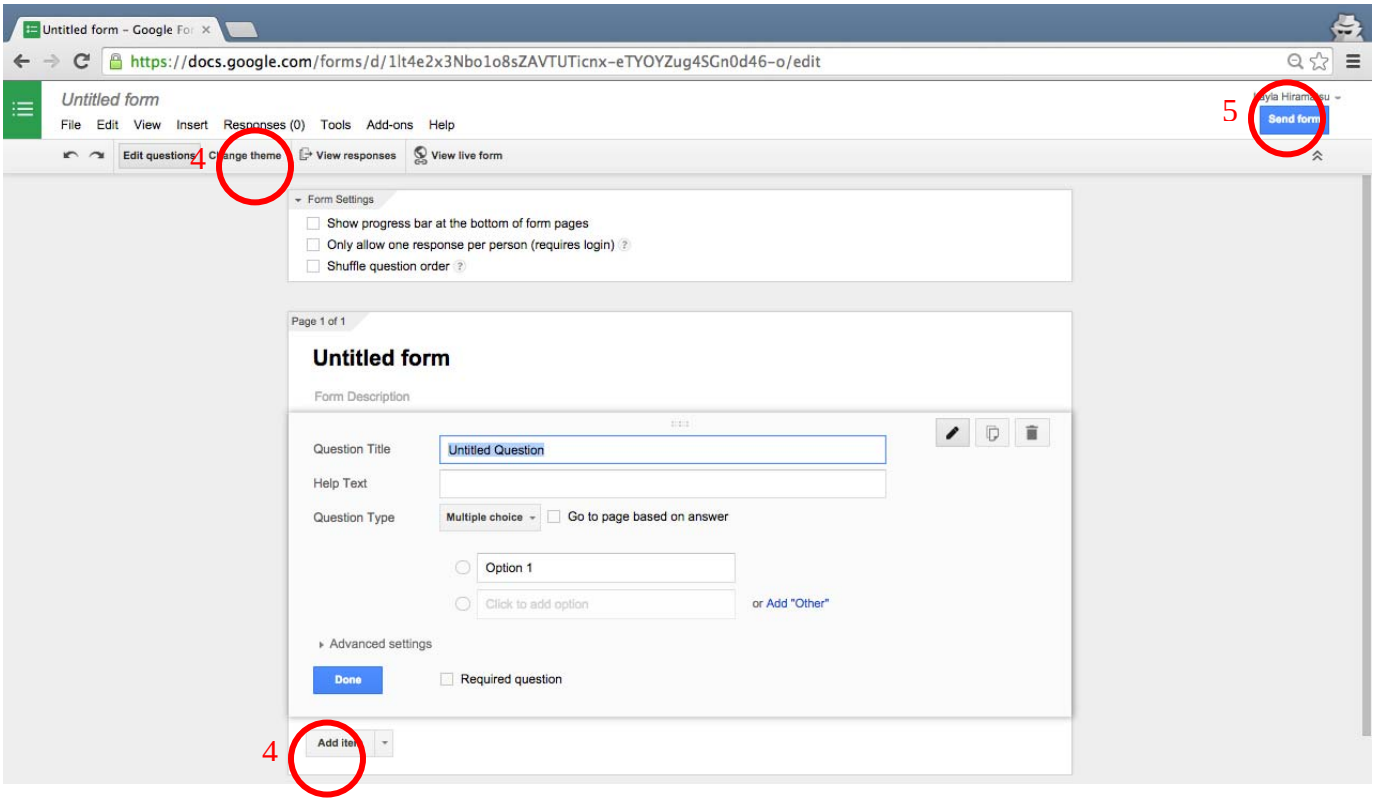
Simulating Genetic Drift – Teacher's Packet

By Layla Hiramatsu and Theodore Garland, Jr., Ph.D.
University of California, Riverside

Create Google Form

1. Open web browser, type in URL: forms.google.com
2. Log in to your account
3. You will see a screen like this:



4. Add questions as appropriate. You can also change the theme. For an example of the questions used, see next page or follow link below.
5. When ready to send to students, click "Send Form" on the upper right corner. You can copy+paste the URL, or email students the form directly.

