MPBSpread

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Overview

My notes on the `MPBSpread` model presented at the fRI MPB Workshop held in Edmonton, AB on October 26, 2016.

This workshop was live streamed at youtube.com/watch?v=ChdU___G21Cs.

Presenter: Clive [something]

- `MPBSpread` is a spatially explicit model on a forest landscape
- 10-20 year horizon
- uses 400 m x 400 m (16 ha) cells
- stochasticity
- no life history; only dispersal (with mortality) within and among stands
- univoltine dynamics

Barry's summary:

> logistic stochastic cellular automaton at 16 ha resolution, driven by numerous environmental variables known to have nonlinear influence on probability of establishment.

Model construction

The model calculates the probability of successful colonization of unoccupied cell i at time t:

$$P_{i,t} = HQ_i \sum_{j=1}^{n} BEF_{j,t} G_{j,t} W_{i,j}$$

- HQ_i is habitat quality scaled from 0 to 1;
  - $HQ_i = PADL$
  - P is the percentage of susceptible pine (data source??)
  - A is age [of cell??]
  - D is density [of pine??]
  - L is a location factor [??]
- $BEF_{j,t}$ is a 'beetle export factor', which is an index of dispersal from occupied cell, scaled from 0 to 1;
  - linear increase then exponential decline
- $G_{j,t}$ is a directional scaler for wind, between 0 and 1;
  - circular frequency distribution of wind directions (biased eastward)
- $W_{i,j}$ is a weighting factor for distance from unoccupied to occupied cells, between 0 and 1.
  - approx. exponential decline, but it's modified to be non-monotonic (flat-tailed distribution) that declines from weight 1 at distance 0 km to near 0 at 10 km.

Cumulative probability of occurrence follows a logistic curve, with two different curves defined for:

1. 'experienced' pine, which has an evolutionary history of MPB outbreak (*i.e.*, BC);
2. 'naive' pine, which doesn't have this history (*i.e.*, AB)

Experienced pine has a lower curve than naive pine (MPB less likely to occur in a cell).

Model summary

- captures short-distance "diffusive" dispersal as well as larger-distance "jumps" [unclear how...]
- model accounts for:
  - infested trees at stand and landscape levels
  - stand susceptibility
  - [beetle] mortality
  - MPB reproductive output (including climate effects)
  - habitat connectivity
  - [beetle] dispersal
  - beetle control

Implementing control

- **level 1:**
  - cells where infestation detected ≤ 2 years of establishment
  - a proportion of green attack trees is removed
- **level 2:**
  - cells with infestation ≥ 3 years and ≤ 7 km from a road; else no treatment
  - all trees removed

Application control

- "leading edge focused"
- begin with cell at easternmost longitude and highest latitude
- proceed sequentially by longitude to southernmost cell, then onte northernmost cell to the west
- continue until all cells sampled or total area allocated for control in that year is reached s each infested cell has probability of being detected ($P_{detect} = 0.90$) and subsequent probability of successful eradication ($P_{eradicate} = 0.65$)

Model validation

`MPBSpread` validated using BC survey data 1999 for the Burns Lake – Quesnel – etc. region.

- 10 model runs to account for stochasticity
- get means and 95% confidence intervals for two metrics:
  1. total area infested
  2. total pine killed
- spread projections were compared to data

Model application

`MPBSpread` applied to AB region using 2008-2015 data from Alberta Agriculture and Forestry.

- used 'naive' pine curve for thresholds

- used 2008 data to set initial conditions
- two scenarios considered:
  1. 'do nothing'
  2. 'business as usual'
     - level 1 control: 10,000 ha
     - level 2 control: 1,500 ha in 2008 increasing to 3,000 ha in 2017
     - $P_{detect} = 0.90$
     - $P_{eradicate} = 0.65$

Conclusions

1. survey data match reasonably well;
2. control does make a difference;
3. control efficacy is not immediately apparent – it takes time to manifest.

Other model applications

Also explored different combinations of 'do nothing' and 'business as usual' for different amounts of level 1 and level 2 control.

Comments

From email discussions.

from Barry

- Their model is a "twitch model" describing fast dynamics of eruption, not the slow dynamics of coupled forest-insect feedbacks. The long-range "slow-the-spread" cannot be answered without forest depletion and climate change as drivers.
- Formulated at a resolution of 16 ha and representing establishment & eruption as a simple logistic process removes a lot of detail. It's going to be good enough over large extents and small time frames where details don't matter. Hence the quality of their validations in BC and AB. OTOH a lot of their simulated stochasticity (those wide confidence intervals) is going to come from (mis) representing a continuous growth process as binary. That misrepresentation error grows as time horizon (and other process uncertainty) grows.
- The single biggest limitation in their modeling approach is that it doesn't connect to forest depletion and regrowth, and has no capacity to connect to other people's models of forest growth, weather, climate, fire occurrence, and so on.
- Note that they "reinvented the wheel"" of trying to re-estimate the weather effect on r value. `SpaDES` seeks to avoid that duplicity.
- Note that they have no capacity for dynamically re-parameterizing their efficacy model when the 2015, 2016 data come in. Recall that question: "We think we're better now in the last three years than the first seven years. Can you re-estimate your detection and control efficacy parameters?". Allan's reply was that it required a boatload of GIS data pre-processing, none of it scripted. Again, that's what `SpaDES` workflows are for.
- re: habitat connectivity – The primary agent for increased fragmentation is likely to be ... fire. Hence the notes from last week bout the FortMac fires and the CLAWR.