**Proposed Updating of Everkite**

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**Version 6.0 of Everkite**

Some changes in Everkite 5.05 are suggested on the basis of the April 12 snail kite workshop. Changes in the model can be made without fundamentally changing in the structure of the model itself. I suggest as a start to think about the following suggestions below. We need to get the model structure right. The actual parameter values are not so important from the point of view of the modeling. They are read as input files, not hard-wired. I am in favor of letting the empirical people make the decisions about what the best parameter values are. The model needs to be designed with sufficient flexibility that they can make all the choices that are needed.

I believe that we can decide on a set of changes to Everkite 5.05 that will address the issues raised at the April 16 Snail Kite Workshop. This is a first draft of proposed changes.

**Landscape**

The current set of wetlands is as follows

0. Everglades National Park (gauge P-33)

1. Big Cypress National Preserve (gauge P-34)

2. Water Conservation Area 1 (gauge 1-9)

3. Water Conservation Area 2A (gauge 2A-17)

4. Water Conservation Area 2B (gauge Site-99)

5. Water Conservation Area 3A North (same data used as in 6.)

6. Water Conservation Area 3A South (gauge 3-28 and Site-65)

7. Water Conservation Area 3B (gauge Shark-1)

8. Loxahatchee Slough (average of gauges CNTL3, CNTL4 and STA7)

9. Lake Okeechobee (regulatory stage Okeechobee)

10. Upper St. Johns Marsh (stage Blue Cypress Lake)

11. Kissimmee chain of Lakes (average stage of Lake Marion and Lake Weohyakapka)

12. Lake Kissimmee (stage Kissimmee)

13. Lake Tohopekaliga (stage Tohopekaliga)

14. East Lake Tohopekaliga (gauge S-59-H)

15. Peripheral area

***Proposed changes in wetlands included***. This can be revised by adding new wetlands that appear to be important.

One addition will be Lake Istokpoga.  It is about 28,000 acres, between the Kissimmee Lakes and Lake O, and has had nesting Kites.

The added wetlands may include breaking up some of the current wetlands into smaller parts, when there are sufficient internal differences such that they should be treated differently.

This extension can probably be done without increasing the number of sites too drastically.

***Proposed finer scale categorization of the wetlands***

In the grid-based 5.05 version of Everkite, it was possible to be able to use hydrologic information directly from the 2 x 2 mile model and thus eliminate the need for making estimates of carrying capacity of each whole wetland. A snail kite first chooses a wetland based on the criteria of the rules below and then searches for a low-occupancy 2 x 2 grid cell within that wetland. Using the 2 x 2 mile grid allowed us to use temporal output on water stage directly from the SFWMM, and to categorize ‘good’, ‘moderate’, and ‘poor’ condition of 2 x 2 mile cells in terms of hydrologic information.

This approach can still apply to some of the wetlands. However, it will not work for all wetlands. To further refine the landscape aspect of the model, we can divide the set of wetland breeding sites on the Southern and Central Florida region could be divided into a few categories as follows.

Palustrine wetland sites

Lacustrine wetland sites

Others, such as STAs

The large palustrine wetlands can still be subdivided into finer resolution spatial cells, such as 2 x 2 mile. Then hydrology data at that scale can be used to measure condition or ‘state’.

However, the lacustrine and ‘other’ sites may have individual peculiarities that have to be described individually. Other means to measure both the attractiveness and condition of those sites will have to be devised, so that time series data at a weekly resolution can be input to the model for those wetlands. There may be objective criteria to do this, but it is possible that best professional judgment will be needed.

**Wetland states or conditions**

The current categorization of conditions or states of the wetlands comes from a model of Rob Bennetts, in which the time since last drought is used to determine the combine structural quality and apple snail population quality (Figure 3 in Mooij et al. 2002).

(1) Stages are translated into discrete environmental states representing the quality of each wetland/cell for the kites.

