Diversity: the Way it Works Today

New Mexico
Supercomputing Challenge
Final Report
April 2nd, 2008

Team Number 96
Los Alamos Middle School

Team Members:
Nadine Sanchez
Miguel Roman

Sponsoring Teacher:
LeAnne C. Salazar-Montoya

Project Mentor:
Jorge Roman

Overview of Diversity:

The objective of our project is to show diversity as a benefit in today's society. In order to reach this objective many variables and circumstances must be taken in to consideration. When talking about diversity, we mean cognitive diversity. That is, diversity in the way people think. This leads us to the question- What exactly gives people cognitive diversity? Cognitive diversity is derived from the environment one has been exposed to- the education one received, the experiences one has gone through, and the interaction one has had with others. The benefit of cognitive diversity comes in handy when trying to solve difficult, complex problems. In solving these complex problems, cognitive diversity allows different perspectives. The diverse group of people will each have their own idea of how they think the best solution can be found, so they will have different approaches towards solving it.

Diversity in our Project:

In our project the hypothesis is that "cognitive diversity trumps ability[2]." We also think that cognitive diversity is useful in solving complex problems. To solve complex problems today, people use methods like linear optimization.

Linear optimization has two important features: the objective function and the constraints. The objective function is, "a single performance to be maximized or minimized." "Constraints are limitations or requirements on the set of allowable decisions. Constraints may be further classified into physical, economic, or policy limitations or requirements.[1]"

Furthermore, models are deterministic or nondeterministic. Deterministic models are models where the answers are always the same given the same input. Non-deterministic models are models where the answers are not always the same. Linear optimization is deterministic by itself. Some non-deterministic models use random numbers in them to represent the variability in the real world.

Random number generators are used in computers to make deterministic models behave in a non-deterministic manner. A random number generator is like rolling a dice. A random number generator is deterministic because it uses a “seed” to create a sequence of random numbers. In Starlogo TNG, the seed is created with the time. Depending on the time is what the seed will be. This way, it is nearly impossible to get the exact same answer each time.

Examples:

There are many examples that can be seen in the real world involving diversity and solving complex problems. In order to obtain the best solution of these problems, variables, or attributes, of the problem need to be used. Depending on the number of variables, the best solution can become more difficult to come across.

Real world problems have hundreds of variables. One way to solve them would be the brute force. The brute force method is when you try every single possible solution. The Monte Carlo method is an advantageous strategy in solving complex problems because it is much faster than the brute force method. The Monte Carlo method does a random guess of the solution, trying to find the best solution. This method was developed here in Los Alamos.

Say that people were trying to find a cure for AIDS. As of today, this is a complex and problem. For this reason, this is an example where cognitive diversity can benefit.

Consider the possible variables for this example: efficiency, side-effects, cost, dosage etc. With so many variables, the best solution that takes all of them into consideration is difficult to find. Once a diverse group of people is put upon this problem, they each have their own idea about solving it. Perhaps several people agree on where they should start to solve the problem, but based on their personal exposition to the world, their opinions on which direction to move to next may differ. Because of this, diversity is a necessity to solve these problems quicker and possibly cheaper.

Another example that is well represented in our project is called "A Cup of Joe." This example is based on an example mentioned in the book, The Difference. In this example, there are two variables: the amount of cream in a cup of coffee, and the amount of sugar.

The objective function in, "A Cup of Joe," is to find the best cup of coffee.

The constraint equations for a Cup of Joe:

1.) $C + S + Cr \leq T$,

2.) $0 \leq C \leq T$,

3.) $0 \leq S \leq T$,

4.) $0 \leq Cr \leq T$,

5.) $0 < T$.

The first equation says that the amount of coffee, sugar, and cream are smaller or equal to the total volume of the cup. The second equation says that the coffee is greater than or equal to zero, but less than or equal or to the total. The third equation says that sugar is greater than or equal to zero, but less than or equal to the total. The fourth equation says that the cream is greater than or equal to zero, but less than or equal to the total. The last equation says that the total is greater than zero.

We derived these equations which would be needed if linear optimization were to be used to solve “A Cup of Joe”.

Program- Dips:

Dips is our model for the Super Computing Challenge. However, it only illustrates linear optimization, since it doesn't actually use the formulas listed above. In our model, we have eleven agents from two different breeds: diverse and homogeneous. Ten of the agents are diverse, while one is homogeneous. Since all homogeneous agents move in the same way, there’s no point in having more than one.

The landscape in Dips is full of hills and ditches. The hills and ditches represent the possible solutions. The hills are the high quality solutions, while the ditches are the lower quality answers.

To create the agents, we have a setup function that is activated at the beginning of the model. First, the setup removes all of the agents on the landscape. Second, it creates the homogeneous agent, and makes it leave a trail when it walks. It also sets all of the homogeneous agent's values (such as height) to zero. Third, the setup creates ten diverse agents. It also sets each diverse agents' values to zero, and to make each agent leave a trail. Last of all, the setup scatters all of the agents, because in real life, people start in different places.

The model works the following way: first, the 11 agents (our guinea pigs) are created. Second, the agents move one step forward. Third, the diverse will keep moving one step forward until their height starts declining, in which case they take a step back and stop moving. The homogeneous group will also move one step forward, and if the landscape begins declining, then they move to the left. If it continues to decline, then they turn right. If the landscape is still declining, then they stop. Since in our hypothesis we state that diversity “trumps” ability, we decided that we needed the homogeneous group to be more “able” than the diverse, while the diverse is not very able, but are more spread out.

While the agents are moving, a monitor is checking all of the diverse agent's steps, assigned agent number (like agent zero, or agent one, etc.), and their x- y coordinates. However, it only displays the agent with the highest height's steps, agent number, and x-y coordinates. This makes it easier to record the results of our runs. Instead of using a monitor, we have to look at the agent's statistics.

