

COMP 3201 Final Project Report

Appendix & Graphs

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Github Link: <https://github.com/ZacharyMN709/COMP-3201---TSP-Evolutionary-Algorithm>

This project has a vast amount of data in it, and there are several interesting graphs which stem from this data. Most of the graphs are split into multiple parts, and so each page in the appendix only contains one graph, and a small description

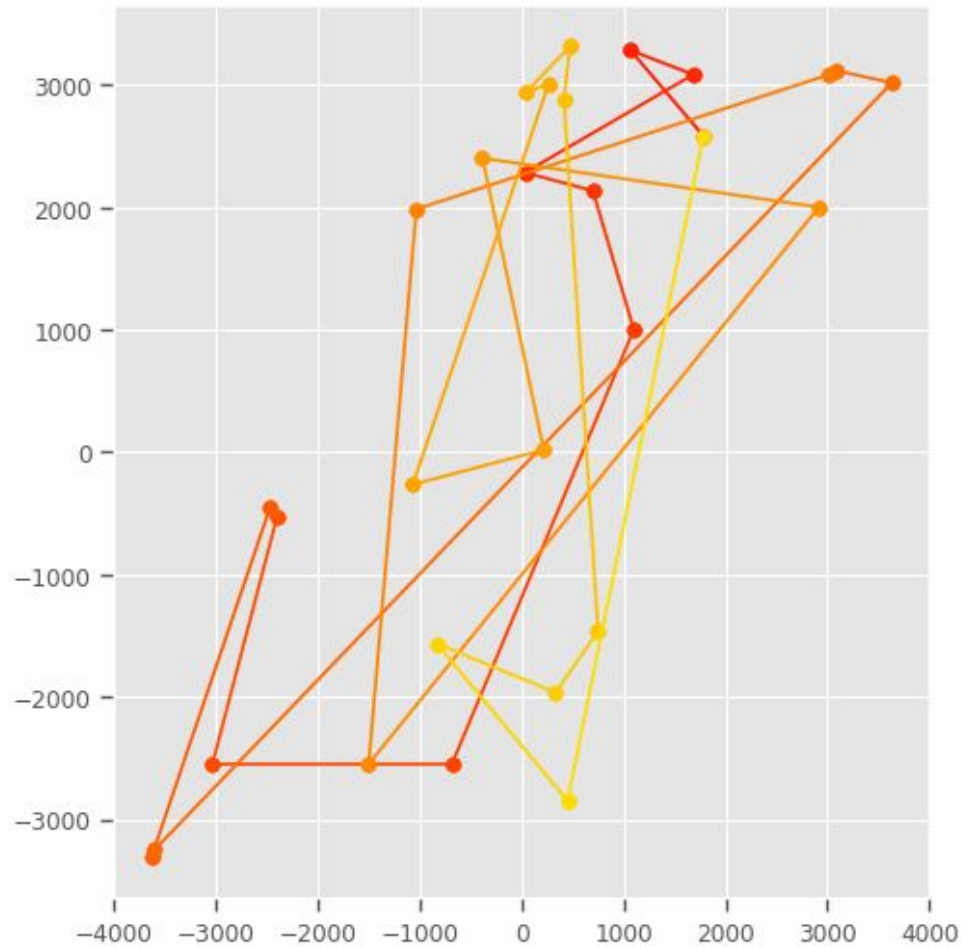
City Tour Plots

The plots below are random individuals created by various initialization techniques for the different datasets that we used.

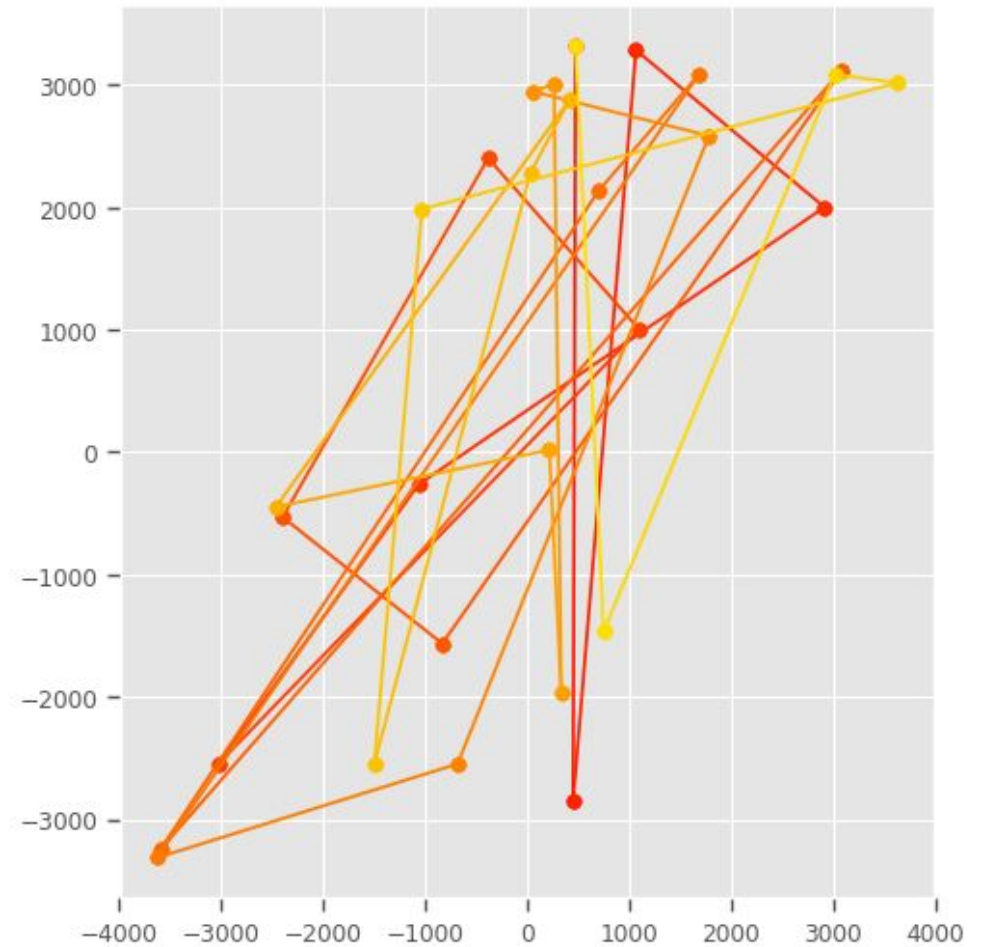
Graph 1

Sahara Dataset - Cluster Initialization Vs. Random Initialization

Using Cluster Method

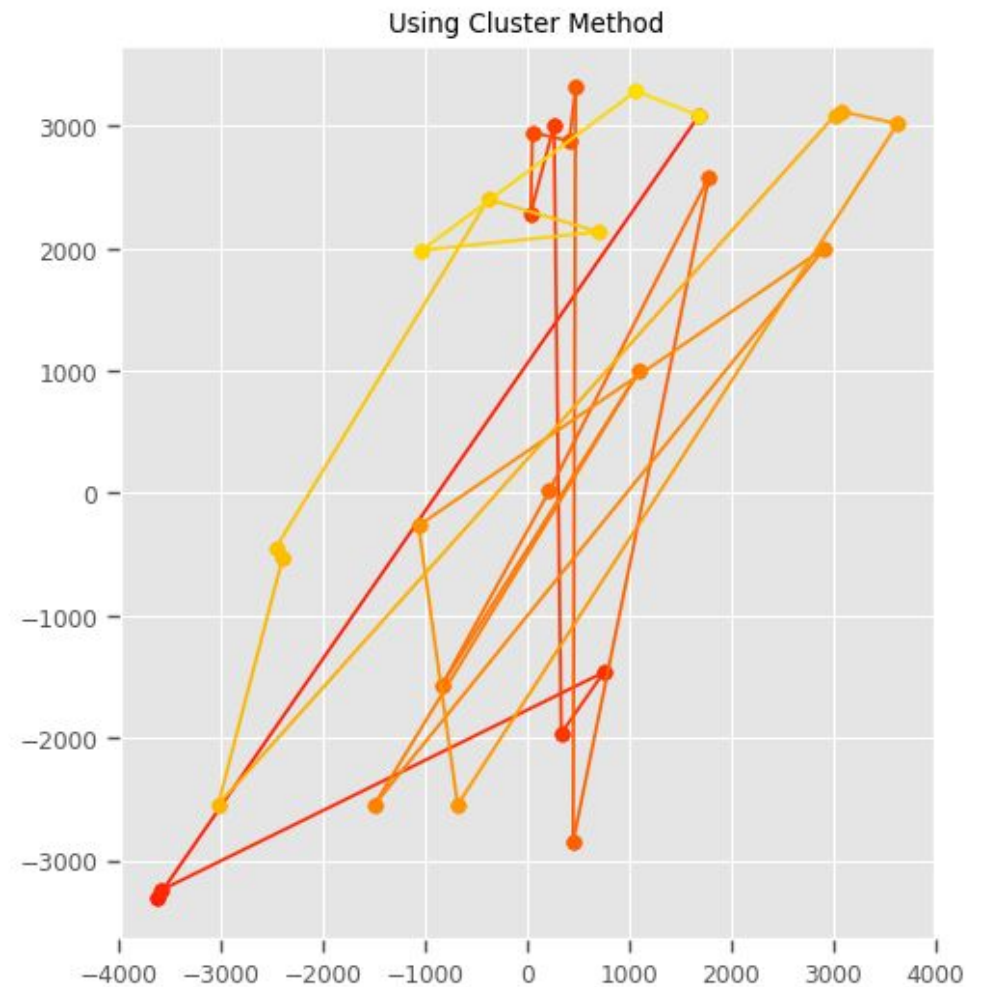
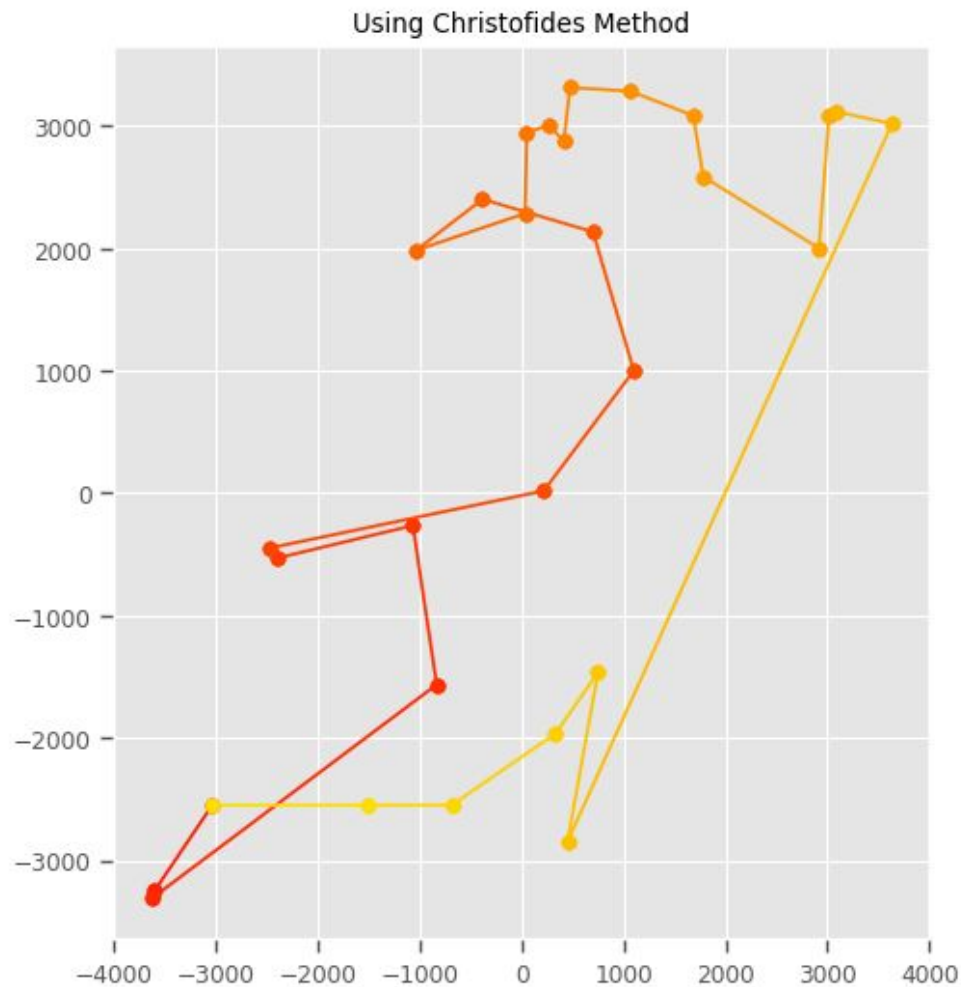


Using Random Method



Graph 2

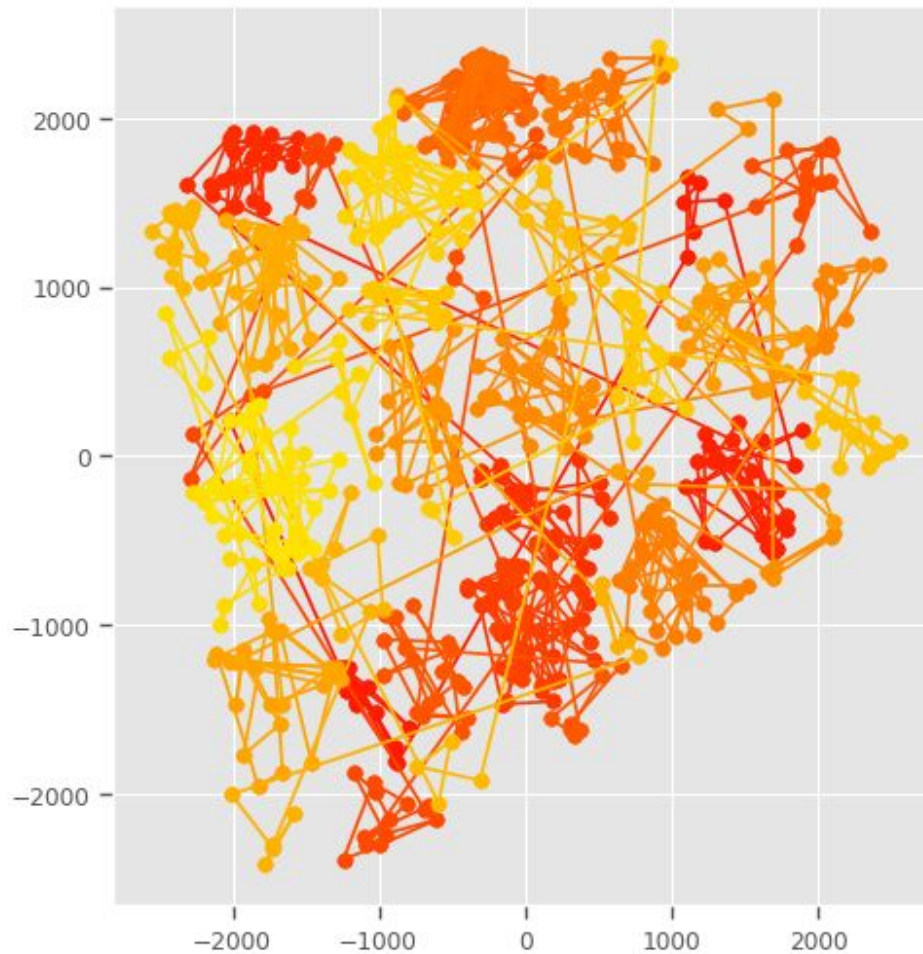
Sahara Dataset - Christofide Initialization Vs. Cluster Initialization



