Analysis of the Carrying Capacity, Population Growth and Initial Population in Sugarscape Immediate and Constant Growback Model

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1 Introduction

This paper aims to investigate to what extent carrying capacity is dependent on the initial population between the immediate and constant grow back model, and research how population growth change as the initial population is varied with a comparison of these models.

2 Methods 300

2.1 Carrying Capacity Experiments

In terms of population ecology, carrying capacity is defined as the environment's maximal load (Hui,2006). Carrying capacities in these models are the numbers of the final stable population. To estimate the dependence of carrying capacity on the initial population, BehaviourSpace settings details are included in the appendix section). Carrying capacity can be set as a dependent while the initial population will be considered as the variable independent variable.

The range of the initial population is set from 100 to 1000 and the interval of values is 10. There are nearly 91 initial population values are taken to participate in the experiment. Through utilising the feature of this tool in Netlogo, each round of the experiment will be run simultaneously in parallel 20 while the results will be collected by the mean values of the final population.

What should be noticed is that the time limit in the experiment of the immediate grow back model should be set at 30 because many agents are no longer moving or are only moving a little after 20 ticks or so.

The hypothesis of the relationship between initial population and carrying capacity will be represented in the below formula.

$$carryingCapacity = \beta_0 + \beta_1 \times initialPop$$

Where *carryingCapacity* represents the carrying capacity of a grow back model and *InitialPop* is the value of initial population.

Simple linear regression will be processed in Python and decent visualisation will be presented via *ggplot* and *seaborn*, two third-party extended packages in Python, to show different results in these two models.

2.2. Population Growth Experiments

The initialisation of independent value in this experiment is similar to the first experiment of carrying capacity. Simultaneously, the independent value is the initial population while the dependent value is the growth of the population. The formula to calculate the natural population growth is given below.

$$growth = \frac{currentPop - initialPop}{averagePop} \times 100\%$$

$$avaragePop = \frac{currentPop + initialPop}{2}$$

Where *growth* represents the growth of population. *currentPop* is the final stable population.

The new reporter which can indicate the population growth will be added in these two agent-based models respectively in Netlogo (coding details will be introduced in the appendix section).

3 Results

3.1 Carrying Capacity

The results can be observed in the scatter graph in a 2-dimensional coordinate system as shown in figure 1. The line in red is the visualization of the pre-regressing linear model with those results in the immediate pattern.

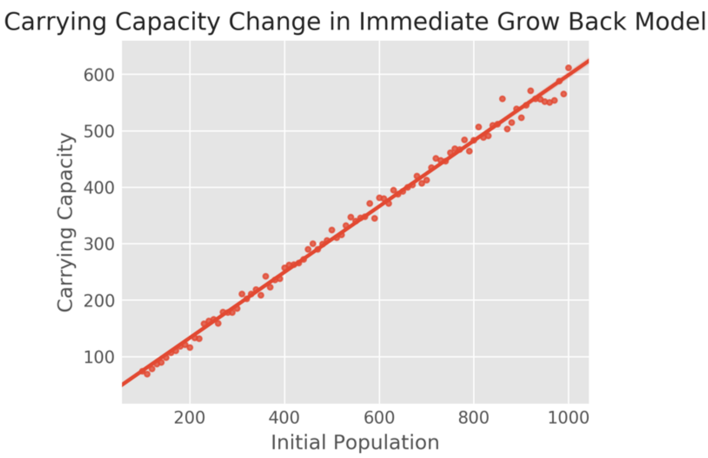


Figure 1 Results of carrying capacity as initial population is varied in immediate pattern

Simultaneously, the line in blue is the visualisation of regression with those results in the constant grow back model generated in the experiment as shown in figure 2.

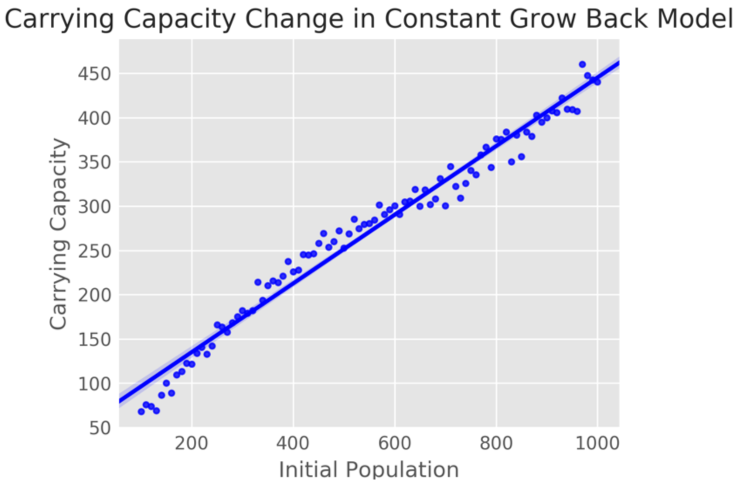


Figure 2 Results of carrying capacity as initial population is varied in constant pattern

