**Dynamic Population Model (DPM) Sensitivity Analysis**

*Motivation*

At the GBADs Informatics Technical Workshop in Liverpool in December 2023, Wudu expressed interest to Deb and me in performing a sensitivity analysis of the DPM.

The DPM currently has a large number of parameters (*e.g.*, ~80 for cattle). This is not a lot by simulation model standards. However…

**Are all these parameters actually needed to accurately quantify disease burden via the Animal Health Loss Envelope (AHLE)?**

**If yes, the sensitivity analysis will help shed light on the overall behaviour of DPM parameters on model output.**

**If no, we can remove some or most parameters without sacrificing accuracy. This would greatly speed up model processing even though 10000 runs takes only a few minutes to complete on a standard laptop without parallelization.**

*What We’re Envisioning*

Let’s assume the **species** is **cattle**.

Let’s assume (for simplicity) the **number of simulation runs** is **10**.

Let’s assume the **number of timesteps** is **12 months.**

Let’s assume the **number of timesteps per month** is **30 days.**

**Model parameter inputs** are measured as both **integers (1, 2, 3, …)** or **proportions (0-1)**.

Let’s assume we would like to **test values in increments of 100 for integers** and **0.1 for proportions**. So, this means we would t**est values of 100, 200, … say, for integers,** and **0.1, 0.2, 0.3 *etc*. up to and including 1 for** **proportions.**

Let’s assume the **current mean value outputted by the DPM** **is** **0.5 for all age (Juvenile, SubAdult, Adult)/sex (M/F) combinations** for this hypothetical scenario (**this is unrealistic**).

The DPM outputs two CSV files:

1. a **summary statistics** file with the **minimum, mean, median, quantiles, standard deviation,** and **maximum** across all output variables.

(2) a **cumulative total file** showing the **accumulated values for the last timestep (month 12)** across all output variables.

We envision needing a chart like the one shown below to perform a proper sensitivity analysis of the DPM for the most important DPM parameters (inputs below are only an example provided by Wudu):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter**  **Input** | **Range** | **Increment** | **Model Output Variable**  **(from DPM CSV file)** | **Current Mean Value**  **(from DPM CSV file)1** | **Expectation**  **(Model behaviour)** |
| Offtake | 0-1 | 0.1  (0.1, 0.2, …, 1) | Juvenile M/F  SubAdult M/F  Adult M/F | 0.50/0.50  0.50/0.50  0.50/0.50 | Constant  Constant  Constant |
| Milk yield (in litres?) | 0-1000 | 100  (0, 100, 200, …, 1000) | Juvenile M/F  SubAdult M/F  Adult M/F | 5/5  100/100  500/500 | Linear  Linear  Linear |
| Liveweight (in kilograms?) | 0-500 | 100  (0, 100, 200, …, 500) | Juvenile M/F  SubAdult M/F  Adult M/F | 50/50  500/500  100/100 | Asymptotically increasing  Asymptotically increasing  Asymptotically increasing |
| Mortality | 0-1 | 0.1  (0.1, 0.2, …, 1) | Juvenile M/F  SubAdult M/F  Adult M/F | 0.50/0.50  0.70/0.70  1/1 | Asymptotically increasing  Asymptotically increasing  Asymptotically increasing |

1This column would be the result of running the sensitivity analysis. For some model outputs a

total across all age/sex groups is also outputted by the DPM.

Ideally, based on the sensitivity analysis, for each parameter input, we would like to produce a plot showing how said input parameter values affects the output. This is described in the **Expectation (Model behaviour)** column above. For instance,

The above plots are an oversimplification, but seem to suggest that inclusion of offtake for juveniles (and all other age/sex categories in the above table) within the DPM has no impact on model output since output values are unchanged for every input value. Thus, perhaps, all the offtake parameters can be removed from further consideration.

On the other hand, Milk yield, Liveweight, and Mortality would be kept in the DPM since output values change for every input value.

*What We Need from You* (Gemma/Wudu)

We require information in the first four columns of the above table.

1. **Column 1**. Which parameter inputs should be included? Rank them from most important to least important. We don’t want to make the sensitivity analysis too large and complex.
2. **Column 2.** What are the appropriate ranges for each parameter?
3. **Column 3.** What input values (increment) should be tested?
4. **Column 4.** What age/sex levels should be assessed?
5. **Column 6.** How do you expect the DPM to behave as parameter values are altered? Trends can be constant, linear, asymptotic, *etc.*