**Modeling Notebook notes for TRACE – BLT Model**

This is not a TRACE document, but a TRACE notebook. General guidelines for TRACE are found on [Grimm et al 2014](http://dx.doi.org/10.1016/j.ecolmodel.2014.01.018) (structure on Table 1).

Interface gráfica do usuário, Diagrama

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| --- | --- |
| **TRACE element/MN entry tag** | **MN keyword** |
| 1. Problem formulation | Model purpose; Research questions |
| 2. Model description | Model development; **Design decisions** |
| 3. Data evaluation | **Parameterization**; **Patterns** |
| 4. Conceptual model evaluation | **Conceptual design decisions** |
| 5. Implementation verification | **Debugging**  Software verification/Testing  Usability tools design |
| 6. Model output verification | Output verification/Goodness- of-fit **Calibration**; Tests on environmental drivers |
| 7. Model analysis and application | Sensitivity analysis; Uncertainty analysis Robustness analysis; Simulation experiment |
| 8. Model output corroboration | Output corroboration/**Validation** |

Implementation 1 refers to Step length + turning angles

implementation 2 refers to Resource visitation rules

implementation 3 refers to Territoriality

**Examples of topics to be included each day and a brief description:**

/purpose

To validate a simulation model of BLT dispersing seeds

/data

Check .xlsx

/verification

/calibration

/calibration/direct parametrization

Obtaining parameter values directly from the literature or experts

/calibration/inverse parametrization

Obtaining parameter values inversely by calibrating the model to observa- tions

/sensitivity analysis

/sensitivity analysis/submodels/energy

/sensitivity analysis/local

Varying one parameter at a time

/sensitivity analysis/global

Varying several or all parameters over their whole ranges

/alternatives

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**2. Model description**

**February 04th 2022**

**MN Keywords: 2. Model description; 3. Model evaluation**

Discussion with Ronald about implementing turning angles and step lengths. We realized we need to check the empirical data a little bit further in order to implement a rule based on sl and ta in the model. I decided to check in [a published ABM](https://doi.org/10.1111/oik.07431) how it was done. Turning angles was implemented with von Mises distribution base on rvm-function from {CircStats} package, however I didn’t have a code for step length. Other two papers did similar implementations (Raghunathan et al 2020 and Gazagne et al 2020) with an HMM model but used also a gamma distribution to step lengths. With this I’ve checked the “Check if the impl. 1 needs model parameters” task. The answer is: Yes, it does. Gamma distribution for step lengths and von Mises distribution for turning angles. **For DPL and Path Twisting: don't know yet**.

After meeting with Ronald at 13:30 we decided to first have the nlrx workflow (to check results after running experiments) ready before making an implementation. Most importantly, we discussed more about step length/turning angles relation, I showed him the results from the ATBC and runned emptyspace analysis, explaining again the idea of taking time windows of resources and clumping measurements to make the home range emerge together with a DPL and Path Twisting based on a random point process specifying the tree aggregation. For last, I explained to him why I didn’t believe tamarins were going after resources and cited the mechanistic home range/central place forager hypothesis.

**February 09th 2022**

*Keywords: Model development; Design decisions*

From Feb 07th to now I’ve been troubleshooting Mayara’s code to match with the nlrx workflow. Two problems have risen:

1. Model output with nlrx to set workflow with R: even though it works with the Wolf-Sheep model, when I try with the BLT model, the px and py positions of the simulations don’t come out with **unnest\_simoutput()** function. Alternatively, [the nlrx vignette (see Step 3) explaining how to take manual output](https://docs.ropensci.org/nlrx/articles/manual-output.html) and relate to the nlrx object requires a reporter in NetLogo code, but when I insert it as a global, NetLogo gives me an error saying I should define it.
2. to-sleeping-trees procedure does not work when using the code for empirical sleeping trees. Thus I’ve created a Chooser **“sleeping-trees-scenario”** of whether simulated sleeping and resting trees are used or not (but only the code for simulated sleeping/resting trees work -> check **to-sleeping-trees** and **search-sleeping** procedure and sleeping-trees-here object is unused)

I also did the following:

* settled a **“tree-scenario”** Chooser for selecting which .shp with feeding trees was being used as input;
* settled an /runtime directory in model interface.

**February 15th 2022**

On the Feb 09th I started receiving this “Exception in thread "main" java.lang.IllegalStateException: unknown NetLogo version: NetLogo 6.2.0”. Ronald and I tried setting a stop condition because sometimes the model would run without stopping. Then I had to leave, and Ronald tried debugging the nlrx code. He was able to run the Mayara’s (the version he had) model, but mine was giving the following error together with same thread:

Exception in thread "main" Expected a literal value. at position 0 in

at org.nlogo.core.Fail$.exception(Fail.scala:27)

at org.nlogo.core.Fail$.exception(Fail.scala:25)

at org.nlogo.core.Fail$.exception(Fail.scala:23)

at org.nlogo.parse.LiteralParser.readLiteralPrefix(LiteralParser.scala:83)

at org.nlogo.parse.LiteralParser.getLiteralValue(LiteralParser.scala:33)

at org.nlogo.parse.CompilerUtilities$.$anonfun$readFromString$3(CompilerUtilities.scala:22)

at org.nlogo.parse.CompilerUtilities$.$anonfun$numberOrElse$1(CompilerUtilities.scala:37)

at scala.util.Either$RightProjection.getOrElse(Either.scala:665)

at org.nlogo.parse.CompilerUtilities$.numberOrElse(CompilerUtilities.scala:36)

at org.nlogo.parse.CompilerUtilities$.readFromString(CompilerUtilities.scala:22)

at org.nlogo.fileformat.LabLoader.$anonfun$readProtocolElement$4(LabLoader.scala:70)

at scala.collection.TraversableLike$WithFilter.$anonfun$map$2(TraversableLike.scala:874)

at scala.collection.Iterator.foreach(Iterator.scala:943)

at scala.collection.Iterator.foreach$(Iterator.scala:943)

at scala.collection.AbstractIterator.foreach(Iterator.scala:1431)

at scala.collection.IterableLike.foreach(IterableLike.scala:74)

at scala.collection.IterableLike.foreach$(IterableLike.scala:73)

at scala.collection.AbstractIterable.foreach(Iterable.scala:56)

at scala.collection.TraversableLike$WithFilter.map(TraversableLike.scala:873)

at org.nlogo.fileformat.LabLoader.readEnumeratedValueSetElement$1(LabLoader.scala:66)

at org.nlogo.fileformat.LabLoader.$anonfun$readProtocolElement$5(LabLoader.scala:77)

at scala.collection.immutable.List.flatMap(List.scala:366)

at org.nlogo.fileformat.LabLoader.valueSets$1(LabLoader.scala:74)

at org.nlogo.fileformat.LabLoader.readProtocolElement(LabLoader.scala:94)

at org.nlogo.fileformat.LabLoader.$anonfun$apply$1(LabLoader.scala:45)

at scala.collection.immutable.List.map(List.scala:293)