The details of the simple regression linear model for two grow back models can be found in table 1 and table 2. The coefficients of the initial population and constants can be applied in the following intersection analysis.

Table 1 Regression results in immediate growback model

Dep. Variable:		Carrying Capacity		**R-squared:**		0.995
	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	16.3184	2.730	5.977	0.000	10.894	21.743
Initial pop	0.5823	0.004	129.997	0.000	0.573	0.591

Table 2 Regression results in constant growback model

Dep. Variable:		Carrying Capacity		**R-squared:**		0.975
	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	57.4668	4.046	14.203	0.000	49.429	65.508
Initial pop	0.3877	0.007	58.406	0.000	0.375	0.401

The final results categorised by the growing back pattern for the regression model can be obtained as given below and the intersection point of these two linear models is (212,139).

3.2 Growth Change

As shown in figure 3, though the initial population varies from 100 to 1000, the growth in the immediate pattern fluctuates in a range without showing an increasing or decreasing trend.

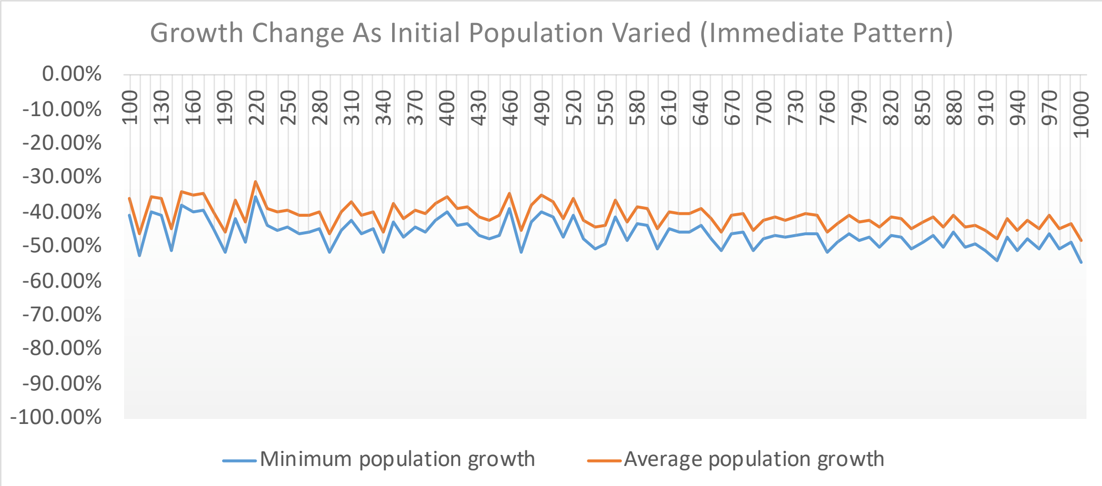


Figure 3 Growth change line chart in immediate grow back model

However, as shown in figure 4, there is a decreasing trend in population growth for the constant pattern can be witnessed as the initial population is varied from 100 to 1000.