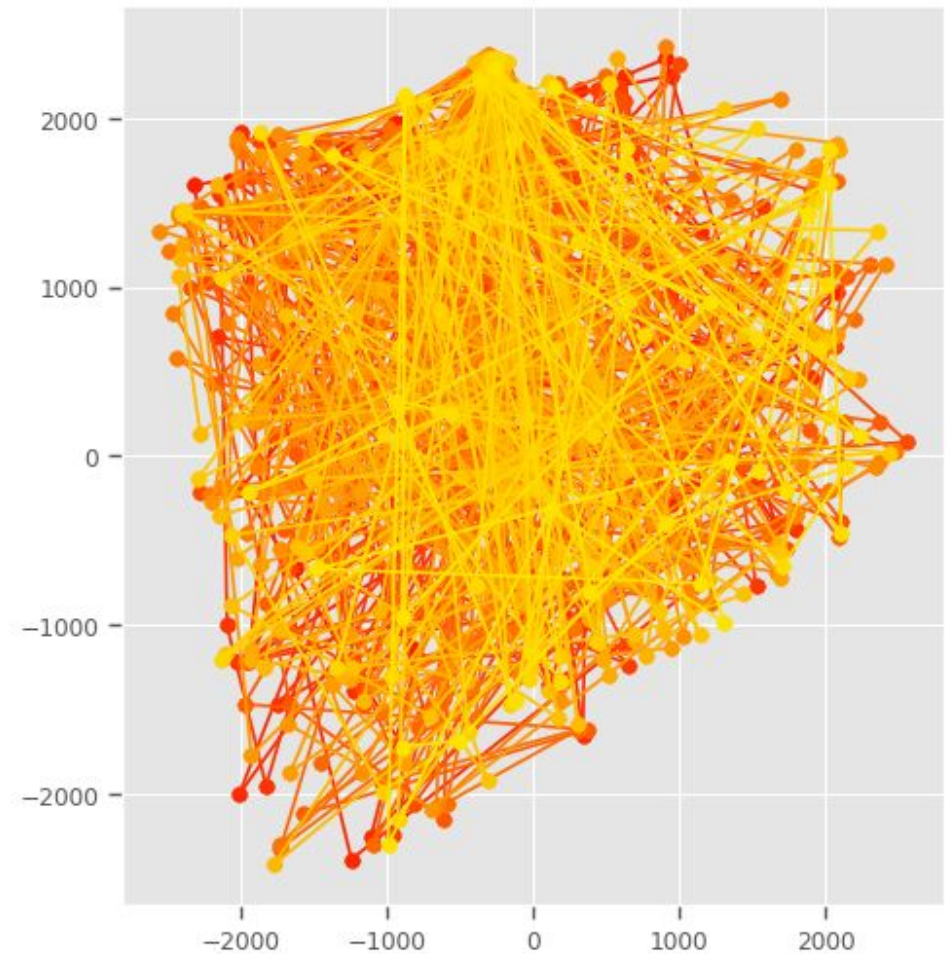
Graph 3

Uruguay Dataset - Cluster Initialization Vs. Random Initialization

Using Cluster Method



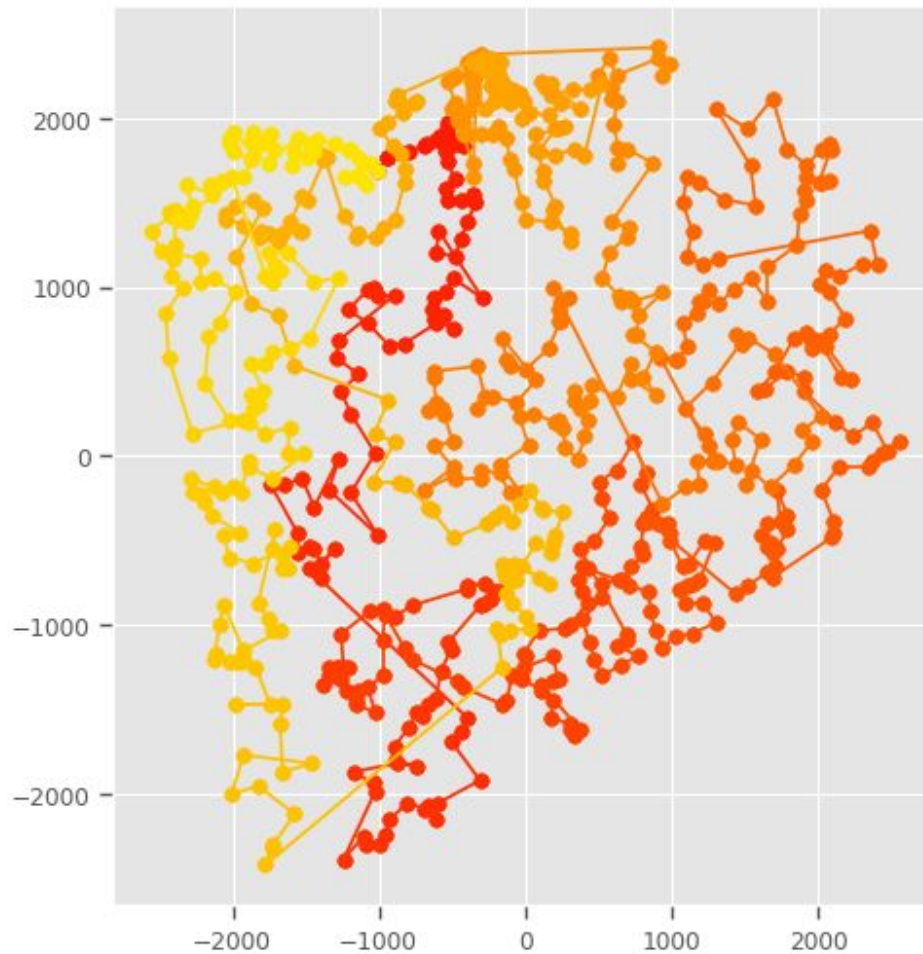
Using Random Method



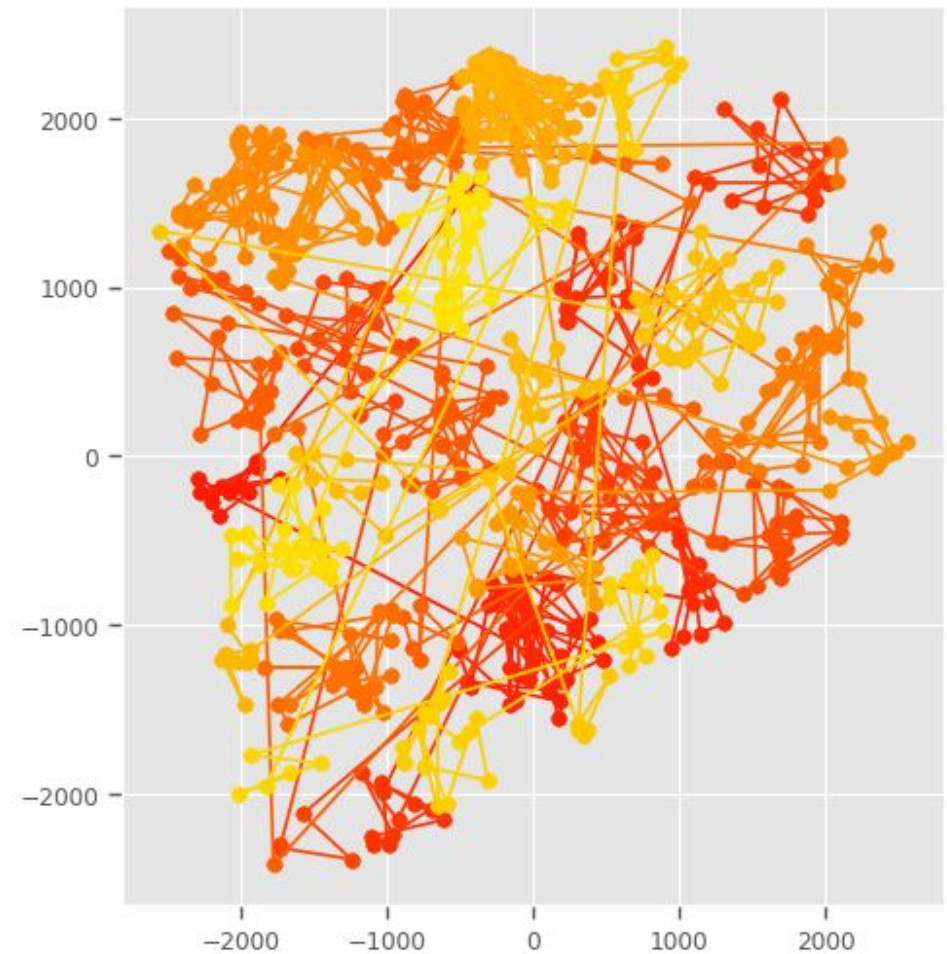
Graph 4

Uruguay Dataset - Christofide Initialization Vs. Cluster Initialization

Using Christofides Method



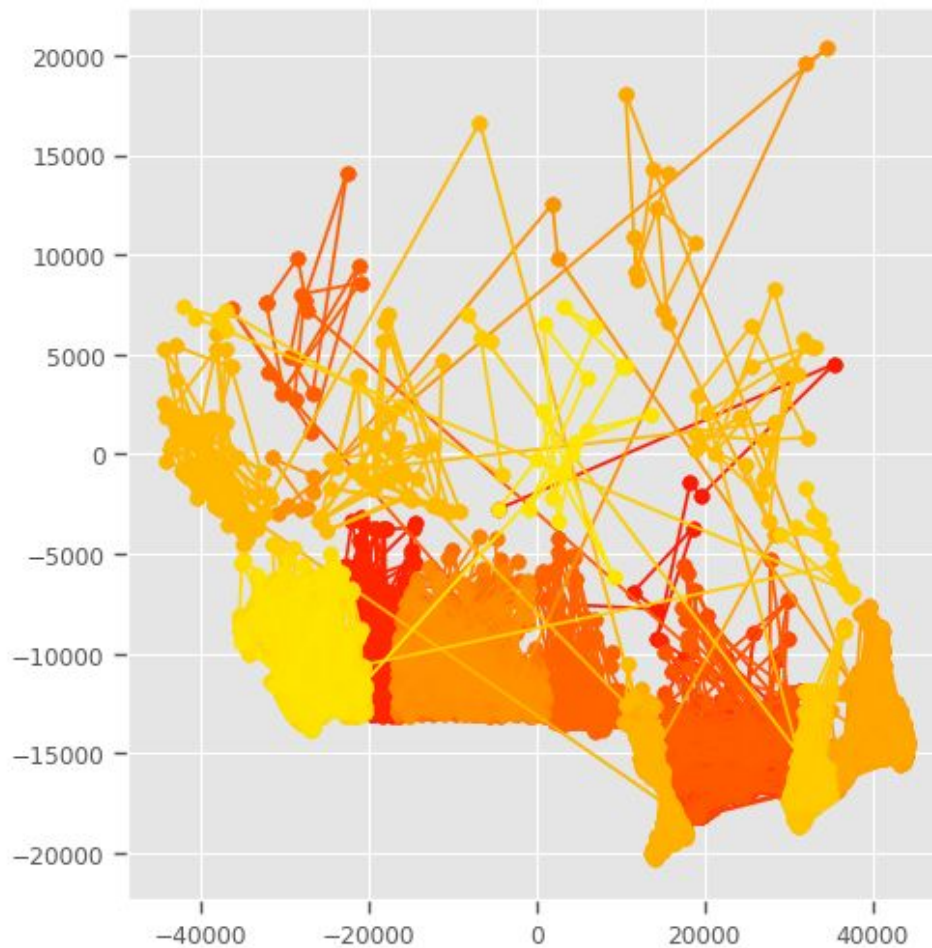
Using Cluster Method



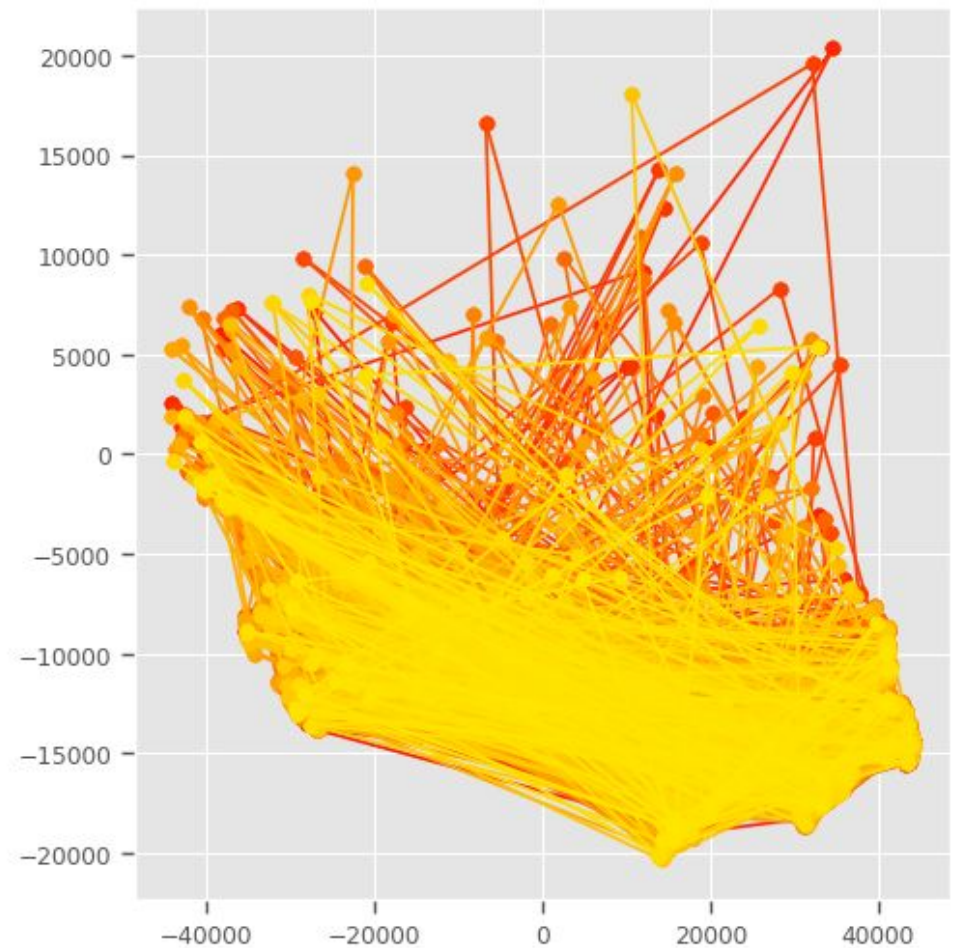
Graph 5

Canada Dataset - Cluster Initialization Vs. Random Initialization

Using Cluster Method



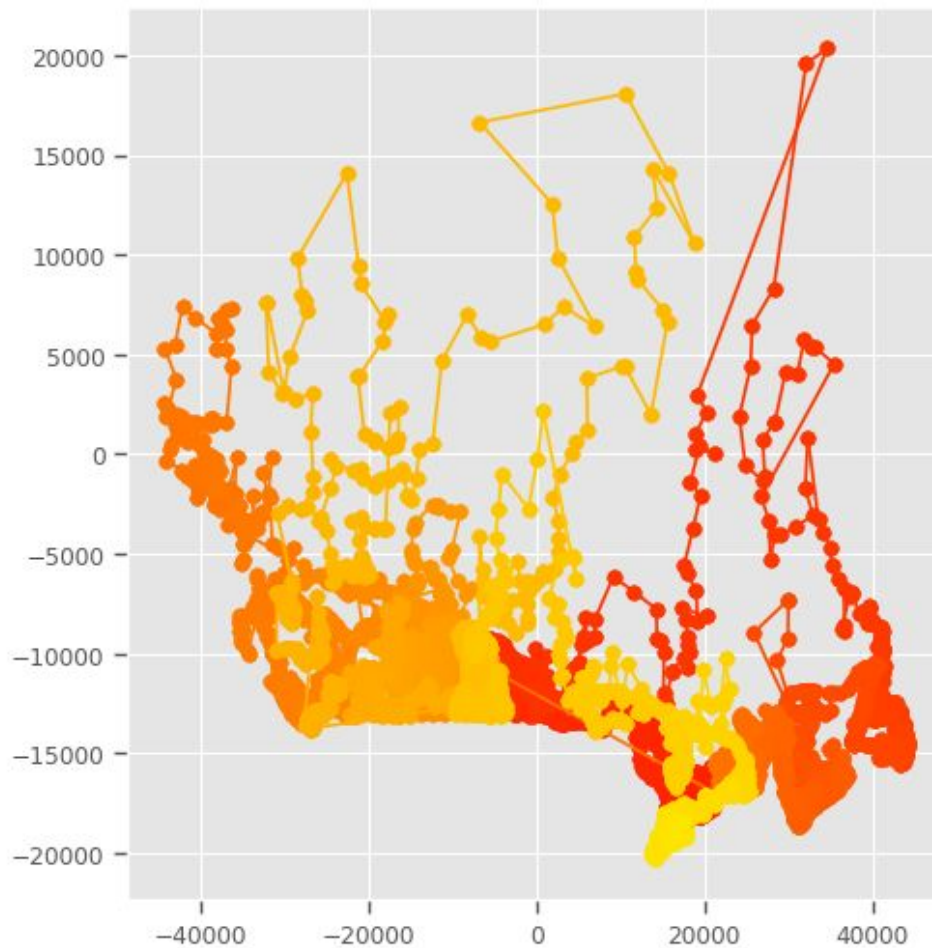
Using Random Method



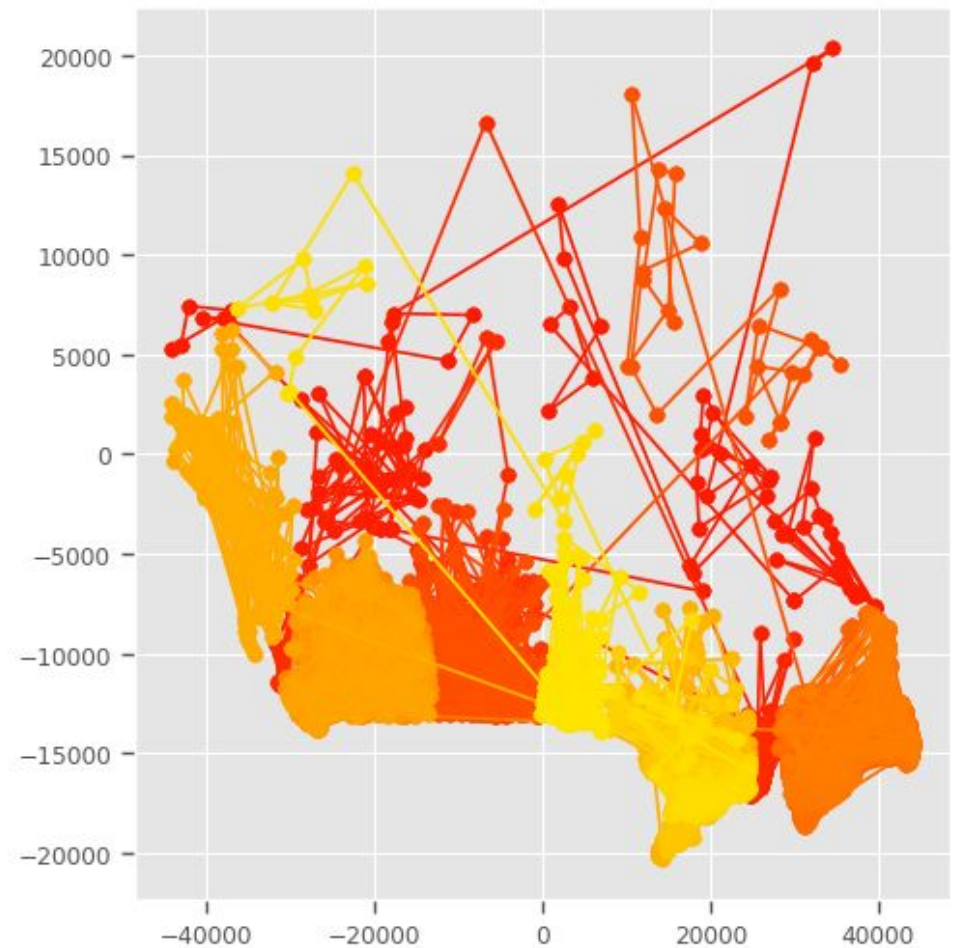
Graph 6

Canada Dataset - Christofide Initialization Vs. Cluster Initialization

Using Christofides Method



Using Cluster Method



Graphs of Run Data - Sahara

The following graphs are the aggregated statistics of several runs of the EA algorithms.

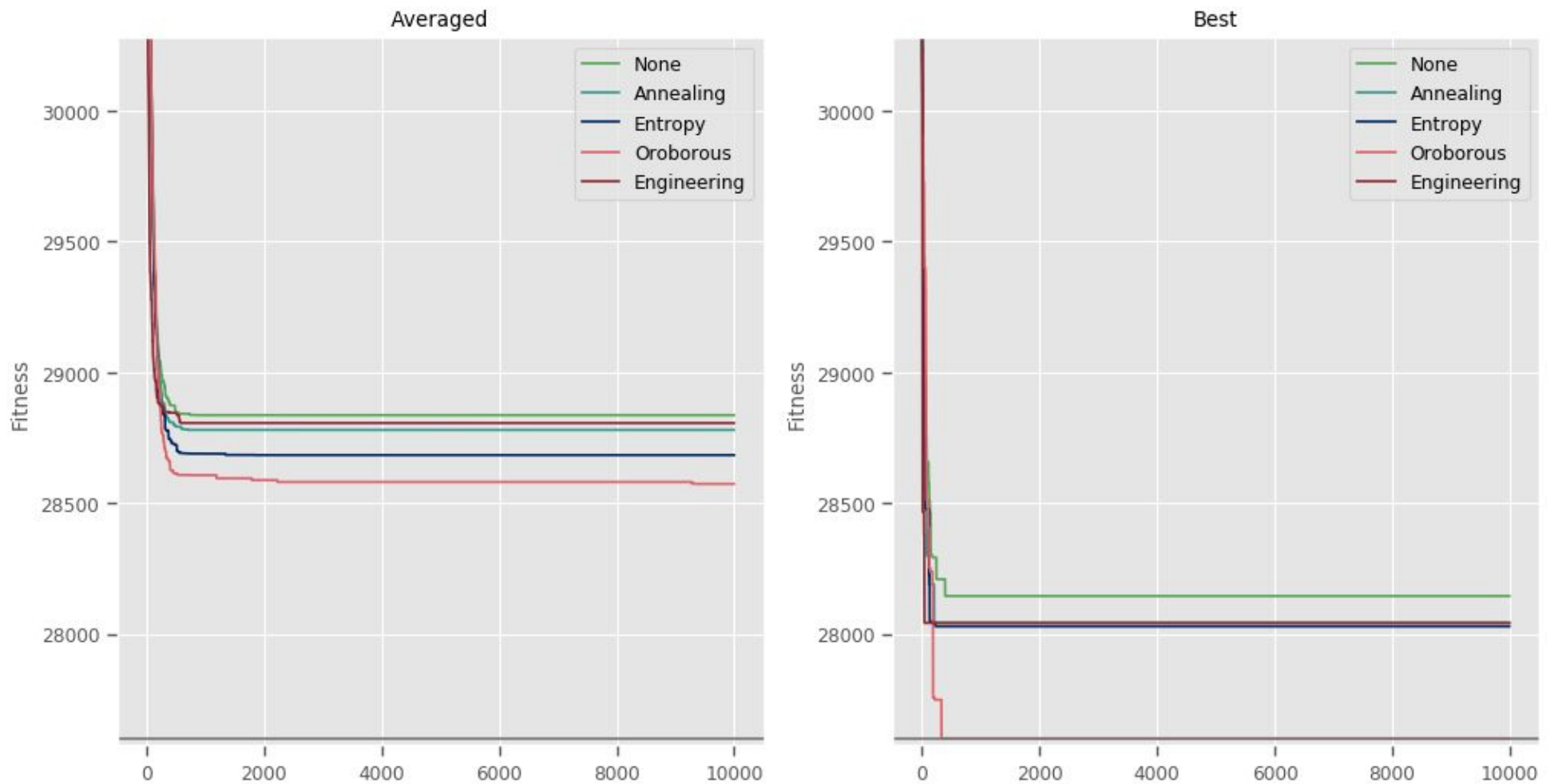
In particular, they directly compare the efficacy of different methods.

Each graph has been set to a reasonable range so that data is visible, but this causes some of the very first

Individuals to be left off the graphs, as their fitnesses are higher than the upper limit of the y-axis.

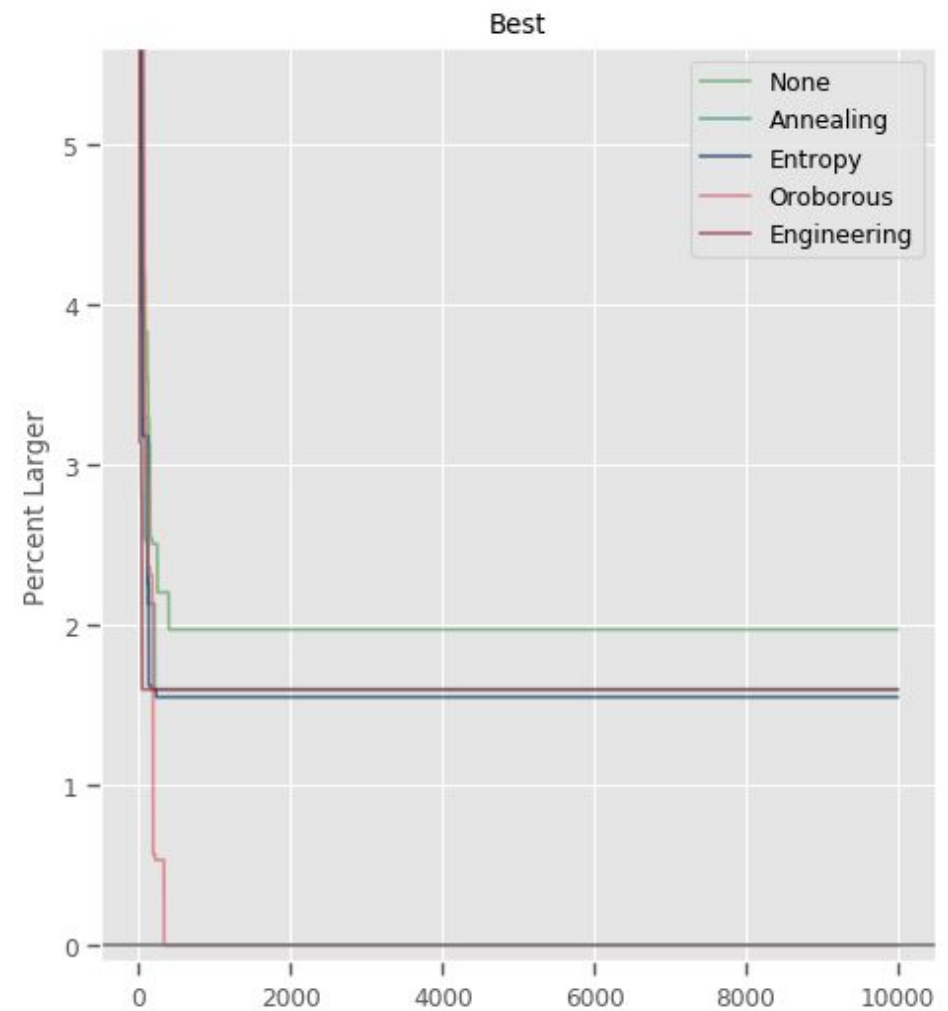
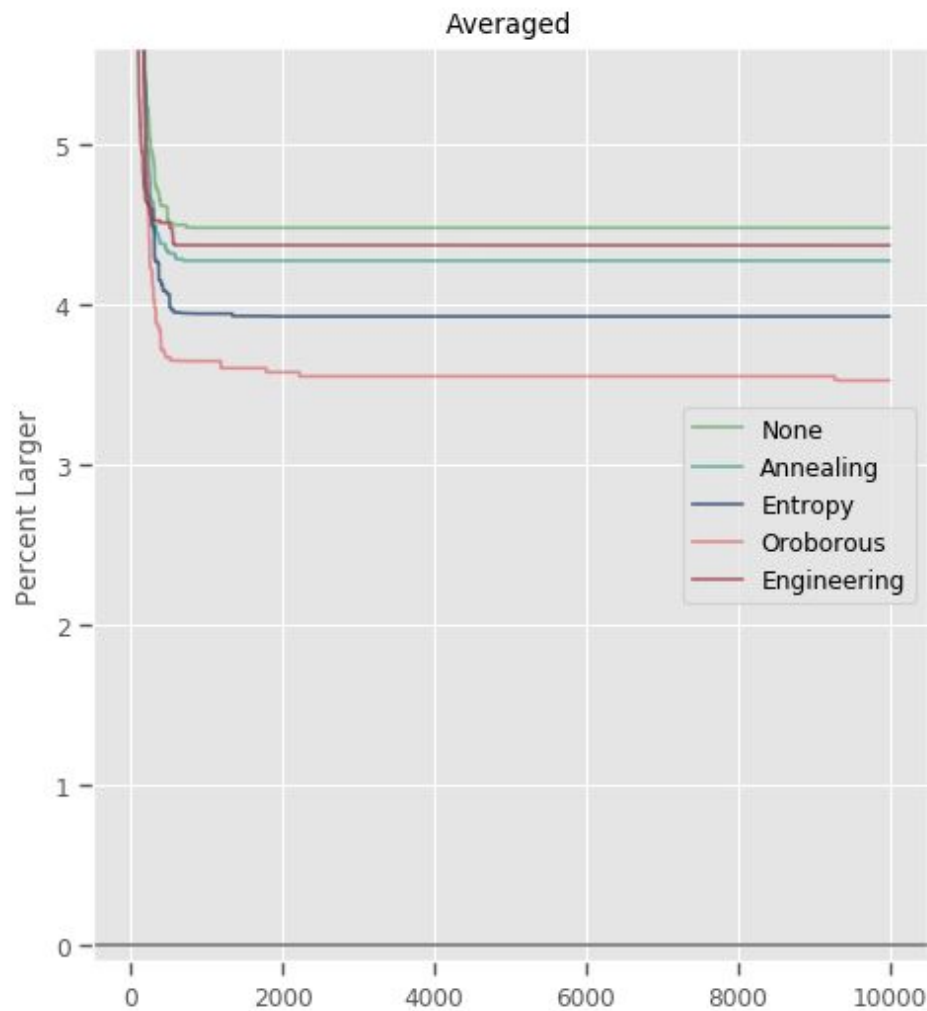
Graph 7

Population Management Comparisons - Sahara - List Implementation - Actual Fitnesses



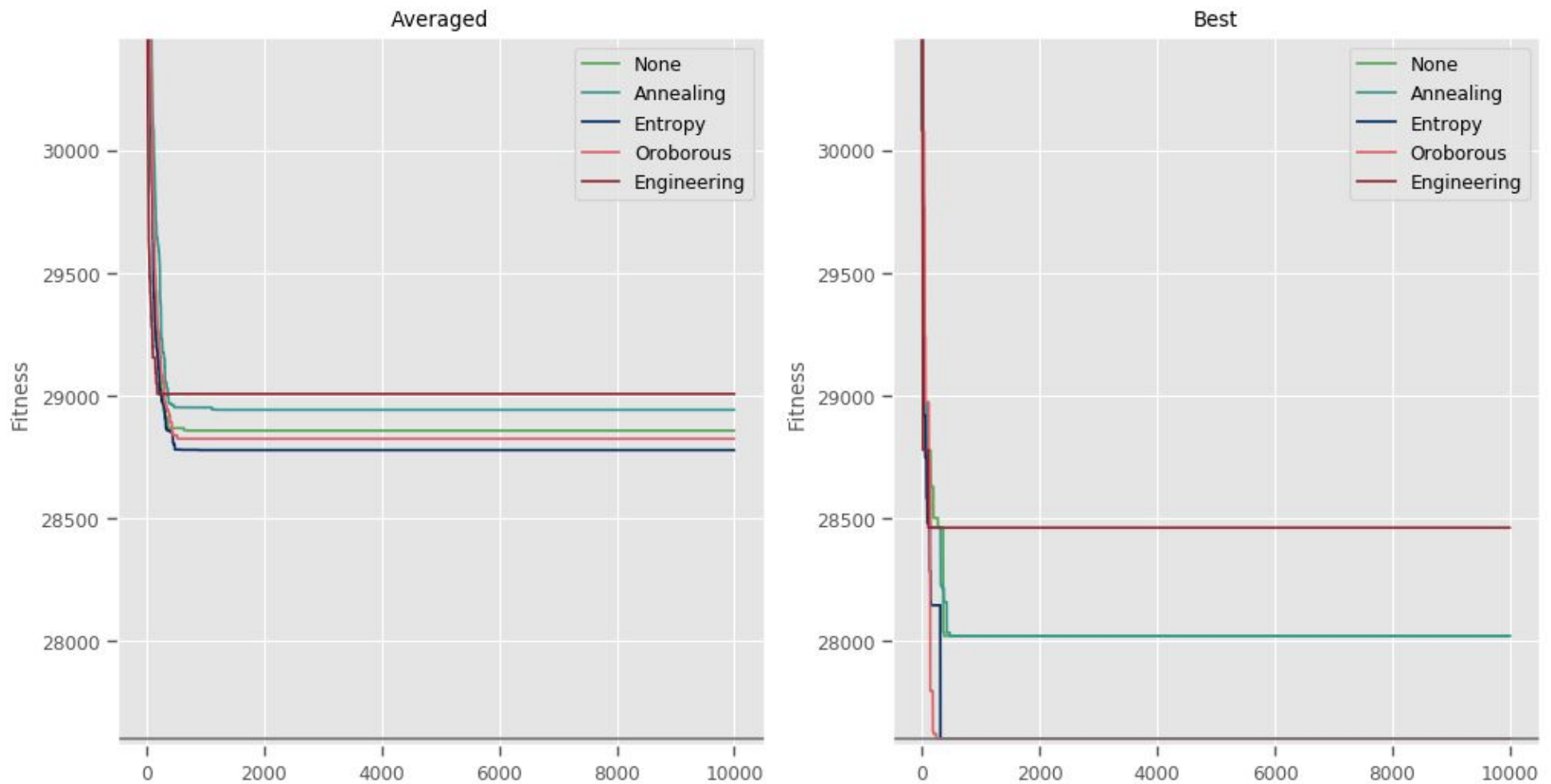
Graph 8

Population Management Comparisons - Sahara - List Implementation - Relative Fitnesses