The dips model relates to cognitive diversity through the Monte Carlo method and linear optimization. It is analogous to the Monte Carlo method because the agents are placed randomly on the solution space. The homogeneous group has a more complex searching technique, which means it has greater ability than that of the diverse group. The diverse group is less able, but since they start in different places and move in different directions, they traverse more of the solution space.

Developing the Genetic Algorithm:

A genetic algorithm is something that we would apply to our project if we had enough time to do so. With a genetic algorithm, the agents would start out where their last generation ended. A genetic algorithm is when one generation, starting from its previous generation learns from them and improves from it. A genetic algorithm has two parts: first, it has a set of generations, second, is how the generation learns from its previous generation.

Results of the Study:

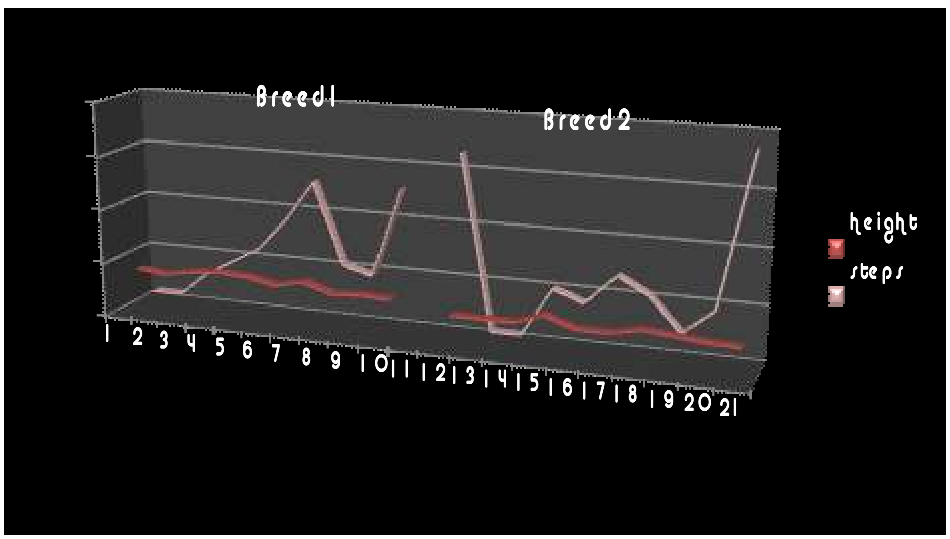

Figure 1, the results of the 50 runs on the mode

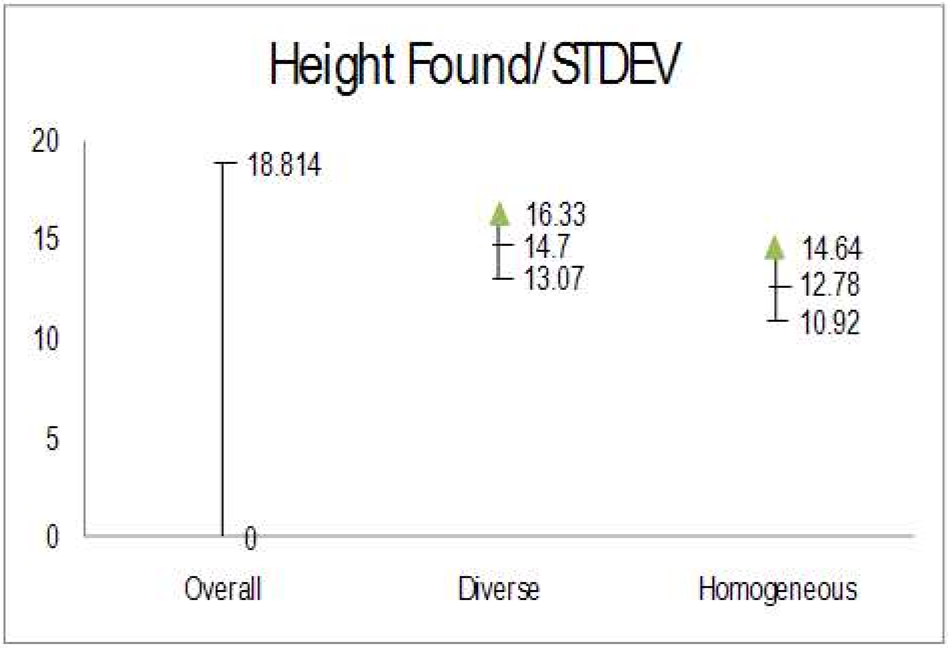

Figure 2, the Height Standard Deviation for each breeds.

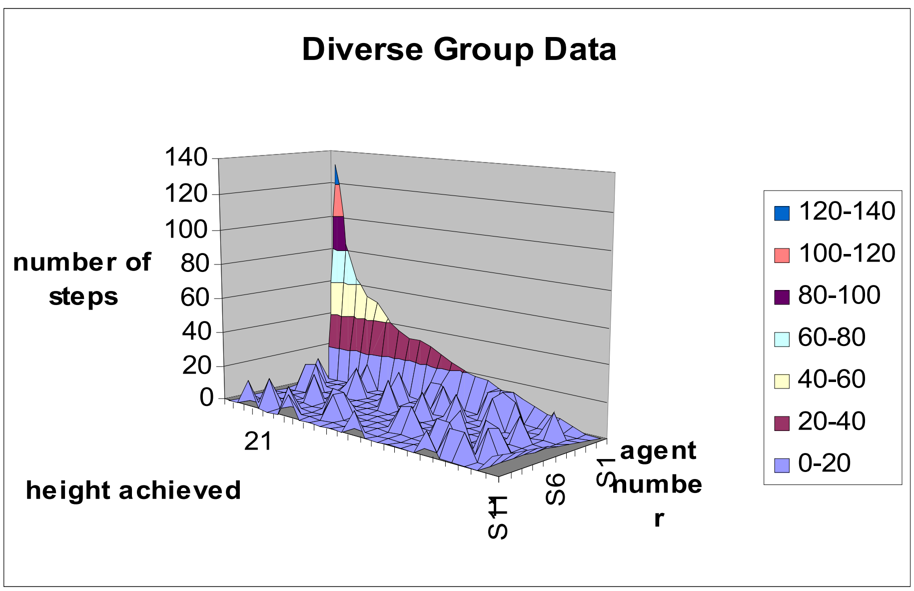

Figure 3, the number of steps vs. height for the diverse group.