at org.nlogo.fileformat.LabLoader.apply(LabLoader.scala:45)

at org.nlogo.fileformat.LabLoader.apply(LabLoader.scala:30)

at org.nlogo.fileformat.LabFormat.load(NLogoLabFormat.scala:37)

at org.nlogo.fileformat.LabFormat.load$(NLogoLabFormat.scala:35)

at org.nlogo.fileformat.NLogoLabFormat.load(NLogoLabFormat.scala:40)

at org.nlogo.headless.BehaviorSpaceCoordinator$.$anonfun$selectProtocol$1(BehaviorSpaceCoordinator.scala:34)

at scala.Option.map(Option.scala:230)

at org.nlogo.headless.BehaviorSpaceCoordinator$.selectProtocol(BehaviorSpaceCoordinator.scala:32)

at org.nlogo.headless.Main$.runExperiment(Main.scala:23)

at org.nlogo.headless.Main$.$anonfun$main$1(Main.scala:12)

at org.nlogo.headless.Main$.$anonfun$main$1$adapted(Main.scala:12)

at scala.Option.foreach(Option.scala:407)

at org.nlogo.headless.Main$.main(Main.scala:12)

at org.nlogo.headless.Main.main(Main.scala)

**Error in util\_gather\_results(nl, outfile, seed, siminputrow) :**

**Output file is empty - simulation aborted due to a runtime error!**

**Make sure that parameter value definitions of the experiment are valid and the model code is running properly!**

So I went to the model (BLT\_model\_developm.nlogo) which I did the last implementations and realized that the model was breaking (running eternally) sometimes it was initiated. Then I checked the go, move-monkeys, run\_days and next\_day procedure. I did the following:

* go: nothing
* move-monkeys: moved in the “timestep > simulation-time” condition from the to go procedure and broke the multiple ifelses with the ‘if timestep < simulation-time’. I also took out from the setup the ‘if timestep = simulation-time’ condiditon (it was before the move-monkeys) and included it in the move-monkeys procedure
* run\_days: blocked the output code
* next\_day: added a stop condition: if day > no\_days [ stop ]
* commented out all the output procedures

The model was not breaking anymore but it still didn’t work out in the nlrx.

After one or two hours trying to debug it (BLT\_model\_developm-debug.nlogo), I assessed [this issue in nlrx](https://github.com/ropensci/nlrx/issues/27) and realized that the categorical variables should have a double quote like this:

constants = list( 'tree-scenario' = "\"trees\_all\_2\"",  
 'sleeping-trees-scenario' = "\"simulated\"" )

Now the problem is: I still can’t take pxcor and pycox coordinates. Maybe because I was doing one run with only a simple design? But how, if the tamarin run for days and 108 steps per day in different pxcor and pycor? The solution I found was setting up the number of runs in nlrx (and also in the model interface) to 1, and then specifying more runs in “repetitions” on the @experiment design

Milles et al 2020 model had an export-view function linked to an interrupter which allowed him to export the view of the run when it ended. I implemented it in a separate model (BLT\_model\_2022-developm\_issue-print-final-landscape.nlogo) but I was not able to see the tracks tamarins did. I let it like that for now.

Fiquei de fazer o cabeçalho dos arquivos output (que nem em Milles et al 2020) e de lembrar que diabos é aquele número no início de cada arquivo (o Ronald tinha descoberto já).

By the start of the night, I reassessed the move-monkeys code related to routine (the one I changed the ifelse condition in timestep < simulation time) and when I used the same code as Mayara I had a model break (infinite running). I could not understand what it was, but I think there lacks a stop condition.

I have also noticed that the tamarin was moving much less than I was used to see in the model, but it might be because I’m restricting the no\_days. -> Nope. It was because I had commented out the ‘let n random 100’ argument from the ‘search-sleeping-tree’ procedure. This is basically what moves tamarins.

**Left to fix/decide:**

* (**SOLVED**) Why the output of seeds and sleeping, resting and feeding trees text files contain information only for the last ran day even though the Mayara model works perfectly.

**February 16th 2022**

I have realized that Mayara’s model does not output seed and trees location by day. The problem was that I had copied the code ‘file-write day’ and ‘file-write timestep’ into the procedures ‘write-seeds’, ‘write-sleep’, ‘write-rest’ and ‘write-trees’.

Thus, I proceeded to add a header on each of those files and I also changed it to .csv

While running Mayara’s model I also realized that the simulations are faster when the locations of each day are written in a different file

I was succeed in extracting the pxcor and pycor from each agent by unnest\_simoutput() and proceeded with the spatial plot vignette. With this plot (one run of I don’t know how many days) it was possible to visualize that the rule of creating sleeping sites is not working properly (too many sleeping sites, a lot of them in the matrix):

Tela de jogo de vídeo game

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**Left to fix/decide:**

* Check if using different files for each day of monkey locations increase velocity of the model run
* go/run\_days/next\_day procedures have two stop conditions. I think this is breaking the execution from nlrx
* include day in the nlrx simoutput
* gif animation and sequential plots not working: try to include an informative unique variable for each run (seed-number is not informative at all) -> patches explodindo
* Make the model run with the empirical sleeping sites

**March 04th 2022**

**TRACE Tag: 2. Model development**

**Keyword: Design decisions**

Me and Ronald had a meeting and a very nice discussion about:

1. **Theoretical landscapes of Tierry et al 2 022**

* We basically ignored this landscape generation because it is useful for the simulations but not for the implementations. Thus I scheduled to discuss it in other date;
* I wrote a ‘contact Vincenot’ task in Google Calendar to discuss about manually defining landscapes (as Vincenot itself and Tierry did).

Furthermore, my questions for discussion were:

- Não explica se as paisagens foram feitas "na mão" (apesar de parecerem ter sido feitas)

- Destaca que é modelado apenas o seed rain, sendo que seedling recruitment é outro processo: "seed dispersal patterns may not be accurate indicators of recruitment patterns (Schupp and Fuentes 1995)"

1. **The methods and model of memory + resource of Ranc et al 2022.** Ronald gave the following directions and suggestions:

* Play around with working memory (how fast they forget trees visited)
* Spatial memory is fixed at the moment
* RSF is not so interesting for the moment
* GA for the energy model to maximize DPL. ONLY AFTER GA RESULTS we can change model rules/implementationss. This allows for us to say that there's something in the structure
* IF there is no combination of energy variables that reproduces the expected patterns (DPL, etc), we can implement other rules
* BUT FOR THIS I should finish the R workflow, set all variables defined manually as slider
* Compare model diagrams (Mayara and Ronald)

Furthermore, my questions for discussion were:

- Usa Wasserstein metric para comparar diferentes distribuições de NSD, step lenght, turning angles e number of revisits, and associated times since last visit.

R: Ronald suggested me to use other patterns (such as step length, turning angles and number of revisits), but I didn’t comment about using the Wasserstein metric

- Is Fig 4 enough to say that simulations based only on resources are going to underestimate tendencies of directional movement?