An example of a Google form that we have used can be found here (or see next page):

https://docs.google.com/forms/d/1BfkDuJz3OCCjLqa6Hlk8efR6ZTyKqvW3Osw-f5RweHc/viewform?usp=send_form
Short URL: http://goo.gl/forms/0ND7TVpcFo

Edit this form

You are editing your previous response.

Be careful when sharing the URL of this page, because it will allow others to also edit your response.

Use this link to share a blank version of the form.

https://docs.google.com/forms/d/1WomHt1zZTqUuUvTyAjwBO-ae-Bc923dXy6WR5UbPWnM/

Genetic Drift Simulations

* Required

First Name *

Layla

Last Name *

Hiramatsu

Student ID (no dashes) *

12

Section Number -- 22 (3-4pm) // 23 (4-5pm) // 24 (5-6pm) // 21 (6-7pm) *

12

1. Genetic Drift is evolution *

- ○ by random mutations
- ○ by migration of populations
- ◉ by sampling error
- ○ by natural selection
- ○ of more adaptive alleles

2. If you picked 10 marbles, an exact representation (same percentages) of the original population would be *

- ○ 10 orange marbles
- ◉ 2 marbles of each color

- ○ 5 blue marbles and 5 yellow marbles

3. If you pick out 50 marbles, your sample will be _____ to the population than when you only picked 10 marbles. *

- ◉ more similar
- ○ less similar

4. So you get closer to the population (less sampling error) when you pick... *

- ○ smaller number of samples
- ○ trick question! Sampling error is always the same.
- ◉ grater number of samples

5. What if the jar holds 1000 marbles, 20% each color? When you pick out 10 marbles, the probability of picking 2 of each color will be _____ the probability of picking 2 of each color from a jar of 100 marbles. *

- ◉ the same as
- ○ greater than
- ○ less than

6. Genetic Drift only occurs in *

- ○ small populations.
- ○ medium populations.
- ○ infinitely large populations.
- ◉ none of the above. It happens in all population.

7. Genetic Drift acts most strongly in *

- ◉ small populations.
- ○ medium populations.
- ○ infinitely large populations.
- ○ none of the above. It happens in all populations.

8. With that in mind, do you think genetic drift will have the greatest effects for traits with *

- ○ some loci (10)?
- ◉ 1 locus?
- ○ many loci (20)?

9. Having environmental factors affect a trait will _____ the effects of evolutionary mechanisms. *

- ◉ obscure (hide)
- ○ amplify (make greater)

- ○ not affect

10. Which of the following describe Genetic Drift? *

- ☐ the most adaptive alleles drift to fixation
- ☐ migration between populations
- ☐ decreases genetic variance among populations
- ☑ can cause loss of alleles
- ☐ effect increases with more loci
- ☑ can cause evolution
- ☐ only occurs in small populations
- ☑ occurs by random sampling error
- ☑ decreases genetic variance within a population

Continue »

50% completed

Edit this form

You are editing your previous response.

Be careful when sharing the URL of this page, because it will allow others to also edit your response.

Use this link to share a blank version of the form.

https://docs.google.com/forms/d/1WomHt1zZTqUuUvTyAjwBO-ae-Bc923dXy6WR5UbPWnM/

Genetic Drift Simulations

* Required

Simulations

You must do three replicates of the parameter combination you were assigned AND two simulations with parameters of your choice.

Simulation 1 (assigned): Population size *

Enter the population size you used for your simulation.

- ○ 10
- ○ 20
- ◉ 50
- ○ 200

Simulation 1 (assigned): Number of loci *

Enter the number of loci you used for your simulation.

