Review: "Combining empirical and mechanistic understanding of spruce bark beetle outbreak dynamics in the LPJ-GUESS (v4.1, r13130) vegetation model" (gmd-2024-239)

In this manuscript, the authors describe the implementation and performance of a module to represent spruce bark beetle infestations in the LPJ-GUESS dynamic global vegetation model (DGVM). This is important work because, while pests and disease are major drivers of forest disturbance in some regions, they are woefully underrepresented in DGVMs. I appreciate how the authors seemed to focus on building a system that is extensible for additional pest types, since the important species vary widely across the world.

The manuscript is for the most part well-written, but I do have some questions and suggestions for clarification. Similarly, the analyses are appropriate, and the figures are mostly clear. I thus recommend this to be reconsidered after what are probably minor revisions, but they are important enough that I would like to see them before they're accepted.

1. One citation of previous work is missing: Marie et al. (2024, *GMD*): "Simulating *Ips typographus* L. outbreak dynamics and their influence on carbon balance estimates with ORCHIDEE r8627"
2. L98: Patch area is unnecessary
3. L125-127: Not sure what this means
4. L128: What age classes? Are those in the inventory data you're talking about? Inventory data should probably get its own introductory paragraph, before you start talking about how you incorporate forest management into LPJ-GUESS sims.
5. L132: 5 patches per treatment seems low. Have you tested how replicable any of the results are at 5 patches, or the effect of increasing to 20 patches? It would be useful to demonstrate that 5 patches are enough for replicable results, or to increase the number of patches until it is.
6. L129-141:
    a. I would use "unmanaged vegetation" rather than PNV. There are still anthropogenic effects on the unmanaged patches (e.g., population density affecting fire).
    b. Were patch-destroying disturbances also turned off for unmanaged patches?
    c. Was fire turned off for any patches?
7. L153-166:
    a. Where does the initial (t=0) bark beetle population come from?
    b. Is there no term to describe how population increases when a low population experiences a big surge in substrate? Or is that 2nd term on the LHS of Eq. 4

positive at low values and negative at high values? (Later, in Fig. 1, I see that the latter is the case. But you should mention this before then.)

8. L168-169:
   a. What do you mean, ranges? Is this for parameterization purposes? Explain.
   b. What parts of your model correspond to which parts of the Marini et al. (2017) model?
   c. What are the ranges?
9. L171-172: Is that realistic?
10. Fig. 1a:
    a. Are the ranges used just the dark part? Or the light + dark parts?
    b. Where does the -3.8 number come from?
11. Fig. 1b-e:
    a. Lines are too thin, and pink is especially hard to see.
    b. What are the k parameters? They're not defined until after the figure. In the caption, refer the interested reader to eq. 7.
12. L187-192: Eqs. 7 and 8 were initially confusing because I couldn't figure out why Rgridcell wouldn't just be the mean of all Rpatch values. However, these aren't actually describing the population change exponent as is implied by the use of R; they're describing different additive terms *within the equation for* R. (On reread, I see that the Rgridcell and Rpatch convention is introduced in Fig. 1, but that's easy to miss.) For clarity, the right-hand side of these equations should be $f\left(P_{gridcell\ t-1}\right)$ and $f\left(P_{patch\ t-1}/L\right)$, respectively. In addition, before showing the equations, remind the reader in words what those terms are supposed to represent (respectively: effect of landscape-scale and substrate-scale competition [or the relief thereof, at low densities]).
13. It seems like the change in available material (L) is used in all these equations. I think that makes sense. But it also sounds from your text like only the POSITIVE component of L is used; e.g., L196-197. What about the NEGATIVE component— losses to fire, decomposition, and bark beetles? L should represent the NET change in substrate availability, no?
14. L202-203:
    a. Why was wscal calculated for both the previous and current year?
    b. This raises the question: When is this calculation happening? Is it at the end of the calendar year?
15. L205: I'm confused about how the weighted mean (wscal_mean) is calculated. Please add an equation explaining it.
16. L207: How is autumn swarming period defined? A reference to Marini et al. (2017) isn't enough; for *GMD* you need to go into these kinds of details.

17. L214-221:
    a. When salvage and/or sanitary cutting is performed, is the prescribed harvest fraction reduced for that year? E.g., if damage_available > salvmax, there should be no additional capacity for wood harvest in the first half of the year (when salvage/sanitary cutting is performed).
    b. Where did the 5 m3 number come from?
18. L252-271:
    a. It's not surprising that CRU wind data aren't very informative for wind damage, as mean wind speeds don't account for damaging gusts. For a similar finding with regard to fire Lasslop et al. (2015, DOI:10.1071/wf15052)—this would be interesting for you to note/cite.
    b. Wouldn't it be simpler to just force with the observed storm damage? I think you don't do this because you want to account for the cohort/height-specific situation. This should be mentioned.
19. L276-279: Is "CRU" here referring to the CRU-JRA dataset? If so, replace all bare "CRU" references with "CRU-JRA." If not, cite the CRU dataset separately.
20. Table 2: Include a column referring to the equation(s) where each parameter is used.
21. L333-336: I don't understand.

Results

22. L405-406: This is confusing. What is "the LPJ-GUESS run with calibrated parameters"? I thought that was what you were describing at the top of this paragraph.
23. Sect. 3.4 adds nothing; it can be deleted, with any important information moved into the Discussion.

Discussion

24. L422-423: What are galleries? What is "the defense?"
25. L425: "tree density" initially had me thinking in terms of individuals/ha. Rephrase to "wood density" for clarity. Unless... is it actually individuals/ha? If so, please explain the connection there.
26. L427-428: This is confusing. Each country/region had multiple gridcells, no?
27. L462-465: Not sure what this bit is adding to this paragraph.
28. L474: "but" doesn't seem to fit here.

29. L493-495: How do # of generations emerge from the phenology function, which seems to just be Eq. 14?