R: I didn’t ask this one

- Revisitation is important -> they cite Bracis et al 2015 (othr publication of the author of recurse package) but don't use the package

R: Does not matter

- What would be equivalent to the deltaAIC approach they did?

R: I don’t remember what Ronald said about this

- Conspecific avoidance can't be discarded from our model

R: ok

- What this next paragraph helps with Parameterization 1 in terms of paramtrization/validation? "In this study, we characterised the biological drivers of fine-scale behavioural decisions through the fitting of a mechanistic movement model to empirical trajectories, and evaluated resulting predictions of space- use patterns. Although challenging, this approach is appealing because the space- use pattern itself is not fitted to data, but rather arises as an emergent property from the underlying movement process (Potts & Lewis, 2014)"

R: See the first topic of Wasserstein metric

- Where Resource Selection Functions/Habitat preference goes into the tamarin model? In your opinion, should it? Think about Suzano movements and also into Taquara group that uses a wet part of the home range which was not sampled

R: I showed him the cases where tamarin were using other parts of the home range but he said that RSF is not so interesting for the moment

**Decision for the BLT Model:**

* **GA for the energy model to maximize DPL. ONLY AFTER GA RESULTS we can change model rules/implementationss**. This allows for us to say that there's something in the structure
* **IF there is no combination of energy variables that reproduces the expected patterns (DPL, etc), we can implement other rules**
* **BUT FOR THIS I should finish the R workflow**
* **For this, set all variables defined manually as chooser. This also includes the timevisit variables** (which represents working memory, or how fast they forget trees visited)
* **Compare model diagrams (Mayara and Ronald)**

For this, I created a new model version called “**BLT\_model\_2022-developm\_ga.nlogo**“ from the model “BLT\_model\_2022-developm.nlogo”

**Left to fix/decide:**

* I’ve got an error with tree\_current/tree\_pot\_list for the first time:

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* As far as I understood the workflow through the implementation process will be: 1) Implement rule -> 2) run GA for parameters > 3) See if the values reach the desired values (DPL for example)
* Remove sleeping sites being created out of nowhere
* Check Monthly trees .shp
* Print activity in the output file (activity bugdet)
* Check .shp from github not working in Ronald’s computer

**March 09th 2022**

**(continuing from March 04th)**

**Files:** BLT\_model\_2022-developm\_ga.nlogo

I reached Ronald for a briefing meeting and I decided to do this for the day:

1) model diagram

2) get .shp of sleeping, feeding and resting sites separetely

2) remove simulation trees

3) Do First R workflow to verification

4) Check memory procedures (forget\_trees, forget\_seeds procedure)

When possible - See why commenting "action" in in the model makes

And then the GA in the next day

He would take a look in the optimization within

1. **Model diagram**

Extraordinary fail to understand how to put loops in the diagram.

[Done on 17/03/22 but I still had some questions]

1. **get .shp of sleeping, feeding and resting sites separately**

[Done one 16/03/22]

1. **remove simulation trees**
2. **Do First R workflow to verification**

[Done on 11/03/22 (but still the kernel analysis were not good)]

1. **Check memory procedures (forget\_trees, forget\_seeds procedure)**

[specific implementation on Implementation 2 designed by Ronald (check Model\_development/memory folder)]

**Left to fix/decide:**

* [DONE; Ronald say it is wrong to renew the energy] energy when the day starts: ‘set energy start-energy’ commented out -> tamarins accumulate a lot of energy

**March 10th 2022**

Context: BLT Model Meeting 1 with Laurence, Eckhard and Ronald is going to happen tomorrow. I started doing the R workflow for analysis of pattern validation (on “Model\_analysis/Workflow”) to present the contrasting results of runs with input\_forget low and high values. The results of this comparison are in “Model\_development/BLT\_Model\_Meeting1/00\_Input\_forget.pdf”

**March 11th 2022 – Day of BLT Meeting 1 (w/ Eckhard and Laurence)**

I showed Ronald how my code version (Mayara’s) was different from the one he was running. He realized that there was completely different stuff (for example, not using travel\_speed to move, etc). THEFEFORE THE DAY THAT I WAS LISTENED ABOUT THE FACT THAT MAYARA DID SOME REALLY WEIRD STUFF). Thus, I asked for his code (the model he was using) to implement my modifications into. He didn’t send me. We had a very nice discussion and **that’s what we are doing next week (14/03):**

**1) Troubleshoot code + flowchart** (to identify where else Mayara changed the code and if the code we were running makes sense)

**2) Distances to next feeding tree** (step length output (see “00\_Input\_forget.pdf”) is too small.

**3) GA/recurse package** -> Ronald quer explorar os padrões de step lenght e turning angles em escalas maiores de tempo por algum motivo. Disse que podemos fazer tanto o GA quanto analisar métricas de revisitação com o pacote ao mesmo tempo. Ele também concordou em eu tentar contatar o Ranc (autor da publicação de memória)

**Let to fix/decide:**

* Seminar dates
* [Done on 16/03/22] month shapefiles with sleeping, feeding and resting trees in different files
* Phenology values (does it stay?)

**March 14th 2022**

* Finished doing model diagram with Ronald but didn’t finish including the layers in the diagram to check the status and action each step
* Identified that the step when “night” is set does not change energy (thus it is wrong, it shouldn’t count as one timestep)
* Included a column “behavior” that matches the activity budget

**Let to fix/decide:**

* [Kind of done on 15/03/22 but still get tree target errors some times] clean run\_days/go
* clean set status/target etc (colocar tudo dentro dos procedures e tirar do loop)
* [?] colocar no workflow quando status, action (e se der tempo, tree\_target/tree\_current)
* checar se defecation ocorre somente antes do timestep 84 (depois de 3 pm)
* ifelse random ( 2 \* 5) > action time -> conferir quantas vezes eles podem executar a mesma atividade seguida e colocar como slider (APENAS FORAGING OU RESTING)
* Desimplementar "species-time"
* Include “idle” behavior
* Esse erro em to-feeding-tree

Interface gráfica do usuário, Texto, Aplicativo

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**March 15-17th 2022**

* Button go does not work if I click Run Days or Next Day before
* [Kind of done on 15/03/22 but still get tree target errors some times] Tried cleaning the go/next\_day procedures and it was a pain in the ass. I settled a ‘step’ procedure only for debug porposes but could not get rid of the next\_day/run\_days structure
* Continued having the run-time error from the previous day (but only sometimes)
* Error in sleeping procedure (target 0) when running ‘go’ after Run Days or Next Day -> set heading towards tree\_target -> I think I have solved by setting the tree\_target correctly in each procedure
* [solved -> check “Data/Guarei-Trees/Tree-points-unique.R”] Bug: sleeping-tree 1112 e 1113 são a mesma -> checar no shp -> acontece quando a árvore se repete nas observaçõe (linhas) do dataset que é transformado em .shp

