Below all the steps can be used to code the FNNR GGM habitat use ABM. All these rules are subject to changes in the future. Each version has a name with its date as the last extension—for instance, this version is named Pseudo-code-GMMs-05-14.docx. When creating a newer version, the earlier version will have no track change, while the newer version will be in track change to show all changes from the earlier version.

1. Tentatively I recommend temporal resolution to be 5 days and spatial resolution to be consistent with the DEM or the vegetation map.
2. Import the FNNR DEM into your code.
3. Import or assign slope to each pixel (slope measure in degrees not in percent)
4. Import other data (MaxEnt maps, vegetation, etc.) into your model
5. GGM initiation

* Draw a random number n from (25, 45). Then create n GGMs, and randomly place them in a place that is consistent with habitat types and suitability in Section 8 (Environment; see below).
* The n GGMs should be members of a small group (family)—give a family ID. The ages and sexes of these n GGMs should be based on the following table:

Table 1. Sex/age structure of GGMs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group | Baby | Juvenile | Young | Sub-adult | Adult | Senior |
| Age thresholds | <1 year | 1 to <3 years | 3 to <7 | 7 to <10 | 10 to <25 | 25 or above |
| % | 11% | 16% | 15% | 20% | 34% | 4% |
| F:M ratio at each age group | 1:1 | 1:1 | 1:1 | 1:1 | 2.9:1 | All females |

All these n GGMs should have the same family ID or label.

* Repeat the above step to create more small groups (families) with unique family IDs until the total number of GGMs reach 760±K (let K be a parameter; default K=30).

1. GGM birth:

Each female GGM between 10-25 may give a baby every three years; if the baby dies, the mother can give another baby the following year. See Step 8 (Grouping) for baby-bearing location etc.

1. GGM mortality:

Each year, the mortality rates are 20% for 0-1 year old, 5% for 1-8 (or 10) years old, and 9% for GGMS of >8 (or 10) years old. If the time steps are not year, but for instance day, week, or month, then the above rates should be divided by 365, 52, or 12, respectively. If other time interval (e.g., 4 days) is selected, the above mortality rates should be divided by the corresponding number too (e.g., by 4).

If a GGM survives to 30 years or older, let the yearly death rate to be higher (set as a parameter m, default to 0.25 or so).

1. GGM growth:

Each GGM grows until a mortality event happens (a randomly generated number is greater than the related mortality rate). When a male reaches 10 years old, he has a chance to be driven out of the small group at a probability p (default to 40%--this is a yearly rate; if time step is not year, only do it at p=0.4 when a GGM reaches 10 or one whole year elapses later) each year. Once a male GGM is driven out, 10-15 such male GGMs may form a group of all males (use a different label and color for such groups).

By the end of each year (note that if time step is not year, you do not do it at each step; only do it when one year is passed), calculate 1) the number and sex ratio at each group; 2) the percent of reproductive females (10-25 years old) in all female GGMs

1. Grouping
2. Allow 3-4 small groups or families, if they are close enough (say, shorter than y m; set y default to 200 m), to come together and stay for x days (x parameter, default to 10 days);
3. Each year in April 1-30 and Sept 1-30 let all GGMs come to one location at Yangaoping.
4. All female GGMs (10-25), if available for baby bearing (the last baby was born 3+ years ago), may bear a baby GGM in Sept. The baby should have a family (small group) ID the same as the mother GGM. Be specific that each baby is born in September.

Note: 1) consider to let one 30x30 m cell contain one family or small group; 2) the farthest group may start moving to Yangaoping m steps (let m default to a random integer between 10 and 25) before Sept 1.

1. Travel and stay:

In summer, a small group travel a shorter distance in a day (e.g., 500 m/day) and stay in areas as low as 0.05 km2/day. In winter they travel longer distances such as 5000 m/day and stay in areas as big as 1.2 km2/day. Note that depending your time step choice, you may change the above numbers: say if you choose 5 days, then they travel 500 x 5 = 2500 m per day (not necessarily straight line distance, but sum of all zig-zap sects)

If you want to be more variable and realistic, use the data below in Tables 3 and 4.

Table 3. Daily travel distance of GGMs (Km)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group size | spring /fall | | summer | | winter | |
|  | Sunny/cloudy | Rain/foggy | Sunny/cloudy | Rain/foggy | Sunny/cloudy | Rain/foggy |
| Small group | 1-3 | 0.5-3 | 1-4 | 0.5-2 | 2-5 | 1-4 |
| Big group | 1-3 | 0.5-2.5 | 1-3 | 0.5-2 | 2-5 | 1-3 |
| Super group | 1-3 | 0.5-2 |  |  |  |  |

Note that from April to October most (e.g., 80%) of the days are rainy or foggy days.