- ◉ 1
- ○ 10
- ○ 20

Simulation 1 (assigned): Fixed or Not Fixed *

Enter APPROXIMATE generation number when the simulation went to fixation OR enter 100 if the simulation did not go to fixation.

20

Direction of fixation?

- ○ Positive

- ◯ Negative
- ◯ Neutral

Simulation 1 (assigned): Fluctuation *

Enter the closest total amount of fluctuation (in trait units)

5

Simulation 2 (assigned): Population size *

Enter the population size you used for your simulation.

- ◉ 10
- ◯ 20
- ◯ 50
- ◯ 200

Simulation 2 (assigned): Number of loci *

Enter the number of loci you used for your simulation.

- ◉ 1
- ◯ 10
- ◯ 20

Simulation 2 (assigned): Fixed or Not Fixed *

Enter APPROXIMATE generation number when the simulation went to fixation OR enter 100 if the simulation did not go to fixation.

0

Direction of fixation?

- ◯ Positive
- ◯ Negative
- ◯ Neutral

Simulation 2 (assigned): Fluctuation *

Enter the closest total amount of fluctuation (in trait units)

1

Simulation 3 (assigned): Population size *

Enter the population size you used for your simulation.

- ◉ 10
- ◯ 20
- ◯ 50
- ◯ 200

Simulation 3 (assigned): Number of loci *

Enter the number of loci you used for your simulation.

- ○ 1
- ◉ 10
- ○ 20

Simulation 3 (assigned): Fixed or Not Fixed *

Enter APPROXIMATE generation number when the simulation went to fixation OR enter 100 if the simulation did not go to fixation.

23

Direction of fixation?

- ○ Positive
- ○ Negative
- ○ Neutral

Simulation 3 (assigned): Fluctuation *

Enter the closest total amount of fluctuation (in trait units)

3

Simulation 4 (choose your own): Population size *

Enter the population size you used for your simulation.

12

Simulation 4 (choose your own): Number of loci *

Enter the number of loci you used for your simulation.

12

Simulation 4 (choose your own): Fixed or Not Fixed *

Enter APPROXIMATE generation number when the simulation went to fixation OR enter 100 if the simulation did not go to fixation.

12

Direction of fixation?

- ○ Positive
- ○ Negative
- ○ Neutral

Simulation 4 (choose your own): Fluctuation *

Enter the closest total amount of fluctuation (in trait units)

1

Simulation 5 (choose your own): Population size *

Enter the population size you used for your simulation.

12

Simulation 5 (choose your own): Number of loci *

Enter the number of loci you used for your simulation.

12

Simulation 5 (choose your own): Fixed or Not Fixed *

Enter APPROXIMATE generation number when the simulation went to fixation OR enter 100 if the simulation did not go to fixation.

12

Direction of fixation?

- ○ Positive
- ○ Negative
- ○ Neutral

Simulation 5 (choose your own): Fluctuation *

Enter the closest total amount of fluctuation (in trait units)

3

11. Did the three trials of the same combinations give the same graph? Why or why not? (2-3 sentences) *

12

12. Did your combinations change the graphs in the way you expected them to? (2-3 sentences) *

12

« Back Submit

100%: You made it.

Never submit passwords through Google Forms.

Analyzing Student Response Data in Google Spreadsheet

1. Go to File, Make a Copy, and enter a new document name. This will protect the original data from disasters.

2. Make two additional copies: one for grading (keep all columns with questions) and one for analyzing (keep all columns with simulation results).