Interface gráfica do usuário, Aplicativo

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* I did distinct shape files for the model. One with all trees (for all months and for each month, which is equal as what Mayara did) and separate shapes for all months or each month with sleeping, feeding or resting trees.
* Added sleeping-trees? interrupter in the interface (to don’t have to make distinct shapefiles for each type of tree)
* After selecting shape files, as there were few resources each month, the tamarins were dying and the model would not stop running the run\_days, so I did a stop condition that for some reason does not work:

if not any? monkeys [ stop ]

* I realized that for debugging purposes I should print the DPL in the end of the day

**Meeting with Ronald 17/03 afternoon:**

- [Done on 17/03, check “Data/Trees-Guarei/Tree-points-unique.R”) do shapefiles with all sleeping sites

- Path Dependence in Operational Research (pathways of modelling)

- [Fixed on 17/03, but the status is kind of wrong and we should look at it again] wrong behavior when going to resting tree

**Left to fix/decide:**

* Gráfico, Gráfico de dispersão

  Descrição gerada automaticamenteAfter I specified a distinct input for all sleeping trees (all-slp-trees? chooser), monkeys started to die earlier than expected. It looks like it is because of the sleeping sites because they keep changing sleeping-site in target:
* [18/03] Troubleshooting this problem with Ronald: the problem was something related to the position of the set tree\_target in the code, but I don’t remember where exactly
* REVIEW search-resting-defined (input de árvores de Descanso não deveria ser necessário)

**18/03/22**

[18/3] For debugging:

> let agentset [self] of sleeping-trees print agentset

We realized that an error was happening: the tamarins would forget all the potential trees thus the list would become empty, giving the error of 0 agentset. I did a graph ploting the length of the list and realized the problem was the *‘set tree\_pot\_list remove-item ( position [who] of tree\_current tree\_pot\_list ) tree\_pot\_list* of the *to-feeding-tree* procedure. If this is commented out, the tree\_pot\_list increases (surprisingly)

In the image below, basically, the forget\_trees procedure is commented out, but the memory procedures inside the move-monkeys procedure are not. The only thing that is running that influences the memory is the move-monkeys code with the tree\_ate\_list and tree\_pot\_list being changed inside the move-monkeys. Similar code inside feeding etc procedures are commented out.

* tree\_pot\_list increases more than the number of available trees
* **Interface gráfica do usuário, Aplicativo

  Descrição gerada automaticamente**tree\_mem\_list does not increase too much

Then that’s what happens:

Interface gráfica do usuário, Texto, Aplicativo

Descrição gerada automaticamente

Interface gráfica do usuário, Texto, Aplicativo

Descrição gerada automaticamenteThe problem was in this procedure, probably because it is being called 3 times in the same move\_monkeys loop.

Interface gráfica do usuário

Descrição gerada automaticamenteNow when it is taken out, that’s the result:

Interface gráfica do usuário, Texto, Aplicativo

Descrição gerada automaticamenteBut if I keep running, eventually I get this:

So, everything seems to be solved, but we came back to getting the error I was having with Ronald before.

**Left to fix/decide:**

1. Now, the memory increases a lot, not getting any asymptote
2. The tamarin does not move from a specific patch of trees -> probably related to the distance to the next feeding tree. This might be solved by the patch based implementation planned by Ronald

**March 21st 2022**

**MN Keyword: 2. Model description**

Although scent marking behavior was already taken out from the model, this process was not documented. Reading Heymann ([2021](https://www.tandfonline.com/doi/full/10.1080/03949370.2021.2015454)), which cites Franklin et al. 2007 study on *Leontopithecus rosalia* assigning a function of marking to reducing predation at sleeping sites, and considering that we don’t have enough data to perform the *quasi experiment* scenario which fragmentation produces (n=4 sites), I think this is enough for us to disregard scent marking as a process that influences movement and seed dispersal. Also, from Sussman & Kinzey (1984):

“*Marmosets frequently scent-mark exudate holes (Coimbra- Filho and Mittermeier, 1977; Ramirez et al., 1977; Rylands, 1981; Lacher et al., 1981). This behavior has been considered to be territorial (Coimbra-Filho, 1972), but the groups studied by Lacher et al. did not avoid holes marked previously by other groups. Marking may be a way of indicating relative time elapsed since a particular exudate source was last used, and does not appear to have any territorial significance*”

**Debbuging:**

* Now the model puts 0 values in the tree\_mem\_list, resulting in a list like: [0 0 0 0 0 0 0]. Furthermore, this increases much slower than the version of 2022-03-11d
* Had to go back at the code and check where the problem was. Basically:

1. I had removed the set action-time and set status from inside the move monkey to inside the called procedure but positioned it wrong.
2. The procedure in yellow above didn’t work if I put it in the *forget-tree* procedures
3. I could not identify why the tree\_mem\_list was not getting bigger in the graph (pen-plot) -> it was too close to the red line, the seed\_mem\_list (they have the exact value)
4. For some reason, the tree\_pot\_list was getting bigger after a certain time even though the tamarin was barely moving [image below]

Gráfico

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**March 22nd**

Conversei com o Ronald e expus os problmas dos dias anteriores. Concordamos em:

1. [ Não consegui mexer nas camadas com o yEd] Fazer o flowchart focando no set status/tree\_target (como eu estava fazendo antes)

2) Primeiro iremos mexer no componente de memória (forget\_trees, diminuição e aumento das listas), depois o critério de seleção de árvores (que provavelmente vai entrar em step lengths)

* Changed input\_forget to step\_forget (makes more sense)
* step\_forget has to be dependent on the number of trees available, otherwise the pot\_list gets empty
* included the memory code that was inside the move\_monkeys loop as a distinct procedure ‘mod\_memory’
* [solved on the same day, it was a problem with the agent feeding-tree 0 because of the set tree\_target 0 being called in the code] the pot\_list diminishes and receives the consumed trees back, but for some reason it keeps getting smaller

Ronald helped me troubleshoot the model in the afternoon and then we made a lot of progress: memory is working as desired (after some if/ifelses and moving the remove-item tree\_pot\_list line, in yellow above, from the ‘to-feeding-tree” to the ‘feeding’ procedure)

**Left to fix/decide:**

* Make input\_forget dependent on the number of trees
* First days of simulation to establish the memory with the input\_forget value
* Distance to next tree

**Meeting w/ Felipe, Anne e Gabi 22/03/22**

[ver Nota Keep “LaP Meeting BLT Model 22/03/2022 Anne, Felipe e Gabi”]

**MN Keyword: 2. Model description**

In this meeting, some important things were discussed:

1. **Simulation time**

For Anne e Felipe, they don’t think the phenology changes too much up to 30 days, so it is okay to simulate up to 30 days (but also okay to simulate less)

1. **Resting trees/Idle**

* Are resting sites fixed as sleeping sites (= IBM model of Peru). R: No.
* Why there is only one resting tree in May? R-Felipe: because they didn’t rest, lol
* BLTs rest usually every day at the same time? R: Yes, but in Guareí they tend to rest less (and not every day). Gabi and Anne talked about two general periods of resting: 12-14 and 16-17. There is a relation with temperature (GAM picture of Felipe below)

Gráfico

Descrição gerada automaticamente

* Is ‘idle’ equal for Anne and Felipe datasets? R: Yes. Usually when resting tamarins behave differently than just ‘idle’, i.e., they stay together and keep at least 15 min (3 steps) resting, but can also eat something meanwhile. Criteria: > 15 min in the same place chillin’ -> resting ; just stopped a little bit -> idle.