Conclusion Analyzed:

Dips illustrates how people's diverse thinking can find a better and faster solution. The diverse group has a higher probability of finding the highest answer than the homogeneous group (80%). The average height found for the diverse group was 14.78 and the standard deviation was 1.63. The average for the homogeneous group was 12.78 and the standard deviation was 1.86 .This means that most of the heights found by the diverse group will most likely be close to the average, which means the confidence in this average is higher.

The homogeneous group also found the answer quicker and better only 16% while the diverse group found it quicker and better 40%. The diverse group also found the best answer twice, while the homogeneous group only once.

The hypothesis of our project was proven to be correct. The diverse group was able to find the answer more quickly and efficiently than the homogeneous group was. An example from The Difference that also proves this in real life has to do with a chess game. Once, a chess game was posted on the Internet. The players were Gary Kasparov and Internet users, which were beginning chess players. They played a game of chess on the Internet, where each move had to be presented within 48 hours. In the end, Kasparov won, but the match was a very close game (62 moves). This proves that one person with great ability is comparable to many people with less ability.

Finally, another example from The Difference is related to Nobel Prize winners. In the past, many Nobel Prize winners were single people, but nowadays, most Nobel Prize winners are teams. It seems that the easier problems have been solved, but now, problems are much harder, so they will need diverse team of people to find the answers.

References:

Jonas, Michael. "The Downside of Diversity." International Herald Tribune. 5 August 2007.

Page, Scott E. The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies. Princeton: Princeton University Press, 2007.

Putnam, Robert D. "E. Pluribus Unum: Diversity and Community in the Twenty-first Century." The 2006 Johan Skytte Prize Lecture 30.2(2007): 137-174.

"The Tower of Babel (Genesis 11:1-9)" http://www.omniglot.com/babel/english.htm#esv

Jojola, V, Brynne.Rienstra, Nick. Wright, Tristan. Modeling a Caste System. April 4, 2007.
http://www.challeneg.nm.org/archive/06-07/finalreports/23.pdf

Clement, Alex. Examining the Evolution of Social Behaviors. April 4, 2007.
http://www.challeneg.nm.org/archive/06-07/finalreports/p4.pdf

[1]*Quoted text is from web page titled, "Deterministic Modeling: Linear Optimization with Applications."* http://home.ubalt.edu/ntsbarsh/opre640a/partVIII.htm *is the original address.*

[2]*Quoted text is from the book, The Difference, by Scott E. Page.*

Acknowledgements:

We would like to thank Jorge Roman for guidance, Cecilia Sanchez for providing snacks, and LeAnne Salazar for sponsoring us.

Appendix 1: Model Explanation

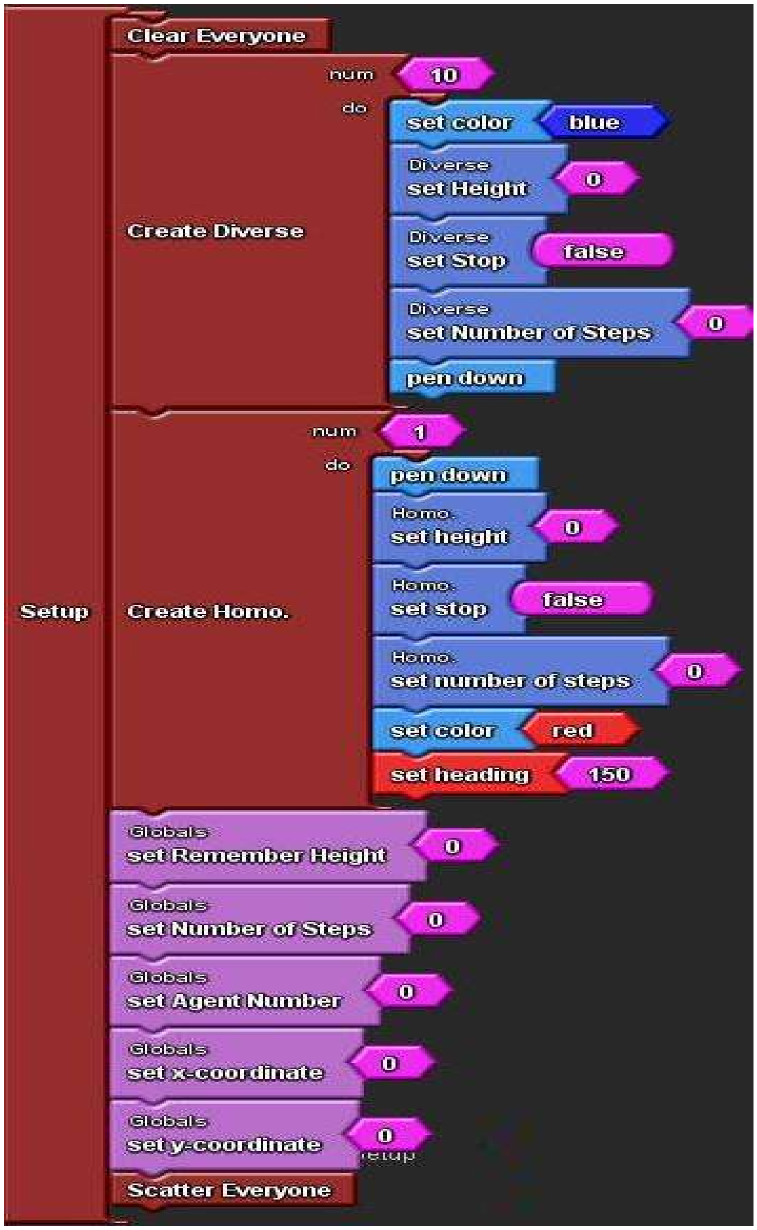

Figure 1, Setup Function

This is the setup function, used to create all of the agents, it:

- deletes everything on the landscape (except for the terrain),
- creates the diverse agents and sets all of their variables to zero,
- creates all of the homogeneous agents and sets their variables to zero as well,
- sets all of the monitored variables to zero, and
- scatters randomly all of the agents on the landscape.

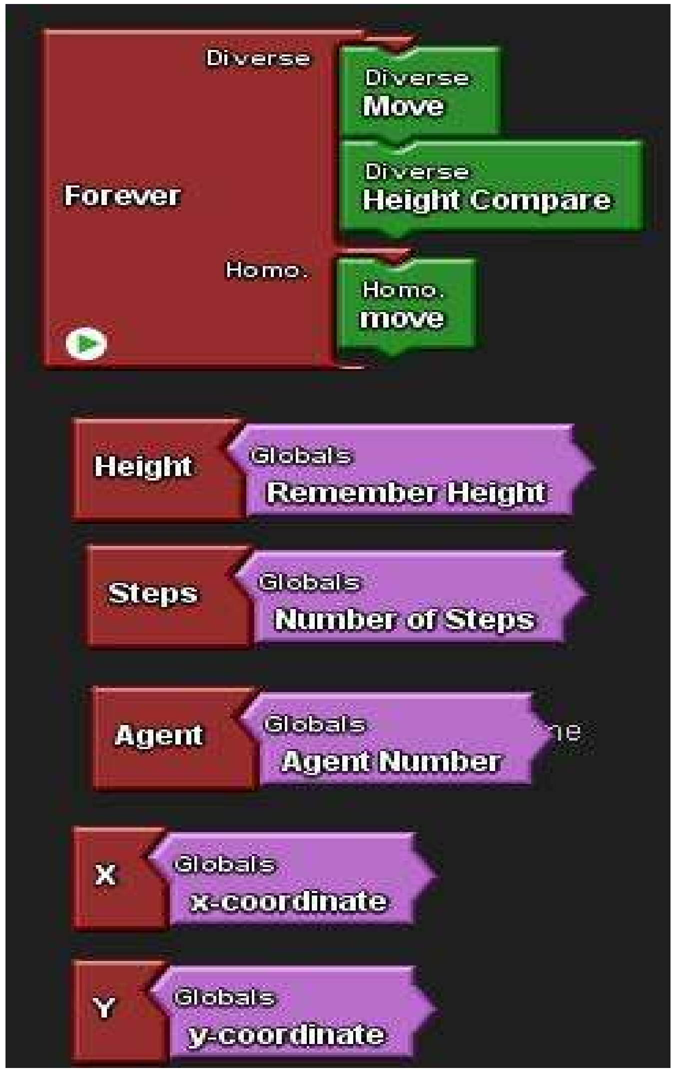

Figure 2, Forever and Monitor Functions

These are the calls to the agent's movements and the monitored variables. By clicking on the forever block, it makes the agents move (forever), and makes the diverse group, “Height Compare.” at each step of the model. “Height Compare” checks all of the diverse agents' statistics and then puts the best result on the monitored variables. The monitored values are automatically put on the subscreen (the subscreen will be shown later in figure 6).