3. Open the copy for analyzing.

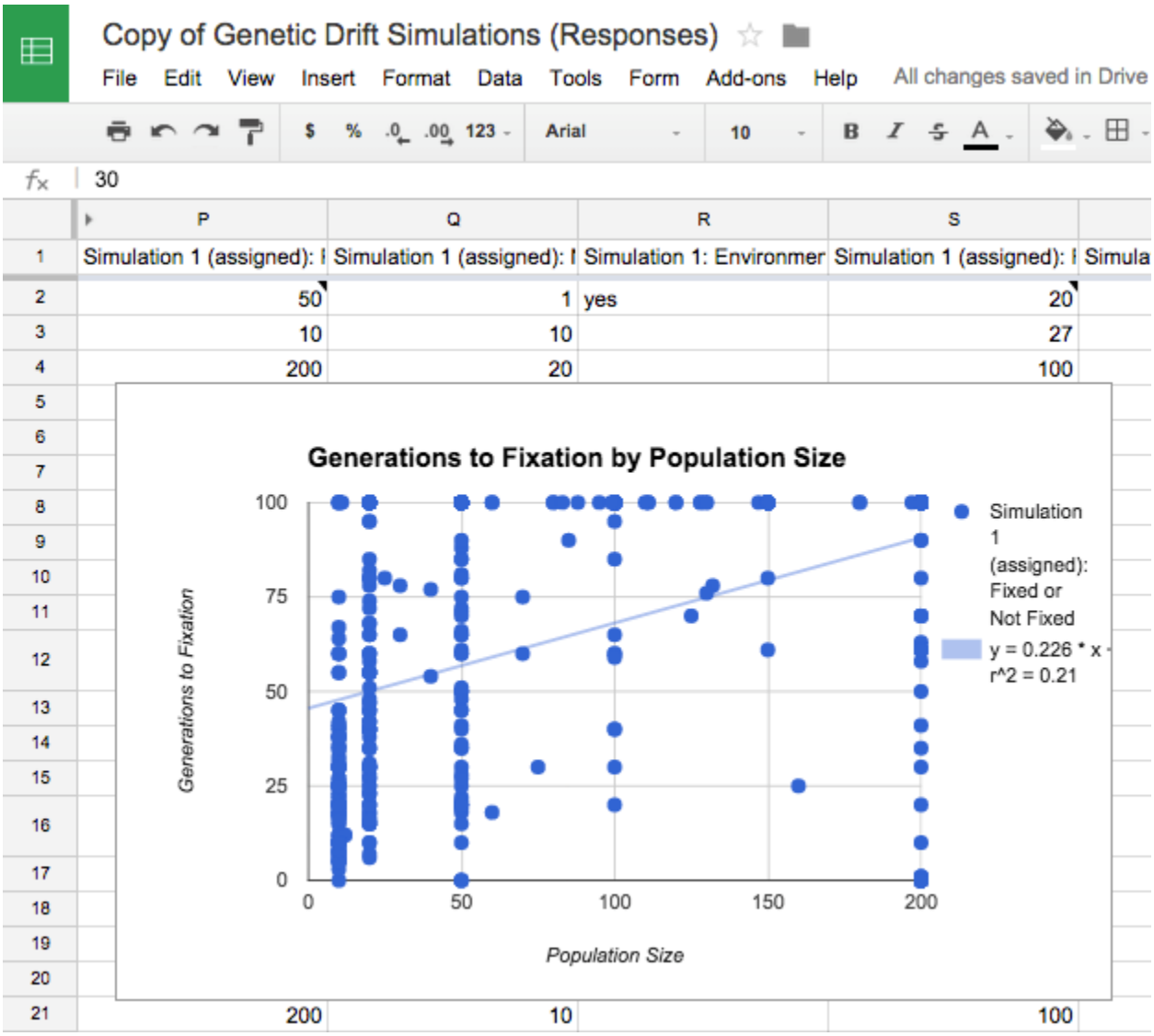
4. Stack columns for simulations 1-5:
    i. Go to the column for “Simulation 2: Population Size” and highlight the first response in row 2. While holding down the Shift key, click on the last column for Simulation 2 questions. Scroll down to the last response of the last column and holding down the Shift key, click on the last cell. This will highlight all responses for simulation 2
    ii. Copy the responses for simulation 2 by clicking Ctrl+c at the same time.
    iii. Go to the first column for simulation 1 and scroll down to the last response. Click the cell below the last response, and press Ctrl+v to paste all responses from simulation 2.
    iv. Repeat i. – iii. for simulations 3-5.