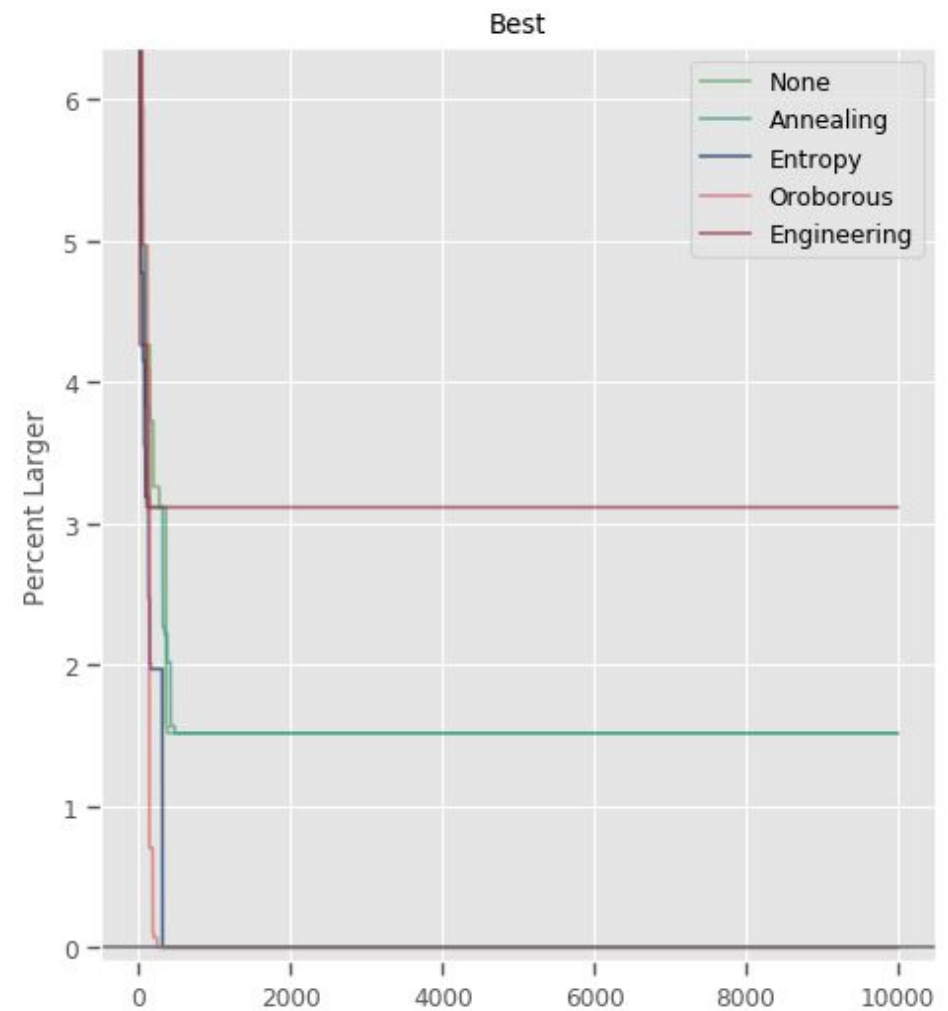
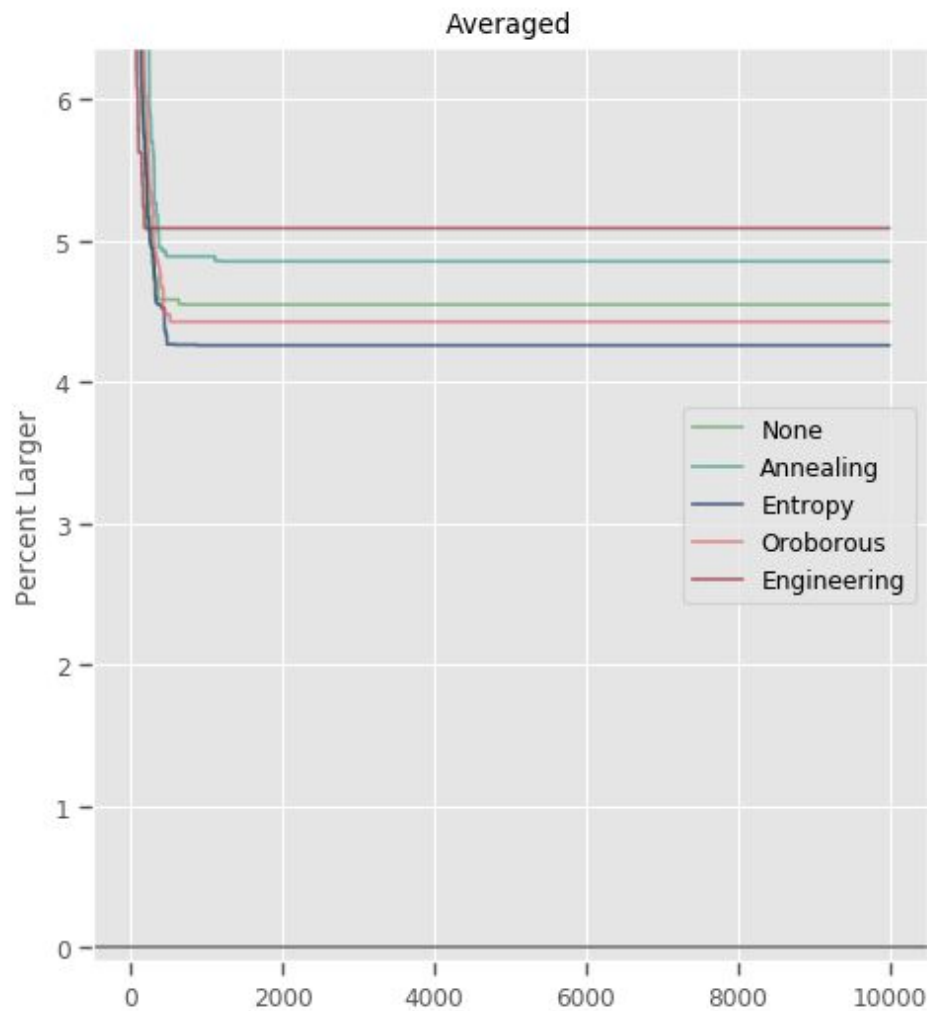
Graph 9

Population Management Comparisons - Sahara - C-Array Implementation - Actual Fitnesses



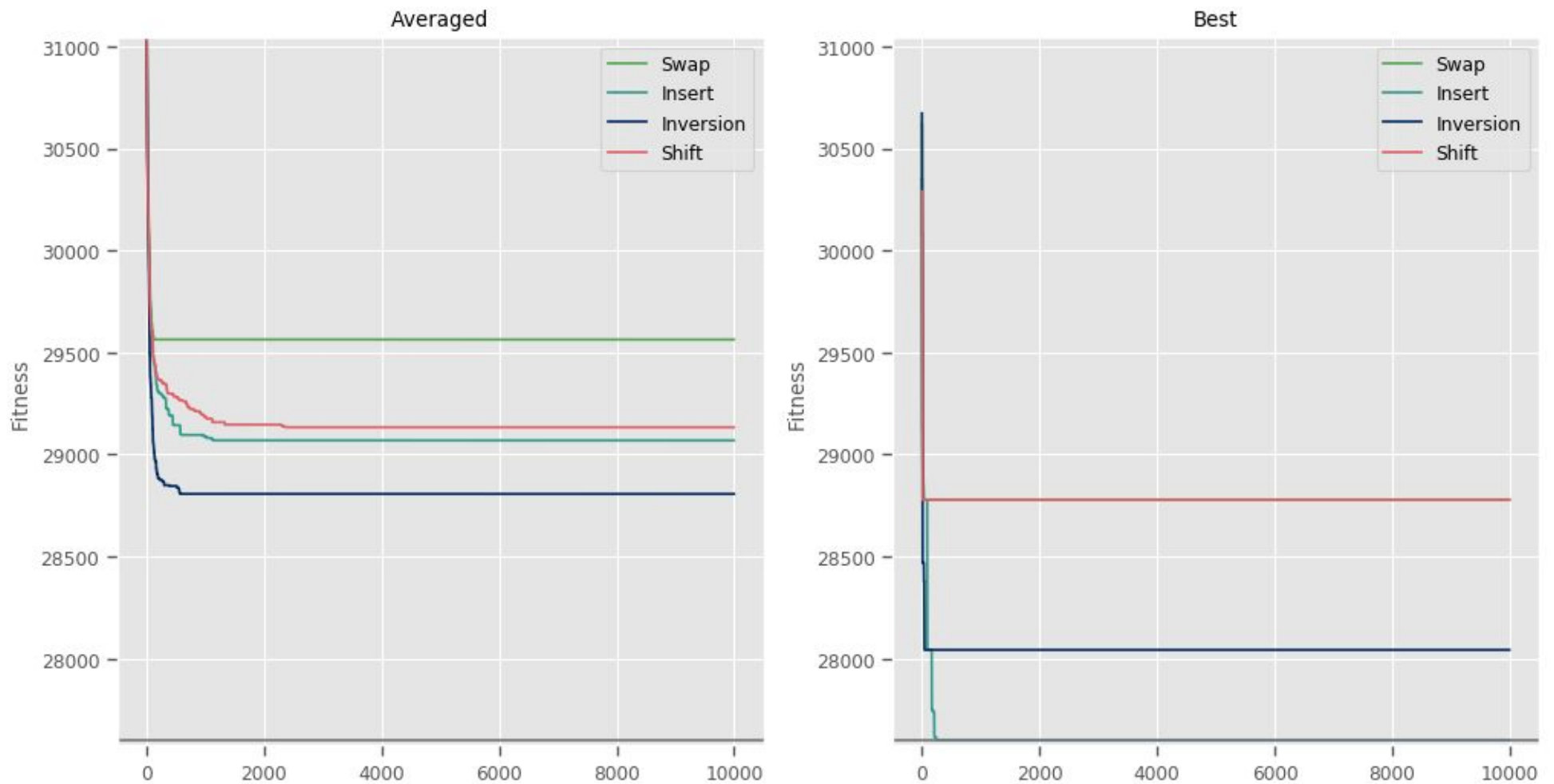
Graph 10

Population Management Comparisons - Sahara - C-Array Implementation - Relative Fitnesses



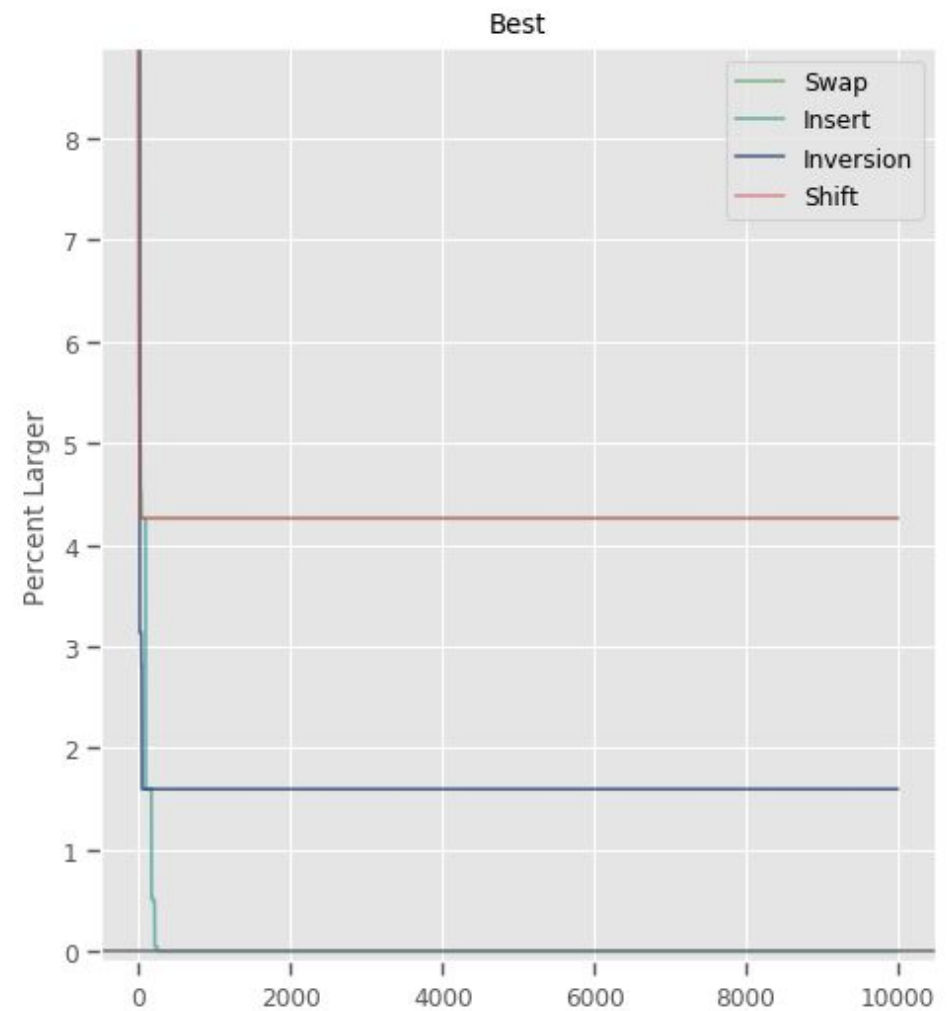
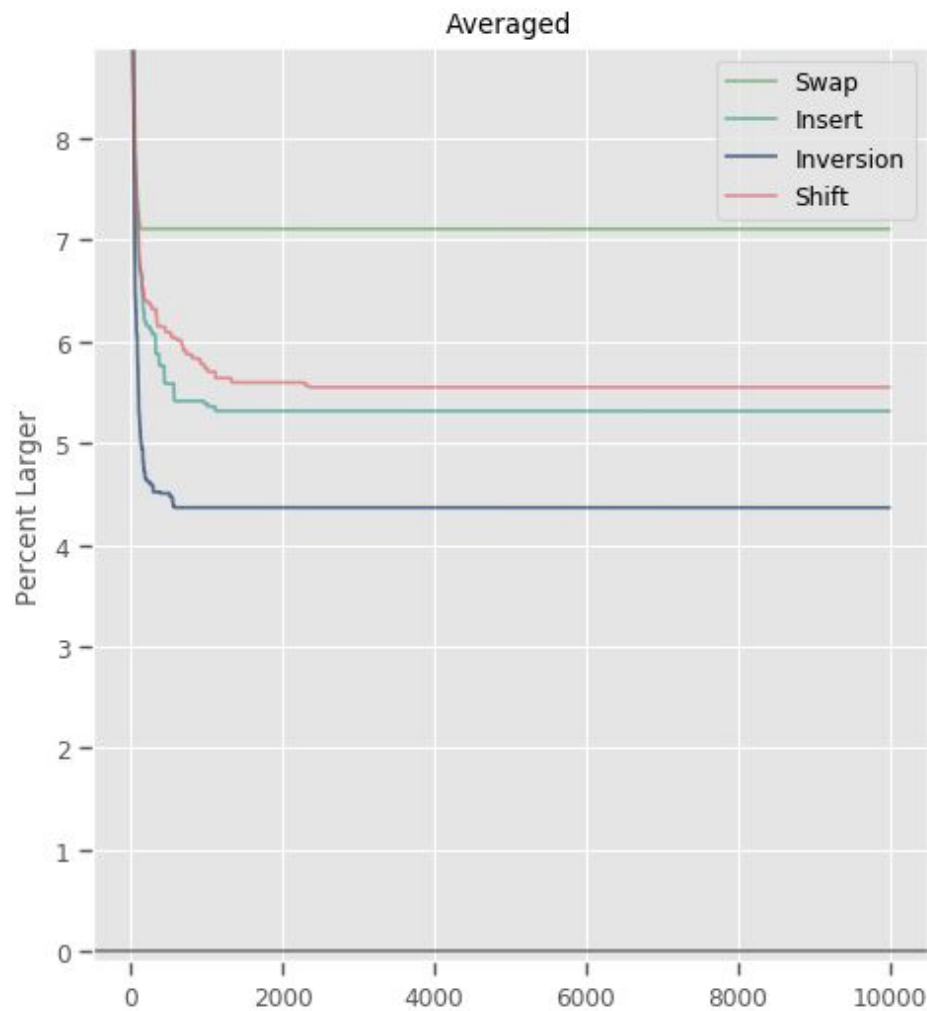
Graph 11

Mutation Comparisons - Sahara - List Implementation - Actual Fitnesses



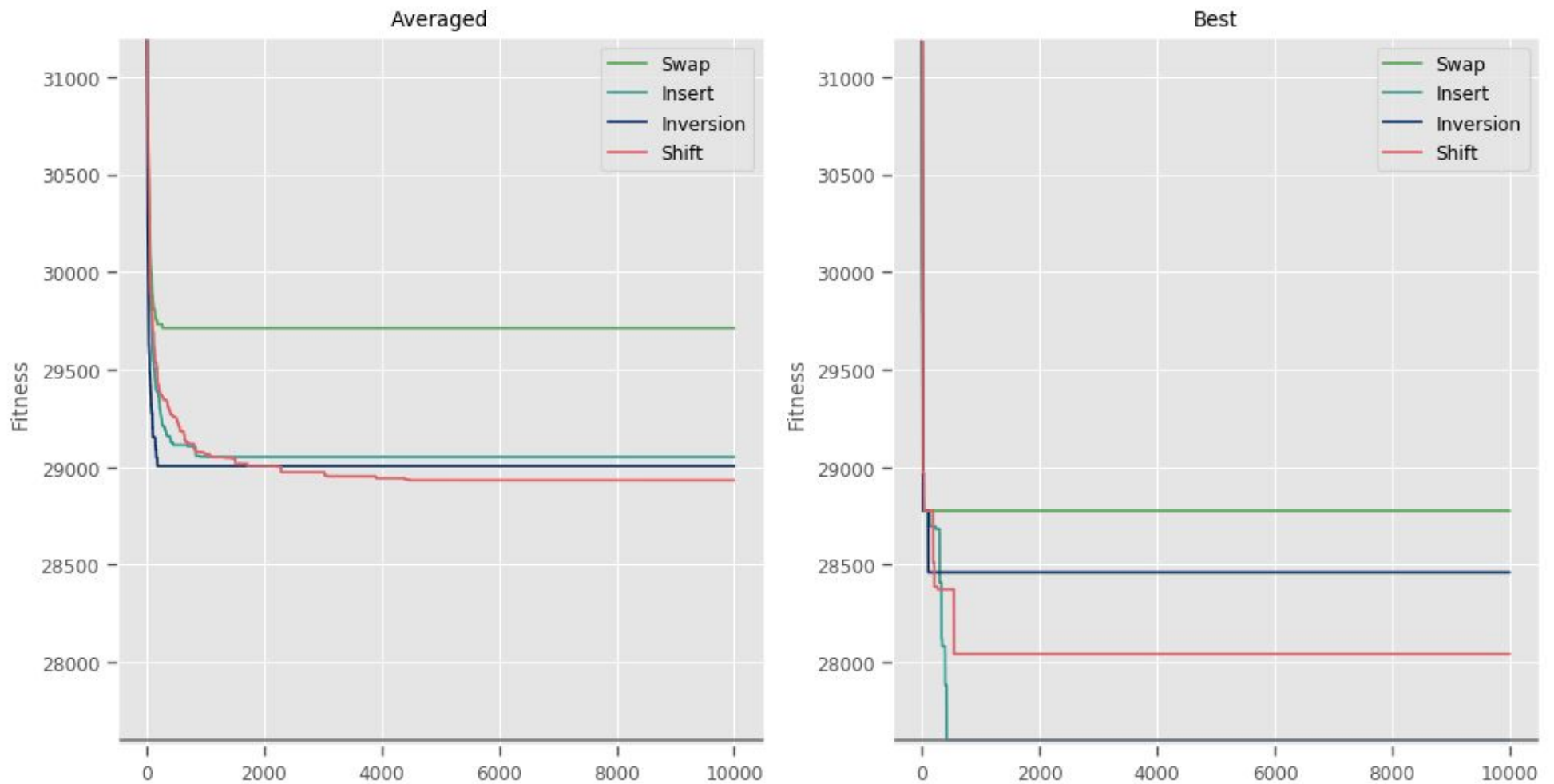
Graph 12

Mutation Comparisons - Sahara - List Implementation - Relative Fitnesses



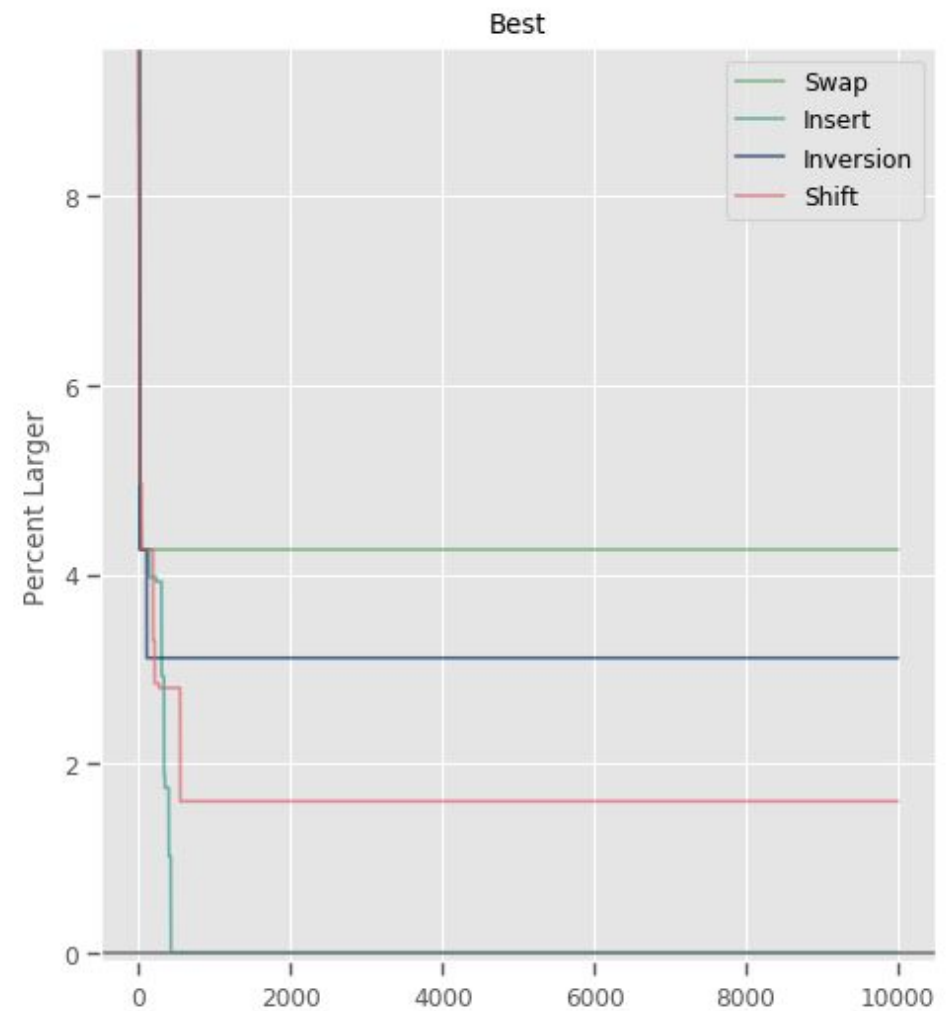
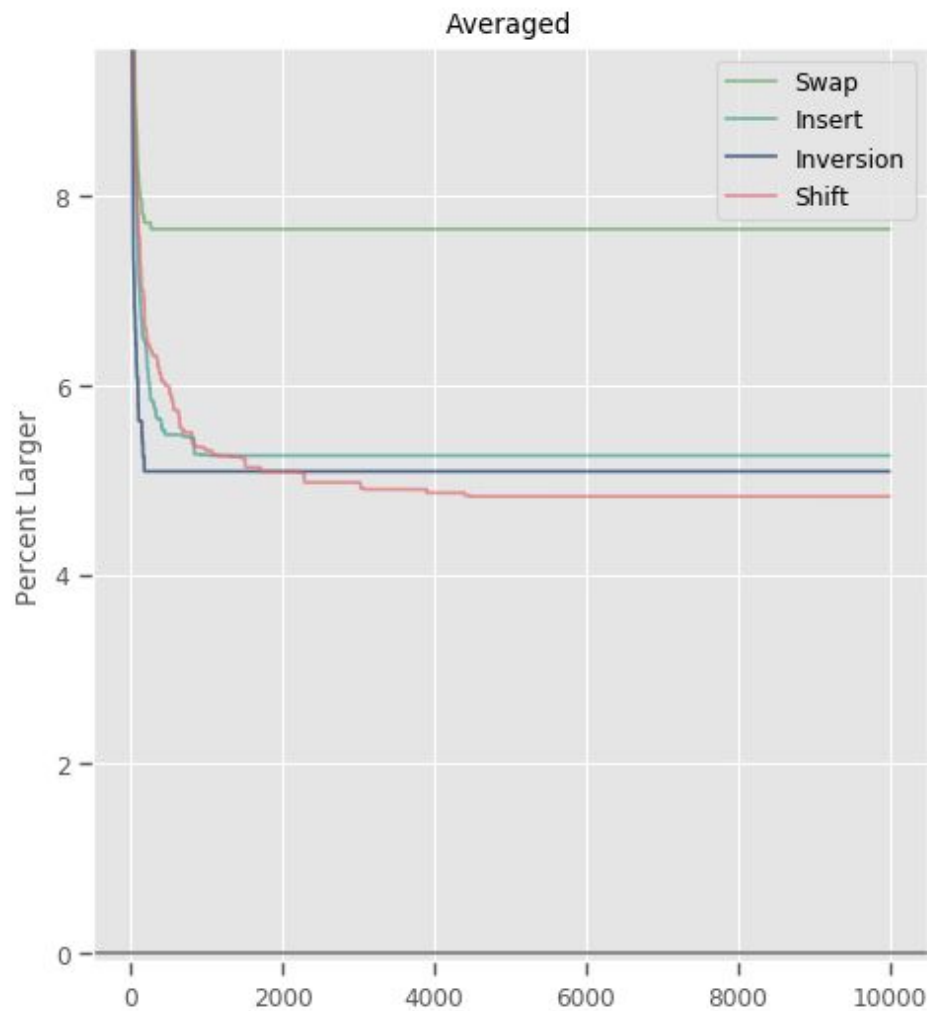
Graph 13

