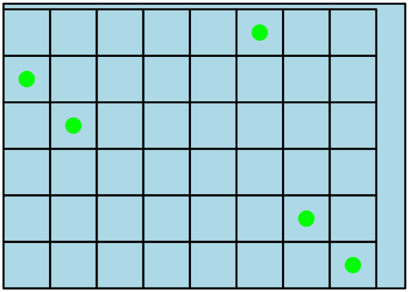
1 Round

Best Energy Output: 12077.04 W/h

Efficiency: 100 %

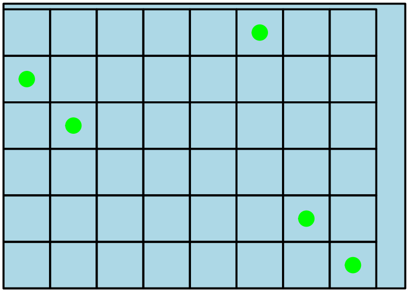


Number of turbines: 5

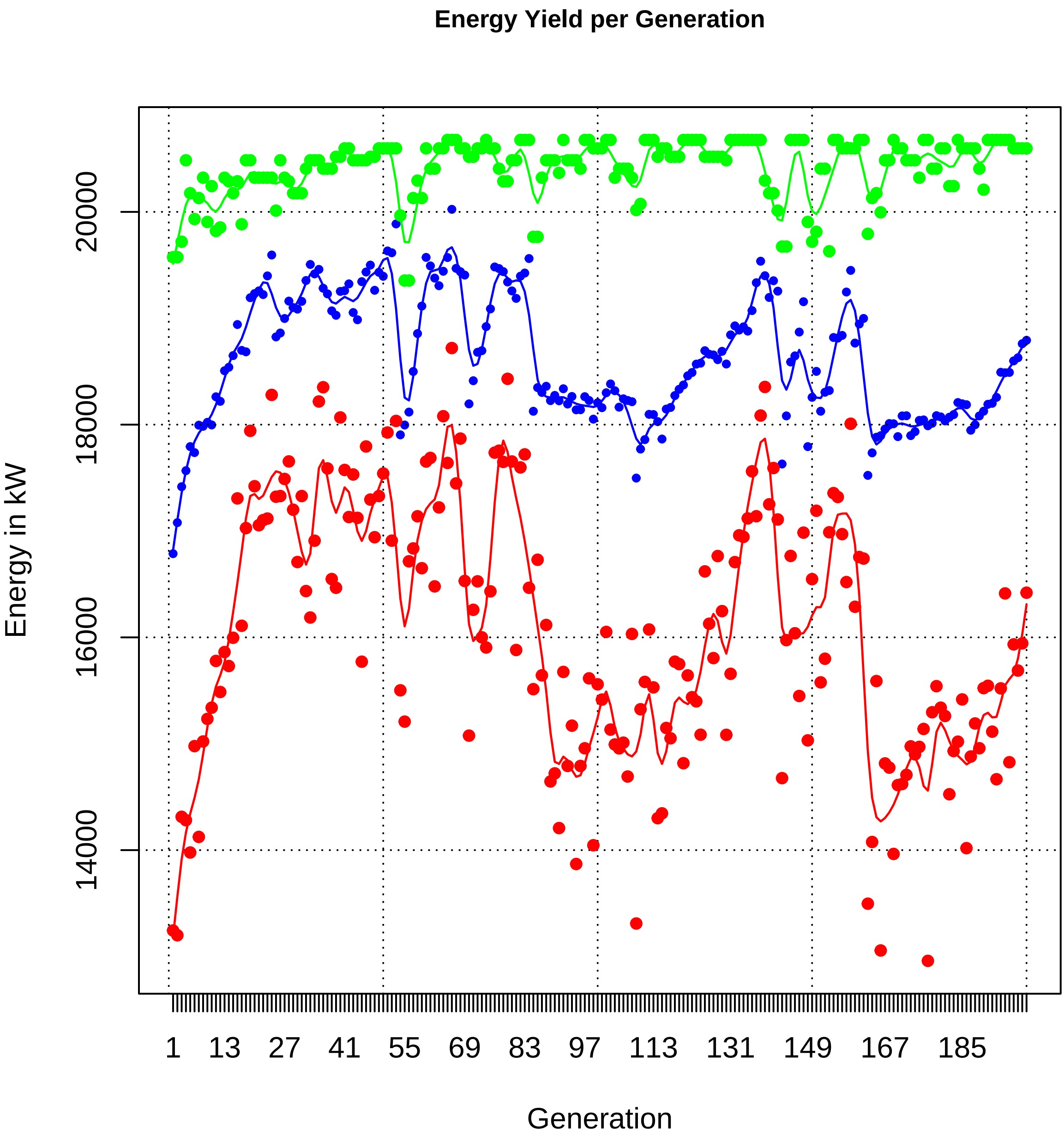
1 Round

Best Efficiency Output: 12077.04 W

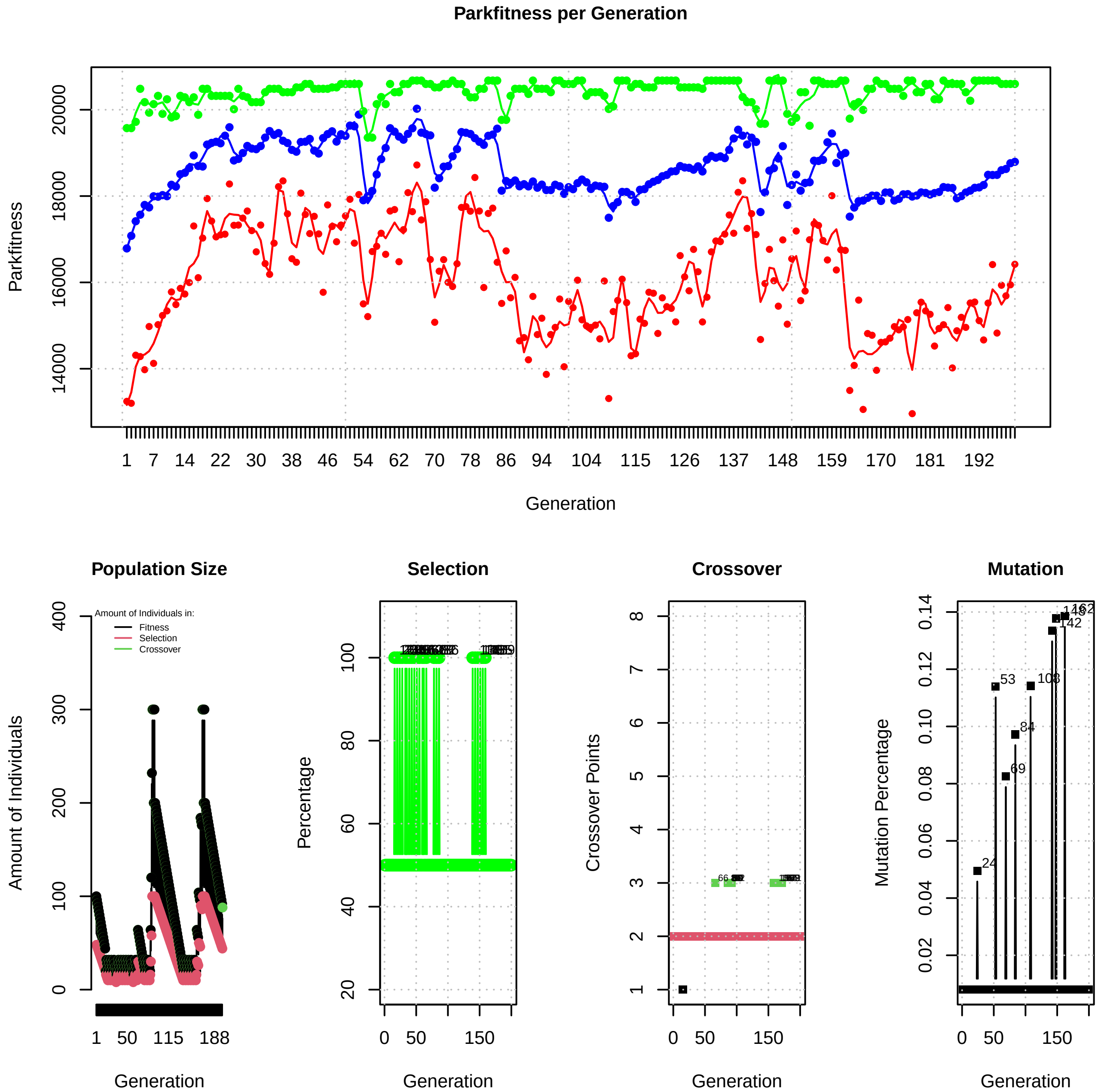
Efficiency: 100 %

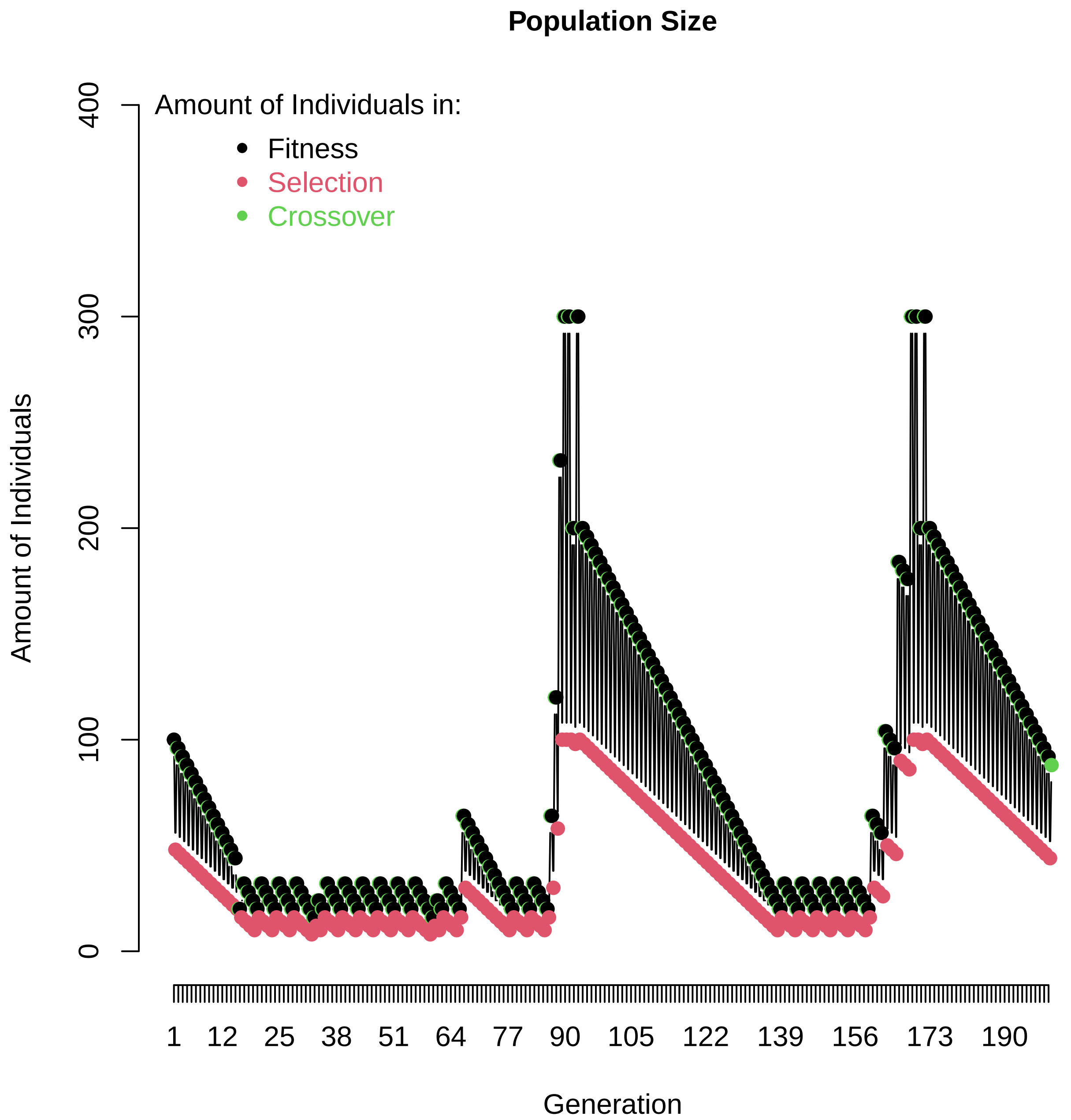