5. Select columns to create a chart
    i. Select the column letter (above the form question) of the independent variable (what you want on the x-axis).
    ii. While holding down the Ctrl key, click on the column letter of the dependent variable (what you want on the y-axis).
    iii. You should now have two columns highlighted.

6. Insert scatter chart
    i. Click on Insert, Insert Chart, click chart tab, select scatter, click scatter chart to highlight (top)
    ii. Click on Customize tab, type in informative Chart Title, such as "Fixation by Population Size" (you can see update in real time on the right)
    iii. Scroll down in Customize tab, type Axis title, horizontal, e.g., "Population Size"
    iv. Axis dropdown menu, switch to Left vertical axis, type in title, e.g., "Generations to Fixation"
    v. Scroll down in customize tab, add trendline, select Linear.
    vi. Next dropdown menu for Label, select "Use equation"
    vii. Click on Show R^2 box.
    viii. Click on Insert on the bottom left.
    Note: You may have to search for the chart. It will be where you last clicked in the spreadsheet. Drag chart to convenient place

7. Edit Trendline (if necessary):
    i. Click on a data point. right most logo > Trendline > linear
    ii. Click on new trendline, click on R^2,
    iii. Right click on treadline, click advanced edit.
    iv. Under customize tab, scroll to bottom. Under Label, click "Use Equation", click Update.

    Your graph should look something like the following:



8. The effect of the x-variable can be seen in the slope of the line (though it may not be statistically significant). In the above chart, the slope is 0.226, which means that increasing population size increases the generations to fixation.

9. The coefficient of determination, R^2, translates to the percentage of the variation in the y-variable that can be explained by variation in the x-variable. In the above chart, the coefficient of determination is 0.21, which means that 21% of the variance, or differences, in the generations to fixation between different trials can be predicted by the population size used in that trial.

Sample email describing the assignment:

Dear students,

I have uploaded the material for the Genetic Drift Exercise. Please read the description below before starting the assignment.

This assignment focuses on using a computer program to simulate populations undergoing genetic drift. The assignment is due this Thursday, **October 22nd, at 11:59pm**.

1. You will first open a powerpoint presentation (linked below). The introduction is on genetic drift and sampling error. You will read these slides and answer questions in a new window when prompted. The answers will be entered and saved on a Google Form.
    Note: These answers will be graded for correctness, but I encourage you to review your answers using multiple resources--the slides, the textbook, and your classmates. You will be able to change your responses and resubmit the form as much as you'd like, until the deadline.

2. After the introduction, you will learn about the specific online simulators that you will be using. This section gives a brief overview of what you input into the program, and how to interpret the results. After this overview, you will click on the link to go to the simulation website in a new window. You will do a total of 5 simulations using the simulator.

    Simulations 1 and 2: Use the simple one-locus simulation model to run 2 simulations. You will input the population number you were assigned (find in excel sheet linked below). Enter your data for each simulation on the second page of the Google Form.

    Simulations 3-5: All three will use the **same** combination of population size and number of loci. You are assigned a specific combination, as outlined in an excel sheet (link below). Again, enter the data on the Google Form.

3. After doing the simulations and getting your results, you are asked two more questions. Answer these using specific numbers from your simulations. The length of your answers should be **2-3 sentences**. Unlike with the questions in the introduction, please answer these last two questions (#11 and #12) using your own words and your own data.

Links

- The Articulate lecture can be found here (**insert URL here**).
- The combination assignment for the simulations can be found here (**insert URL here**).
- The Google Form can be found here (**insert URL here**).
- The online simulator programs can be found here (https://hilayla.shinyapps.io/ drift/) and here (https://hilayla.shinyapps.io/simpledrift/).