Mutation Comparisons - Sahara - C-Array Implementation - Actual Fitnesses



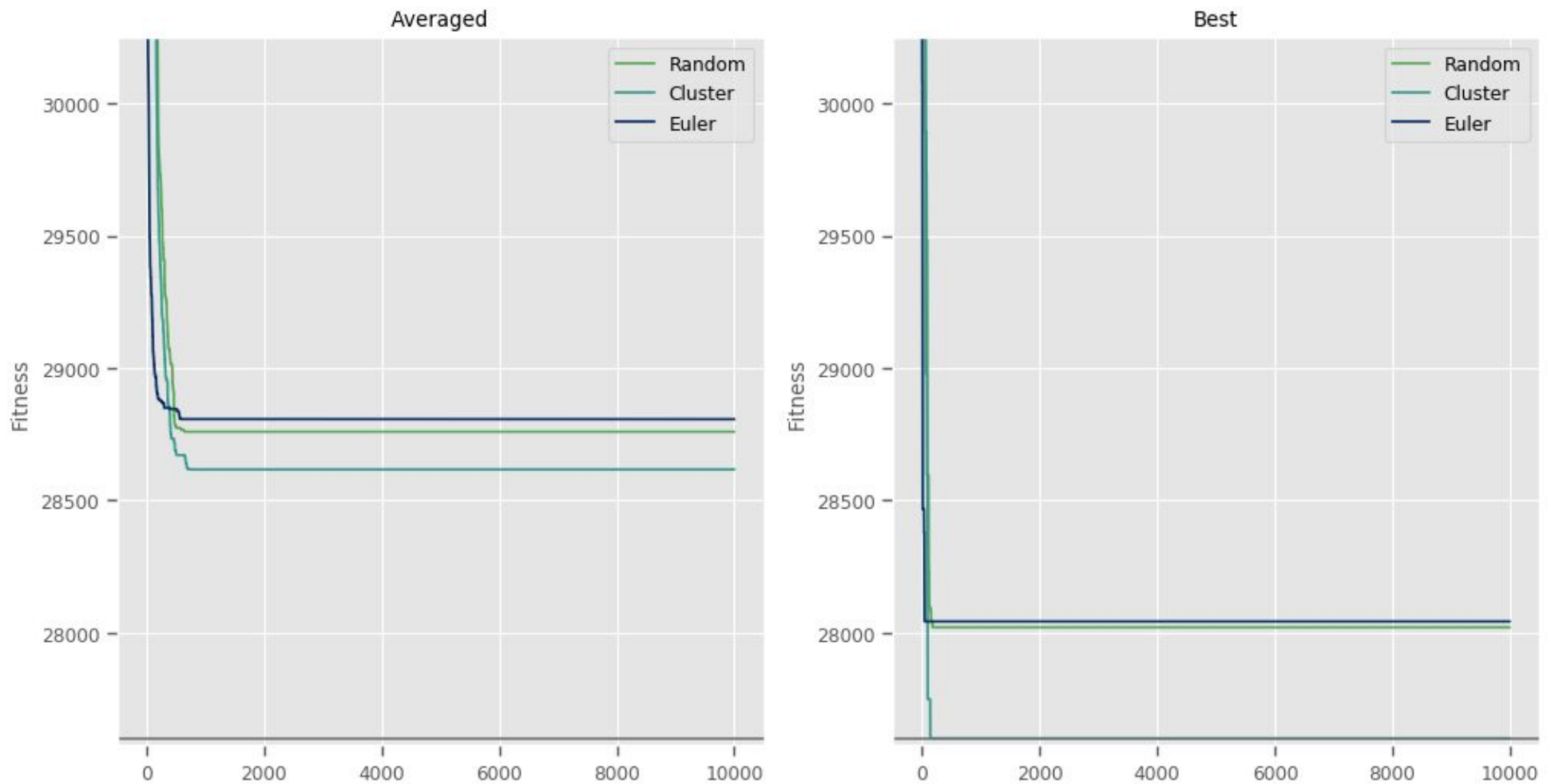
Graph 14

Mutation Comparisons - Sahara - C-Array Implementation - Relative Fitnesses



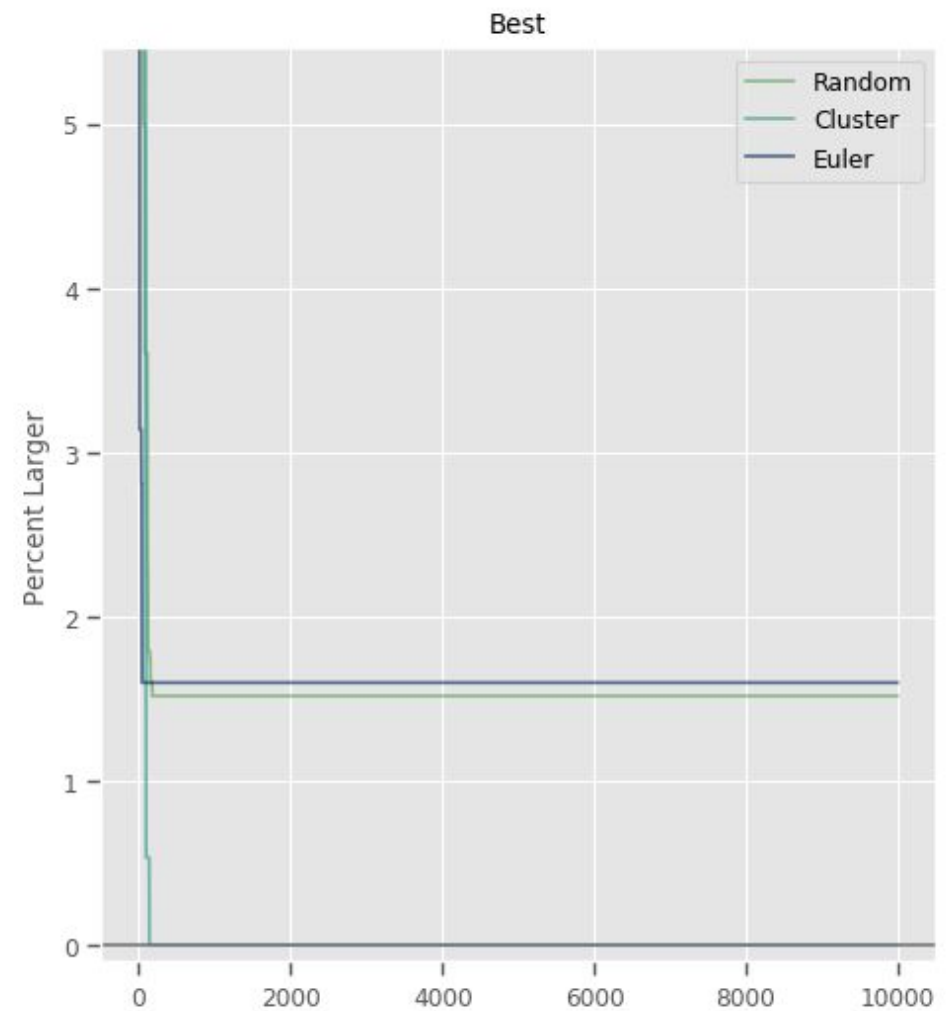
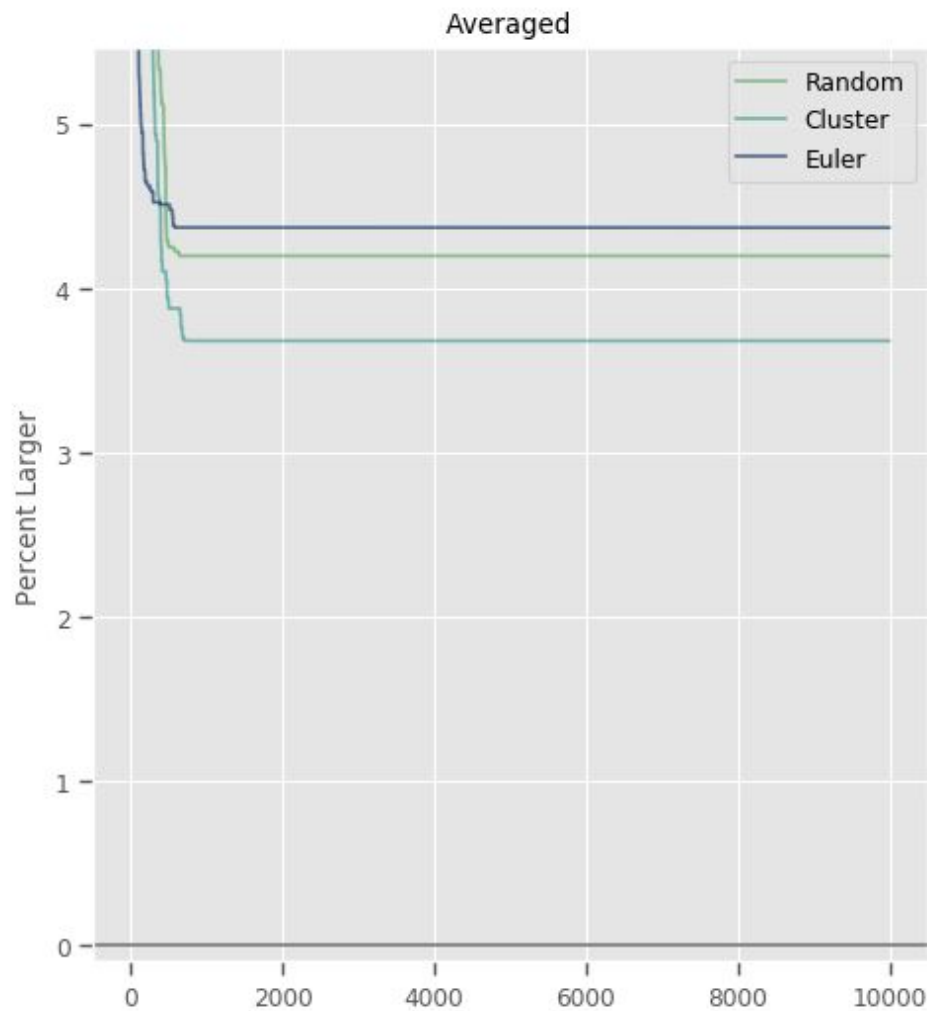
Graph 15

Heuristic Comparisons - Sahara - List Implementation - Actual Fitnesses



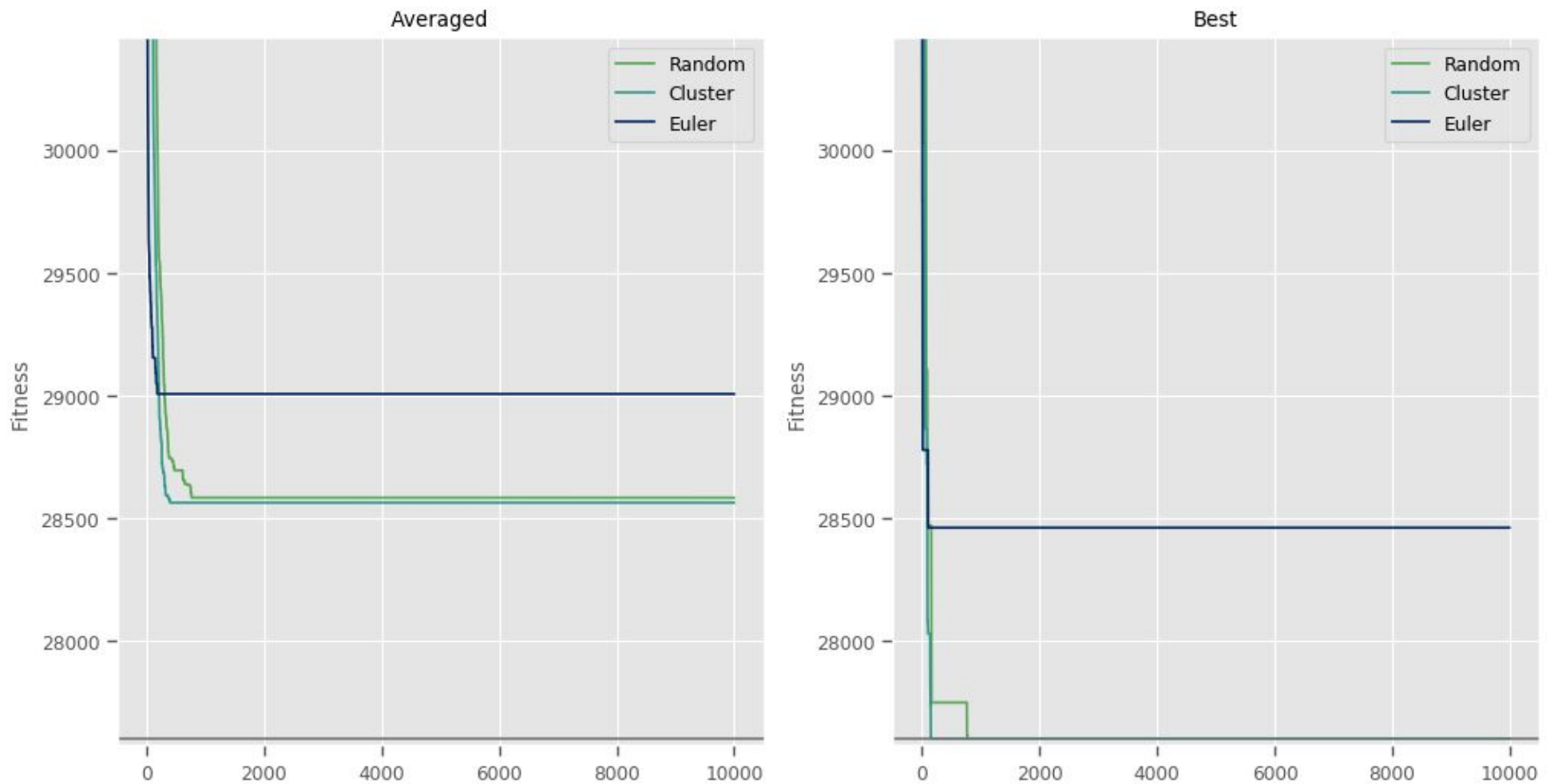
Graph 16

Heuristic Comparisons - Sahara - List Implementation - Relative Fitnesses



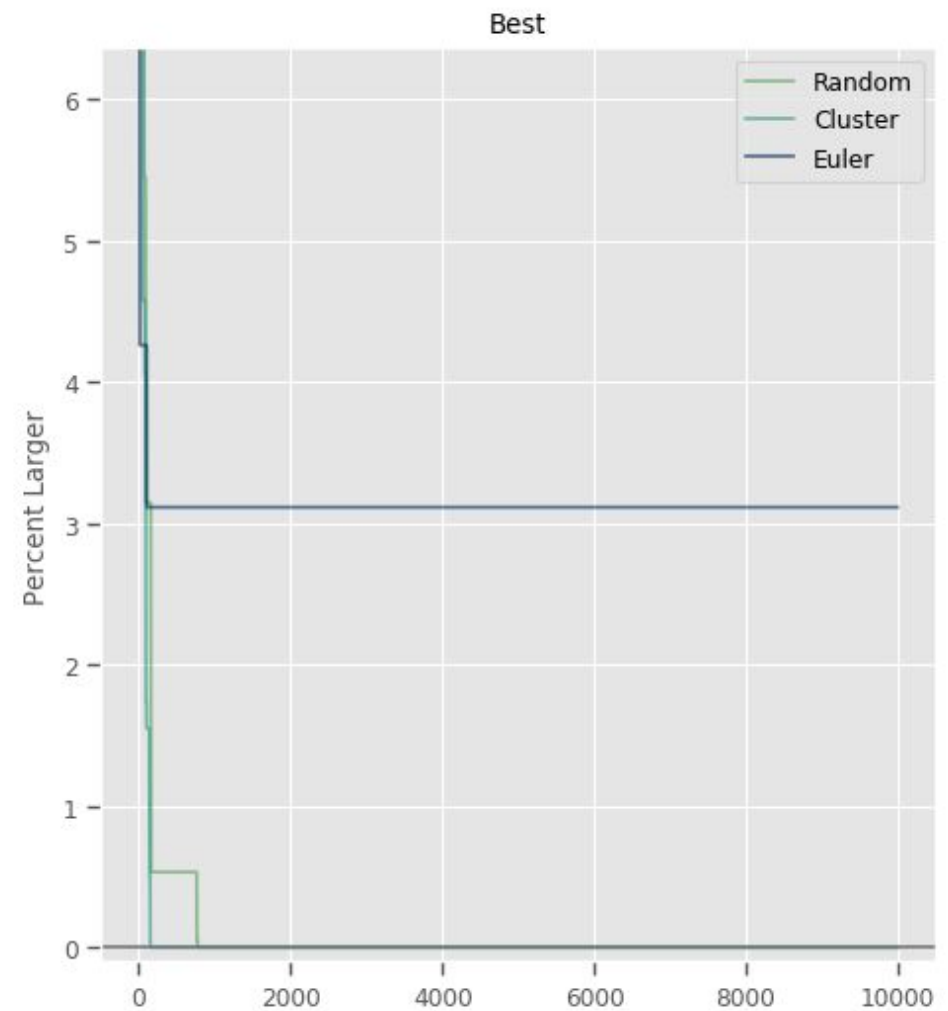
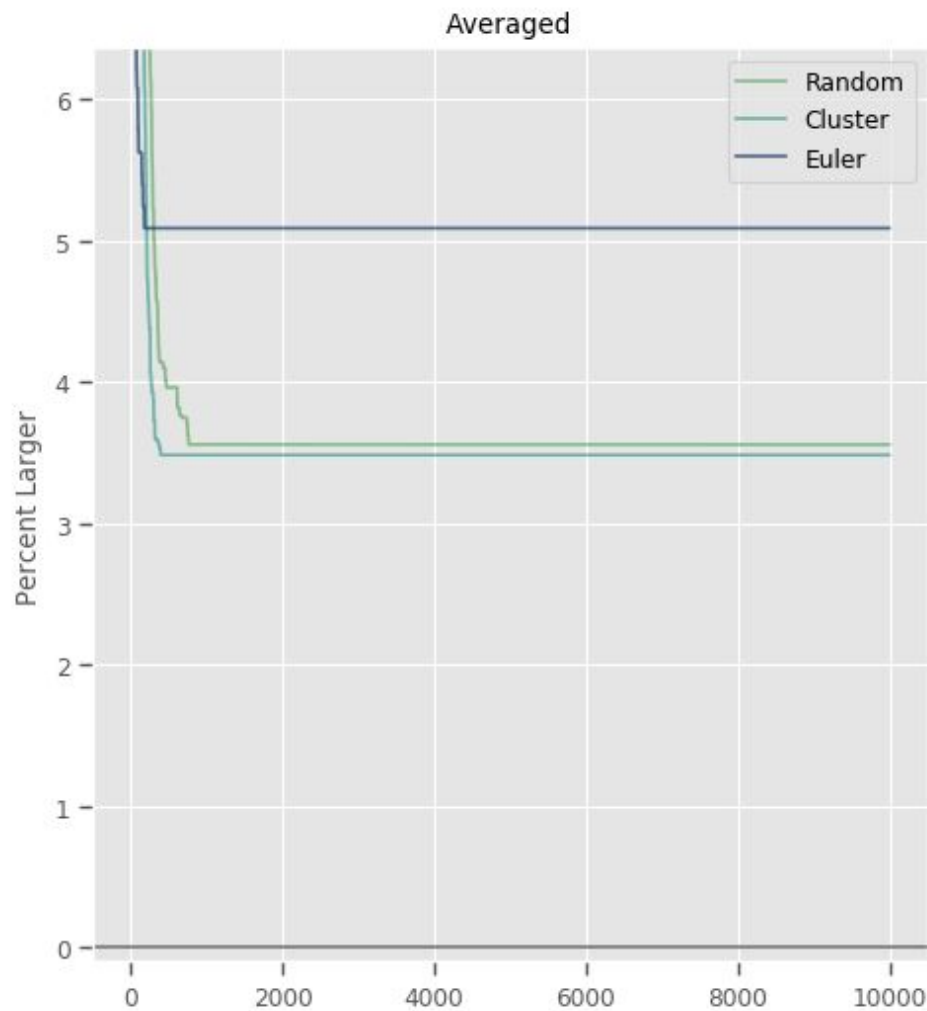
Graph 17

Heuristic Comparisons - Sahara - C-Array Implementation - Actual Fitnesses



Graph 18

Heuristic Comparisons - Sahara - C-Array Implementation - Relative Fitnesses



Graphs of Run Data - Uruguay

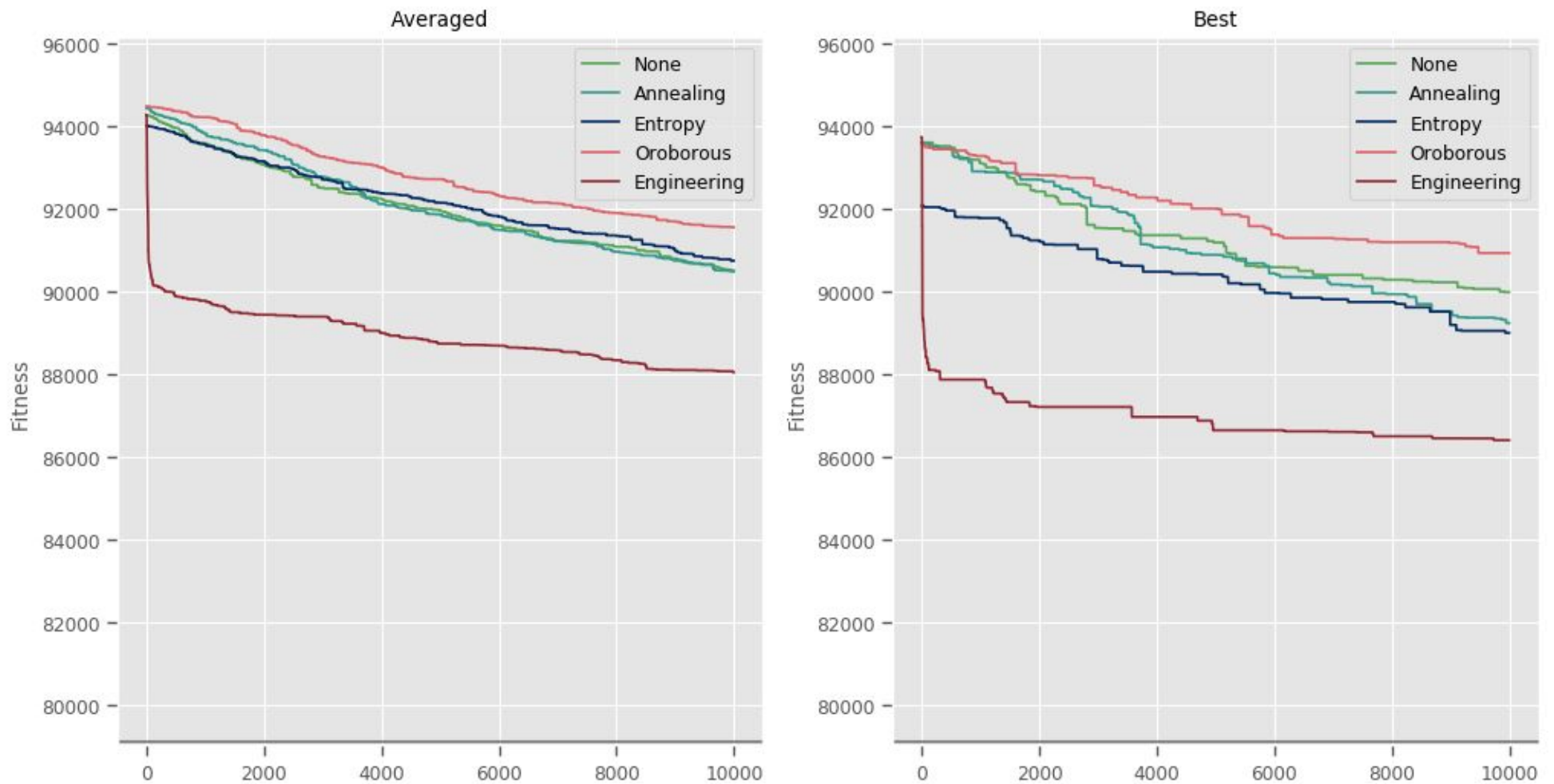
The following graphs are the aggregated statistics of several runs of the EA algorithms.

