Project Earth Capacity (EC)

New Mexico

Supercomputing Challenge

Final Report

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Team #62

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Table Of Contents

Table of Contents Page 1

Executive Summary Page 2

Introduction Page 3

Results

Oil Resources Data, Results, Conclusions, Recommendations Page 5

Edible Vegetation Data, Results, Conclusions, Recommendations Page 9

Clean Air Data, Results, Conclusions, Recommendations Page 13

Conclusions Page 15

Recommendations Page 16

Acknowledgements Page 17

Bibliography Page 17

Appendices

Oil Resources Code Page 19

Edible Vegetation Code Page 21

Clean Air Code Page 24

Executive Summary

We chose to use NetLogo to model an important problem in our world today. We modeled how fast the U.S. is using up its resources of clean air, oil reserves, and edible vegetation. We designed a program that had three separate individual parts that could run independently. Each part of the program addressed one of these problems.

We found that if we continue to use our known oil reserves (about 21 billion barrels) at our current rate (21 million barrels per year), we will run out of our reserves in 4 to 5 years if we don't begin to import more oil or develop more of our own reserves. When we looked at the edible vegetation that we need to live, we found that wheat could run out in 162.2 years when the population is about 847,000,000. Sugar could run out in 42.3 years when the population is about 448,000,000. Finally, soybeans could run out in 134.4 years when the population might be about 755,000,000. For clean air, we looked at different ratios of people to oxygen producers (trees) and found that if we changed the ratio of people to trees, we dramatically altered the ratio of oxygen to carbon dioxide in our atmosphere.

Running all of these models demonstrated that we need to be more aware of how our consumption and destruction of the Earth's natural resources is affecting the future availability of these resources that we depend on for survival.

Introduction

Our Super Computing project is about earth capacity. We created three programs to measure how long it takes for certain resources to run out while sustaining our growing U.S. human population. We base this estimate on the fact that technology doesn't improve to reduce the amount of the resources that we use to survive. Our team found this to be one of the most important topics today. Our team members, Ethan Clements, Justine Dombrowski, and Haley Henson, each researched and created a program on three resources that we find most important to the human race. There are so many resources that, unfortunately, we can't do them all.

The resources we chose were fossil fuels, clean air, and edible vegetation, because these are the things that an average person uses on a daily basis. To measure the resources we used the computer program NetLogo. Ethan was researching fossil fuels, Justine did edible vegetation, and Haley did clean air. We ran our models several times and gathered data varying the numbers of different things. We evaluated the data using Microsoft Excel.

Here are some facts we found about these resources.

The facts we have about fossil fuels are that fossil fuels (coal, oil, and natural gas) provide 85% of all energy produced in the United States (1). One quarter of the world's coal reserves are found in the United States (2). Coal supplies more than half of the electricity consumed by Americans. Oil currently supplies 40% of the total energy used in the United States (3). More than 99% of the fuel we use in cars and trucks is supplied by oil (4).

The facts we found out about edible vegetation are that, for the moment, we produce more rice, wheat, sugar and soybeans than we consume (7,8).

The facts we found about clean air are that a mature tree removes 48 pounds of carbon dioxide from the air per year. It requires 22 trees to produce the amount of air consumed by one person. A resting, healthy adult on an average cool day breathes in about 53 liters of oxygen per hour. That same adult on that same day breathes in about 500 milliliters of oxygen per breath. The average plant produces 150 milliliters of oxygen per hour. An average human exhales about 1 kilogram of carbon dioxide per day (9).