**Idea: Take out resting trees**

**Idea: Implement ‘idle’ behavior**

1. **Memory**

I commented in general about Ranc et al 2022 paper and Ronald idea. Felipe largely agreed with me about the patch-based memory in the place of the tree-specific memory. I also commented about the burn-in days for tamarins to “know” the trees available.

1. **Feeding tree selection**

On the model, the basic choice of the tamarin is the next feeding tree; This means that the model is based on feeding trees selection, and not territory occupancy. How is that in nature? Have you seen tamarin passing by a known-to-be-consumed resource/fruit without eating eat? If there are 5 trees with fruits available in a line, is that possible that they don’t stop on them and just go through without eating it?

R: YES and YES and YES. Felipe: From one event of frugivory to the other, they walk more than the distance to the closest feeding tree. In the mornings, BLTs do not repeat the same fruiting tree eaten in the last day. Actually, they usually leave the site in silence and go feeding some 200 m far (Guareí; Anne confirmed it to the other sites). When they were feeding in the same tree (‘enchendo o bucho’) they would usually stay for 30-45 min and then just go in a specific direction passing by lots of fruits. It also happened that they were eating the same fruit species of different trees throughout the day.

1. **Sleeping tree selection**

In the model, BLTs select the sleeping tree only in the 108th timestep. In the nature, do BLTs select a sleeping site and go to its direction earlier in the day?

R: Yes. Felipe suggested one hour (12 timesteps). Anne confirmed. Also, they usually visit one more patch of fruits and then go to the sleeping site

**Idea: After the 108 – 12 timesteps, don’t let BLT’s select trees that gets them away of the sleeping site (distance from sleeping site can’t increase)**

1. **Defecation up to the 84th timestep**

Does defecation occurring up to the 84th timestep make sense? R: Yes, in general. But when seeds are big the gut passage time is usually shorter and when they go to sleep later (e.g. they take a while to arrive at the sleeping site), they defecate in the way.

**[not priority] Idea: If they take more than x steps after step 108, they defecate in the way; otherwise, just in the morning**

**Left to fix/decide:**

* Take out resting trees
* Implement ‘idle’ behavior
* Ronal’s idea: implement resting based on temperature
* After the 108 – 12 timesteps, don’t let BLT’s select trees that gets them away of the sleeping site (distance from sleeping site can’t increase)
* If tamarins take more than x steps after step 108, they defecate in the way; otherwise, just in the morning

**March 23rd 2022**

**MN Keyword: 2. Model description; 3. Data evaluation**

I started having a meeting with Ronald where we discussed the next steps after fixing the memory on the March 22nd. This is what was decided:

1. **Check the distance walked AND step lengths and turning angles after leaving the sleeping site to the first feeding tree (empirical data)** -> see if it varies/is a strong pattern (probably varies as the step lengths in general)
2. **Check QGIS if they move prior to resting** -> [**Done** **on 24/03**, check “QGIS-prints-Guareí.pdf” on [path](file:///D:\Data\Documentos\github\BLT_IBM-Model\Documentation\resting-behavior)] -> It does not seem that they do (in Guareí) and Anne commented they don’t do it either in Taquara and Suzano. **Problem**: have to review Santa Maria behavior data (vigilant behavior should be the same as idle)
3. **Implement in the forget\_trees procedure a code for tamarins to avoid consuming trees in the same patch** (draw a circle of e.g. 25 m around the feeding tree and then exclude all the trees inside from the potential list) **[Done on 31/03/22]**

- Isso vai gerar problema com a quantidade de recurso disponível (n° de dias)

- O certo seria escolher o mesmo número de dias pro mesmo mês (e.g três dias por mês, e aí criar as árvores somente desses mesmo número de dias)

1. Another possible implementation: define memory of each cell with a "Burn in" round to establish patch-memory values, then select patches not visited when tamarins have enough energy and direct them to those sites. Then they come back to searching for the next feeding tree

However, as I was reading Patrícia Medici dissertation and I had a meeting from GT Congresso, I read it and went home.

* **Black lion tamarins had very distinct activity budgets after translocation**. Comparisons of activity budget between L. chrysopygus studies and other *Leontopithecus* species. Cites Sussman & Kinzey 1984 about general variation and Robinson 1986 about resource spatial distribution. Citing Valadares-Padua, “it is impossible to explain activity budgets without considering the local influence of the habitat”
* Comparison with L. rosalia reintroduction (Pinder 1986). **The author showed that translocated animals had similar activity budget as another resident group**, but would go to the sleeping site earlier, with the possibility of ingesting less food.
* **Territoriality: ranging patterns (very high and exploratory) in Mosquito linked to absence of other tamarin groups:**

Papel branco com texto preto sobre fundo branco

Descrição gerada automaticamente com confiança média

* Texto

  Descrição gerada automaticamenteThe important resources for lion tamarins that distinguishes them from other primates:

Texto, Carta

Descrição gerada automaticamente com confiança média

* When translocated, black lion tamarins exhibit ‘exploratory’ behavior:

Gráfico

Descrição gerada automaticamente

* Establishing home range depends on neighbors:

Texto, Carta

Descrição gerada automaticamente

* Tamarins range less when bearing children (how much not specified)
* Regular routes to patches of feeding trees (usually Syagrus) are acknowledged but not explicitly evaluated

Texto, Carta

Descrição gerada automaticamente

* Texto

  Descrição gerada automaticamenteAnd that L. rosalia defend territory to exploit resources (citing Peres 1986), thus consuming more resources in the edge than in the interior.
* Tamarins in riparian forests have smaller home ranges because riparian forests have more ‘resources’ (but no good reference is given):

Texto

Descrição gerada automaticamente

**March 25th**

**Memory – comparison between *Callithrix* and *Leontopithecus rosalia* (Platt et al 1996):**

“*In order to make efficient use of widely separated, ephemeral patches ofripe fruit and insect foraging sites distributed over a relatively large home range, golden lion tamarins may require enhanced spatial memory and navigational ability (cf. Clutton-Brock & Harvey, 1980; Milton, 1981). Marmosets, however, may use spatial memory to return to particular closely spaced gum-feeding sites (which number in the hundreds on anyone tree: Sussman & Kinzey, 1984) over relatively short time intervals. The possibility thus exists that the observed differences in feeding ecology in these otherwise similar species may be correlated with differences in the ability ofthese animals to retain and use information about the location of food over different time intervals.* ***Wied's marmosets, for example, might be expected to remember spatial in- formation equally or more accurately than golden lion tamarins after short retention intervals, but as the retention interval is increased, golden lion tamarins might be expected to remember spatial information more accu- rately than would Wied's marmosets****.”* (Platt et al. 1996)

The conclusion that “*These differences […] in the typical return time to resources in the wild by each species: marmosets usually revisit food sources within 24 h, whereas days or weeks may elapse between visits by tamarins to their widely separated foraging sites.*” **suggests that tamarins depend a lot on spatial memory, possibly more than on visual cues: “*It is possible that both tamarins and marmosets use location as the primary source of information for finding food resources and rely on direct visual cues as secondary sources of information***”

**This means for the model that the implementation of “forgetting patches” in a specific ray (see March 23rd notes) might be realistic. We just have to set the step-forget to be similar to this revisitation interval.**

**March 25th**

During the meeting with Eckhard at the DPZ, the following topics were discussed:

1. If the best implementation would be the memory-based patch (Ranc et al 2022, which Ronald is kin to) or the forget-patch procedures (which I propose, but I need a value for how far tamarins identify resources). He said it was difficult and I concluded that I’d go through the easier (my proposal)
2. We didn’t really speak about the resting based on temperature
3. When I showed him the seed dispersal related variables, he said to me it would make sense to consider the number of defecation events and not the number of seeds. This was a nice one.