Table 4. Daily area of activity (Km2)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group size | spring /fall | | summer | | winter | |
|  | Sunny/cloudy | Rain/foggy | Sunny/cloudy | Rain/foggy | Sunny/cloudy | Rain/foggy |
| Small group | 0.2-0.8 | 0.05-0.4 | 0.1-0.75 | 0.05-0.45 | 0.2-1.2 | 0.1-0.8 |
| Big group | 0.5-0.15 | 0.25-1 | 0.5-1.5 | 0.25-1.1 | 1-2.5 | 0.5-2 |
| Super group | 1-3 | 0.5-2.5 |  |  |  |  |

1. Environment (Alternatively, you can code this step before Step 1 above):
2. Let the GGMs only stay within 1000 and 2200, and mostly between 1300 and 2000

The elevations of GGMs should also be based on the seasons as below:

Table 2. GGMs seasonal habitat change

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seasons | Spring | Summer | Fall | Winter |
| Elevation (m) | 1000-1900 | 1300-1800 | 1500-2200 | 1000-1800 |
| Vegetation | Evergreen, broadleaf/deciduous | Same | Same | Same |

1. Overlay your MaxEnt map with the map on p.19 (where : vertical lines (≡) stand for good habitat, vertical lines (|||||) for marginal habitat, forward slash (/////) lines for GGM movement corridors, and backward slash (\\\\\) lines for excellent habitat), and identify map of various types.
2. Visualization:

If the small group is equal to or greater than 30 GGMs use two adjacent pixels to indicate where the GGMs are; if the group has less than 30 GGMs, use one pixel to show where GGMs are. Make sure the related pixel contains all the GGMs that stay inside it. Once a group moves out of a pixel, all individual GGMs move out too.

12. Report:

Every year (73 steps), output the age and sex structure data to an CSV or Excel file.

13. Map human disturbance

Note that: All data are saved at …\Human-disturb-2016HH\_data [I will make a copy to you].

13.1) Map/import all households we surveyed in 2015 according to the shapefile named 2015\_household\_survey.shp;

13.2) Map/import all households we surveyed in 2016 (note the HHs surveyed in 2016 should be able to locate under the 2.1-d field of shapefile 2016\_landparcel\_all.shp).

Note that the HH\_ID’s in the above two shapefiles might NOT be coded in a consistent way (i.e., a household with HH\_ID = xxx in the 2015 file may be a different one from the one with HH\_ID = xxx in the 2016 file—but I did not check; check and assure it).

13.3) Map/import all the **GTGP parcels** based on 2015-16\_landparcel\_PES.shp, which contains HH\_ID, Question\_I, x, y, plant, Year\_enrol, and survey (Year) are the attributes we will use later. Note that for Question\_I, 1.2-1, 1.2-2,…, up to 1.2-7 are GTGP parcels surveyed in 2015, and 3.3d\_i\_A and 3.3d\_i\_A GTGP parcels in 2016. All the GTGP pacels are associated with their related HH\_IDs.

13.4) Map/import all the **self Mt. and resp Mt. forest parcels** based on 2015-16\_landparcel\_forest.shp, which contains HH\_ID, Question\_I, x, y, type, patrol\_mon, and survey (year). Check  
 a) Are the HH\_IDs here the same as in 3) above (i.e., 2015-16\_landparcel\_PES.shp)? You can check it in ArcGIS and see whether the forest

Check all **GTGP parcels** and **self Mt. and resp Mt. forest parcels** under the same HH-ID: are they spatially near and consistent? The key is to make sure that the HH\_IDs in 2015-16\_landparcel\_PES.shp are the same as those in 2015-16\_landparcel\_forest.shp.

13.5) Map/import all the **farm parcels** based on 2015-16\_landparcel\_farm.shp, which contains HH\_ID, Question\_I, X, Y, Area (mu, it is named hectare, which is a mistake), crop\_damag, damage\_bef, and survey (year). Note that Question\_I has 1.13-1, …, up to 1.13-7 (all are 2015 farm parcels) and 3.14f\_i, …, up to 3.14f\_iv (all these are 2016 farm parcels).

Overlay all **farm parcels**  in 2015-16\_landparcel\_farm.shp with the above shapefiles and examine whether the HH-IDs are spatially near and consistent.

So far you should have mapped / imported all farm parcels, GTGP parcels, and self Mt. and resp Mt. forest parcels. There are two files that have you to check the quality and quantity of 2015 data (then 2016 data): the sum of all farm, GTGP, selt Mt, and resp Mt parcels in 2015 should be close to 3772 (the number of records in 2015\_landparcel\_all.shp). Similarly, the sum of such parcels in 2016 should be close to 873 (the number of records in 2016\_landparcel\_all.shp).

14. Simulate human disturbance for the whole FNNR

14.1 For each household location, create a buffer with x radius (x default to 400 m). Assign a probability of p1 (default to 0.00) under which any GGM individual or GGM family would enter into.

14.2 For each farm parcel (non GTGP parcel), create a buffer with y radius (y default to 300 m). Assign a probability of p2 (default to 0.05) under which any GGM or GGM family would enter into.