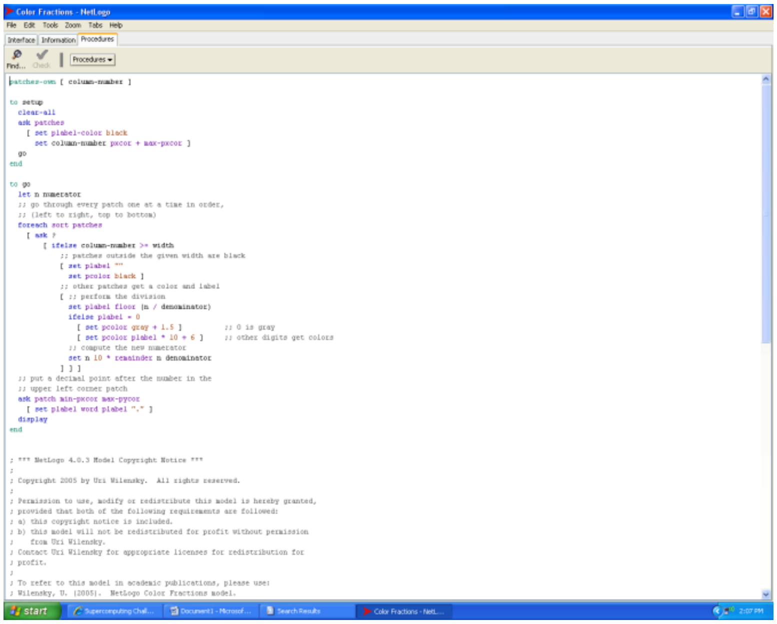
This project was wonderfully challenging and difficult to make. We had problems along the way that we had to solve, but we were excited to study and learn a new computer programming language this year. We are proud to present this to the final judging.

RESULTS

Oil Resources

The program I used was in the programming language of NetLogo. Here is some background information about NetLogo. First, NetLogo is more advanced than Starlogo TNG because you are actually there putting in the code for your program rather than dragging in blocks with all the code put into pre-programmed blocks.

StarLogo



NetLogo

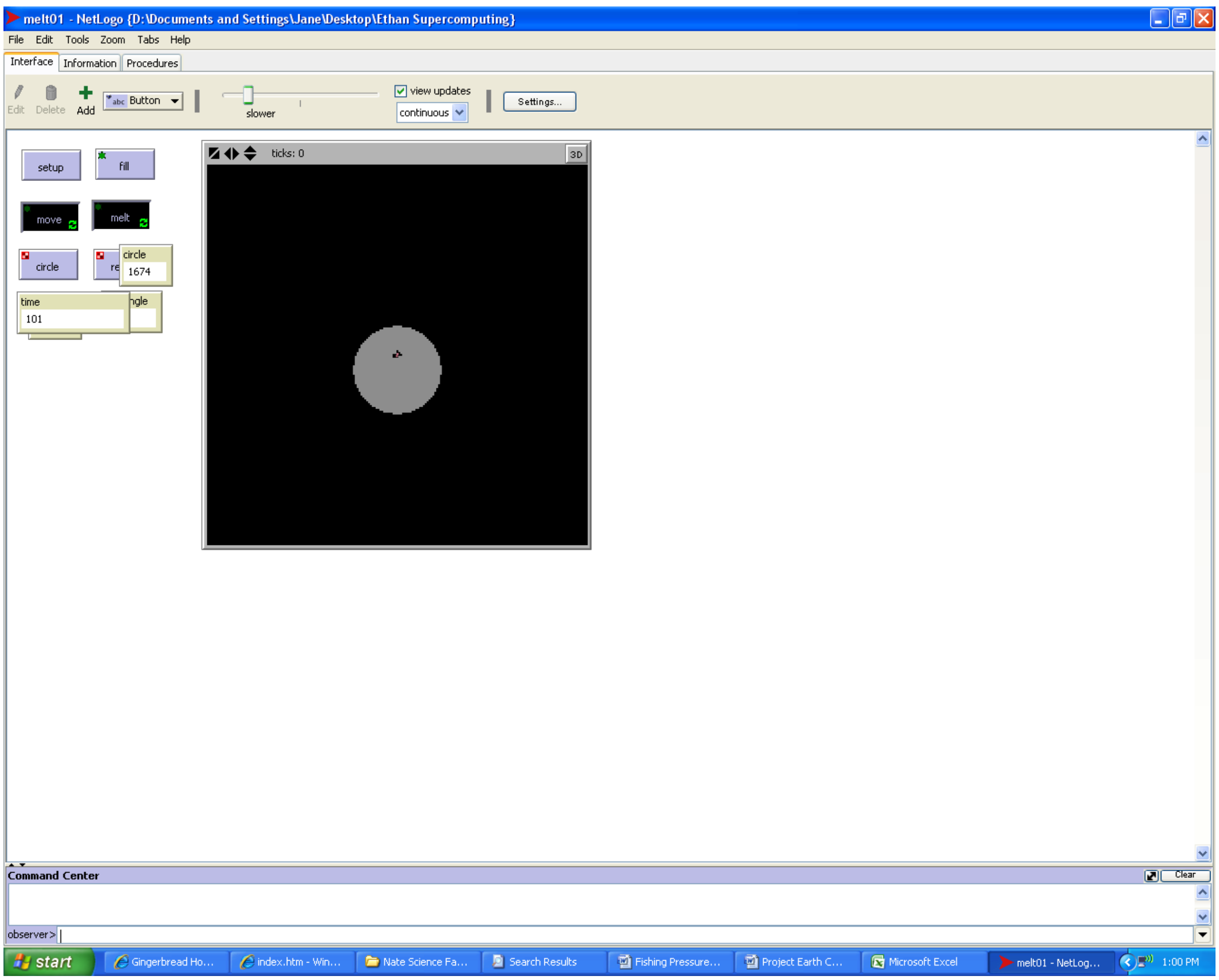
For NetLogo I based my model off of a model I worked on during the Glorietta workshop. This model involves people changing the patch color to black. (This symbolizes people taking oil from the reserves that the U.S. has).