Decisions for the model:

1. Do the forget-patches for the agent to forget trees inside a radius. Try Ranc et al 2022 implementation afterwards if needed.
2. **Seed dispersal patterns: number of defecation events** **and not the number of seeds**. Try to input a distribution of number of seeds defecated if you want a specific tree to be estimated. Also, ask Anne & Felipe if there should be more than one defecation event. Probably there is data published about how many seeds primates defecate by dropping -> perguntar Lo

**March 30th**

I was building the flowchart diagram again as Ronald started doing the implementation of the forget-trees-in-radii and got some errors. I rebuilt the flowchart in draw.io because it allows having layers and created one layer for status/action and other for tree\_target.

File: Model-Diagram\_2022-03-30\_Implementation2-forget-trees-in-radii.drawio

Left to fix/decide:

* tree\_target is constantly changed to -1 after each condition
* ( set energy energy + energy-loss-resting ) AND ( set timestep timestep + 1) could be a procedure ‘scheduling’ only called only after forget\_trees procedure instead of being called throughout the code
* resting procedures has 3 possibilities and they don’t seem congruent -> it should be equal to the search-feeding-tree procedure
* resting called after random-action procedure does not set tree\_target as after midday
* first possibility of resting after midday does not set tree\_current or tree\_target
* random-action procedure set tree\_current and tree\_target after calling resting and forage -> should be taken out.
* change-bonus is not an ifelse, thus it is calling both a random-action and last-action-again:

Interface gráfica do usuário, Linha do tempo

Descrição gerada automaticamente com confiança média

**March 31st**

Meeting with Ronald to see github issues and check the flowchart. We did some big changes:

* **deleted ‘status’ from the model and based it solely on the action**
* eliminated status = “hungry” (there’s already a condition if energy > level 1)
* **changed action to ~match behaviors (but kept behaviors to use as validation)**
* changed status = “none” to action = “travel” when the monkeys are set up or next\_day is called -> that’s the first behavior of the day
* took out action = “on resting tree” for action = “traveling” or “resting”
* new reporter to substitute “on-feeding-tree?” to substitute status “search feeding tree” and “on feeding tree”
* we solved the error of the specific location being equal to the target by running through the tree\_target workflow
* **Made the forget-trees-in-radii work**
* Took out to-resting-tree subprocedure and took out tree\_target stuff from the resting procedure
* **Created a procedure “frugivory” to simplify the move\_monkeys procedure**

Next implementations:

1. Instead of selecting the closest tree, selecting one random between the closest 5 trees
2. Foraging + travelling -> check empirical data -> print/send movement patterns for Ronald
3. Make foraging more directional
4. Changing travelling velocity
5. Discuss Ranc paper once more

Problems identified during documentation:

* [DONE 01/04/2022] check else condition of:

ifelse (action = "feeding" or action = "travel") [] []

* [DONE 01/04/2022] change-bonus and last-action-again and random-action tree\_target
* change name of frugivory (and group on feeding tree? + species time > action-time as a decision/group in the flowchart

Before BLT Model Meeting 2:

1. Have home range and seed dispersal output analyzed
2. Do mean output of runs (either with nlrx or not)

Interface gráfica do usuário

Descrição gerada automaticamente**Left to decide:**

1. **Ronald said we should discuss the travel + forage** (tamarins intertwin travel and foraging, as I showed him in QGIS). This would add more variation in the daily paths, as there is not too much now >>>>>>>>>

Maybe including in the territoriality implementation

1. Interface gráfica do usuário, Texto, Aplicativo, Email

   Descrição gerada automaticamenteNathan Ranc answered me in the end of the day and said he did not use the recurse package and took the locations by using the patch/grid in the model. On the contrary, for real GPS locations would be more complex but interesting  
   I showed this to Ronald, and he asked me for coming back to this afterwards (because in Ranc’s paper there is a step length/ turning angles input, and it is not only an emerging property)

**April 03rd**

Started tackling Eyal’s code to generate patches. Path: Model-simulations/

**April 04-05th**

Checked Amanda Melin studies of distance detection of fruit. Melin et al 2014 AJP:

* Distance detection based on fruit color is not assessed in studies:

“Yet, despite the importance of color during distance detection, **most investigations of the consequences of primate color vision have examined real or simulated foraging efficiencies at close (<2 m) to moderate (<6 m) distances** (Caine and Mundy 2000; Hiramatsu et al. 2008;Melin et al. 2009;Pessoa et al. 2005a; Smith et al. 2003b; Vogel et al. 2007), with little attention devoted to long-range foraging advantages**, perhaps owing to the difficulties in testing the latter under captive or field conditions**.”

* Other factors can make inference about the influence of color detection difficult: important fruit resources (such as figs), feeding preferences (Stevenson & Links 2010) (fruits are usually a preferred resource), size of feeding patch, spatial-temporal memory, and vision:

“What is more, the **size of the food patch** is anticipated to affect foraging strategies and rewards associated with discovery. **Spatial-temporal memory likely plays a large role in (re)localization of large, productive fruits trees that are returned to on successive days or monitored from year to year** (Cropp et al. 2002; Garber 2000; Oluput et al. 1998). Alternatively, small, ephemeral fruit patches are more likely to be discovered a new each time via sensory search (Bunce et al. 2011). Among the senses, **vision plays a particularly important role in guiding food search over distances of up to ca. 30 m (Janson and Di Bitetti 1997; Lucas et al. 2003)**”

* This paragraph might be enough to define 25-30 m radii for the forget-trees-in-patch procedure but also calls attention to the fact that this process should occur only in small spatial scales, while long travels for specific food patches might be relying in memory. Thus, the patch-memory process might be as well implemented.