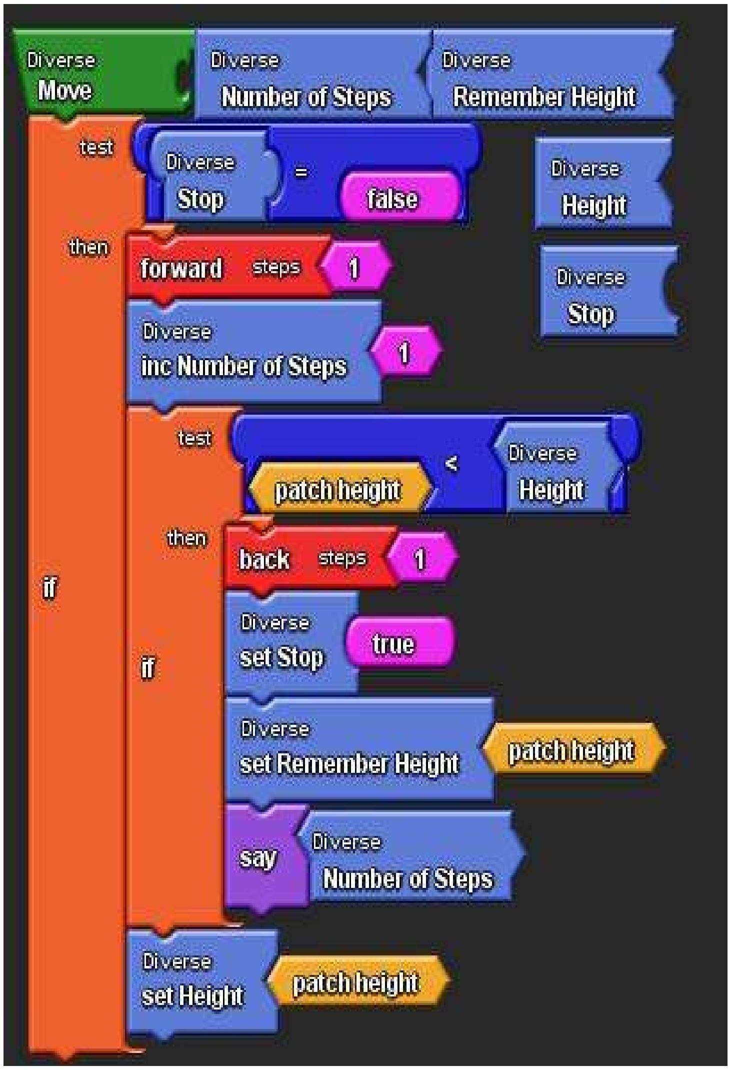

Figure 3, Diverse Agents Movement Procedure

This is the move procedure that was called earlier in the figure 1. It:

- tells the agent to first move forward one step and increment the step counter,
- then, it tests if that patch height is higher or smaller than their previous patch height. If it is higher, then it continues moving forward, but if it is lower, then it will take one step back and stop moving, and
- it will also say the number of steps taken from the beginning once they stop.

The four blocks at the top are the agent variables used in the model.

- "Number of Steps," is an agent variable for the number of steps each agent has taken since the start of the model.
- "Remember Height" variable is a variable that remembers the highest point each agent found.
- "Height" variable represents the agent's current height.
- "Stop," variable shows whether the agent is stopped or not.

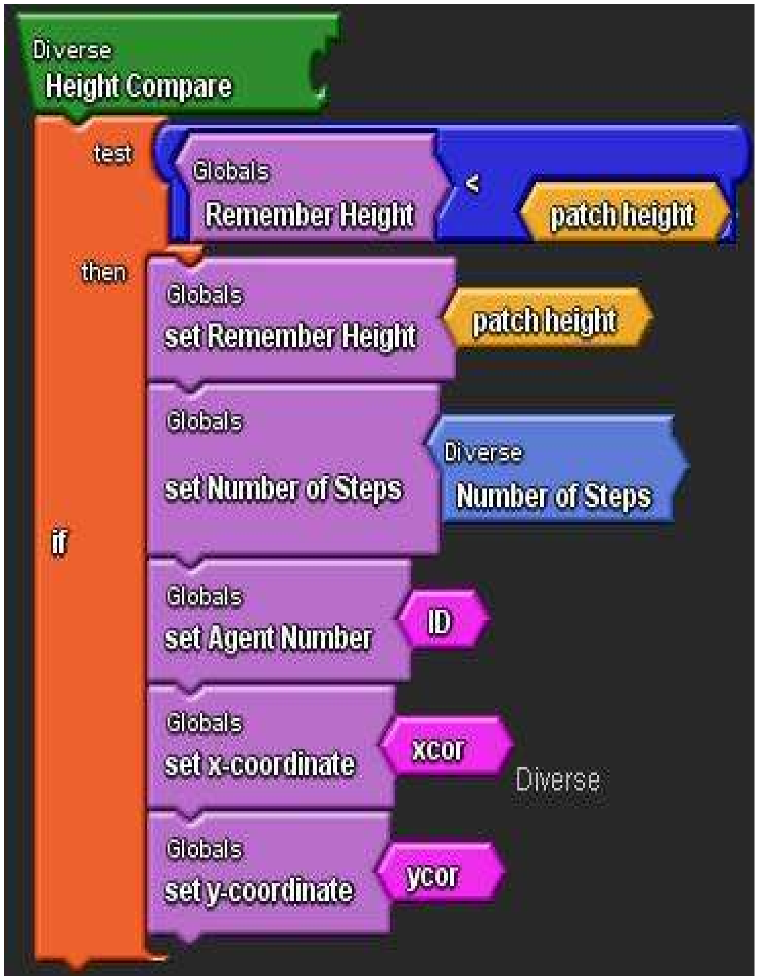

Figure 4, Diverse Height Compare Procedure

This is the procedure called, ”Height Compare.”

- For each diverse agent checks their height when they stop moving. The highest agent then has all of it's variables put on the monitored variables. These variables include: the number of steps, the agent number, the agent's current x-coordinate on the landscape, and the y-coordinate on the landscape.