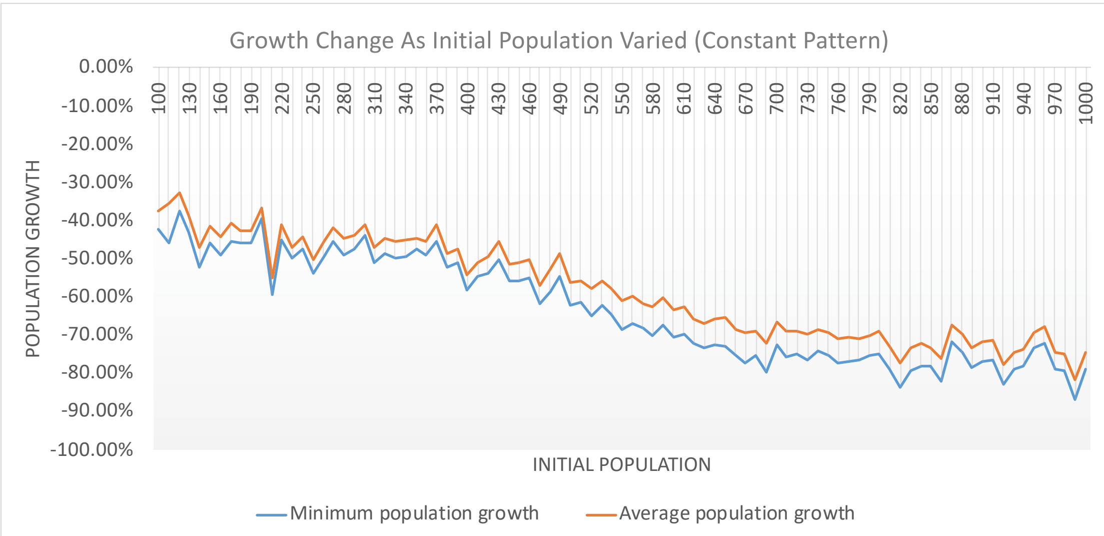


Figure 4 Growth change line chart in constant grow back model

4 Discussion

The carrying capacity is strongly dependent on the initial population. It can be seen that carrying capacity and initial population have a positive linear relationship. The more people participating in natural selection, the more people who can survive if resources can be regenerated.

In an environment where resources are recovering rapidly, the initial population has a less obvious impact on population growth. On the contrary, in an environment where resource recovery is slow, the population growth rate is limited by the size of the initial population. The larger the initial population, the smaller the population growth rate.

Overall, the faster the resource recovery, the greater the environmental carrying capacity. The carrying capacity regression models of the two growing back patterns will intersect at (212,139). When the initial population is below 212, the carrying capacity is relatively strong in the constant pattern environment. But when the initial population is above 212, the environmental carrying capacity of the immediate mode will always be stronger than that of another mode.

5 Conclusion

Overall, this study found a highly dependent relationship between carrying capacity and initial population. Carrying capacity in the immediate grow back model is stronger than that in the constant one when the initial population is above a specific level. In addition, the population growth in the immediate model does not increase or decrease with the change of the initial population. On the contrary, the population growth in the constant model will decrease with the increase of the initial population.

Word Count: 965

References

Hui, C., 2006. Carrying capacity, population equilibrium, and environment's maximal load. Ecological Modelling, 192(1-2), pp.317-320.

Appendix

Project Raw Files

The altered agent-based models for two grow back pattern, analysis and visualisation python method can be found in this Github repository.
Github Repo Link: https://github.com/Hereislittlemushroom/CASA0011-ABM

Reporter Coding

Firstly, to place the new reporter which can indicate the population growth, it is necessary to place a global variable "growth" in the head in code section.

```
globals [
  growth
]
```

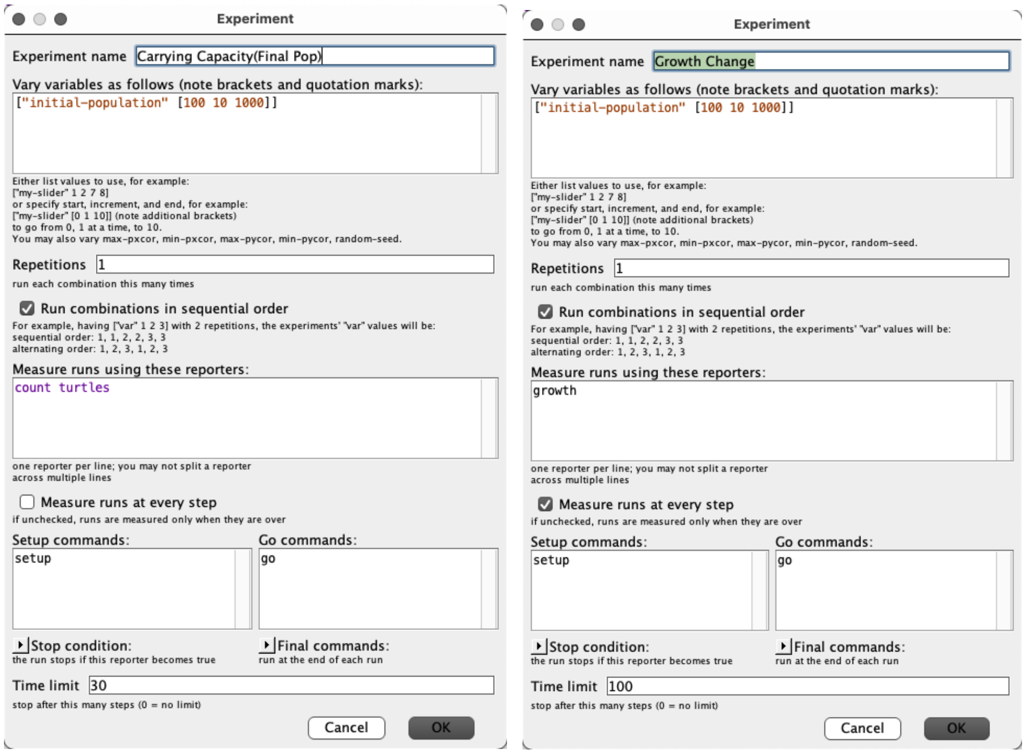
Then set this indicator with its calculation method as shown in bold font below

```
to go
  if not any? turtles [
    stop
  ]
  ask patches [
    patch-growback
    patch-recolor
  ]
  ask turtles [
    turtle-move
    turtle-eat
    if sugar <= 0
      [ die ]
    run visualization
  ]
  set growth calculate-growth
  tick
end
```