Oil Resources Data

For this project, I had to make a model. In this model I needed to gather data. For this process I had to put the known reserves (about 21 billion barrels) and the consumption rate (21 million barrels) into proportion (5,6). After I did this, I ran the model a number of times. When I ran the model, I found that it took about 4 or 5 years for the U.S. to use up it's oil reserves. To back up my model, I had to do the math. After the math I found out that the oil reserves will be used up in about 3 years.

Oil Resources Conclusion

In conclusion, I found out that it will take about 3 to 3.5 years for the U.S. to run out of oil from our reserves. This will be a bad thing accounting on how much we rely on this black gold. There are some things though that we can do to stop this monstrosity of over usage. First we can drive a lot less, Second we can ride our bikes or walk to places.



Screen shot of the model working.

Oil Resources Recommendations

For this project, there were some problems. First, I did not know how to make a basic circle in NetLogo. I solved this problem by looking in the model's library for help, also I asked one of our mentors, Brad Clements for help. Second I didn't know how to put my model into scale for the production and consumption of oil. Third, I think this is one of the most important problems in the world, but the problem is that the problem was so complicated that I got tired of this project. The main thing for this, I think, is that you have to have fun while you're doing the project, or you won't want to keep learning and doing the project. So we should have picked a different problem to work on.

Edible Vegetation

The resource I chose to study was edible vegetation, such as rice, wheat, sugar, and soybeans. I chose this resource because I think that even if it isn't a pressing issue in today's society; if it disappeared all together it would be a big problem. I designed my program to eventually show me when such edible vegetations run out. I did not incorporate the fact that (a) you even if you ran out of one of these, there are things that could be done to reintroduce it to the world and (b) the population increase rate would increase or decrease (stays at a steady 0.883%). I incorporated the data I gathered about consumption, production, and population growth rates. The model reacts to the population increase that I programmed in. The model also reacts to the consumption and production rates I inserted for each type of vegetation (7,8). The model also only allows so much of the crop to build up. This represents storage of the crop. The plots and monitors I put in help me to look at the decrease or increase of the vegetation. In this program, each consumer equals 10 million consumers in real life. Also, each tick represents 1 day. In this model, 1 rice agent is equal to 1,000,000 metric tons of rice, 1 wheat agent is equal to 1,000,000 metric tons of wheat, 1 sugar agent is equal to 1,000,000 metric tons of sugar, and 1 soybean agent is equal to 1,000,000 metric tons of soybeans.

Crop	Production	Consumption
Rice	6,174,000	3,882,000
Wheat	63,590,000	33,203,000
Sugar	8,786,000	7,20500
Soybeans	85,740,952	25,261,750

Edible Vegetation Results

The data I gathered is the following (see table). To gather this data I ran my program ten times and put it into a table. Then I averaged each set of data to get the data you can see below. From the data I gathered that rice could run out in about 4.2 years (saying "a" and/or "b"(see above) do not happen) when the population is about 320,000,000. Wheat could run out in 162.2 years when the population is about 847,000,000. Sugar could run out in 42.3 years when the population is about 448,000,000. Finally, soybeans could run out in 134.4 years when the population might be about 755,000,000. From the data I gathered, I can conclude we would run out of rice first, sugar second, soybeans third, and wheat last.