Points

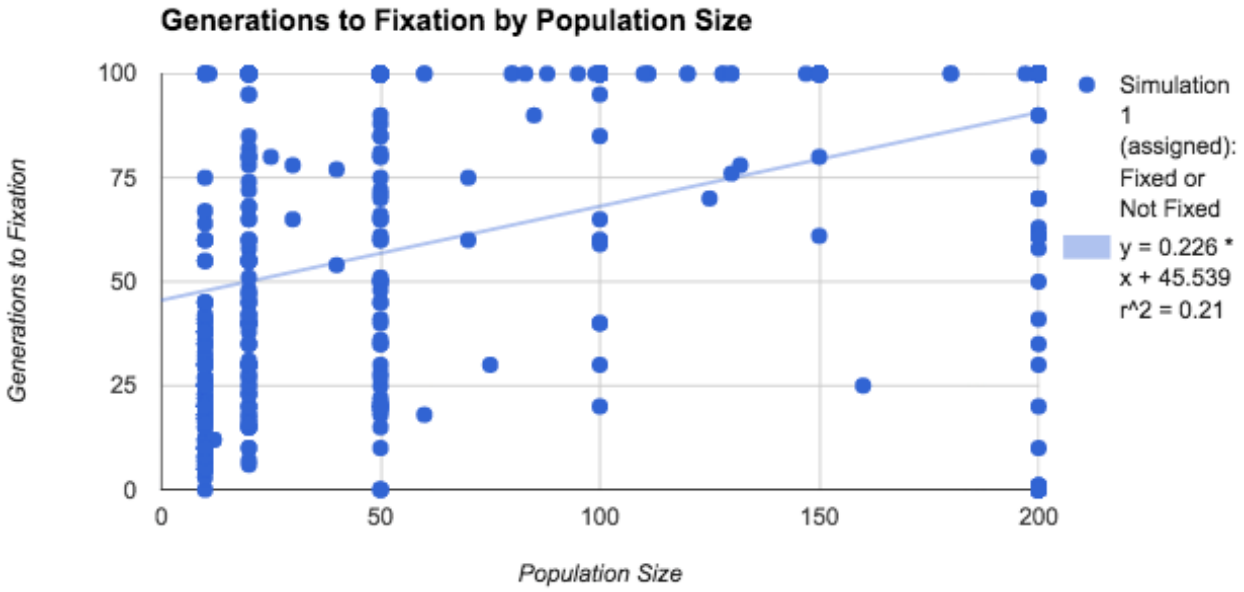
The exercise is assigned 15 points total.

1. The first 10 questions will be each worth 0.5 points (graded for correctness) = 5 points.
2. The data for each simulation will be 1 point (must not be missing any data) = 5 points.
3. Each of the last two questions will be awarded up to 2.5 points (graded) = 5 points.

Example of Data Gathered by Students

Students gathered the following data in a college upper-division Evolution course. The plot shows the number of generations each trial took to reach fixation based on the population size used at the start. The data for this plot are in the table following the plot.

The equation of the trend line is on the right side of the plot, along with the coefficient of determination R^2. The slope of trend line is 0.226, so increasing population size increases the generations to fixation. A statistical test would indicate that this slope differs significantly from zero.