In particular, they directly compare the efficacy of different methods.

Each graph has been set to a reasonable range so that data is visible, but this causes some of the very first Individuals to be left off the graphs, as their fitnesses are higher than the upper limit of the y-axis.

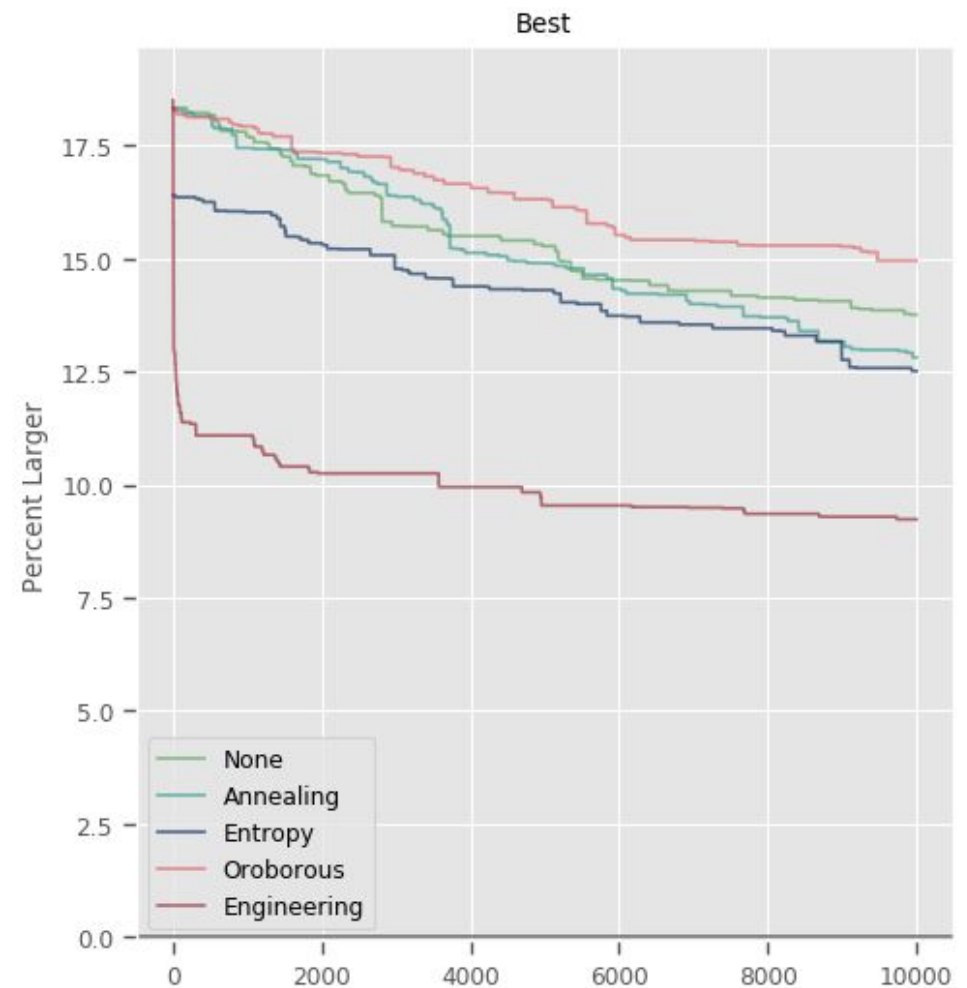
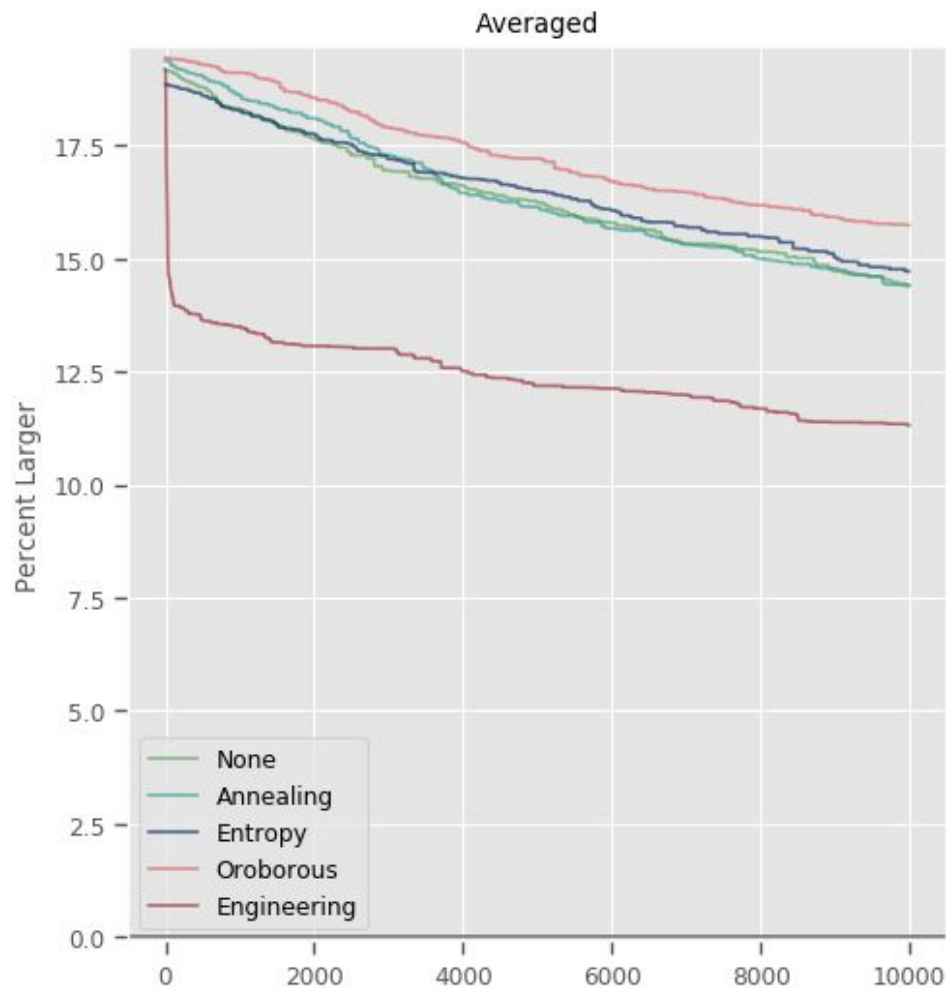
Graph 19

Population Management Comparisons - Uruguay - List Implementation - Actual Fitnesses



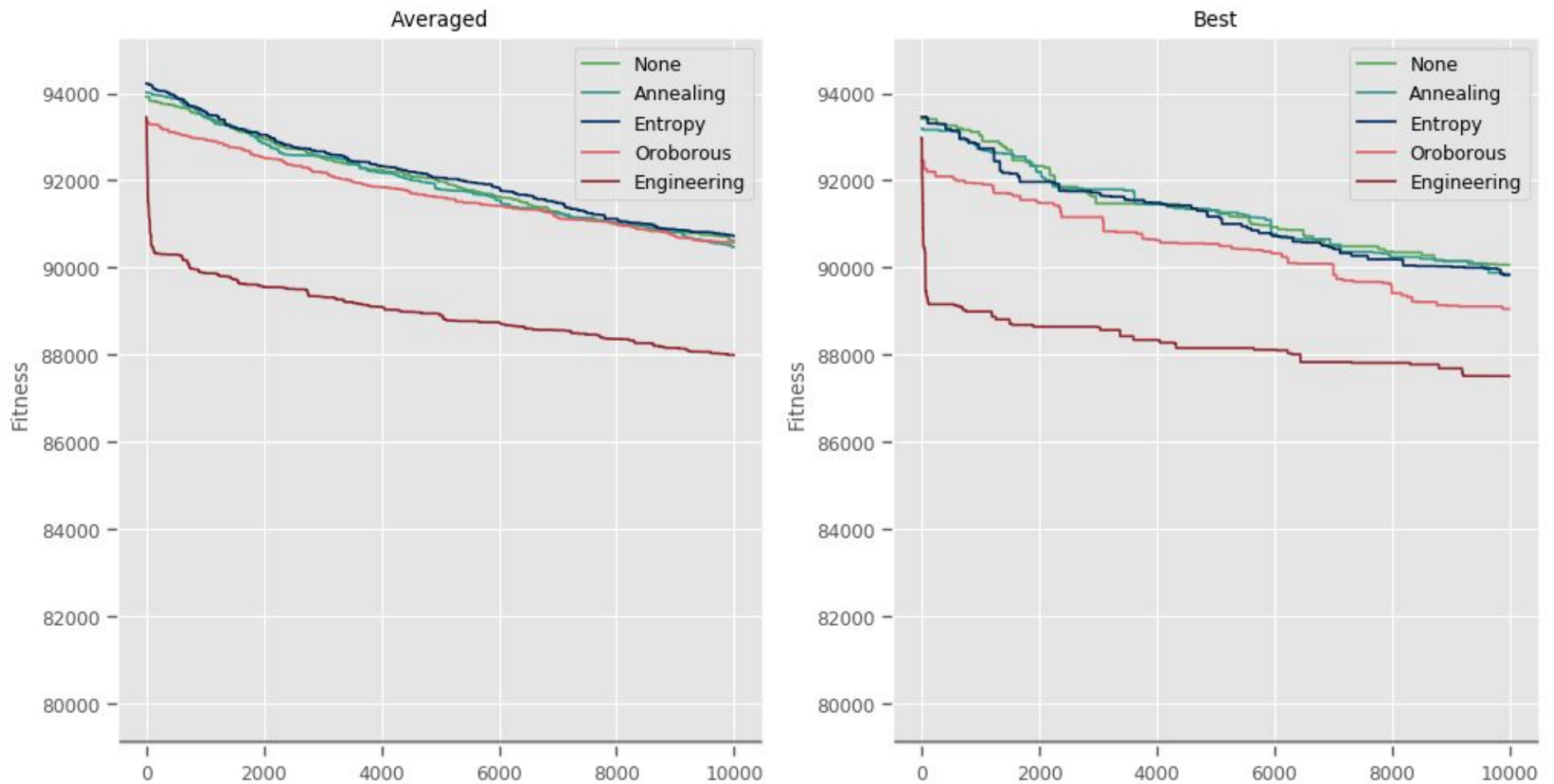
Graph 20

Population Management Comparisons - Uruguay - List Implementation - Relative Fitnesses



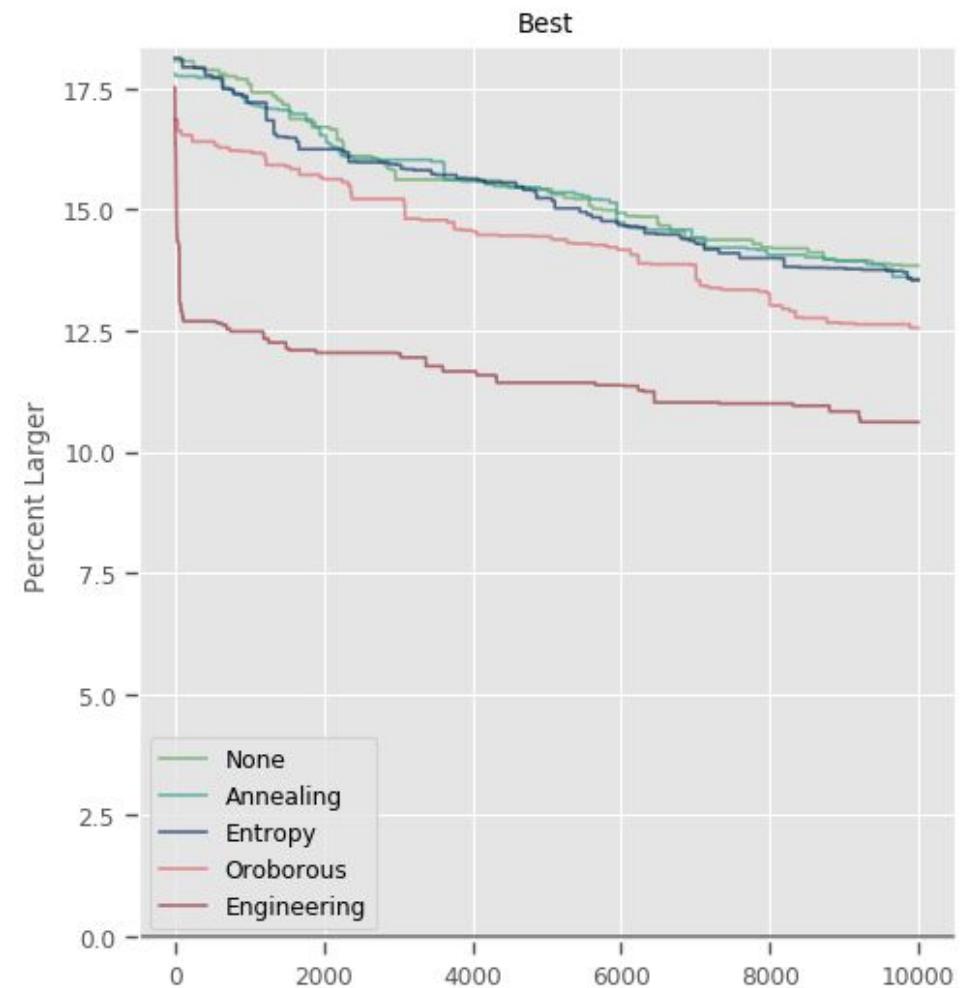
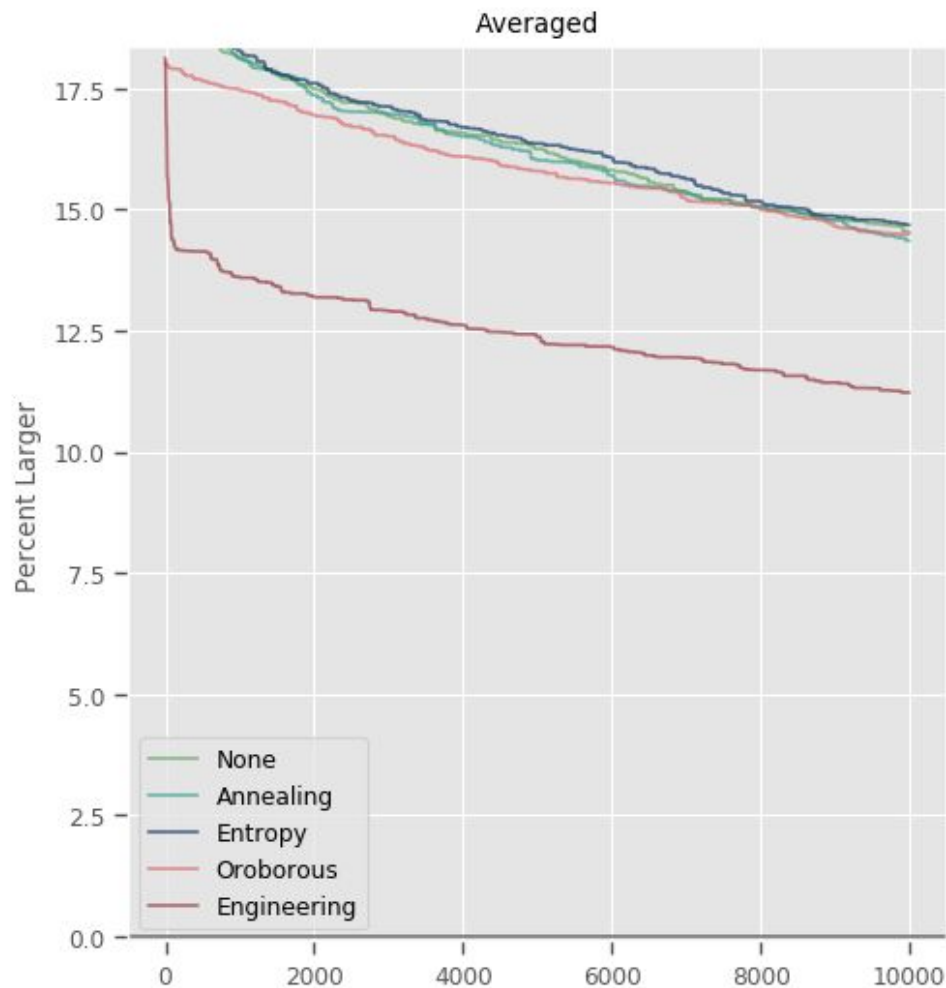
Graph 21

Population Management Comparisons - Uruguay - C-Array Implementation - Actual Fitnesses



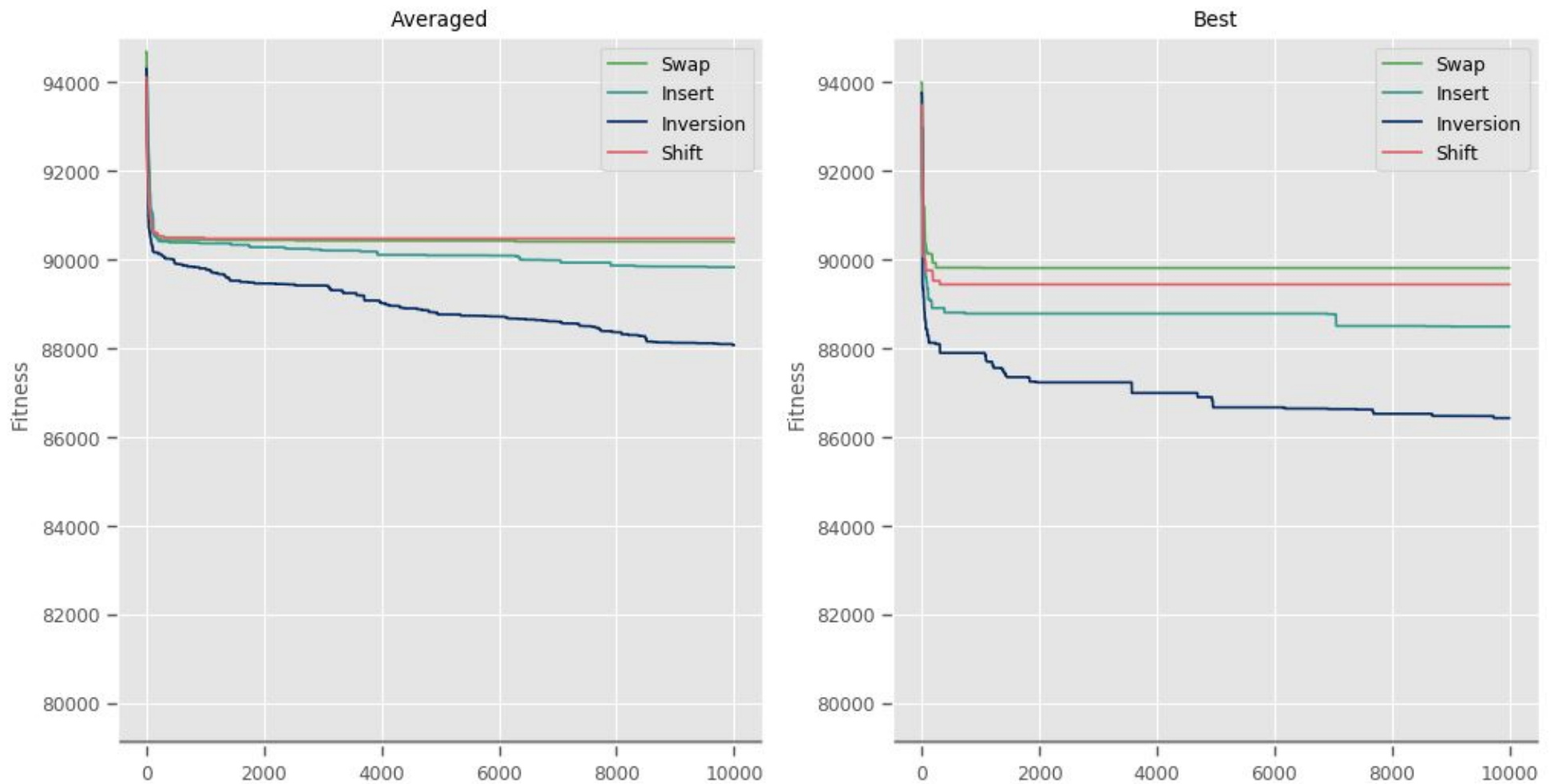
Graph 22

Population Management Comparisons - Uruguay - C-Array Implementation - Relative Fitnesses