Vegetations	Average Years	Average Population
• Rice	4.2	32 million
• Sugar	42.3	44.8 million
• Soybeans	134.4	75.5 million
• Wheat	162.2	84.7 million

Edible Vegetation Conclusion

The conclusion I drew from the data I received from my program is the following. I conclude that we could run out of valuable food resources sooner than we think (saying “a” and/or “b” don’t occur). I ran a series of ten tests. I drew data about how long it would take for each resource to be used up and what the population would be when such a thing occurred. I then averaged each set of numbers for each breed. I came up with that we could run out of rice in about 4 years. Some may seem far away, but some are very close, such as rice and sugar. If we did run out of them we would run out of them very quickly. We could run out of some in maybe as little as 4 years. Yet maybe we would run out in as many as 162 years. It’s hard to tell. I thought that we would run out in maybe 200-300 years, nothing this close. Yet from what my data says, it is likely to happen.

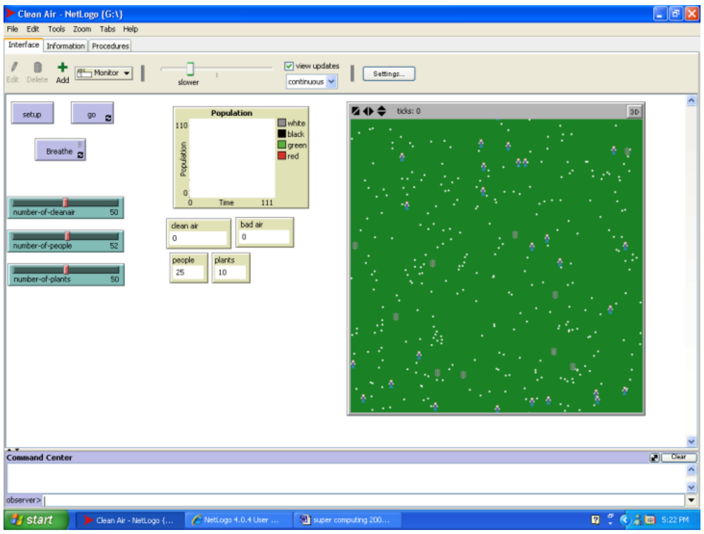
Edible Vegetation Recommendations

I would like to recommend several things.

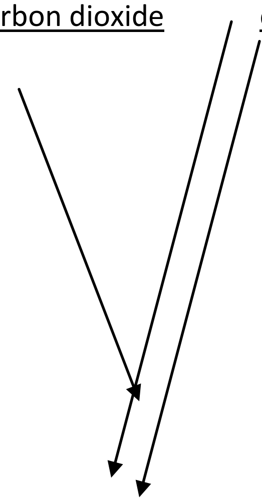
1. I would recommend getting more accurate sources for the consumption and production rates. It's hard to tell what is a reliable source and what is not.
2. I would also recommend talking to some experts on population growth, production and consumption rates and other things. It would always be good have an expert's opinion.
3. I would like to recommend making the program I used much more elaborate to get any data better than an estimate or average.
4. I would finally like to recommend to run the program MANY more times to get a more accurate average or estimate.

