datasets are provided for two grid spatial resolution: a grid of 18,317 100 × 100 m cells (dataset 1) and a grid of 722 500 × 500 m cells (dataset 2). For each cell of a grid, the dataset contains the presence or number of mountain pine beetle infested trees as well as topography, weather, vegetation, and management factors (Table 1). The topography factors included are latitude, longitude, elevation, slope, aspect, northerness, easternness. The weather factors included are maximum temperature in summer, minimum temperature in summer, minimum temperature over the year, degree-days, cold tolerance, relative humidity in spring, soil moisture index, wind speed in summer, and an estimate of mountain pine beetle emergence peak from degree-days. The vegetation factors include pine cover, pine height, pine age, and number of pines. The management factors included are presence of managed and unmanaged mountain pine beetle infested trees the previous year in the same cell and in neighbouring cells, and the distance between the cell and a limited patch of unmanaged infestations outside the park’s southern limit.

2. Experimental design, materials, and methods

2.1. Mountain pine beetle infested trees

Saskatchewan Ministry of Environment Forest Service is responsible for surveying mountain pine beetles in this portion of the park. Every year, a complete aerial survey of the park extent is performed
in order to detect red-top trees [3]. These are later ground-truthed for beetle attacks and trees fading from other causes than mountain pine beetle are removed from the survey. Ground surveys with a radius of 50 m are conducted around each red-top tree containing beetles to find currently infested pines with live brood. However, in some areas, red-top trees are clustered together. To thoroughly

| Table 1 |
| Description of the variables. |
| Variable | Description | Unit |
| MPB | Presence (dataset 1) or number (dataset 2) of pine trees currently infested by living mountain pine beetle eggs or larvae | pines |
| Latitude | Latitude of the grid cell centroid | dec.° |
| Longitude | Longitude of the grid cell centroid | dec.° |
| Elevation | Elevation at the grid cell centroid | m |
| Slope | Slope at the grid cell centroid | ° |
| Aspect | Compass direction the slope faces | ° |
| Northerness | Spatial property of a slope to face North | — |
| Easterness | Spatial property of a slope to face East | — |
| Tmax | Highest maximum daily temperature during July and August | °C |
| Tmin_Summer | Lowest minimum daily temperature during July and August | °C |
| Tmin_Winter | Lowest minimum daily temperature in the winter | °C |
| DegreeDays | Degree-days above 5.5°C from the fall of the previous year to the summer | — |
| ColdTolerance | Cold tolerance estimates the probability of larva survival over the winter using temperature | % |
| RelativeHumidity | Average relative humidity from March to May | % |
| SMI | The average soil moisture index from May to July estimates soil water availability for tree growth using temperature and precipitation (only available for dataset 1) | mm |
| WindSpeed | Average wind speed in July and August | km/h |
| PeakEmergence | Mountain pine beetle emergence peak estimates when 50% of the beetles have emerged from cumulative degree-days above 2°C starting on May 30th (Julian day 150; only available for dataset 1) | Julian day |
| PineCover | Coverage of Pinus albicaulis (whitebark pine), Pinus banksiana (jack pine) and Pinus contorta (includes subspecies lodgepole pine and shore pine) | % |
| PineHeight | Height of the dominant tree species in the cell when the pine cover is greater than 50% | m |
| PineAge | Age of the dominant tree species in the cell when the pine cover is greater than 50% | year |
| Stems | Number of pine trees greater than 10 cm at breast height | — |
| BP0 | Presence (dataset 1) or number (dataset2) of previous-year mountain pine beetle infested trees in the cell | — |
| BP0man | Presence of previous-year controlled mountain pine beetle infested trees in the cell and no uncontrolled trees (dataset 1) or number of previous-year controlled infested trees in the cell (dataset 2) | — |
| BP0red | Presence (dataset 1) or number (dataset 2) of previous-year uncontrolled mountain pine beetle infested trees in the cell | — |
| BP1 | Number of infested cells (dataset 1) or number of infested trees (dataset 2) the previous year in a 1-cell radius excluding the focus cell | — |
| BP1man | Number of infested cells with all trees controlled (dataset 1) or number of infested trees (dataset 2) the previous year in a 1-cell radius excluding the focus cell | — |
| BP1red | Number of infested cells with uncontrolled trees (dataset1) or number of uncontrolled infested trees (dataset 2) the previous year between a 1-cell and 2-cell radius excluding the focus cell | — |
| BP2 | Number of infested cells (dataset 1) or number of infested trees (dataset 2) the previous year between a 1-cell and 2-cell radius | — |
| BP2man | Number of infested cells with all trees controlled (dataset 1) or number of infested trees (dataset 2) the previous year between a 1-cell and 2-cell radius | — |
| BP2red | Number of infested cells with uncontrolled trees (dataset1) or number of uncontrolled infested trees (dataset 2) the previous year between a 1-cell and 2-cell radius | — |
| BP3 | Number of infested cells (dataset 1) or number of infested trees (dataset 2) the previous year between a 2-cell and 3-cell radius | — |
| BP3man | Number of infested cells with all trees controlled (dataset 1) or number of infested trees (dataset 2) the previous year between a 2-cell and 3-cell radius | — |
| BP3red | Number of infested cells with uncontrolled trees (dataset1) or number of uncontrolled infested trees (dataset 2) the previous year between a 2-cell and 3-cell radius | — |
| Dist2borderS | Distance from the centre of the cell to the park’s southern limit close to external infestations | m |
survey these areas, polygons are delineated by hand around each red-top trees cluster. The extent of each polygon is then entirely checked for infested trees using line surveys. Polygon locations and shapes typically change from one year to the other. However, they are consistently located for the most part in the same highly infested and therefore highly surveyed areas. Infested pines located outside of the circular plots or polygons would be most likely missed by managers. All detected infested trees are treated, primarily using a fall and burn tactic to ensure that the broods are killed. The Forest Service has been following this procedure since the mountain pine beetle infestation was detected in 2006 up to the current state of the outbreak in 2018. In summary, we obtained the following data for each year: locations of red-top trees, locations and shapes of polygons, number of infested trees for each circular survey, and locations of infested trees within the polygons. From this information, we estimated the locations of all infested trees.