Population size	Generations to Fixation
50	20
10	27
200	100
20	18
10	25
200	0
50	100
10	31
200	100
10	25
50	100
200	100

20	60
50	18
200	61
200	70
50	100
20	10
10	45
200	100
20	65
50	100
50	20
20	100
200	100
10	100

50	100
10	41
20	40
20	40
10	8
200	0
20	23
10	20
200	100
50	48
50	100
20	80
20	40
20	42

10	20
20	100
200	100
10	20
200	90
50	65
200	0
10	38
20	100
20	30
20	58
50	100
50	100
10	12
10	40
200	100
200	100
200	100
20	17
50	100
50	100
10	30
20	6
20	38
20	100
20	78
10	25
20	60
50	100
50	30
20	55
200	100
200	100

50	22
20	85
10	11
50	81
10	35
200	100
200	30
10	18
50	100
20	95
200	100
200	0
10	12
20	31
10	30
10	6
10	20
50	0
50	15
200	100
10	23
10	38
20	15
200	20
50	100
50	72
10	30
200	1
20	80
50	100
200	100
10	0
	12

200	100
20	60
10	30
200	0
50	19
10	27
200	90
10	17
50	100
200	100
20	45
50	28
200	61
200	100
50	100
20	55
10	38
200	100
20	30
50	100
50	50
20	100
200	100
10	100
50	100
10	22
20	18
20	100
10	7
200	0
20	15
10	18
200	100

50	35
50	100
20	20
20	45
20	47
10	30
20	100
200	100
10	25
200	100
50	61
200	0
10	18
20	100
20	35
20	27
50	50
50	100
10	5
10	30
200	100
200	100
200	70
20	7
50	85
50	100
10	10
20	20
20	100
20	100
20	68
10	38
20	65

50	88
50	21
20	35
200	100
200	100
50	100
20	95
10	8
50	100
10	25
200	100
200	63
10	45
50	100
20	82
200	100
200	0
10	12
20	40
10	20
10	36
10	17
50	0
50	25
200	100
10	33
10	20
20	15
200	100
50	100
50	71
10	40
200	1

20	20
50	100
200	100
10	23
200	
200	100
20	30
10	38
200	0
50	35
10	41
200	100
10	55
50	100
200	100
20	48
50	90
200	61
200	58
50	100
20	15
10	42
200	100
20	25
50	100
50	50
20	100
200	100
10	100
50	100
10	22
20	40
20	100

10	6
200	0
20	27
10	25
200	100
50	20
50	100
20	16
20	10
20	30
10	17
20	100
200	100
10	25
200	100
50	60
200	0
10	35
20	100
20	51
20	45
50	100
50	100
10	10
10	60
200	100
200	100
200	50
20	23
50	100
50	100
10	10
20	23

20	55
20	100
20	74
10	32
20	72
50	10
50	45
20	30
200	100
200	61
50	27
20	68
10	10
50	66
10	20
200	100
200	35
10	60
50	60
20	80
200	100
200	0
10	15
20	35
10	5
10	3
10	20
50	0
50	65
200	41
10	7
10	64
20	42

200	100
50	100
50	75
10	67
200	1
20	16
50	100
200	100
12	12
10	7
200	100
20	40
10	30
100	100
50	100
200	100
60	100
200	100
100	100
100	100
50	100
75	30
150	80
10	18
50	36
50	100
200	100
20	25
100	100
100	100
150	100
50	51

50	20
100	100
10	21
200	100
100	100
200	100
100	100
100	100
10	20
150	100
50	41
100	100
80	100
200	0
150	100
100	100
10	15
200	100
10	5
10	10
20	55
200	100
200	100
100	65
200	100
85	90
200	100
50	100
60	100
200	100
100	40
100	100
100	30

200	100
100	100
200	80
120	100
200	100
100	100
10	8
150	100
150	100
20	28
10	25
100	100
10	20
200	100
100	100
111	100
150	100
100	100
200	100
10	60
160	25
50	70
50	100
150	61
132	78
100	100
130	76
50	100
200	100
30	78
147	100
10	35
100	95