The calculate method can be written via to-report/end method as given below. Results should be times with 100 because the unit of population growth is the percentage.

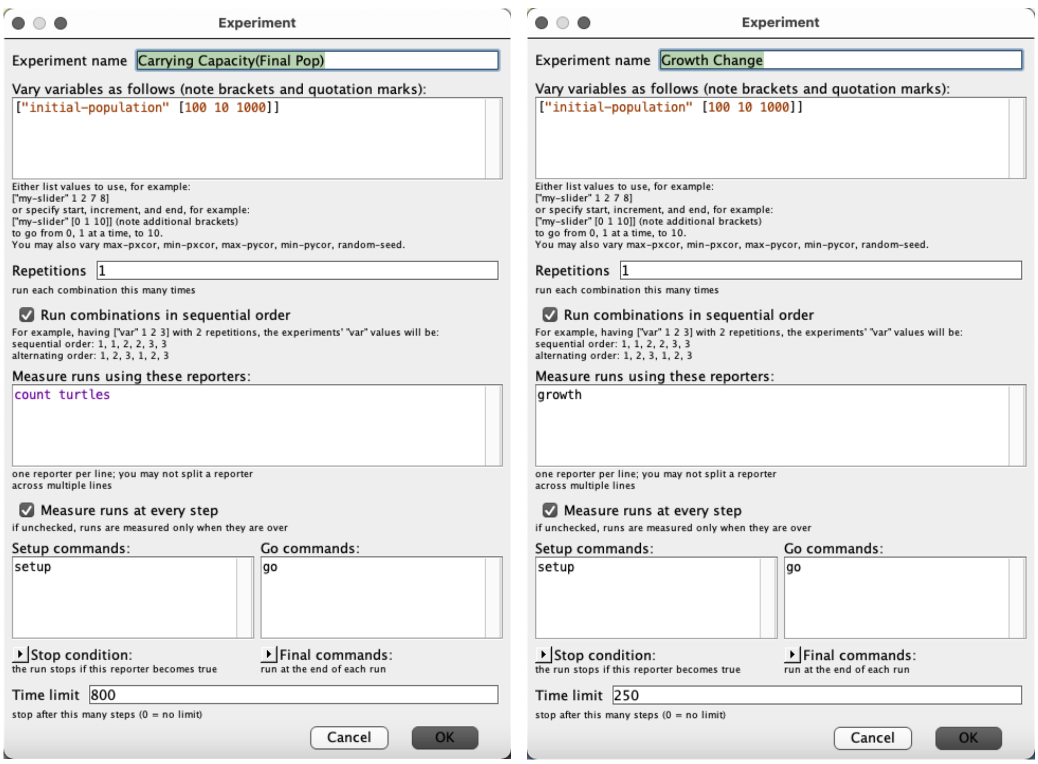
```
to-report calculate-growth
  let currentTurtles (count turtles)
  report (currentTurtles - initial-population) / initial-population * 100
end
```

BehaviourSpace Settings



(a) (b)

Figure 5 Carrying capacity & growth change experiment settings in immediate model



(a) (b)

Figure 6 Carrying capacity & growth change experiment settings in constant model