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Project #4
Functional Decomposition

My Machine:

I ran this program on flip in linux from a windows 10 laptop. My main function is contained in a file called project4.cpp
I compiled and executed the program by typing:

```
g++ -I/usr/local/common/gcc-5.2.0/ project4.cpp -o proj4 -lm –fopenmp
./proj4
```

1. My Added Quantity:

I chose to add a population of coyotes to the simulation. Although most people believe wolves are the main predators of deer, coyotes are an even bigger threat.

In my simulation, if the number of deer is less than 75% of the number of coyotes, there are enough coyotes to kill and eat a deer (resulting in 1 less deer in the population).

If the number of deer is less than 50% of the number of coyotes, the coyotes will not have enough to eat and one will die (resulting in 1 less coyote in the population).

If the number of deer is at least equal to 50% of the number of coyotes, the coyotes will survive through the month and 1 coyote will be born (resulting in 1 more coyote in the population).

For example, if the population contains:

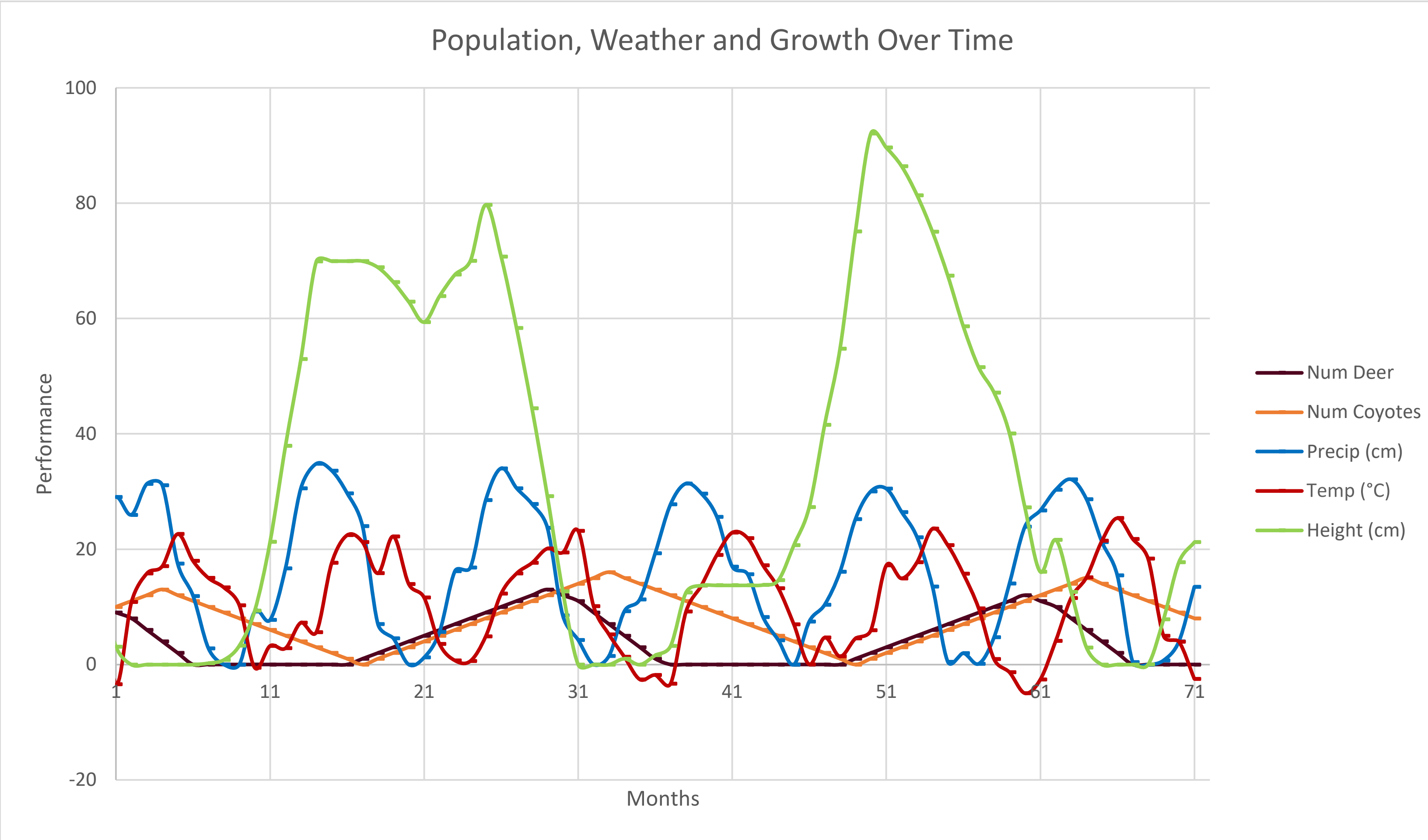
- 3 deer and 8 coyotes, a deer and a coyote will die -> 2 deer and 7 coyotes
  - $3 < .75(8)$
  - $3 < .5(8)$
- 7 deer and 12 coyotes, a deer will die and a coyote will be born -> 6 deer and 13 coyotes
  - $7 < .75(12)$
  - $7 > .5(12)$
- 14 deer and 16 coyotes, a coyote will be born -> 14 deer and 17 coyotes
  - $14 > .75(16)$
  - $14 > .5(16)$