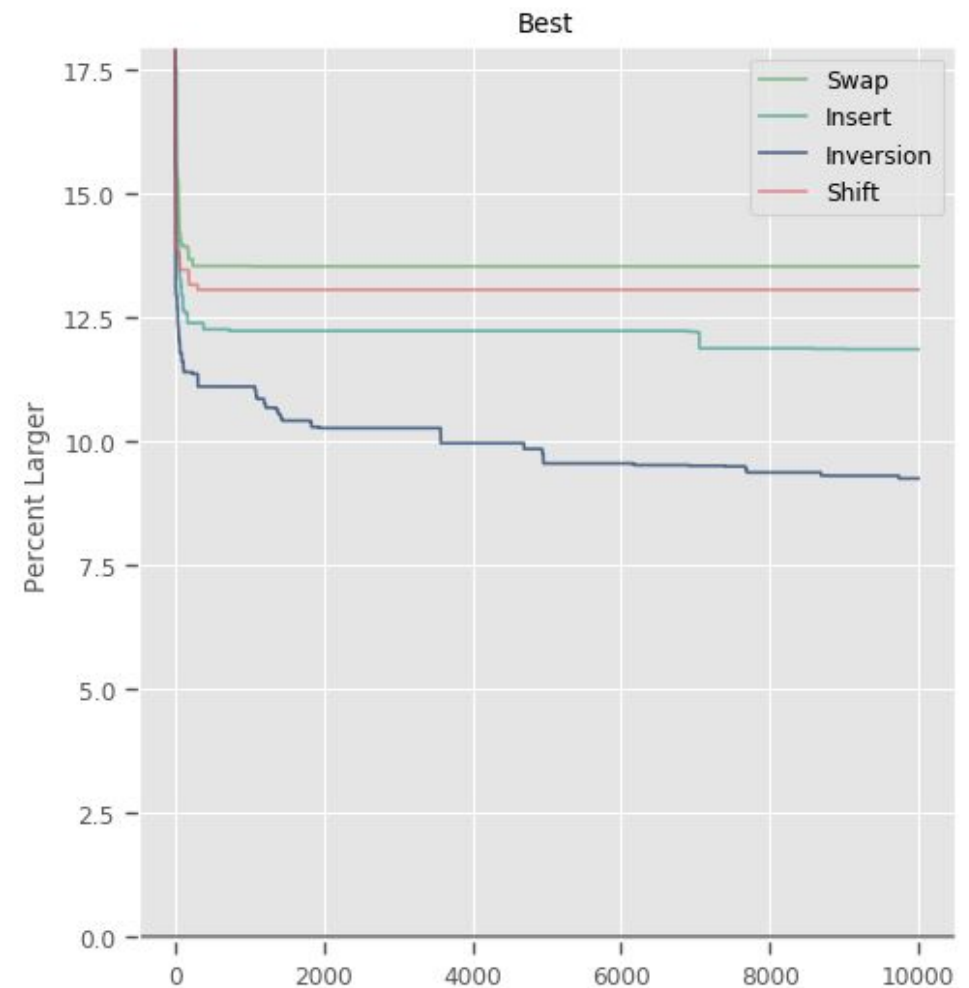
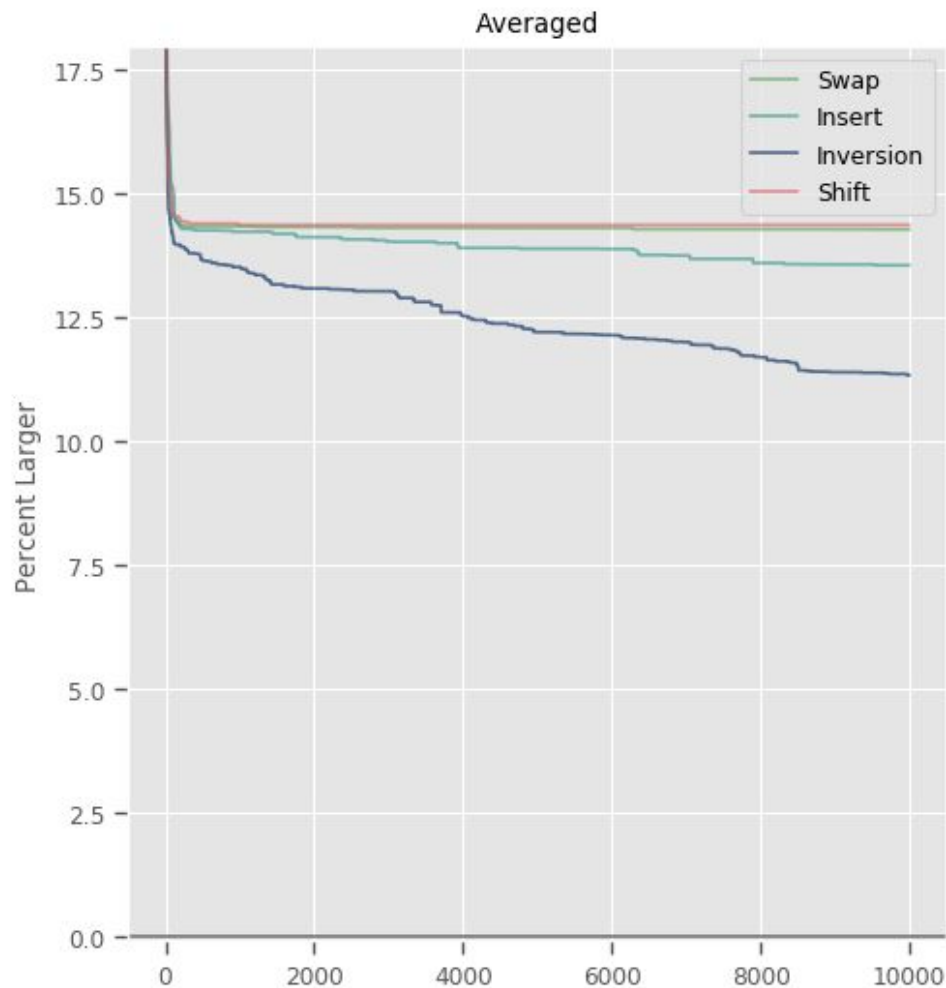
Graph 23

Mutation Comparisons - Uruguay - List Implementation - Actual Fitnesses



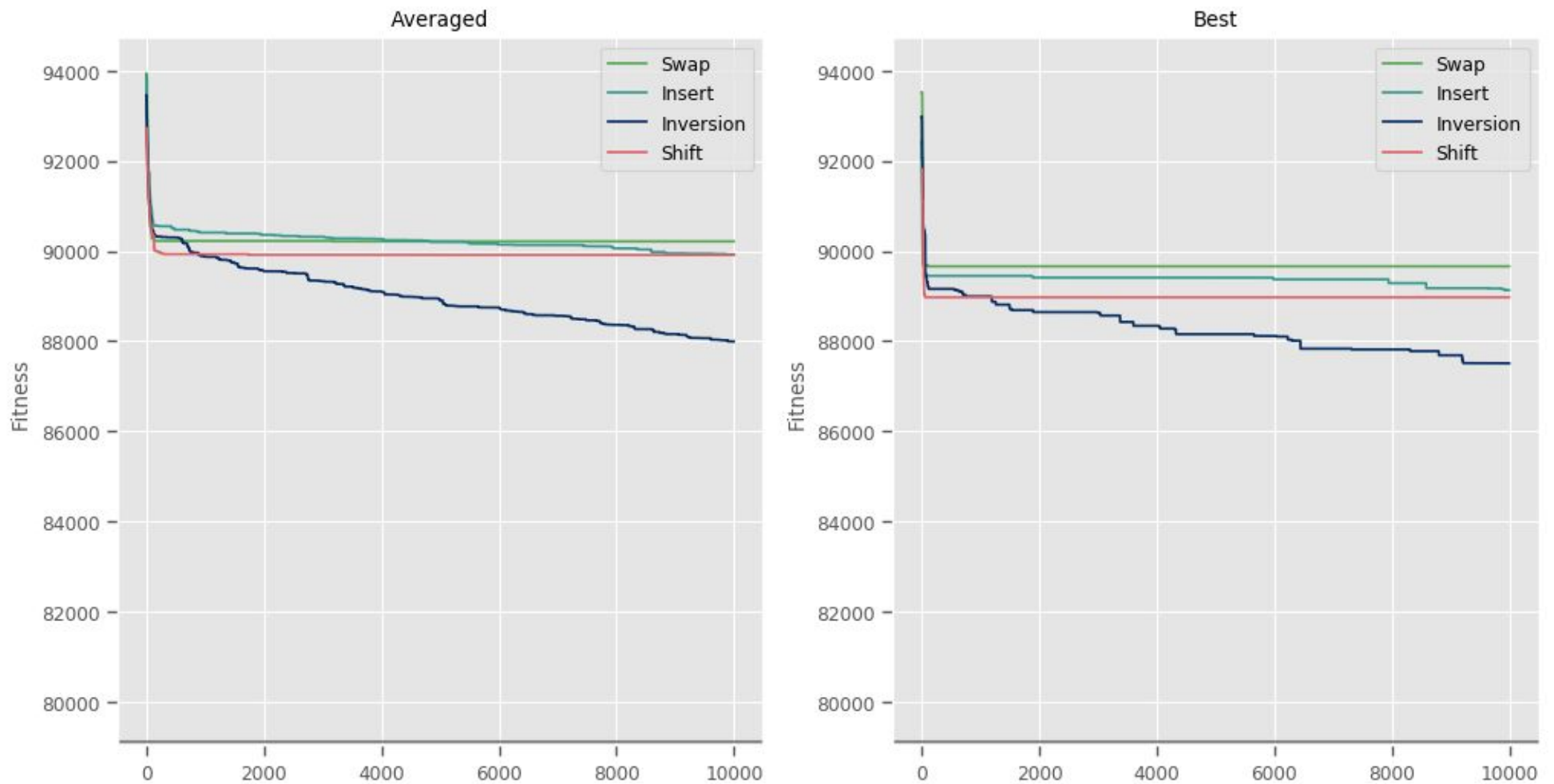
Graph 24

Mutation Comparisons - Uruguay - List Implementation - Relative Fitnesses



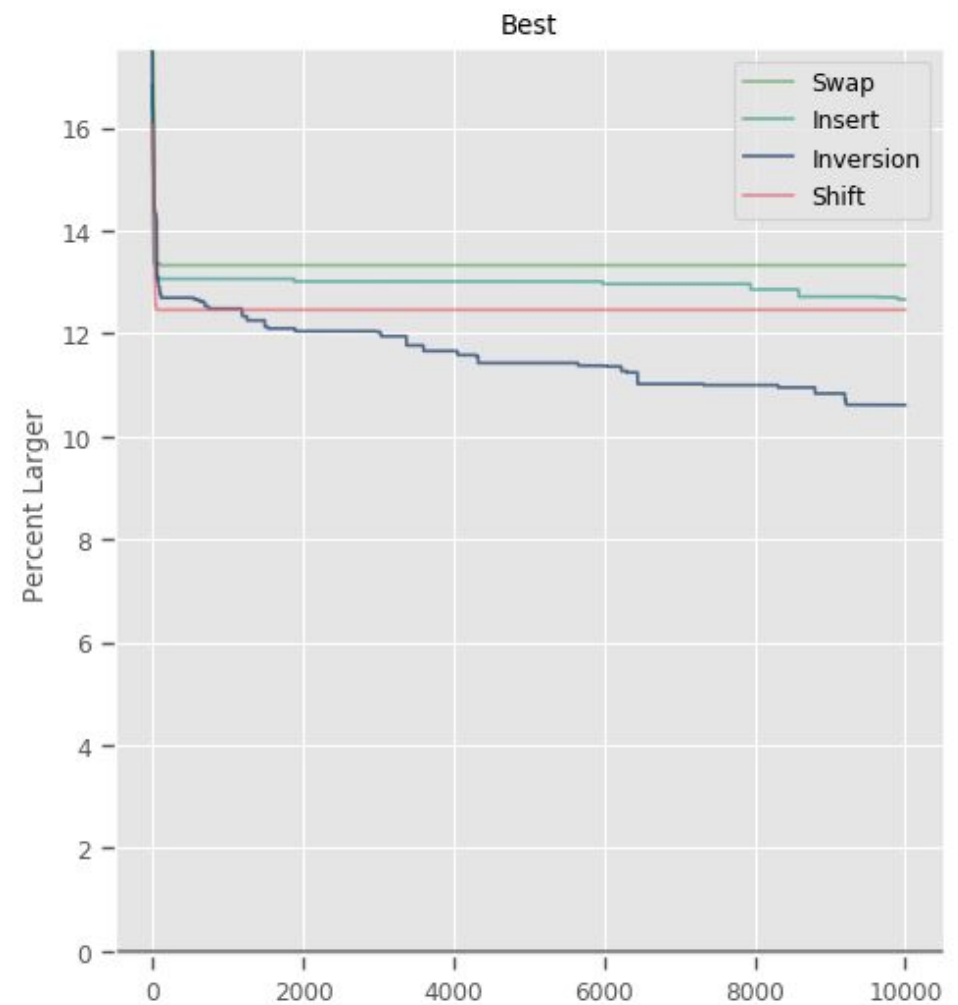
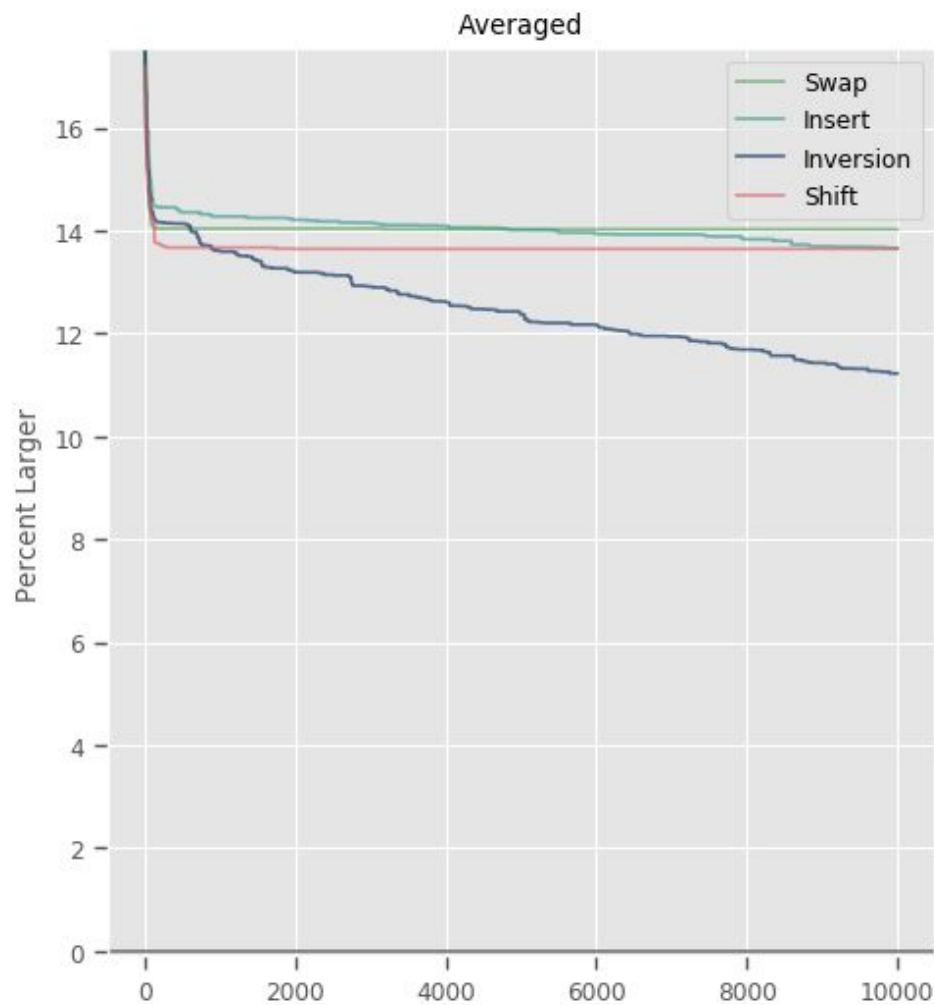
Graph 25

Mutation Comparisons - Uruguay - C-Array Implementation - Actual Fitnesses



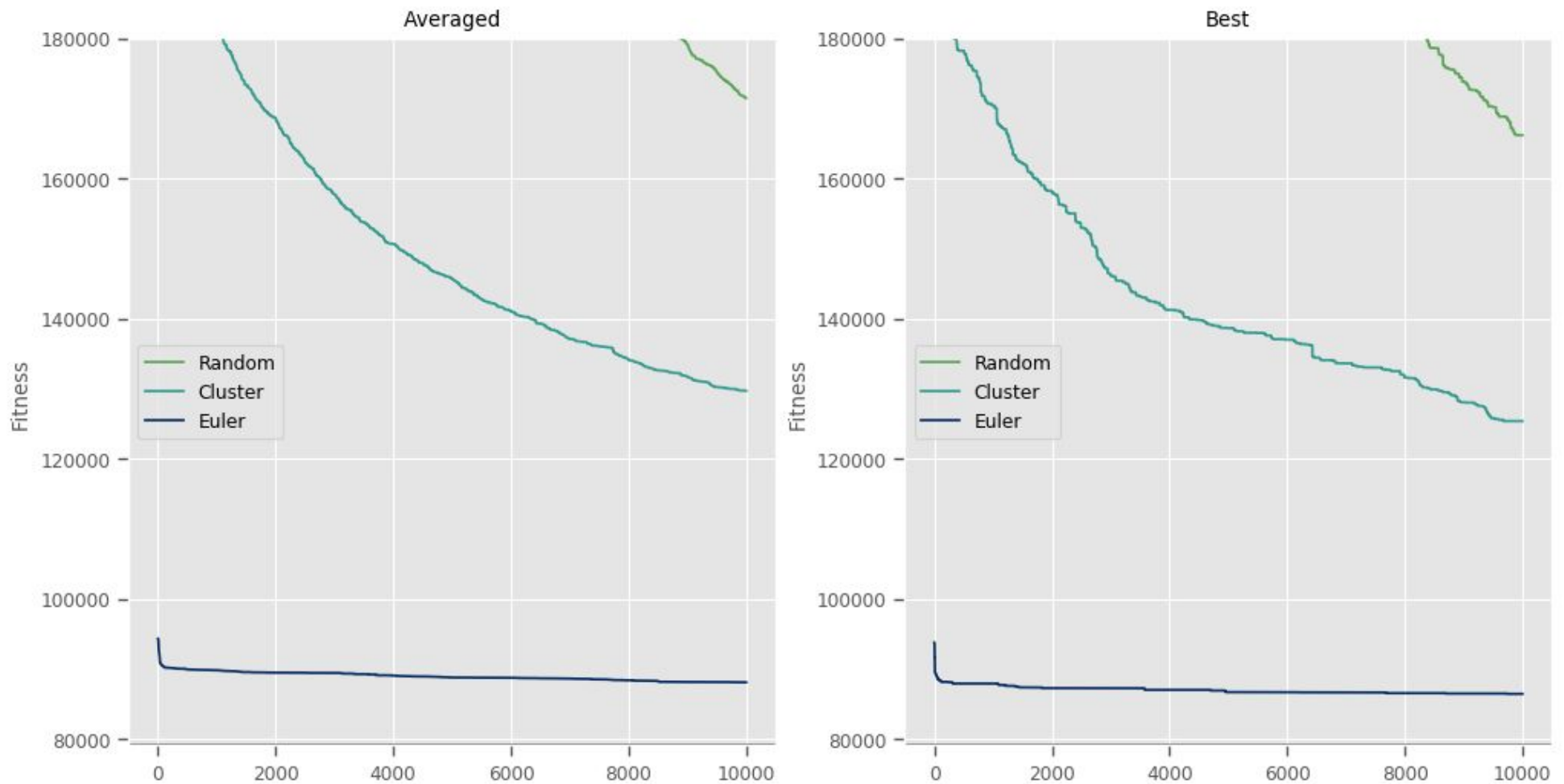
Graph 26

Mutation Comparisons - Uruguay - C-Array Implementation - Relative Fitnesses



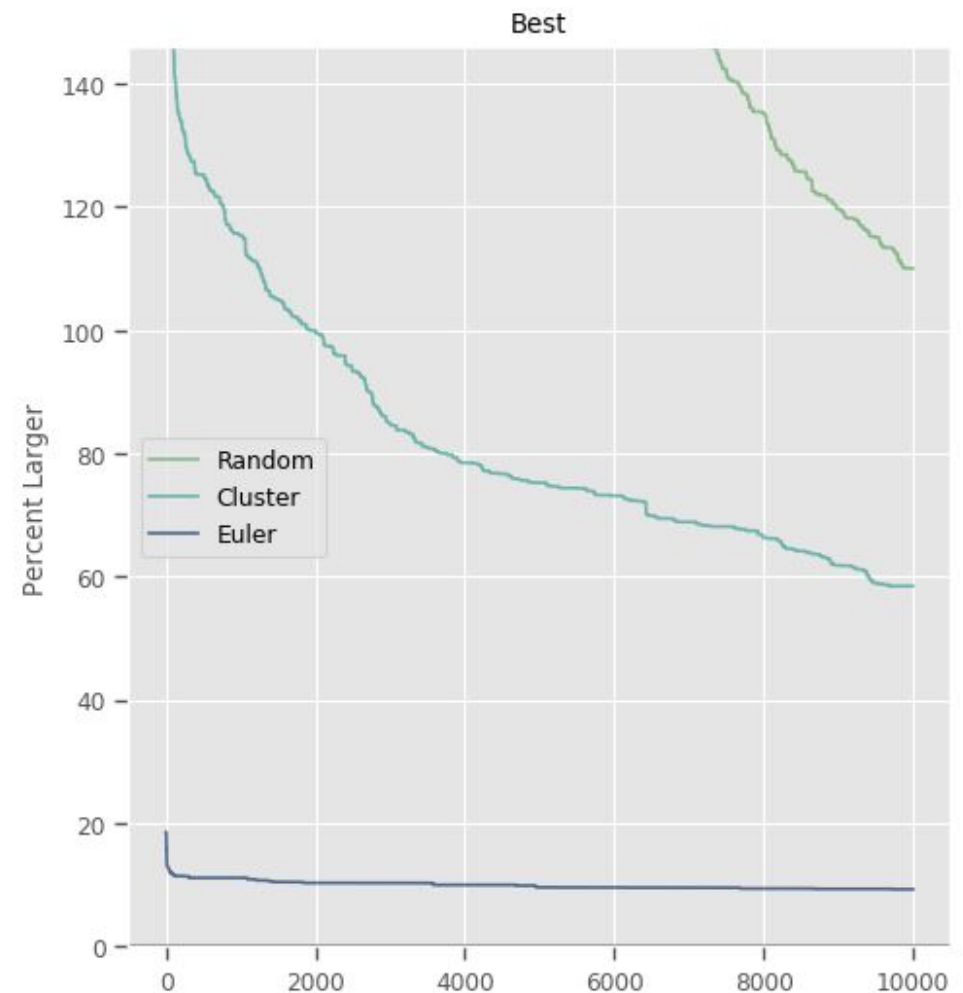
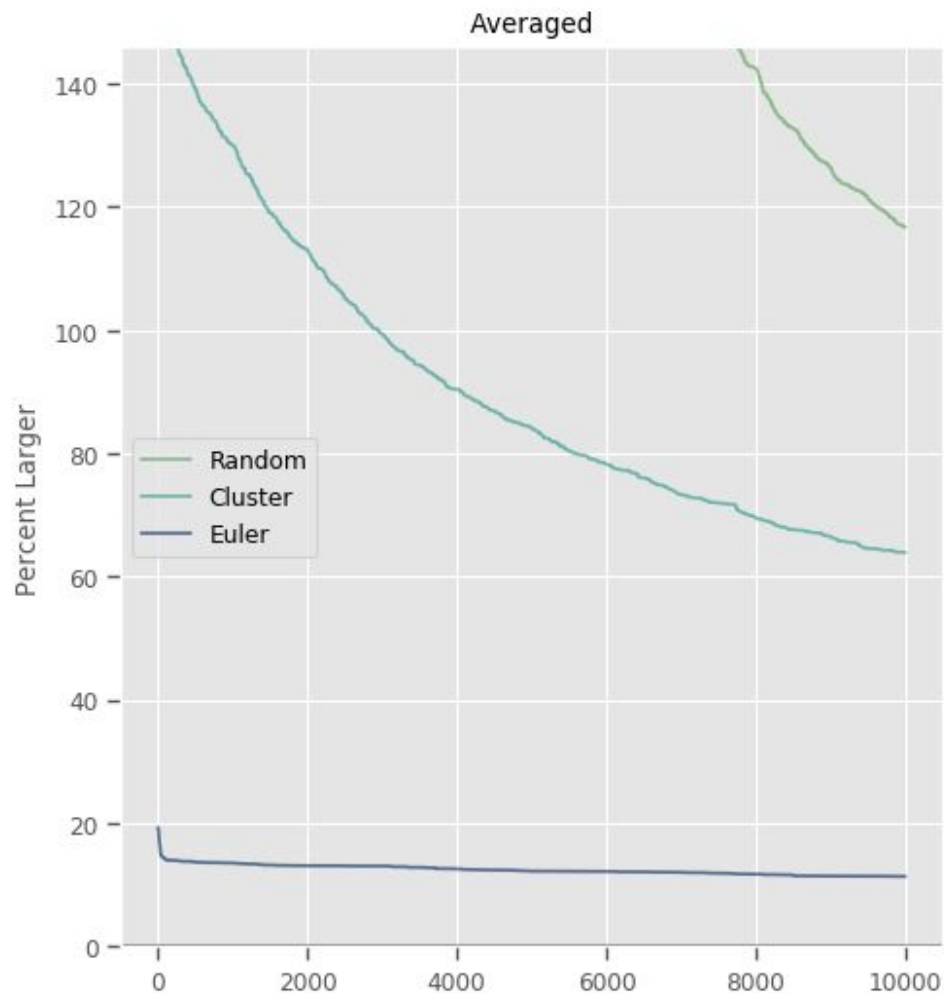
Graph 27