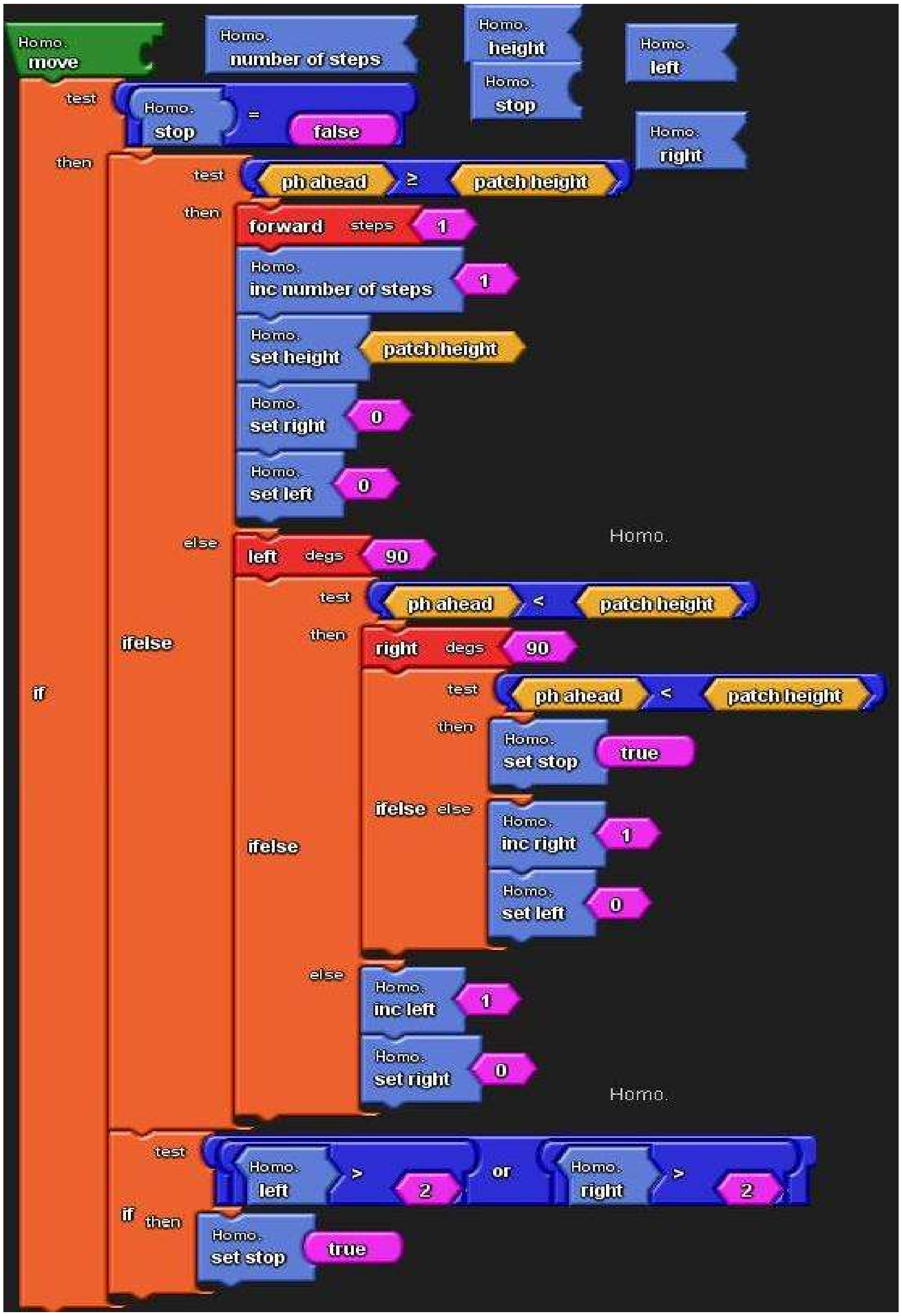

Figure 5, Homogeneous Move Procedure

This is the movement procedure for the homogeneous group. Since they are supposedly more able than the diverse group, it is obvious that they should have more complex instructions on how to move:

- take on step forward and test if the patch height is larger than the previous height. If it is higher, then they keep moving forward,
- if it gets smaller, then they turn left 90 degrees and keep moving.
- if the patch height keeps getting smaller however, then they will turn right 90

degrees, and

- if it continues to get smaller, however, then they will stop.

The variables here are the same as the variables in figure 3, with the exception of two. The “left,” and “right,” variables are agent numbers that represent how many times that agent has gone left or right up to this point. These variables were added because the agent would other wise go in circles forever. Once two lefts or rights are made, the agent stops moving.

Figure 6, Subscreen with monitored variables.

This is the subscreen, which was mentioned earlier. It shows the monitored variable's value, the setup button, and the forever button. If you click on the setup button, then the program would run the setup function once. If you click on the forever button, it would run the “forever” procedure forever.