Accordingly, Ranc et al [2021](https://www.pnas.org/doi/10.1073/pnas.2014856118) (PNAS) shows with an experimental manipulative study that **roe deer (*Capreolus capreolus*) rely on memory, not perception (smell), to track the spatiotemporal dynamics of resources within their home range**. They **disregarded smell (perception model)** as a possible mechanism predicting roe deer revisitations (transition probabilities matrix), **and cite the same conclusion for capuchins in a study by Garber & Paciulli (1997):**

“The ability of roe deer to perceive the smell of supplemental food from afar is largely unknown. It could be that roe deer are not able to perceive food presence through olfaction from afar (i.e., memory is their only source of information). Alternatively, the information encoded in their memory about a resource’s accessibility overrode sensory cues. **Such hierarchical processing of information has been shown for wild capuchin monkeys (Cebus capucinus), which primarily used memory, overriding conflicting perceptual cues, when resource locations were predictable** (10)”

Assuming this is also true for tamarins, at least in relation to the exclusion of resources in the patch, implementing this forget-trees-in-patch process seems to make sense. One alternative is to make resources “unavailable” or “depleted”, but this does not make sense for the tamarins as they rarely deplete a patch. Hopkins call it “**depleted/monitored**”.

Furthermore, Hopkins 2016 cite that “Computer simulations of travel along an olfactory gradient could not explain the directness of tamarin travel between food sources (Garber and Hannon 1993)”. This may also be evidence for us to disregard other senses into the modelling process.

In her study, Hopkins used only 50 m distances between feeding trees, a value “above previous estimated visual detection by primates”:

“[…] *long-distance movements between food trees, as movements exceeding the visual range of primates are the most likely to utilize spatial memory. I defined a ‘long-distance foraging movement’ a priori as* ***a travel bout longer than 50 m that ended at a food tree. By traveling 50 m, mantled howler monkeys would exceed previously estimated visual detection distances of primates, thereby ensuring that they were unlikely to have been able to monitor the target of their travel bout from their starting point*** *(Janson and DiBitetti 1997; Milton 2000).*”

Furthermore, she discusses the range of vision/detection distances in primates and that it is probably even shorter than expected for a group because howlers travels in line:

*“However, primate detection distances have been estimated with a variety of methods, including using human visual detection distances as a proxy, measuring ecological characteristics such as mean crown size of canopy trees, and testing detection distances experimentally (Milton 1980; Janson and DiBitetti 1997; Milton 2000; Janmaat et al. 2006; Normand and Boesch 2009a; Noser and Byrne 2010).* ***In these studies, estimated search windows for primate groups are less than or consistent with a 75-m window (range 10–82 m).******One would expect the search window of a mantled howler monkey group to be towards the lower end of the estimated distribution of search windows, given the propensity of mantled howler monkeys to travel through the canopy in single file*** *(Milton 1980; Hopkins 2011)”*

Furthermore, in her simulation model: “Those cells within 50 m of the group’s current location (\*24 cells) were assumed to be part of the group’s current visual food search and were excluded as target cells.”

Ranc et al 2021 (PNAS) also cites Janson 1998 study that infer revisitation from geographic location -> check after

Also, **based on the revisitation patterns (time since last visit), they estimate** **half-life for spatial memory of 5.6 d (t1/2) (Fig 5)** and states that roe deer covers most of its range in few days (as the tamarins), in contrast to bison and caribou (which use long term spatial information).

Also, **they found effects of temperature on ranging: revisits** “increased at low temperatures, consistent with the higher energetic demand of thermoregulation (44)”.

Decisions for the model:

* 25 m radii is ok, but using a 30 m of vision distance one would make more sense -> need to translate this to the NetLogo GIS Extension
* Implementing the patches memory also makes sense -> how to distinguish between attribute memory and spatial memory (Ranc et al 2020 PNAS) in the tamarin model?

**Ranc et al 2022 rediscussion with Ronald**

After discussion for around two and a half hours, this is what we concluded:

1. **Simulating more than one group of tamarins at the same time is needed** in order to restrict home ranges (otherwise they will range throughout the whole fragment)
2. Ideally, we should not have to calibrate the energy submodel every time we switch areas, especially the variables energy-level-1 and 2 and energy-loss-\*
3. Ronald said the following phrase multiple times: “Movement is more important than resources”, in the sense that moving is the “natural” way that monkeys behave
4. Gráfico, Histograma

   Descrição gerada automaticamenteIn order to make tamarins range though their entire home range, we should input an attractiveness/memory based on patch (as Ranc et al 2022 Fig. 1a). The values of attraction could be initially (at the start) defined as a) the number of trees in the patch or b) we could do a random movement burn-in run. Ronald suggested using **Gillepsie algorithm for deciding which patch would be chosen**
5. We don’t have a Resource Selection Function for tamarins, thus 1b-d are not taken into account.
6. Ronald and I did not identify how Ranc et al model selects the next step: if it draws a circle around the step length and select the highest probability, or other way. If it I always the patch with the highest probability, the agent would backtrack. OR, if the patches visited in the way to the target patches are not accounted, this would not happen. Thus, for Ran email, ask: How do the step selection work in your model?

**April 7-8th and April 12th**

The perspective of finally implementing more than one group into the model to make home ranges emerge, as discussed with Ronald after revisiting Ranc et al 2022 model made me revisits the literature.

* Revisiting Liu et al 2013: they have a “burn-in” procedure for the animals to establish home ranges before starting the simulations
* Revisiting Hopkins 2016 (and realizing is one of the most important publications for my project because she tests distinct heuristic models for Alouatta movement) (check Literatura\_acompanhamento.xlsc for a resumé)
* Her Fig. 2 shows distances traveled between sequential feeding trees that are less than 50 m afar (10 min relocations):

Gráfico, Histograma

Descrição gerada automaticamenteGráfico, Histograma

Descrição gerada automaticamente

Texto

Descrição gerada automaticamente

* Cell sizes for testing effect of patch was 25 m because it is the mean spread of the howler monkey group.
* “*During each time period in which a long-distance movement occurred, the primate group was able to choose from all cells within its home range*” -> This is the same thing as letting the tamarins “know” every tree in the home range or all the patches they have passed by in the burn-in procedure
* Hopkins 2016 used 25 x 25 m as patch size (= mean group spread). But we don’t have this info for tamarins, and we know that tamarin movement scale with habitat availability. **What if we use patch size = mean step length for each area? How would we parameterize this in the simulations?**
* Used a uniform distribution of angles and fixed step length (=25 m) to test the hypothesis of random walk, **but restricted the turning angles to 60° “***in order to maintain the directionality common to primate movements (Garber and Hannon 1993)*.” -> **check empirical travel patterns of tamarins to implement the travel to feeding trees less directional**. This allies to the idea of Eckhard of using the model as it is (v1) as a “null model”. This also implies that my idea of making the travel to feeding trees less directional could be allied to more randomness (30 or 90° turning angles)
* Used a **binary variable for each tree: visited (1) or not (0) in the last tree days** -> I have to check empirical timing of revisitation patterns. **I could also implement this to the patch**. However, howlers do revisit trees that were visited (1) in the last 3 days -> **This is contrary to the implementation I made. Or is it?**
* Most of the inferences for fruit availability (described by Hypothesis 1 and 2, supported) are not possible for my study
* The geometrical model with more than 50 m of reaching (which is equivalent to vision or other senses) was significantly better in reaching food patches than the observed. But most studies estimating primate detection capabilities range from 10 to 82 m and as studies show that howler monkeys travel in a single file through the canopy, she disregards the hypothesis that howler groups are able to search a window greater than 75 m because the sensory gradient models (with 75 m).
* Instead, her conclusion is that models are simplification and other influences (like social) are in play. **She didn’t consider territoriality though**. This is a nice starting point for citing her work.