To get an estimate of all of the infested trees location for every year, we used the following methods.

- For the controlled infested trees found in circular survey plot (called type C1), the exact coordinates of the infested trees were not recorded so we used the location of the plot's centroid.
- For the controlled infested trees found in line surveys (i.e. within polygons, called type C2), we used the exact location of the infested trees.
- For the uncontrolled infested trees that were missed at year t, became red-top trees at year t + 1 and were not part of a polygon at year t + 1 (called type U1), we used the exact location of the red-top trees at year t + 1.
- For the uncontrolled infested trees that were missed at year t, became red-top trees at year t + 1 and were part of a polygon at year t + 1 (called type U2), the exact coordinates of red-top trees were not recorded. We first assumed that, in Cypress Hills, the proportion of uncontrolled infested trees within these highly surveyed areas is 0.11 [4]. Therefore, the proportion of controlled infested trees within ground survey areas is 1 – 0.11 = 0.89. Note that this number is different from the proportion of controlled infested trees in the entire park as ground surveys do not cover the entire park extent. Using these proportions, the number of controlled trees in polygons is equal to 0.89 times the number of infested trees. So, the number of infested trees in polygons is the number of controlled trees in polygons divided by 0.89. Therefore, the number of uncontrolled infested trees in polygons is:

\[
\text{# uncontrolled infested trees} = 0.11 \times \text{# infested trees} = 0.11 \times \text{# controlled infested trees} / 0.89
\]

Second, using the equation above, we modelled, for each t + 1 polygon, the number of infested trees that would have been missed and fell within the polygon areas at year t + 1 as a Poisson random variable with mean equal to the number of uncontrolled infested trees at t that fall into a t + 1 polygon.

Third, we randomly distribute in space the U2 infested trees in each polygon area.

In total, from 2006 to 2018, we had 2672 trees of type C1, 740 trees of type C2, 1819 trees of type U1, and 93 trees of type U2 (Fig. 1). These numbers are consistent with the previously estimated control efficiency over the entire park extent: 60.6% and 73.7% of infested trees were controlled in 2011 and 2012, respectively [4]. We were able to estimate the location of all infested trees every year with a precision of a few meters for 48% of the infested trees (types C2 and U1), 50 m for 50% of the infested trees (type C1), and several hundred meters depending on the polygons size for the remaining 2% (type U2). Finally, a grid with cell size 100 × 100 m or 500 × 500 m is superimposed over the park extent and the presence or number of infested trees in each cell is recorded.

2.2. Ecological and environmental covariates

We obtained topography variables from the Canadian Digital Elevation Map downloaded from the Geogratis website (geogratis.cgdi.gc.ca). We extracted the elevation, slope, and aspect. The aspect was converted into northerness and easterness using, respectively, a cosine and sine transformation. We estimated weather variables at the centroid of each grid cell for each year using the software BioSIM
and the associated weather station data [5]. We obtained an estimate of the mountain pine beetle emergence peak each year by using the model and parameters provided in Ref. [6] (model 1) and cumulative degree-days from BioSIM [5].

From Ref. [2], we estimated, for each cell in 2001 and 2011, the leading species height, the pine cover and the tree volume. Then, we obtained pine height by using the leading species height when the pine cover is greater than 50%. We spatially interpolated the pine height values at the location of each cell using bicubic spline interpolation provided by the function interp of the R package akima [7]. We obtained the pine volume by multiplying the pine cover by the tree volume. To obtain vegetation variable values for every year, we linearly interpolated the values over the time period for each cell. We estimated the number of pine trees in each cell from the pine volume using the process and equation described in Ref. [8]. The expected number of pines greater than 10 cm at breast height \( E(S) \) depends on the pine volume per hectare \( V \) following equation

\[
E(S) = A V \exp(-\delta V)
\]

where \( A \) and \( \delta \) are free parameters. Pines with a diameter at breast height smaller than 10 cm are seldom the target of mountain pine beetle attacks and therefore were not included in the pine count [9]. Based on [10], Cypress Hills has a site index of 15–18 m at 50 year breast height age for lodgepole pine which corresponds to a medium to good site in Ref. [11]. Therefore, we fit \( A \) and \( \delta \) to data from the yield tables for medium and good sites provided in Ref. [11] using a nonlinear regression and obtained the values \( A = 18.18 \pm 0.23 \) SE and \( \delta = 5.4 \times 10^{-3} \pm 0.4 \times 10^{-3} \) SE.

**Acknowledgments**

We thank Brian Poniatowski (Saskatchewan Ministry of Environment) for the highly-detailed data set and the useful discussions around technical and surveillance aspect in Cypress Hills. We also thank the Lewis Research Group for helpful feedback and suggestions. This research was supported by a grant to M.A.L. from the Natural Science and Engineering Research Council of Canada (grant no. NET GP 434810-12) to the TRIA Network, with contributions from Alberta Agriculture and Forestry, Foothills
Research Institute, Manitoba Conservation and Water Stewardship, Natural Resources Canada-Canadian Forest Service, Northwest Territories Environment and Natural Resources, Ontario Ministry of Natural Resources and Forestry, Saskatchewan Ministry of Environment, West Fraser and Weyerhaeuser. M.A.L. is also grateful for the support through the NSERC Discovery and the Canada Research Chair programs.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105293.

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