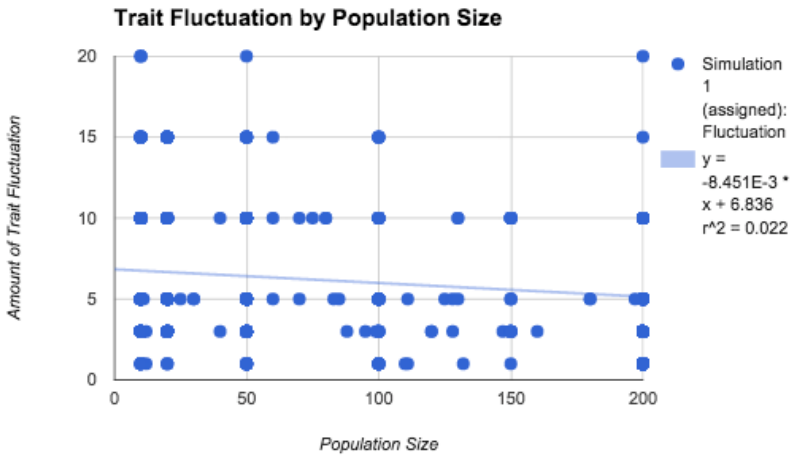
200	3-
100	100
50	45
100	100
11	100
50	100
111	100
20	42
88	100
125	70
80	100
83	100
100	100
12	12
10	18
200	100
40	54
128	100
50	100
150	100
200	100
200	100
200	10
200	100
100	100
200	100
25	80
100	100
50	80
100	85
10	17
10	10

10	5
100	100
100	20
200	100
40	77
150	100
200	100
10	16
100	100
50	80
110	100
10	20
10	45
100	100
50	40
200	100
150	100
50	100
100	40
200	100
50	100
200	100
200	100
10	25
200	100
20	55
10	25
10	5
100	100

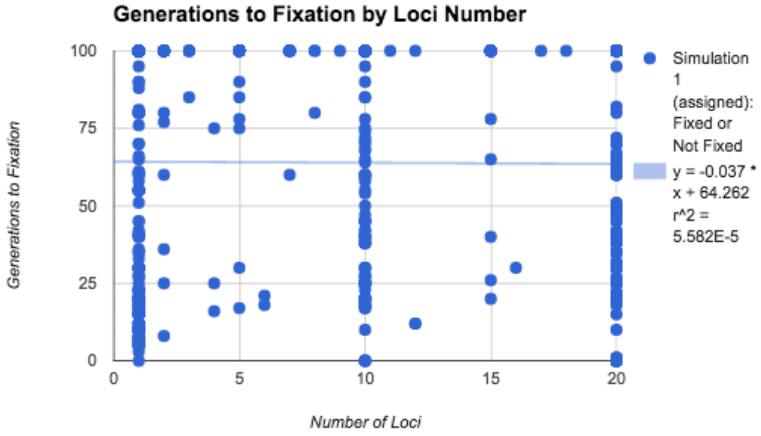
128	100
130	100
10	10
100	100
60	18
150	100
100	100
10	20
150	100
200	100
150	100
10	100
200	100
200	100
100	100
200	100
180	100
50	85
30	65
10	38
150	100
200	70
200	100
100	60
10	75
150	100
10	26
10	8
200	100

10	55
70	60
10	10
50	100
100	60
150	100
130	100
95	100
100	59
20	30
100	100
100	100
10	25
10	10
150	100
150	100
50	100
99	100
197	100
200	100
20	47
180	100
70	75
50	100
120	100
200	100

The following plot shows the amount of trait fluctuation in each trial based on population size. The data for this plot are available at request. The slope of the trend line is -0.008451, so this data likely shows that there is no significant effect of population size on trait fluctuation under genetic drift.



The following plot shows the number of generations each trial took to reach fixation based on the number of loci affecting the trait. The data for this plot are available at request. The slope of the trend line is -0.037, so this data likely shows that there is no significant effect of loci number on generations to fixation under genetic drift.



The following plot shows the amount of trait fluctuation in each trial based on number of loci. The data for this plot are available at request. The slope of the trend line is -0.413, so increasing the number of loci affecting the trait decreases the amount of fluctuation under genetic drift.