Heuristic Comparisons - Uruguay - List Implementation - Actual Fitnesses



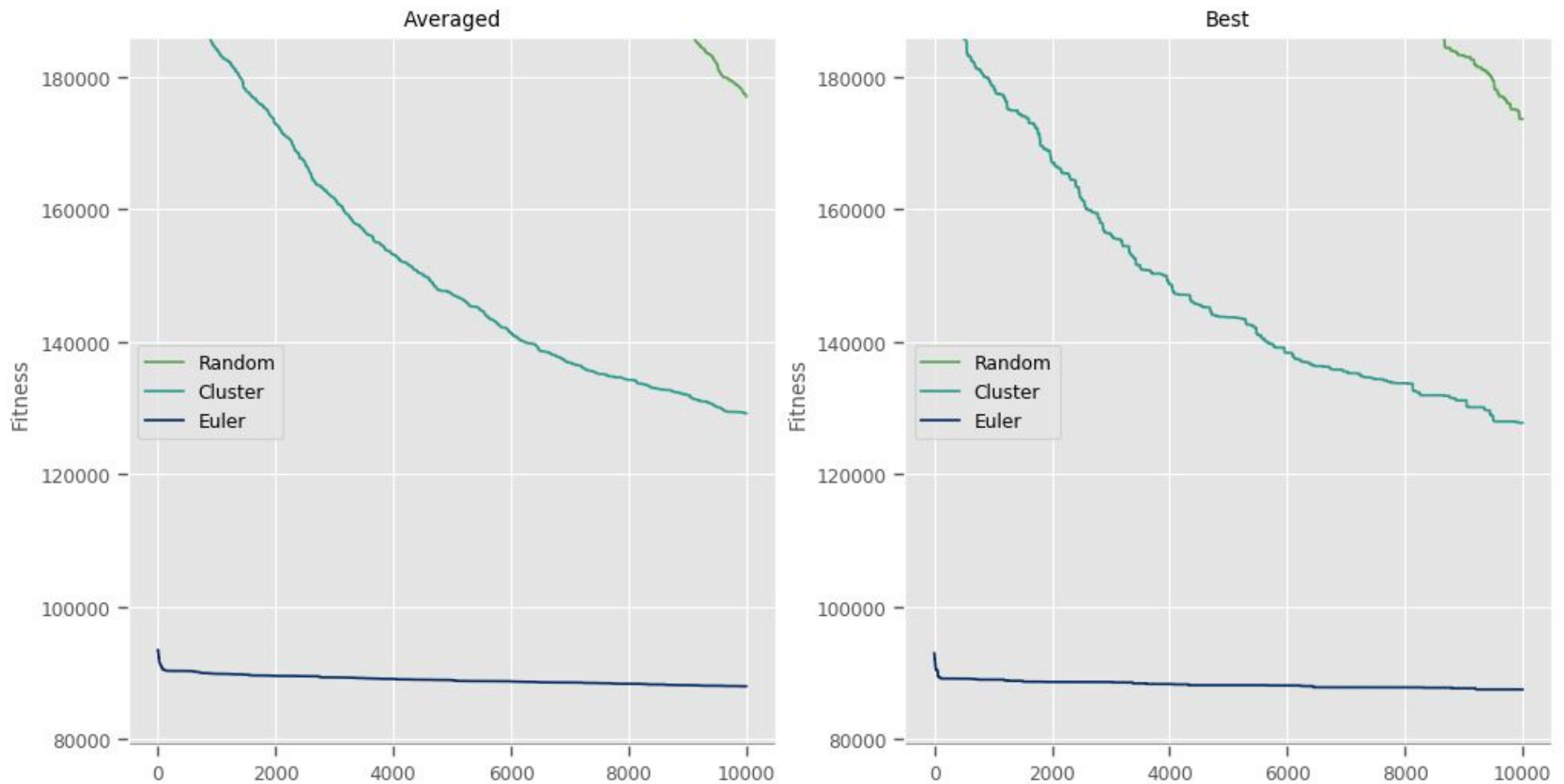
Graph 28

Heuristic Comparisons - Uruguay - List Implementation - Relative Fitnesses



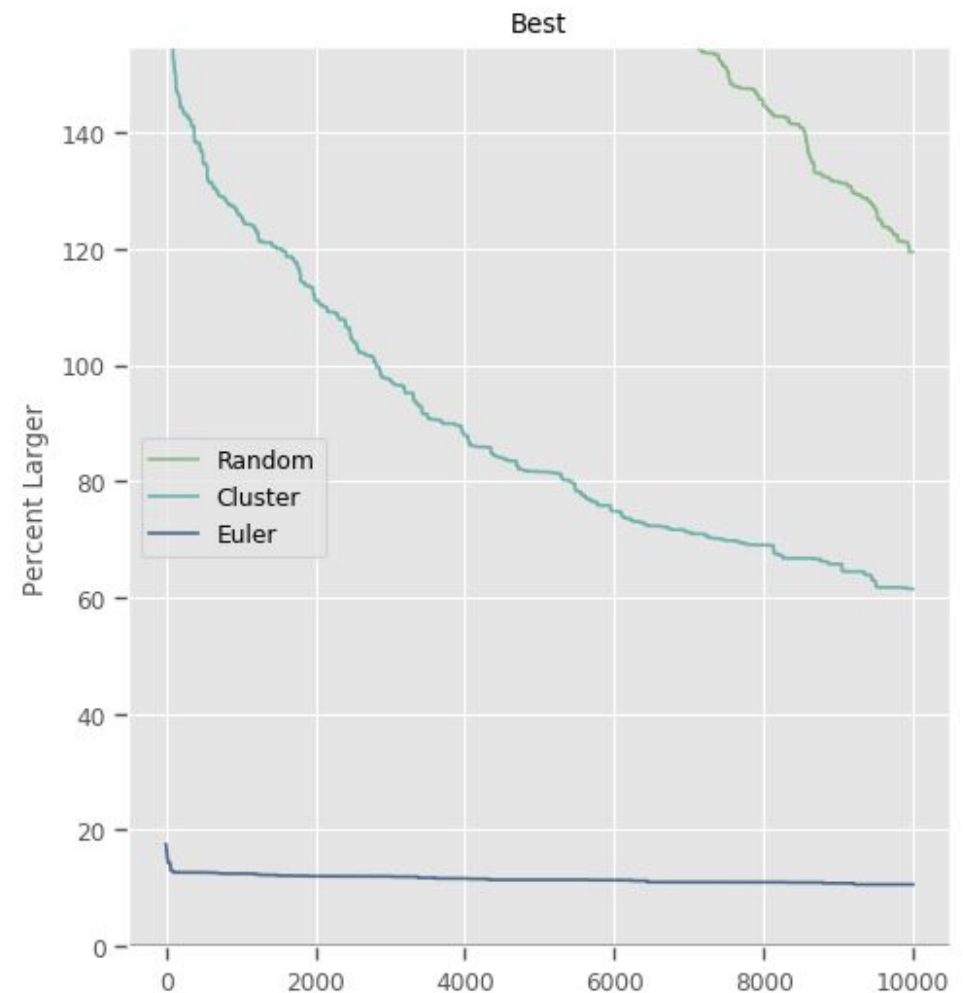
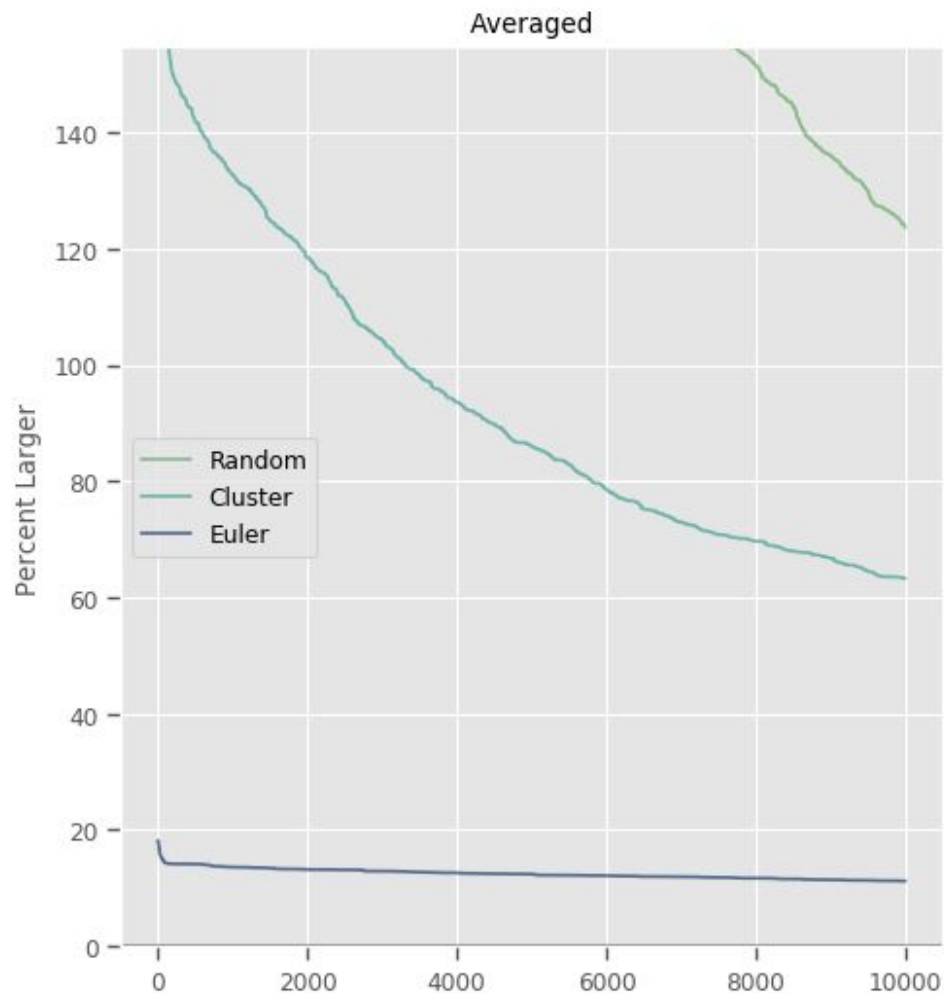
Graph 29

Heuristic Comparisons - Uruguay - C-Array Implementation - Actual Fitnesses



Graph 30

Heuristic Comparisons - Uruguay - C-Array Implementation - Relative Fitnesses



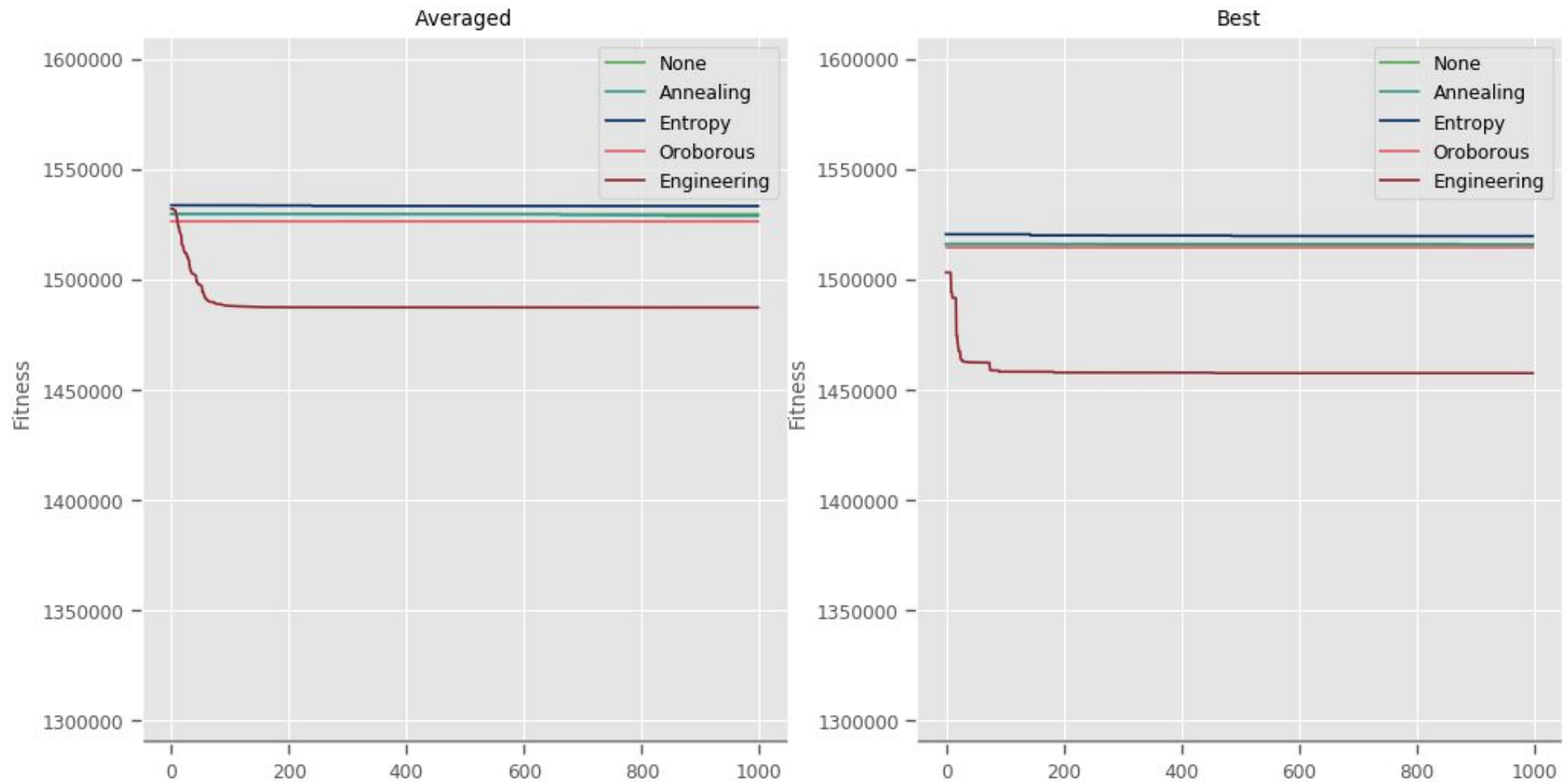
Graphs of Run Data - Canada

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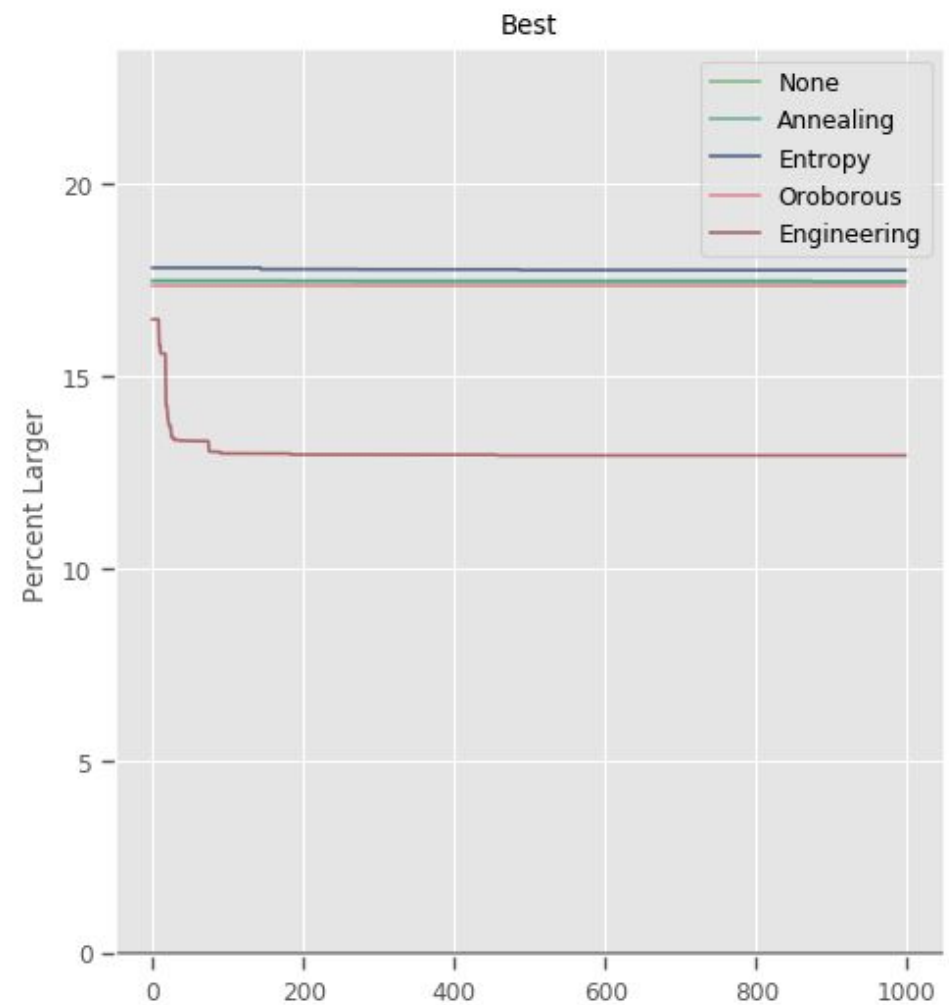
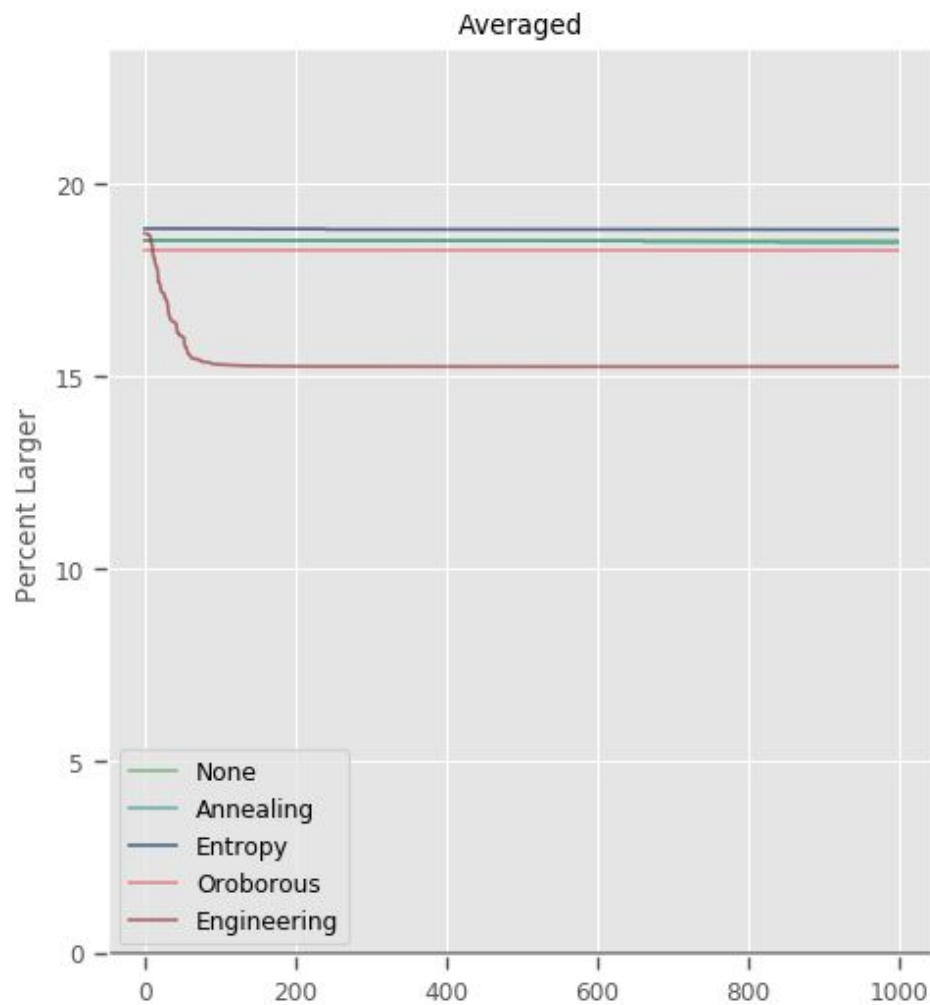
Graph 31

Population Management Comparisons - Canada - C-Array Implementation - Actual Fitnesses



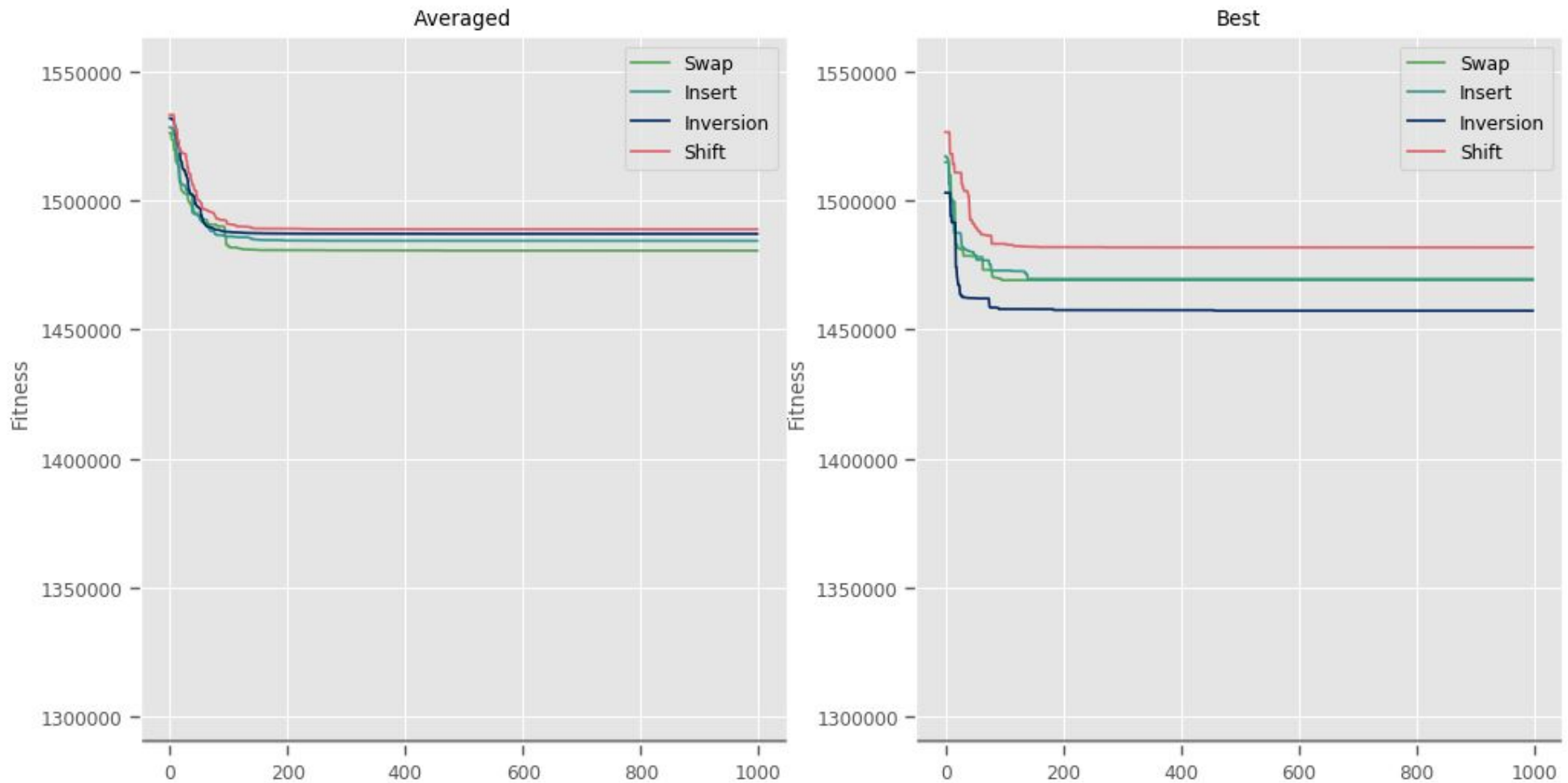
Graph 32

Population Management Comparisons - Canada - C-Array Implementation - Relative Fitnesses