Decisions for the model:

1. As the model up to now is well debugged (2020-04-01d version) and I was suggested to present it to the NWFVA, Ronald and I realized that this version might be a good “version 1” of the model working. I’ll probably branch the github and make a “v1” for it.
2. Implement a “depleted?” or “monitored?” binary variable for patches (See Fig. 1 Hopkins 2016)

**6. Model output verification**

**18/03/22**

Preparing for the Genetic analysis next week, I realized we need the following to proceed:

1. Model not breaking
2. Prepare the nrlx setup again
3. Multi core run

**5. Implementation verification [?]**

**Jan/Feb (não coloquei a data)**

/extensions/gis

Got the code of nlrx running for Mayara’s model. Problem: It is generating one file for each day, thus it dumps everything in github

Files and code: [path](file:///D:\Data\Documentos\github\BLT_IBM-Model\Model_development)

Script: 00\_start-nlrx.R

Left to fix/decide:

* If I’m keeping model output as external files

/extensions/gis

**Feb 2nd 2022**

Debugged shapefiles of the three areas (Guareí, Suzano and Taquara) to initialize with a chooser + if condition.

Files and code: [path](file:///D:\Data\Documentos\github\BLT_IBM-Model\Model_development\gis-extension)

Included a procedure to check if turtles are inside the shapefile: ‘check-agent-in-fragment’

Tried looking how to scale the different shapes (scale parameter in gis extension). Didn’t find anything.

Left to fix/decide:

* Better .shp files to NetLogo (for Suzano and Taquara, too big)

**6. Model output verification/calibration**

**Day 1 – January 14th**

Six steps for making a good calibration (Railsback & Grimm 2012 Chap 20):

1. Identify a few good parameters

Important, uncertain and independent parameters. To know convincingly which parameters are important, we need sensitivity analysis. It is prudent to reconsider model calibration after this sensitivity analysis. A parameter that is highly uncertain but has little effect on results should not be used for calibration.

Decision for the BLT model: activity budget (e.g. time spent travelling?)

1. Choose Categorical vs. Best-Fit Calibration

Categorial gives a range of values (e.g. mean number of agents between 120-150), while Best-Fit Calibration gives single values (e.g. mean number of agents = 127).

Decision for the BLT model: Categorical seems the best option

1. Decide Whether and How to Use Time-Series Calibration

“If our model's purpose includes representing how results change over time (e.g., how long does it take the system to recover from some perturbation? How is the system affected by changes in its environment over time?), then it usually does make sense to use time-series calibration. But some ABMs (e.g., the woodhoopoe model of section 19.4.3) are intended to explain long-term average conditions, so they intentionally do not contain all the processes that cause the real system to change over time and use no input data to represent how the agents’ environment changes over time. In such cases, time-series calibration may not be useful or necessary.”

Decision for the BLT model: As I’ll only be focusing on the mean and sd numbers at the end of the runs, I believe I don’t need Time-Series Calibration

1. Identify Calibration Criteria

* Calibrate the model against all interested patterns
* Of apples and oranges: the observations need to match the same time and space scale
* There are kinds and kinds of variation: Calibrating variability measures (CV, sd) should be done carefully
* Often our data is inaccurate and we need to know if it is inaccurate by 10, 20 or 50%. Using uncertain data is OK and unavoidable: when the calibration patterns are more uncertain, we don't worry so much about matching them exactly, and we recognize that calibrated parameter values are less certain. But we need to have at least some idea how accurate or certain the observations are, so we know how much information they really contain
* We must specify how we will compare the observed patterns to model results. Of particular concern is how to calibrate several different kinds of model results at once: if we want to calibrate a model to reproduce the number, size, and wealth of agents, how do we decide between a set of parameters that reproduces number and wealth well but not size, and a parameter set that reproduces size and wealth well but not the number of agents?
* At the end of this step of defining calibration criteria, we should have a specific algorithm for quantifying how well a set of model results reproduces the selected observations

Decision for the BLT Model:

* Calibrate against SDD, DPL, Home range and Activity Budget
* (In order of importance) prioritize SDD, DPL, Home range and Activity Budget
* Algorithm: the mean (min and max too?) SDD, the Home range and Activity Budget evaluated after 30 running days and the DPL of each of these days compared to data of Guareí (PEMD and Suzano to be independent observations serving as validation?)

1. Design and Conduct Simulation Experiments

This calibration experiment executes the model many times, using combinations of values over the feasible range of all parameters. The results of this experiment will tell us what ranges of parameter values produce results that meet the calibration criteria. Steps:

* Select values for the non-calibration parameters and input data (if any) that represent the conditions (the same time period, environment, etc.) under which calibration patterns were observed.
* Define *parameter space* (It is usually good to include values that bound the range of feasibility) (see Figure 20.3)
* If the model is stochastic, analyze means seems right, but plot model results against parameter values [? p. 357]

Decision for the BLT model:

* Select all non-calibration parameters an input data from Guareí (using values that bound the range of feasibility, e.g. energy-from-fruit 0)

1. Analyze Calibration Experiment Results

* If your ABM does meet all the calibration criteria for one or more combinations of parameter values, then you can in fact complete this step and move on to the kinds of analysis we address in part IV
* What should you do if you cannot meet all the calibration criteria at once?

1. Screen for errors (code, submodels, etc)
2. If there isn’t any error, your model is too simple or too simple in the wrong ways, to reproduce the observed patterns you chose as calibration criteria. You could consider going back to the theory development stage and seeing if you can reproduce the observed patterns you chose as calibration criteria. You could consider going back to the theory development stage and seeing if you can improve the traits for agent behavior, and you could consider adding processes or behaviors that were left out the first time. But keep in mind that there are costs to adding complexity to your model, especially if it is not very clear what change needs to be made.
3. [Alternatively] It is very common for good modelers to keep their model simple instead of adding stuff to it until the model can reproduce all the calibration criteria. Keep in mind the overfitting issue: it can be risky to try too hard to make the model reproduce a limited set of observations. It may make sense to revise your calibration criteria so they are not as restrictive. If you choose not to revise the model to make it fit more of the calibration criteria, simply document your calibration results and the extent to which the model does not meet some criteria under your “best” parameter values, and your decision not to revise the model. Then, when you use the model to solve problems, keep in mind which results are less certain as indicated by the calibration experiment.

**Decision for the BLT Model:** I can’t make any decision right now, but the comment 3) seems very important. I’ll probably proceed if I find a set of values that meet the first 2 variables (SDD, DPL), and then Home Range size (not core home range as it is mostly not stable throughout time)