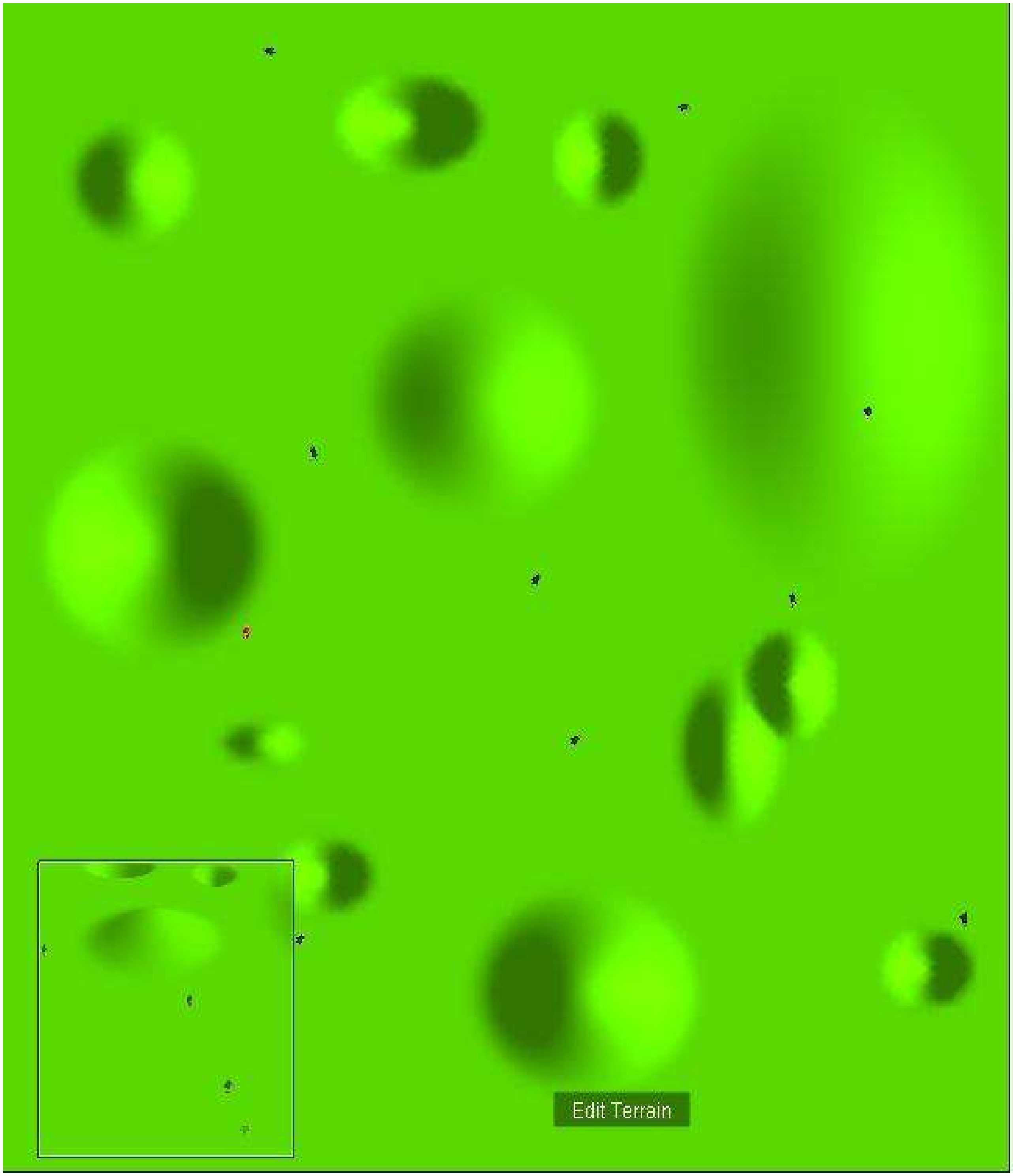

Figure 7, Beginning Screen

This is what the program looks after setup when no movement has yet occurred.

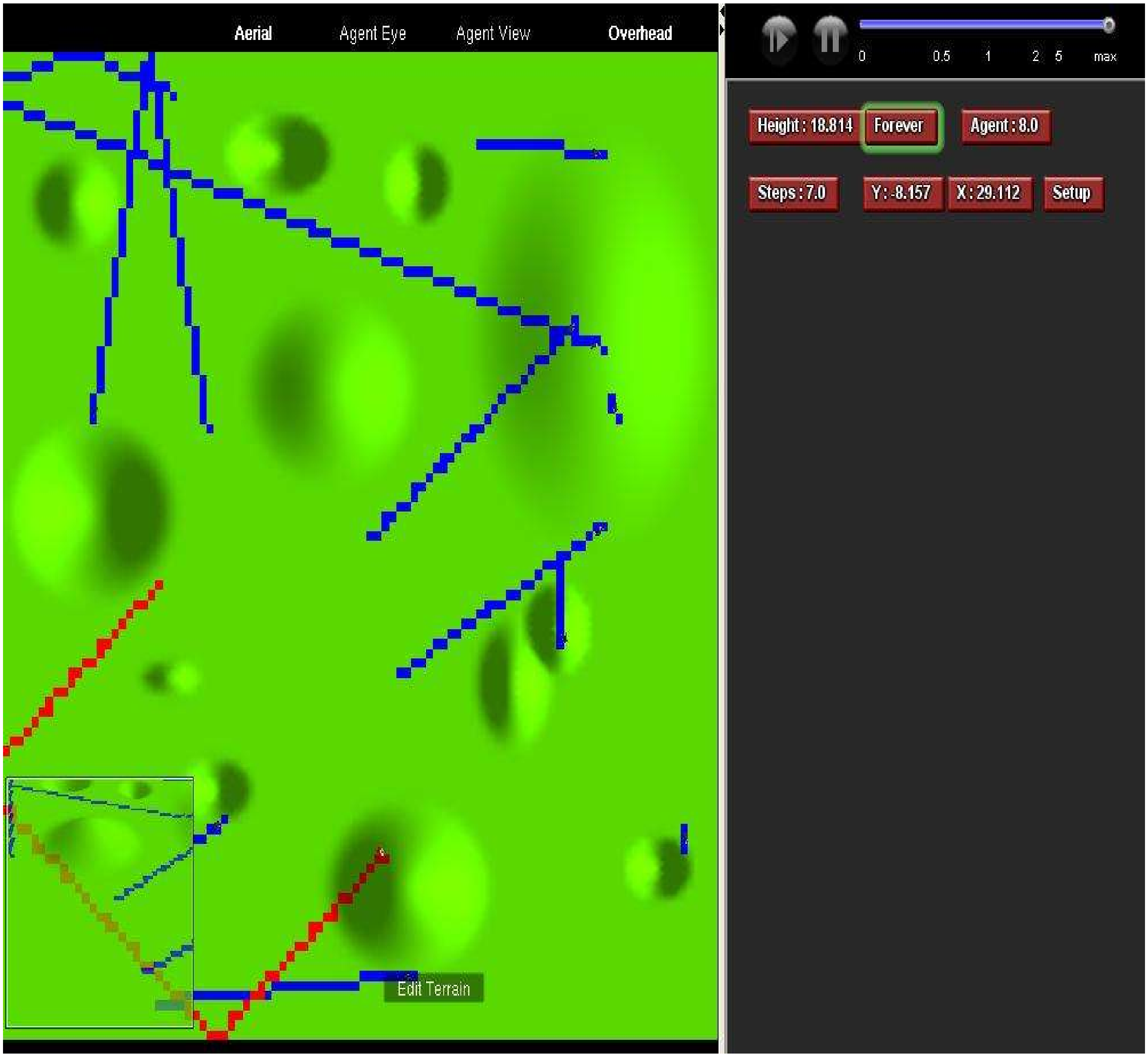

Figure 9, Running Model

This is what the program looks like when it is running. The lines that you see are the trails left behind by the agents. The blue is for diverse agents while the red is for the homogeneous agents.