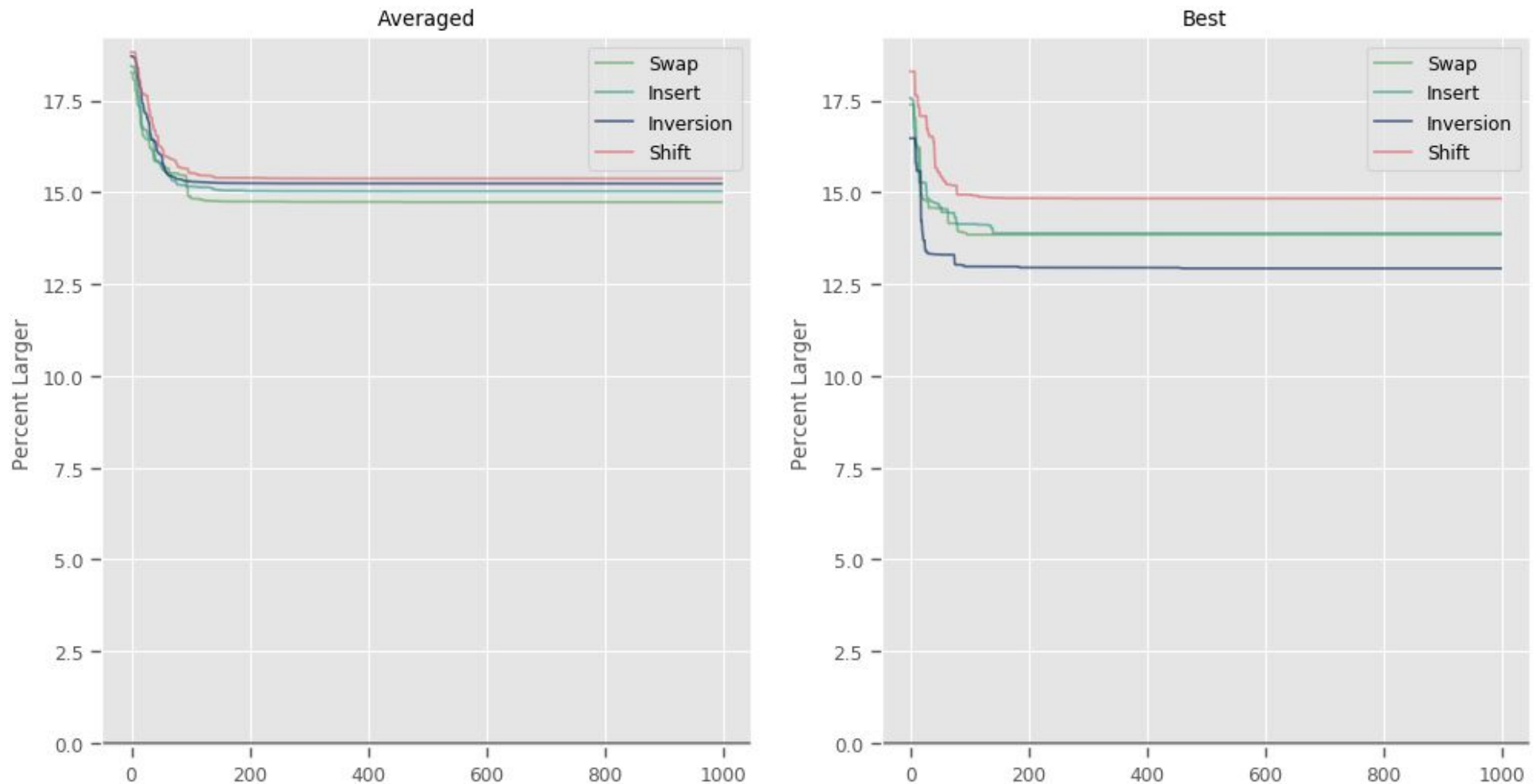
Graph 33

Mutation Comparisons - Canada - C-Array Implementation - Actual Fitnesses



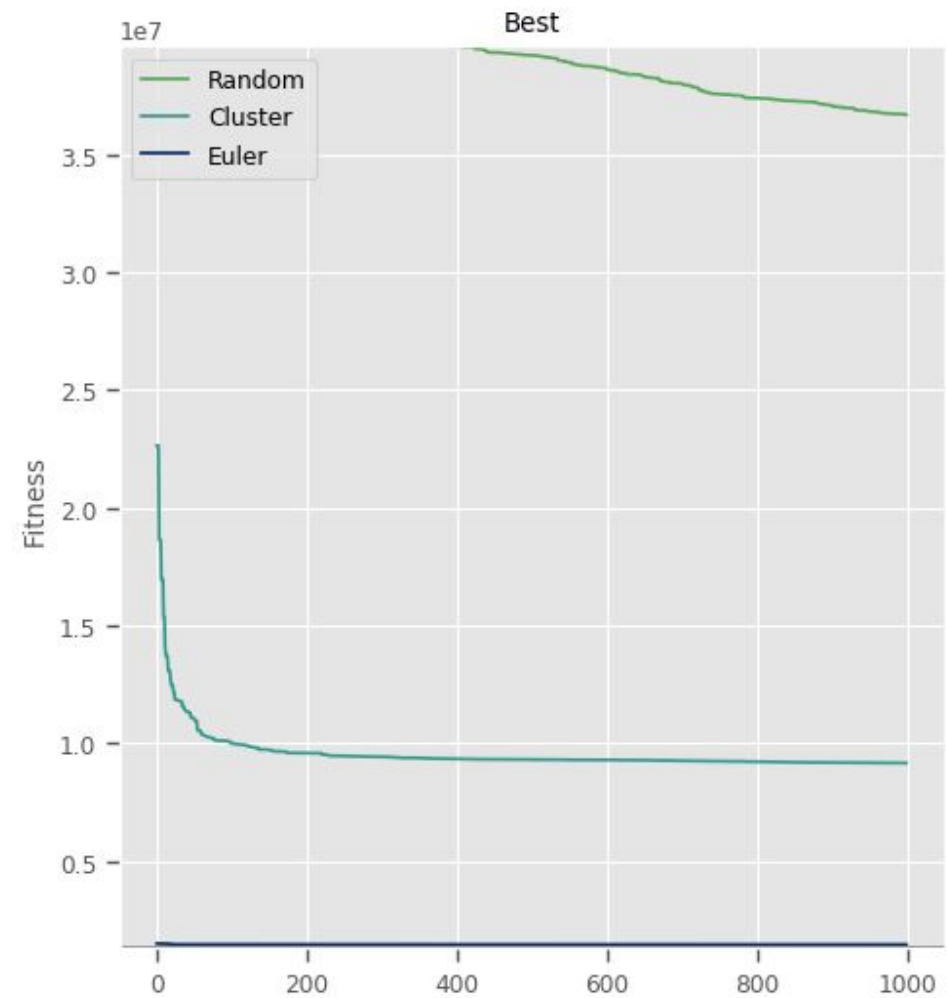
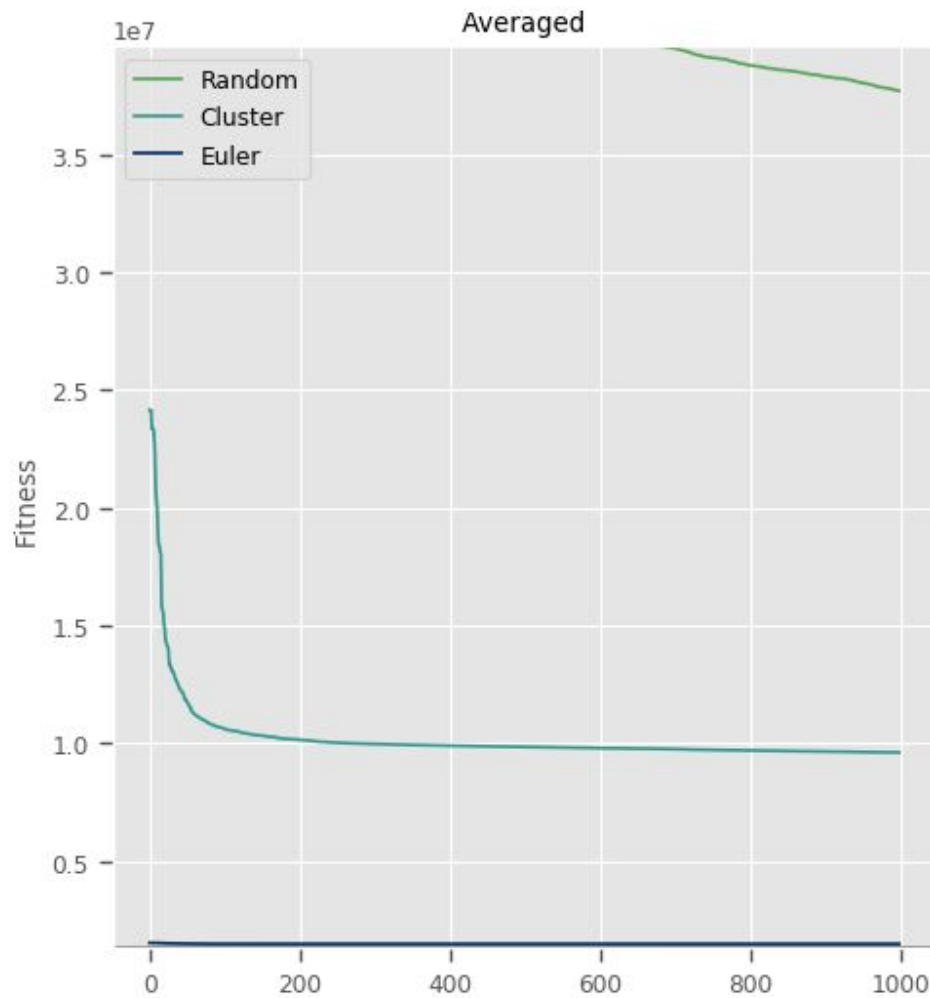
Graph 34

Mutation Comparisons - Canada - C-Array Implementation - Relative Fitnesses



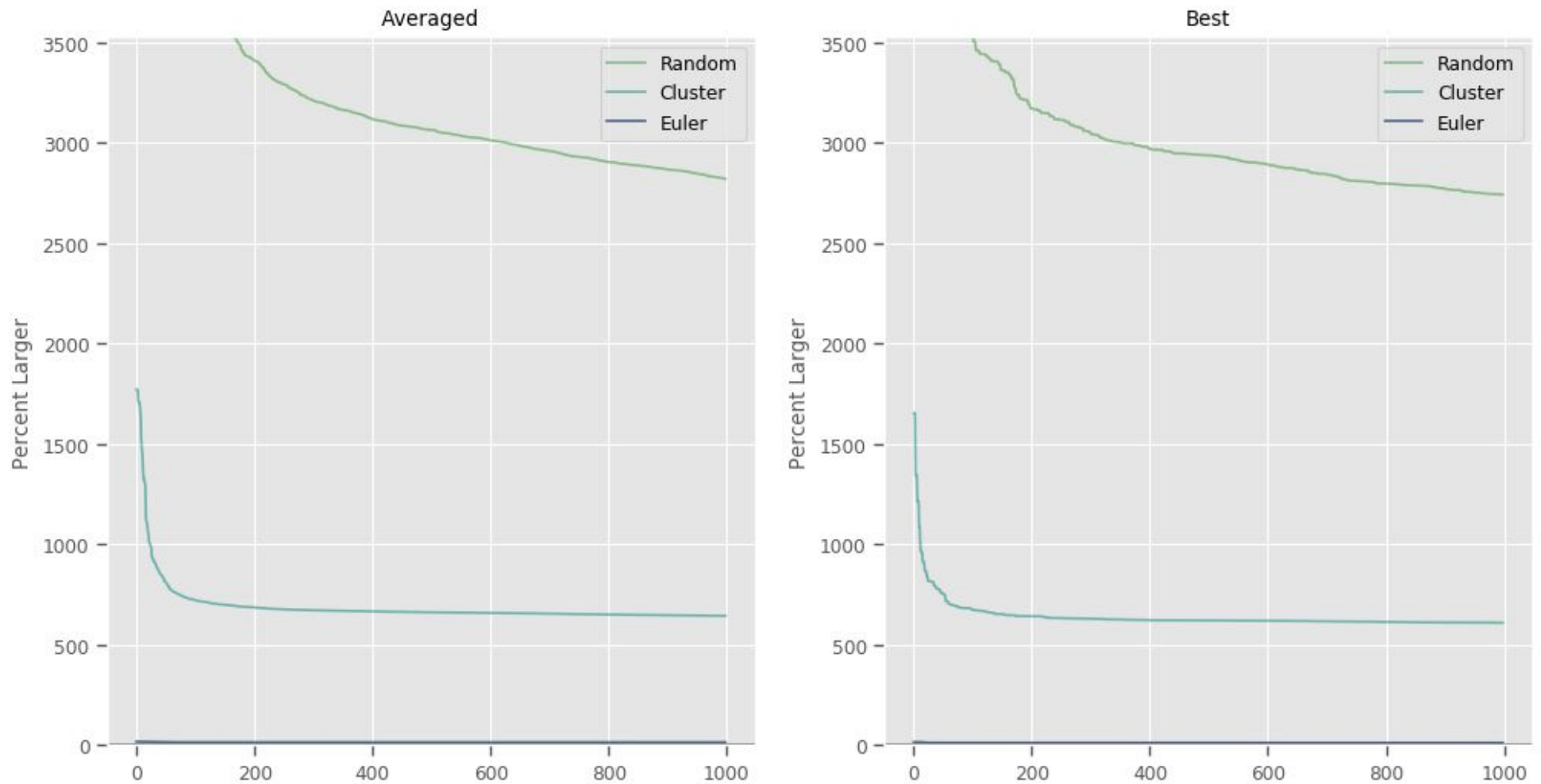
Graph 35

Heuristic Comparisons - Canada - C-Array Implementation - Actual Fitnesses



Graph 36

Heuristic Comparisons - Canada - C-Array Implementation - Relative Fitnesses



Tabular Statistical Data

Table 1*Heuristic Comparisons - Sahara - List Implementation*

Population initialization:	Random	Cluster	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering
Runs:	40	40	40
Lower 95%CI:	28569.80 km	28413.79 km	28691.91 km
Mean:	28759.12 km	28616.38 km	28806.44 km
Upper 95%CI:	28948.44 km	28818.97 km	28920.98 km
Standard Dev:	610.91 km	653.72 km	369.58 km
SRs (Within 10% of Global):	100.00%	97.50%	100.00%

Table 2*Heuristic Comparisons - Sahara - C-Array Implementation*

Population initialization:	Random	Cluster	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering
Runs:	40	40	20
Lower 95%CI:	28424.47 km	28363.65 km	28894.78 km
Mean:	28583.23 km	28563.01 km	29005.92 km
Upper 95%CI:	28741.99 km	28762.37 km	29117.06 km
Standard Dev:	512.29 km	643.30 km	253.59 km
SRs (Within 10% of Global):	100.00%	100.00%	100.00%

Table 3

Heuristic Comparisons - Sahara - List Implementation

Population initialization:	Euler	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Swap	Insert	Inversion	Shift
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering	Engineering
Runs:	40	40	40	40
Lower 95%CI:	29345.35 km	28870.20 km	28691.91 km	28960.52 km
Mean:	29563.06 km	29068.69 km	28806.44 km	29133.40 km
Upper 95%CI:	29780.76 km	29267.18 km	28920.98 km	29306.27 km
Standard Dev:	702.49 km	640.49 km	369.58 km	557.83 km
SRs (Within 10% of Global):	80.00%	100.00%	100.00%	97.50%

Table 4*Heuristic Comparisons - Sahara - C-Array Implementation*

Population initialization:	Euler	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Swap	Insert	Inversion	Shift
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering	Engineering
Runs:	40	40	20	40
Lower 95%CI:	29528.72 km	28854.55 km	28894.78 km	28790.44 km
Mean:	29713.65 km	29051.99 km	29005.92 km	28932.39 km
Upper 95%CI:	29898.57 km	29249.42 km	29117.06 km	29074.35 km
Standard Dev:	596.72 km	637.10 km	253.59 km	458.07 km
SRs (Within 10% of Global):	90.00%	100.00%	100.00%	100.00%

Table 5

Heuristic Comparisons - Sahara - List Implementation

Population initialization:	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	None	Annealing	Entropy
Runs:	40	40	40
Lower 95%CI:	28691.33 km	28628.40 km	28550.61 km
Mean:	28836.66 km	28780.04 km	28684.06 km
Upper 95%CI:	28981.99 km	28931.69 km	28817.50 km
Standard Dev:	468.96 km	489.33 km	430.61 km
SRs (Within 10% of Global):	100.00%	100.00%	100.00%
Population initialization:	Euler	Euler	
Parent selection:	Tourney	Tourney	
Survivor selection:	Mu + Lambda	Mu + Lambda	
Mutation Method:	Inversion	Inversion	
Recombination Method:	PMX Crossover	PMX Crossover	
Management Method:	Ouroboros	Engineering	
Runs:	40	40	
Lower 95%CI:	28427.54 km	28691.91 km	
Mean:	28573.76 km	28806.44 km	
Upper 95%CI:	28719.99 km	28920.98 km	
Standard Dev:	471.84 km	369.58 km	
SRs (Within 10% of Global):	100.00%	100.00%	

Table 6

Heuristic Comparisons - Sahara - C-Array Implementation

Population initialization:	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	None	Annealing	Entropy
Runs:	20	20	20
Lower 95%CI:	28707.41 km	28767.76 km	28586.06 km
Mean:	28856.75 km	28941.01 km	28777.19 km
Upper 95%CI:	29006.09 km	29114.25 km	28968.33 km
Standard Dev:	340.75 km	395.29 km	436.11 km
SRs (Within 10% of Global):	100.00%	100.00%	100.00%
Population initialization:	Euler	Euler	
Parent selection:	Tourney	Tourney	
Survivor selection:	Mu + Lambda	Mu + Lambda	
Mutation Method:	Inversion	Inversion	
Recombination Method:	PMX Crossover	PMX Crossover	
Management Method:	Ouroboros	Engineering	
Runs:	20	20	
Lower 95%CI:	28620.82 km	28894.78 km	
Mean:	28823.25 km	29005.92 km	
Upper 95%CI:	29025.69 km	29117.06 km	
Standard Dev:	461.89 km	253.59 km	
SRs (Within 10% of Global):	100.00%	100.00%	

Table 7

Heuristic Comparisons - Uruguay - List Implementation

Population initialization:	Random	Cluster	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering
Runs:	4	4	5
Lower 95%CI:	165821.33 km	126836.20 km	87281.57 km
Mean:	171444.62 km	129661.93 km	88064.16 km
Upper 95%CI:	177067.91 km	132487.66 km	88846.74 km
Standard Dev:	5738.05 km	2883.40 km	892.82 km
SRs (Within 10% of Global):	0.00%	0.00%	20.00%

Table 8*Heuristic Comparisons - Uruguay - C-Array Implementation*

Population initialization:	Random	Cluster	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering
Runs:	5	5	6
Lower 95%CI:	175144.40 km	128463.32 km	87780.52 km
Mean:	176990.26 km	129163.58 km	87993.87 km
Upper 95%CI:	178836.11 km	129863.85 km	88207.22 km
Standard Dev:	2105.85 km	798.90 km	266.64 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%

Table 9

Heuristic Comparisons - Uruguay - List Implementation

Population initialization:	Euler	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Swap	Insert	Inversion	Shift
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering	Engineering
Runs:	5	5	5	5
Lower 95%CI:	89984.18 km	88705.46 km	87281.57 km	89675.07 km
Mean:	90390.78 km	89822.09 km	88064.16 km	90465.88 km
Upper 95%CI:	90797.38 km	90938.72 km	88846.74 km	91256.70 km
Standard Dev:	463.87 km	1273.91 km	892.82 km	902.21 km
SRs (Within 10% of Global):	0.00%	0.00%	20.00%	0.00%

Table 10*Heuristic Comparisons - Uruguay - C-Array Implementation*

Population initialization:	Euler	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Swap	Insert	Inversion	Shift
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering	Engineering
Runs:	5	5	6	5
Lower 95%CI:	89882.41 km	89151.38 km	87780.52 km	89153.19 km
Mean:	90210.14 km	89920.72 km	87993.87 km	89909.78 km
Upper 95%CI:	90537.87 km	90690.06 km	88207.22 km	90666.37 km
Standard Dev:	373.89 km	877.70 km	266.64 km	863.16 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%	0.00%

Table 11*Heuristic Comparisons - Uruguay - List Implementation*

Population initialization:	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	None	Annealing	Entropy
Runs:	5	5	5
Lower 95%CI:	90126.26 km	89530.47 km	89641.01 km
Mean:	90525.30 km	90500.97 km	90758.49 km
Upper 95%CI:	90924.34 km	91471.46 km	91875.96 km
Standard Dev:	455.25 km	1107.19 km	1274.87 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%
Population initialization:	Euler	Euler	
Parent selection:	Tourney	Tourney	
Survivor selection:	Mu + Lambda	Mu + Lambda	
Mutation Method:	Inversion	Inversion	
Recombination Method:	PMX Crossover	PMX Crossover	
Management Method:	Ouroboros	Engineering	
Runs:	5	5	
Lower 95%CI:	91060.69 km	87281.57 km	
Mean:	91569.23 km	88064.16 km	
Upper 95%CI:	92077.77 km	88846.74 km	
Standard Dev:	580.17 km	892.82 km	
SRs (Within 10% of Global):	0.00%	20.00%	

Table 12

Heuristic Comparisons - Uruguay - C-Array Implementation

Population initialization:	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	None	Annealing	Entropy
Runs:	6	6	6
Lower 95%CI:	90321.55 km	90073.35 km	90069.64 km
Mean:	90622.37 km	90472.86 km	90731.12 km
Upper 95%CI:	90923.18 km	90872.36 km	91392.60 km
Standard Dev:	375.94 km	499.28 km	826.68 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%
Population initialization:	Euler	Euler	
Parent selection:	Tourney	Tourney	
Survivor selection:	Mu + Lambda	Mu + Lambda	
Mutation Method:	Inversion	Inversion	
Recombination Method:	PMX Crossover	PMX Crossover	
Management Method:	Ouroboros	Engineering	
Runs:	6	6	
Lower 95%CI:	89919.09 km	87780.52 km	
Mean:	90577.30 km	87993.87 km	
Upper 95%CI:	91235.51 km	88207.22 km	
Standard Dev:	822.59 km	266.64 km	
SRs (Within 10% of Global):	0.00%	0.00%	

Table 13*Heuristic Comparisons - Canada - C-Array Implementation*

Population initialization:	Random	Cluster	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering
Runs:	5	5	8
Lower 95%CI:	36964723.54 km	9376847.50 km	1477293.00 km
Mean:	37674918.06 km	9611262.12 km	1487054.52 km
Upper 95%CI:	38385112.58 km	9845676.75 km	1496816.03 km
Standard Dev:	810226.13 km	267432.16 km	14086.60 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%

Table 14*Heuristic Comparisons - Canada - C-Array Implementation*

Population initialization:	Euler	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Swap	Insert	Inversion	Shift
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	Engineering	Engineering	Engineering	Engineering
Runs:	5	5	8	5
Lower 95%CI:	1472077.38 km	1476830.33 km	1477293.00 km	1483337.12 km
Mean:	1480542.98 km	1484343.10 km	1487054.52 km	1488826.49 km
Upper 95%CI:	1489008.58 km	1491855.86 km	1496816.03 km	1494315.86 km
Standard Dev:	9657.99 km	8570.95 km	14086.60 km	6262.56 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%	0.00%

Table 15

Heuristic Comparisons - Canada - C-Array Implementation

Population initialization:	Euler	Euler	Euler
Parent selection:	Tourney	Tourney	Tourney
Survivor selection:	Mu + Lambda	Mu + Lambda	Mu + Lambda
Mutation Method:	Inversion	Inversion	Inversion
Recombination Method:	PMX Crossover	PMX Crossover	PMX Crossover
Management Method:	None	Annealing	Entropy
Runs:	8	8	8
Lower 95%CI:	1523497.83 km	1524230.55 km	1526909.67 km
Mean:	1529352.81 km	1528565.46 km	1533085.68 km
Upper 95%CI:	1535207.79 km	1532900.37 km	1539261.69 km
Standard Dev:	8449.18 km	6255.60 km	8912.45 km
SRs (Within 10% of Global):	0.00%	0.00%	0.00%
Population initialization:	Euler	Euler	
Parent selection:	Tourney	Tourney	
Survivor selection:	Mu + Lambda	Mu + Lambda	
Mutation Method:	Inversion	Inversion	
Recombination Method:	PMX Crossover	PMX Crossover	
Management Method:	Ouroboros	Engineering	
Runs:	8	8	
Lower 95%CI:	1520498.20 km	1477293.00 km	
Mean:	1526109.83 km	1487054.52 km	
Upper 95%CI:	1531721.45 km	1496816.03 km	
Standard Dev:	8098.00 km	14086.60 km	
SRs (Within 10% of Global):	0.00%	0.00%	