2. <u>My performance results:</u>

MONTH NUMBER	YEAR	MONTH	NUM DEER	NUM COYOTES	PRECIP (in)	TEMP (°F)	HEIGHT (in)
0	2017	0	10	9	10	60	5.146525
1	2017	1	9	10	11.44072	25.867294	1.209797
2	2017	2	8	11	10.223239	51.5158	0
3	2017	3	6	12	12.333856	60.445229	0
4	2017	4	4	13	12.241714	62.699234	0
5	2017	5	2	12	6.890173	72.761185	0
6	2017	6	0	11	4.683146	64.338463	0
7	2017	7	0	10	1.099019	59.012436	0.097533
8	2017	8	0	9	0	56.052402	0.321255
9	2017	9	0	8	0	50.530617	1.292188
10	2017	10	0	7	3.61448	31.033646	3.673705
11	2017	11	0	6	3.052063	37.862236	8.389902
12	2018	0	0	5	6.572194	37.127182	14.939556
13	2018	1	0	4	12.035791	45.108376	20.851898
14	2018	2	0	3	13.709704	42.109818	27.519825
15	2018	3	0	2	13.234959	63.754047	27.545359
16	2018	4	0	1	11.694701	72.390694	27.545574
17	2018	5	1	0	9.445941	70.22715	27.546432
18	2018	6	2	1	2.761499	60.504951	27.117151
19	2018	7	3	2	1.7939	72.020294	26.117294
20	2018	8	4	3	0	57.160519	24.772129
21	2018	9	5	4	0.482207	52.891026	23.385841
22	2018	10	6	5	2.232361	38.441544	25.156601
23	2018	11	7	6	6.380392	33.281513	26.625067
24	2019	0	8	7	6.624178	33.109158	27.565016
25	2019	1	9	8	11.234515	40.821476	31.391029
26	2019	2	10	9	13.394991	54.141743	27.855953
27	2019	3	11	10	12.039192	60.447968	22.973217
28	2019	4	12	11	10.956982	63.735641	17.501556
29	2019	5	13	12	9.34031	68.234932	11.504305
30	2019	6	12	13	3.350579	67.001068	5.007811
31	2019	7	11	14	1.678794	73.717545	0
32	2019	8	9	15	0	50.221195	0
33	2019	9	7	16	0.587338	41.411949	0
34	2019	10	5	15	3.641372	34.394638	0.399776
35	2019	11	3	14	4.451053	27.378744	0
36	2020	0	1	13	7.604177	28.75808	0.634504
37	2020	1	0	12	10.947586	26.065063	1.271782

38	2020	2	0	11	12.355902	48.538799	4.92215
39	2020	3	0	10	11.668402	56.68528	5.402913
40	2020	4	0	9	10.08584	66.206528	5.411238
41	2020	5	0	8	6.688356	73.194473	5.411355
42	2020	6	0	7	6.166811	71.47924	5.411699
43	2020	7	0	6	3.241144	62.981045	5.437466
44	2020	8	0	5	1.650755	55.794334	5.766278
45	2020	9	0	4	0	44.569393	8.154737
46	2020	10	0	3	2.935599	32.082817	10.749683
47	2020	11	0	2	4.080508	40.444382	16.373795
48	2021	0	0	1	6.334573	34.55299	21.572392
49	2021	1	1	0	9.928586	40.164165	29.569828
50	2021	2	2	1	11.823711	42.723389	36.254959
51	2021	3	3	2	12.004155	62.94326	35.294727
52	2021	4	4	3	10.408884	58.896626	34.019413
53	2021	5	5	4	8.685596	63.974937	32.044491
54	2021	6	6	5	5.322556	74.396873	29.544537
55	2021	7	7	6	0.181275	69.228516	26.545132
56	2021	8	8	7	0.776464	60.360573	23.099237
57	2021	9	9	8	0.052111	49.540062	20.296106
58	2021	10	10	9	1.866052	33.674034	18.562798
59	2021	11	11	10	5.5376	29.59029	15.780985
60	2022	0	12	11	9.408552	23.076595	10.735704
61	2022	1	11	12	10.517882	27.337147	6.340957
62	2022	2	10	13	11.930021	39.38628	8.519464
63	2022	3	8	14	12.637474	52.801086	4.968938
64	2022	4	6	15	11.281608	59.263889	1.16138
65	2022	5	4	14	8.365551	70.629059	0
66	2022	6	2	13	6.08366	77.711456	0
67	2022	7	0	12	0.168004	71.230835	0
68	2022	8	0	11	0	65.045837	0.005553
69	2022	9	0	10	0.283193	40.964722	3.088763
70	2022	10	0	9	1.574779	39.165668	6.995244
71	2022	11	0	8	5.30503	27.552235	8.358049

3. <u>Graph of Performance:</u>
As suggested in the project notes, I converted my units to °C and centimeters, so that the quantities would fit better on the axes.



4. <u>Performance Patterns and Explanation:</u>
   - Temperature (red): follows the sin wave +/- randomness.
   - Precipitation (blue): follows the sin wave +/- randomness.
   - Height (green): follows the precipitation and deer curves (when precipitation goes up, so too does height… when deer goes up, height goes down with a bit of lag).
   - Deer (brown): follows the height curve (when height goes up, deer goes up with a bit of lag, then deer goes up)
   - Coyotes (orange): follows the deer curve (when deer goes up, coyote goes up and when deer goes down, coyote goes down with a bit of a lag.

We can replicate the same simulation (under the same conditions and with the same starting values) but removing the coyotes (as can be seen in the graph below). Clearly, there are significant changes to the grain and deer values.

The Temperature and Precipitation curves remain unchanged because they are independent of the number of deer/coyotes.

The number of inches of grain is lower (because without the coyotes, there are more deer in the population eating grain). This curve is also much more closely correlated to the precipitation curve.

The number of deer in the population is higher (because there are no coyotes eating them). This curve is also much more closely correlated to the height curve.

These differences in grain and deer values show that the coyotes are, in fact, affecting the simulation.