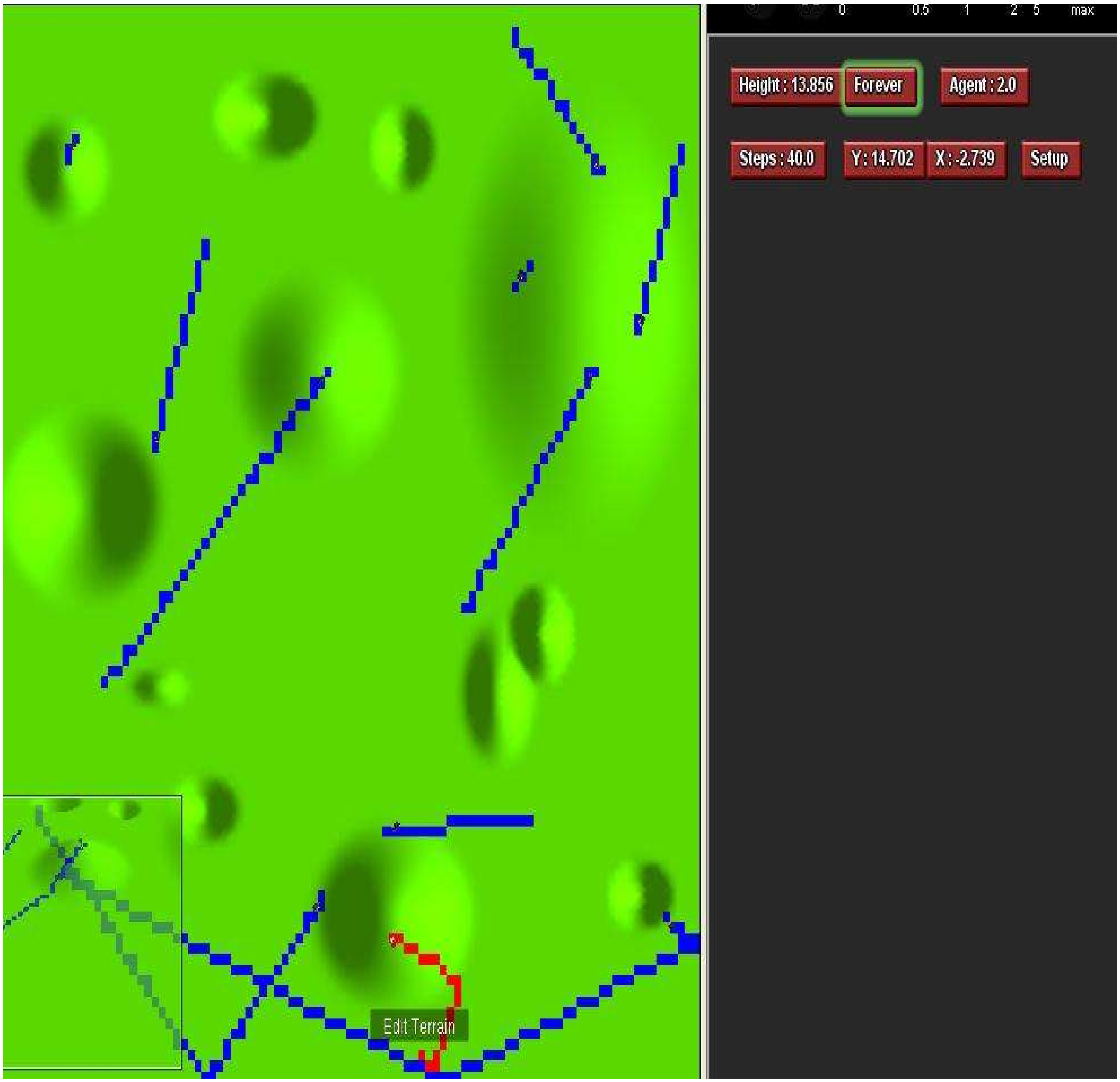

Figure 10, Ending Model

This is what the program looks like at the end when all agents have stopped.

Appendix 2: Results

The table below is the results for the 50 runs for the homogeneous group.

Table 1:

# of steps	Height
132	13.97
130	14.54
25	18.81
7	16.92
5	13.94
44	13.97
1	13.02
31	12.69
55	12.3
178	13.11
143	11.23
41	10
10	13.12
174	13.79
40	10
95	13.19
6	10
8	13.77
77	16.92
14	11.11
48	10.04
65	12.37
28	12.3
51	11.97
31	13.84
32	11.38
14	15.06
16	13.43
16	12.3
76	10
10	11.65
7	11.97
216	13.79
80	11.45
40	12.32
21	15.73
328	13.94
56	13.8
41	10.12
53	13.97
5	12.3
54	11.38
48	12.32
34	12.45
13	12.3
16	13.8
146	11.38
12	12.3
30	12.3
1	10.81

The table below is the results for the 50 runs for the diverse group.

Table 2:	# of steps	Height
	33	12.67
	84	13.76
	18	13.94
	24	12.78
	51	15.25
	27	11.61
	6	16.4
	3	15.73
	3	13.33
	9	13.73
	63	15.25
	12	16.61
	33	12.69
	15	13.67
	21	13.86
	42	14.94
	12	13.94
	30	16.42
	33	16.24
	3	13.01
	9	18.81
	12	18.81
	42	14.44
	12	17.18
	42	16.08
	54	16.61
	3	14.47
	132	13.76
	75	16.24
	36	13.55
	6	13.86
	18	12.47
	3	13.44
	12	16.61
	51	13.6
	21	15.73
	21	13.8
	6	13.94
	6	13.23
	9	15.1
	27	16.4
	108	13.43
	27	13.91
	39	14.17
	6	15.66
	81	16.08
	45	15.73
	69	16.16
	84	13.91
	114	12.01