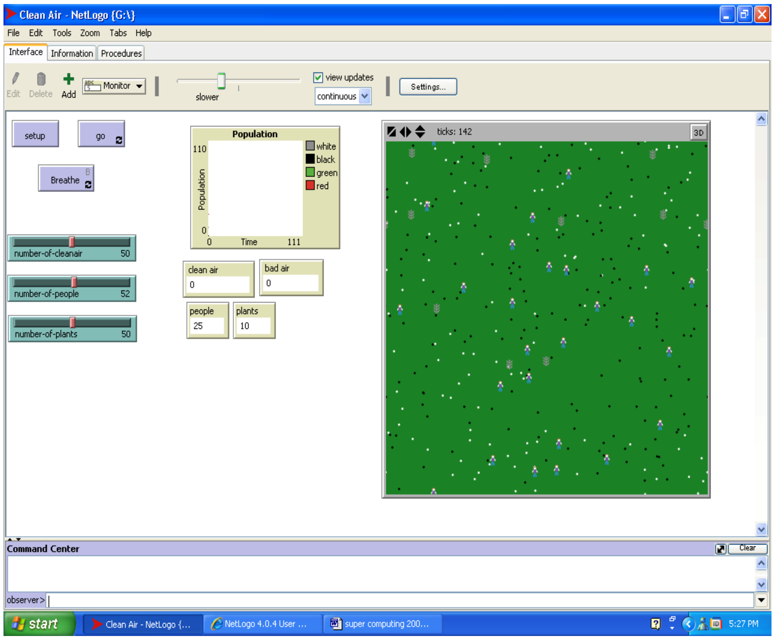
Clean Air

This is the program about the resource clean air. For this program I used NetLogo. This is a picture of what the screen of this program looks like.



In this program I measured human and the average plant interaction. Whenever a clean air particle comes within a certain distance away from a person it gets "breathed in" and turns into carbon dioxide by turning black: carbon dioxide clean air





Results

I ran the program 15 times.

When I started with 25 people and 10 plants and 300 clean airs, the clean air never ran out, but there was more carbon dioxide generated than clean air. When I ran the program with more trees, the amount of carbon dioxide decreased. Once I ran it with 50 people and the same number of trees, and the carbon dioxide levels increased alarmingly.

Conclusions

I concluded that there is a very important balance between the number of people on the earth and the number of trees, and that if the balance is changed, the levels of oxygen and carbon dioxide change, and could become toxic for people.

Recommendations

This program was fun to make and it was challenging. In the future I hope to improve it even further. Maybe make it more accurate and plug in more information, but for now I am very proud of this program.

Conclusions For Project Earth Capacity

In conclusion, I found out that it will take about 3 to 3.5 years for the U.S. to run out of oil from our reserves. This will be a bad thing accounting on how much we rely on this black gold. There are some things though that we can do to stop this monstrosity of over usage. First we can drive a lot less, Second we can ride our bikes or walk to places. Third, we can start to develop more resources for us to depend on rather than just using oil.

The conclusion I drew from the data I received from my program on edible vegetation is the following. I conclude that we could run out of valuable food resources sooner than we think (saying "a" and/or "b" don't occur). I ran a series of ten tests. I drew data about how long it would take for each resource to be used up and what the population would be when such a thing occurred. I then averaged each set of numbers for each breed. I came up with that we could run out of rice in about 4 years. Some may seem far away, but some are very close, such as rice and sugar. If we did run out of them we would run out of them very quickly. We could run out of some in maybe as little as 4 years. Yet maybe we would run out in as many as 162 years. It's hard to tell. I thought that we would run out in maybe 200-300 years, nothing this close. Yet from what my data says, it is likely to happen.

The conclusion I drew from the Clean Air Program was that we need to plant more trees if we are going to be able to continue to live on earth, especially if our population continues to grow.

Recommendations For Project Earth Capacity

For this project, there were some problems.

Most of our problems would have been solved if we had:

1) Found experts who could have helped us with the data we needed to plug into our models. Many of the web and written sources gave conflicting numbers for our original data.

2) Made the programs more elaborate to get a better estimate for our results.

3) Run the models more times to generate better results.

4) Picked a project that was less huge and more manageable.

Even with these problems, we are very glad that we did the Challenge. We learned a new program (NetLogo) and had fun using it, and learned about the Earth's resources.

Acknowledgements

Thanks to our teachers, Mr. Dryja, and Mr. Bonzon; our mentors, Mr. and Mrs. Clements, Mrs. Dombrowski, and Mr. and Mrs. Henson; a student contributor, Charlie Hall; and Mr. Bob Robey and all of the helpers at the Supercomputing project and at Glorietta.

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Appendices

Oil Resources Code

```
globals [time]

breed [oilrig a-oilrig]

to setup

ca

crt 2

set time 0

ask turtles

[set color pink ]

ask turtles

[set shape "oilrig"]

end

to fill

setxy random-xcor random-ycor

if pcolor != black

[fill ]

end

to move

fd .1

if who = 0
```

```
[set time time + 1]
rt random 10
lt random 10
end
to melt
 if pcolor != black
 [set pcolor black
  rt 180]
end
```

Edible Vegetation Code Description

Consumers-Own

The Consumers "own" the following variables;

rice_eat_num

rice_eat_max

wheat_eat_num

wheat_eat_max

sugar_eat_num

sugar_eat_max

soybean_eat_num

soybean_eat_max

Globals

The globals are the variables used in the program.