0. High

1. Low

2. Drought

3. Lag

4. Moderately degraded

5. Severely degraded

6. Degraded drought

7. Degraded lag phase

8. Very high

9. Extremely high

0. High → Good

1. Low → Moderate

2. Drought → Poor

3. Lag → Moderate

4. Moderately degraded → Moderate

5. Severely degraded → Poor

6. Degraded drought → Poor

7. Degraded lag phase → Poor

8. Very high → Moderate

9. Extremely high → Poor

***Proposed changes in the definition of wetland states***

The categorization of three different states may still be the most useful approach. But the approach of Bennetts will not work for the non-palustrine sites. A better module is needed for this, and it could be different for palustrine, lacustrine, and ‘other’ wetland types. Water depth influences the condition of palustrine and lacustrine wetlands in different ways (e.g., presence of hydrilla in lakes), but perhaps is still quantifiable by objective means. Condition of ‘other’ wetlands may depend more on other factors.

Mortality, nest initiation, nest failure, and decision to move could still be weighted by condition of the wetland in which the snail kite currently resides, but the current weightings may need to be changed.

For some of the lakes and ‘other’ systems, we may simply have to estimate conditions based on empirical data or gut feelings and enter the conditions in the input data of the model ‘by hand’. The advantage of the spatially explicit modeling approach is that we can go down to that level of detail if needed.

***Special description of states for Lake Okeechobee***

Lake Okeechobee will require special attention, because there can be extended recovery lag times following high water in Lake Okeechobee.

The rationale as to why we would provide special treatment for Lake Okeechobee is the following:

1. Although we cannot adequately control damaging high water conditions in any of the modeled wetlands, stages in Lake Okeechobee are even more flashy than in other areas. For example, extreme high stages in the Kissimmee Chain are relatively quickly moderated, so we can leave short lag times for poor conditions following high water events.

2. Due to the size of Lake Okeechobee, the fetch across the lake even in moderately high winds (short of tropical storm or hurricane force) can severely damage vegetation in the littoral zone when lake stage is high, and the recovery of emergent and submerged vegetation can take years.

Given the above, we will incorporate the ability to extend the deleterious lag from one year to 3 to 6 year lags in recovery of habitat in Lake O following a prolonged period of moderately high stage (> 15 ft for a year or more) or extreme high stage for a short time (> 17 feet for perhaps 3 consecutive days).

Our emphasis in previous versions of EVERKITE on lag time following extreme lows will still be accounted for though it now may be less significant with the assumption that exotic apple snails can more rapidly recover populations following a drought as compared to native snails.

**Characteristics of individual snail kites**

The characteristics of individual snail kites were based on data available by about 2002. Most of these are simple input data to the model that can be simply updated according to more recent knowledge. But in some cases further changes may be needed to improve resolution or flexibility of the model.

**Ages at which there are transfers from one life stages to the next**

From fledgling to juvenile stage 0.3288 years

From juvenile to subadult 0.75 years

From subadult to adult 1.75 years

From adult to senile 15 years

Maximum age 20 years

***Proposed changes in ages of stage transition***: If there are important changes in behavior or rates of the kite, then additional stages may be necessary.

**Fecundities of female snail kites. If they nest, these are the probable numbers of eggs**

One egg in 54 out of 207 nests

Two eggs in 107 out of 207 nests

Three eggs in 46 out of 207 nests

***Proposed changes***: These values probably need updating

**Nest initiation**

Base nest initiation probability 22.314% per week

Monthly multipliers 0.5, 1, 1, 1, 1, 0.5, 0.25, 0.1, 0, 0, 0,1, 0.25

Life stage multipliers 0, 0, 0.333, 1, 1

Nesting attempt multipliers 1, 0.347826, 0.125, 0.0

Wetland state multipliers 1, 0.54545, 0.6818

* Good 1
* Moderate 0.54545
* Poor 0.6818

***Proposed changes in nest initiation***: At least the monthly multipliers need to be changed, based on data on lakes with exotic snails. It may be that the monthly multipliers should be different for wetlands with exotic snails than those without. Life stage multipliers will need to be adjusted if more life stages are added.