14.3 For each GTGP (PES) parcel, create a buffer with z radius (z default to 200 m). Assign a probability of p3 (default to 0.20) under which any GGM or GGM family would enter into.

14.4 For each self and resp Mt. forest parcel, create a buffer with a radius (a default to 200 m). Assign a probability of p4 (default to 0.30) under which any GGM or GGM family would enter into.

15. Simulate human disturbance in the two villages surveyed in 2016

15.1 Load/import human activity data from 2016\_landparcel\_collection.shp, which contains the following key attributes or variables: HH\_ID, X, Y, Question\_I, and frequency. Here the variable Question\_I variable can take 8.4i-a, 8.4i-b,…, up to 8.4i-g, and below stand for what they mean:

a.Fuelwood

b.Herbs

c.Bamboo/bamboo shoots

d.Mushrooms/fungi

e.Fodder for animals

f.Fish

g.Other\_\_\_\_\_\_

Note the unit of frequency is times/month.

15.2 Load the HH and individual data in the model you created for Shuang (including those agents).

a. Choose one adult (from 15 to 59) from each household, and send the adult to the HH’s sites for a, b, …, g at the related frequency mentioned in the table of 2016\_landparcel\_collection.shp. Let the adult choose a shortest path between the HH and the collection site. Create a buffer zone around the moving adult with radius r (a parameter, r default to 100 m). Any GGM individual or family, if moving towards the adult’s buffer zone, will turn around avoid encounter.

b. Run the migration model you created for Shuang. If the above adult happens to migrate out according to the migration model, choose another adult (also from 15-59; if available) in the same HH, but collect each of the resources at a reduced new frequency:

New frequency = old frequency x PC (PC default to 0.5)

for each activity from a to g (see above). If no one from 15-59 can be found, choose one older than 59 or between 10-15, but set PC to be 0.25 instead.

15.3 Output a subset of area for GGM habitat use in Northeast FNNR (based on the two village survey data collected in **2016**): In GIS create an area that extends 1000 m from the outest human activity parcels (consider including all farm, PES, res Mt., and self Mt. parcels). Once this area is defined, run the model for 730 (730 x n, n = 1, 2, etc.) steps, report the GGM densities (as maps) at the end of each simulation.

15.4 Compare the maps created in step 15.3 (for the subset area, call these simulated maps) with the MaxEnt and occupancy maps (call them reference maps): select N (default =200) points in the subset area, record the GGM density data from both reference and simulated maps, and calculate the related Kappa values.

Rules for GGM habitat use:

**Tier-1 rules (highest priority):**

0) Overarching rule (of avoidance): If a GGM individual or family is on a cell that is less than an r0=200 m distance of any moving human(s) (agents) or static farm(s), let the GGM individual or family randomly move to a cell/pixel that is farther away (i.e., greater than r0 from the human or farm) AND has a land cover that is NOT farm.

Implement this rule (Rule 0) each step, and when this rule is met, then implement the following Tier-2 rules:

**Tier-2 rules (mid-level priority)**

1) First check elevation: if less than 1000 m or higher than 2200 m, choose it at probability p1=0

2) Else if elevation is from 1000 to 1300 OR from 2000 to 2200 m, then consider the following:

2a. If land cover is farm, choose it at probability p2a=0.

2b. else if land cover is NOT farm and

2b1 is NOT within an r2b = 300 m (parameter) buffer zone of GTGP OR NFCP OR any other documented resource collection sites, choose to use it with a probability of p2b1 =0.4 xPvegAdjust (set 0.4 as a parameter). OR:

2b2. Is within an r2b = 300 m (parameter) buffer zone of GTGP OR NFCP OR any other documented resource collection sites, choose to use it with a probability of p2b2 =0.2 xPvegAdjust (set 0.2 as a parameter).

3) Else if elevation is from 1300 to 2000 m, then consider the following:

3a. If land cover is farm, choose it at probability p3a =0.

3b. Else if land cover is NOT farm and

3b1. NOT within an r3b = 300 m (parameter) buffer zone of GTGP OR NFCP OR any other documented resource collection sites, choose to use it with with a probability of p3b1=0.5xPvegAdjust (set 0.5 as a parameter). OR:

3b2. Is within an r3b = 300 m (parameter) buffer zone of GTGP OR NFCP OR any other documented resource collection sites, choose to use it with a probability of p3b2=0.3xPvegAdjust (set 0.3 as a parameter).

**Tier-3 rules (lowest priority or independent of tier-1 and -2 rules):**

If land cover is coniferous OR broadleaf OR deciduous OR mixed then PvegAdjust = 1;

Else if land cover is farm then PvegAdjust is set at 0;

Else if land cover = clouds then PvegAdjust is set at a random number between 0 and 1;

Else PvegAdjust is set at 0.8 (0.8 is a parameter)