Setup

The setup section first starts out as clearing everything off spaceland. The setup then sets its default shapes as consumers, rice, wheat, sugar, and soybean. It creates a certain amount of each breed type and sets the consumption rate of each and scatters them.

Go

First the Go command chain asks the consumers to rotate between 1 and 100 degrees and turn left a random amount then move forward one space and eat if there is an opportunity to. It then restarts the prod_cons procedure. It grows the rice, wheat, sugar, and soybeans. It then restarts the population growth and continues it. Then it updates the plot and sets time in ticks to the number of ticks divided by 365. That all happened in one tick.

Eat

This tells the consumer how to eat. It says that if the rice, wheat, sugar, or soybeans are within a certain range and such than the consumer will “eat” it.

PopGrowth

This creates consumers based on the percentage population growth rate.

Restart_pop_growth

This restarts the population growth of consumers.

Restart_prod_cons

This restarts the production of crops.

Update-Plot

First it tells the program which plot to set data to (In this case there is more than 1) and then it sets the plot pens (plot lines) to rice, wheat, sugar, and soybeans. It then tells the plot to plot the population of each.

Clean Air Code

I started out the program by creating a setup procedure. I first created 300 "cleanairs" to start out with. I made 25 "persons" and 10 "plants." Then I made the program place all of the breeds randomly throughout the screen.

```
breed [ cleanairs cleanair ]

breed [ persons person ]

breed [plants plant]


to setup

 clear-all

 set-default-shape cleanairs "cleanair"

 set-default-shape persons "person"

 set-default-shape plants "plant"

  ask patches

   [set pcolor 63 ]

  create-cleanairs 300          <-- create clean air

   [set color white ]

  create-persons 25             <-- create people

   [set color 28]

  create-plants 10              <-- create plants

   [set color green]
```

set up

```
  ask cleanairs
    [setxy random-xcor random-ycor]
  ask persons
    [setxy random-xcor random-ycor]

  ask plants
    [setxy random-xcor random-ycor]

    setup-plot
    do-plot
end
```

the random setup

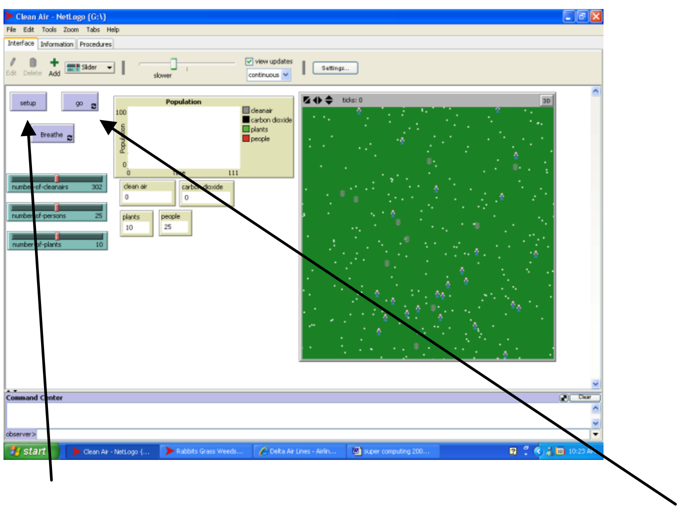
After the setup comes the "go" procedure. Go is the button on the screen that gets everything moving in the program. I could have named it anything ,but it was simplest to just name it go. The go asks the breeds to move. So to make them walk randomly I put the random walk here.

```
to go

  ask cleanairs
   [rt random 360
   forward 1]
  ask persons
   [rt random 360
```

random walk

go procedure

```
forward 1 ]

tick

setup-plot

do-plot

end
```



Following the go procedure comes the breathing procedures. The breathe procedures are the procedures that make the clean air turn black went it comes within a certain radius from a person and turn from black to white when it comes within a certain radius from a plant.

```
to breathe

 let breath one-of cleanairs

 if breath != persons

  [ ask breath [ set color black]]
```