**Nest failure**

Base nest failure probability 10.84% per week

Wetland state multiplier

* Good 1
* Moderate 1.5221
* Poor 2.9124

***Proposed changes in nest failure***: These values probably need some updating.

**Mortalities**

Base mortality probability 0.1561732% per week

Life stage multipliers – good quality habitat 21.85, 1, 1, 1, 5

Life stage multipliers – moderate quality habitat 22.908, 2.054, 2.054, 2.054, 6.054

Life stage multipliers – poor quality habitat 30.813, 9.959, 9.959, 9.959, 13.959

***Proposed changes in mortalities***: These values probably need some updating.

**Movement rules from one wetland to a random other wetland**

Currently the rules for emigration from a given site are as follows.

Base movement probability 8.95994% per week

Current wetland state multiplier of probability of emigration

* Good 1
* Moderate 2
* Poor 8

Potential wetland state multiplier of probability of immigration

* Good 1
* Moderate 2
* Poor 8

There is no distinction among snail kite stages for emigration probability

***Proposed changes in rules for emigration probability***

Stage dependence on movement probability can be easily added on the basis of new information. So there will now be a probability of emigration, Pemig,i , which is the base emigration rate multiplied by a life stage multiplier.

Currently the rules for immigration to a given site are as follows.

First, if the snail kite is already in a palustrine site that has finer internal resolution, let the kite initially search for a better site in that wetland.

If there are no better places to move within the current wetland, the probabilities associated with wetland to be moved to, according to wetland number. These are combined with the above potential immigrations based on good, moderate and poor. The numbers 1 through 16 denote particular wetlands (see list of wetlands earlier)

* 1 0.01566
* 2 0.01479
* 3 0.00695
* 4 0.01147
* 5 0.06201
* 6 0.26705
* 7 0.26705
* 8 0.02884
* 9 0.01127
* 10 0.15628
* 11 0.02292
* 12 0.02794
* 13 0.02794
* 14 0.00873
* 15 0.0091
* 16 0.06201

***Proposed changes in rule for immigration probability***

Once a snail kite has decided to move, movement from one site could be decided as follows.

If there is no desirable site within the wetland, then there should be probabilities of moving to another site. The factors involved in those probabilities are the following.

*Distance of the wetland from the origin of movement* - Apply the rule of philopatry to natal site by assuming the probability of movement from wetland site *i* to wetland site *j* falls off as exp(-α*Xij*) where *Xij* is distance between the center of wetland *i* and wetland *j*. This assumption of exponential assumption decrease is common in models of movement between sites and has been fit to snail kites (see Figure 1 below). For a given origin site, *i*, after the decision has been made to move from site *i*, the probability of movement from site *i* to another site *j*, based on distance along, would be



Values of *Xij* should be easily obtained by first finding the coordinates of the middle of each wetland on an map with x,y-axes.

But these probabilities should be adjusted by weighting according to other measures of the sites.

*Size of wetland* – Large sites that can ideally hold larger numbers of kites, like the WCAs, may be more attractive or more easily found by the kites, and should get higher values of weighting factors, *Wsi*

*Condition* *of wetland* – Water depths and vegetation condition at a site should be combined to given some weighting factor, *Wci* (see below).

*Exotic snail attractiveness index* – Whether there is an abundance of exotic snails can be given a weighting factor, *Wai*.

Each of these weighting factors may have to be entered individually as input and may be somewhat subjective estimates. After the weighting factors are multiplied, the probability of moving from site *i* to site *j* will be



Figure 1. Data from Fletcher et al. (2011; Fig S1). This is the movement distances during the breeding season between 2005-2009. The lines show a negative exponential function (exp(-αXij) and a gravity function you mentioned (1/Xij2). We could more formally test some different functions and let you know which function fits the data the best, if that would be helpful.