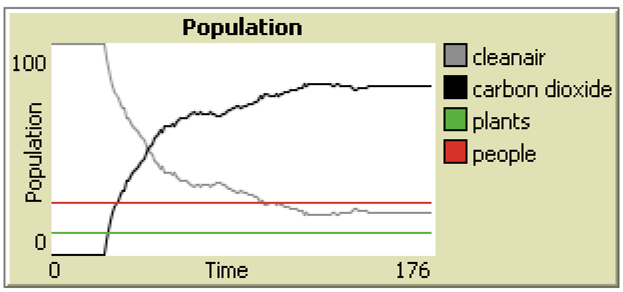
```
 end


to breathe2

ask persons

  [ ask cleanairs in-radius 1

      [ set color black ]

       ]

ask plants

  [ ask cleanairs in-radius 1

      [ set color white  ] ]


end

to breathe3

  ask cleanairs

   [ if patch-ahead 1 = persons

      [ fd 1 ]

  ]

  tick

 ask persons

  [ ask cleanairs in-radius 1

      [ set color black ]

       ]
```

breathe

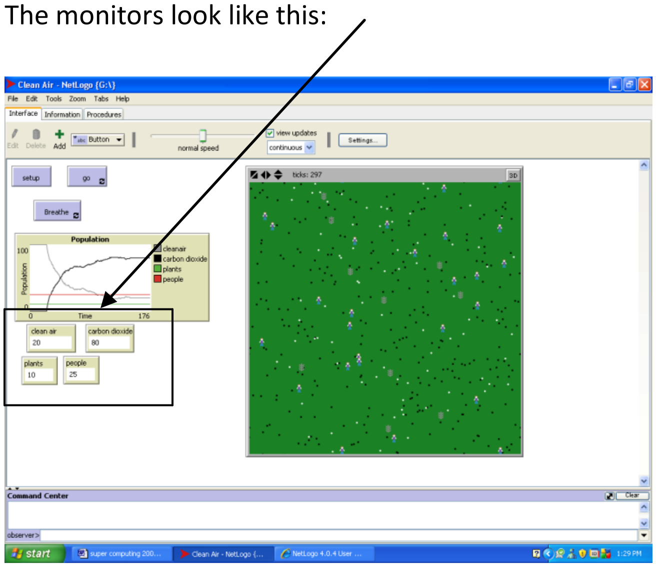
procedures

```
ask plants

  [ ask cleanairs in-radius 1

     [ set color white  ] ]

end
```

The last procedure is the plot to get information from the program.   Along with the plot I had to make monitors to count how many of everything there is. This is what the plot looks like on the clean air program.



The monitors look like this:



To make the plot work I had put plot parts in several places.

One part had to go in the "go" procedure.

```
to go

 ask cleanairs
  [rt random 360
  forward 1]
 ask persons
  [rt random 360
  forward 1 ]
 tick
  setup-plot
  do-plot                    Plot part.

end
```

Then I had to make two more procedures to explain to the program what do-plot means and how to setup-plot.

```
to do-plot
set-current-plot "Population"

set-current-plot-pen "cleanair"
```

```
plot ( ( count cleanairs with [color = white] ) / 4 )


set-current-plot-pen "carbon dioxide"

plot ( ( count cleanairs with [color = black] ) / 4 )


set-current-plot-pen "people"

plot count persons


set-current-plot-pen "plants"

plot count plants


end
```

The do plot procedure

```
to setup-plot

 set-current-plot "Population"

 end
```

setup plot procedure

For the monitors to work I created a monitor for each breed. (People, plants, carbon dioxide, and clean air.) For the clean air monitor I had to tell the monitor to only count the “cleanairs” with a white color and for the carbon dioxide monitor I had to tell it to count only the cleanairs with a black color. Here is what I did:

For clean air:

((count cleanairs with [color = white]) / 4)

For carbon dioxide:

((count cleanairs with [color = black]) / 4)

To make the monitors for plants and people it was much simpler. I just had to ask the monitor to count "persons" and "plants":

For plants:

count plants

For people:

count persons

This program was fun to make and it was challenging. In the future I hope to improve it even further. Maybe make it more accurate and plug in more information, but for now I am very proud of this program.