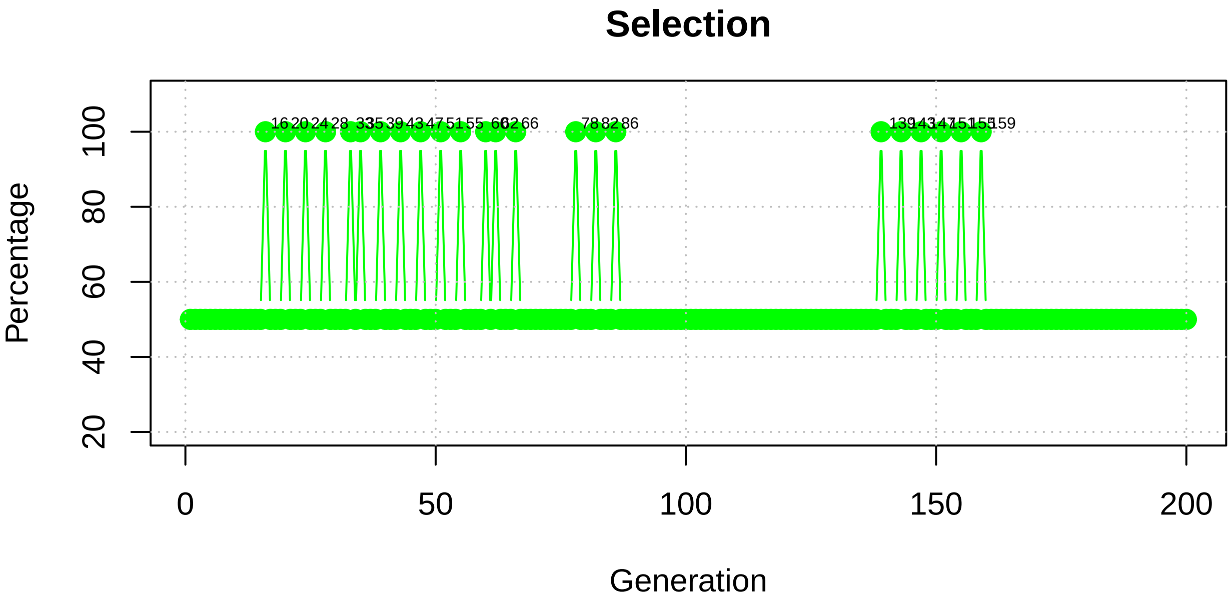
Number of turbines: 5

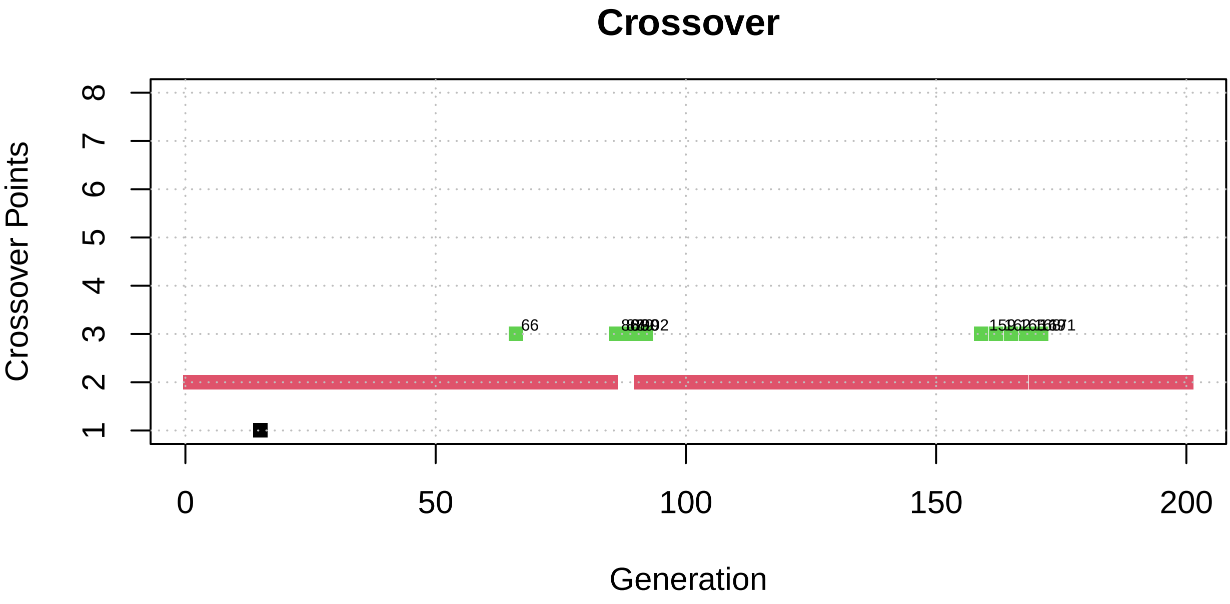


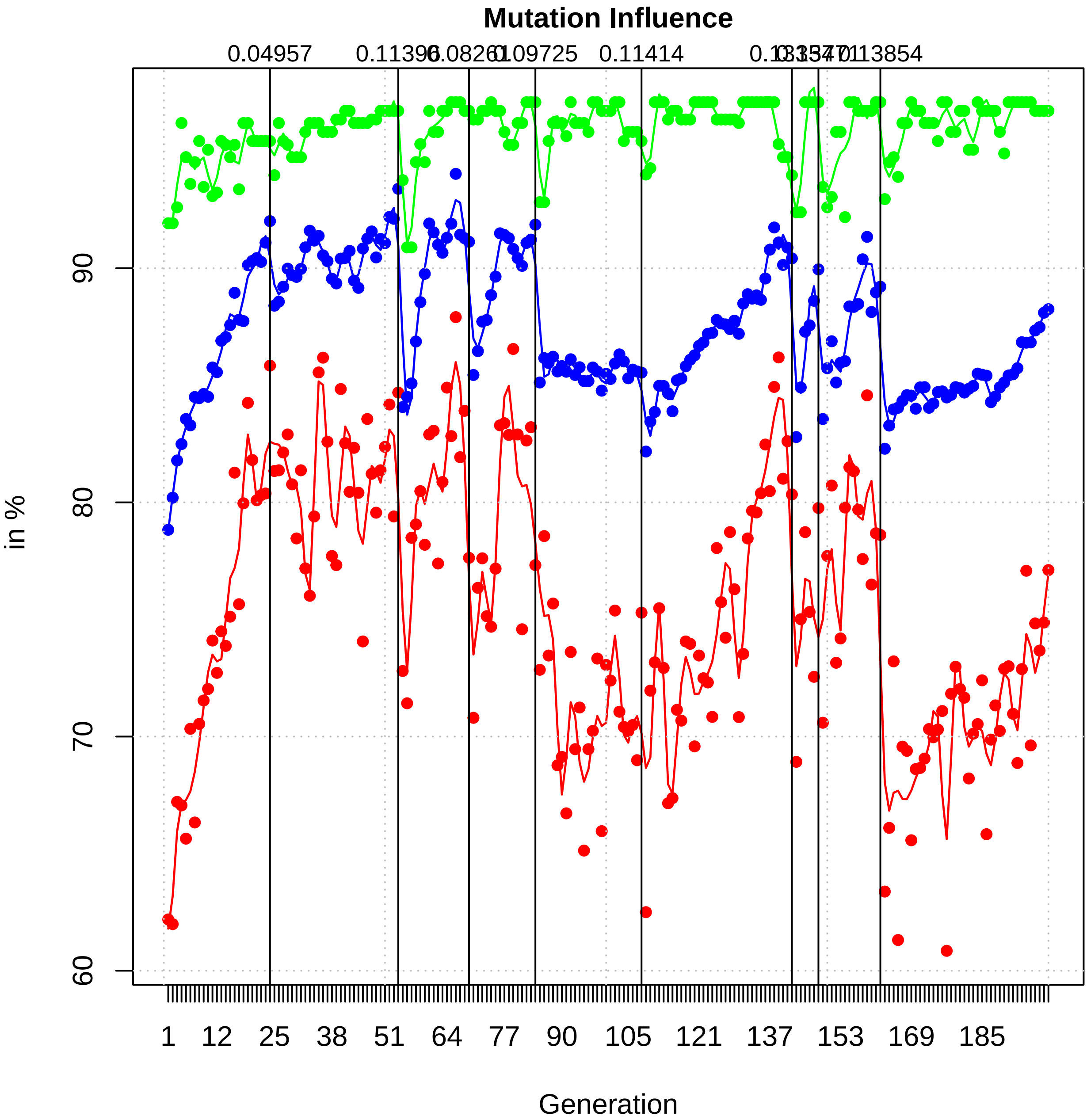
Energy Yield per Generation
Energy in kW
14000
16000
18000
20000
1
13
27
41
55
69
83
97
113
131
149
167
185
Generation


Parkfitness per Generation
Parkfitness
Generation
Population Size
Amount of Individuals in:
Fitness
Selection
Crossover
Amount of Individuals
Selection
Percentage
Crossover
Crossover Points
Mutation
Mutation Percentage

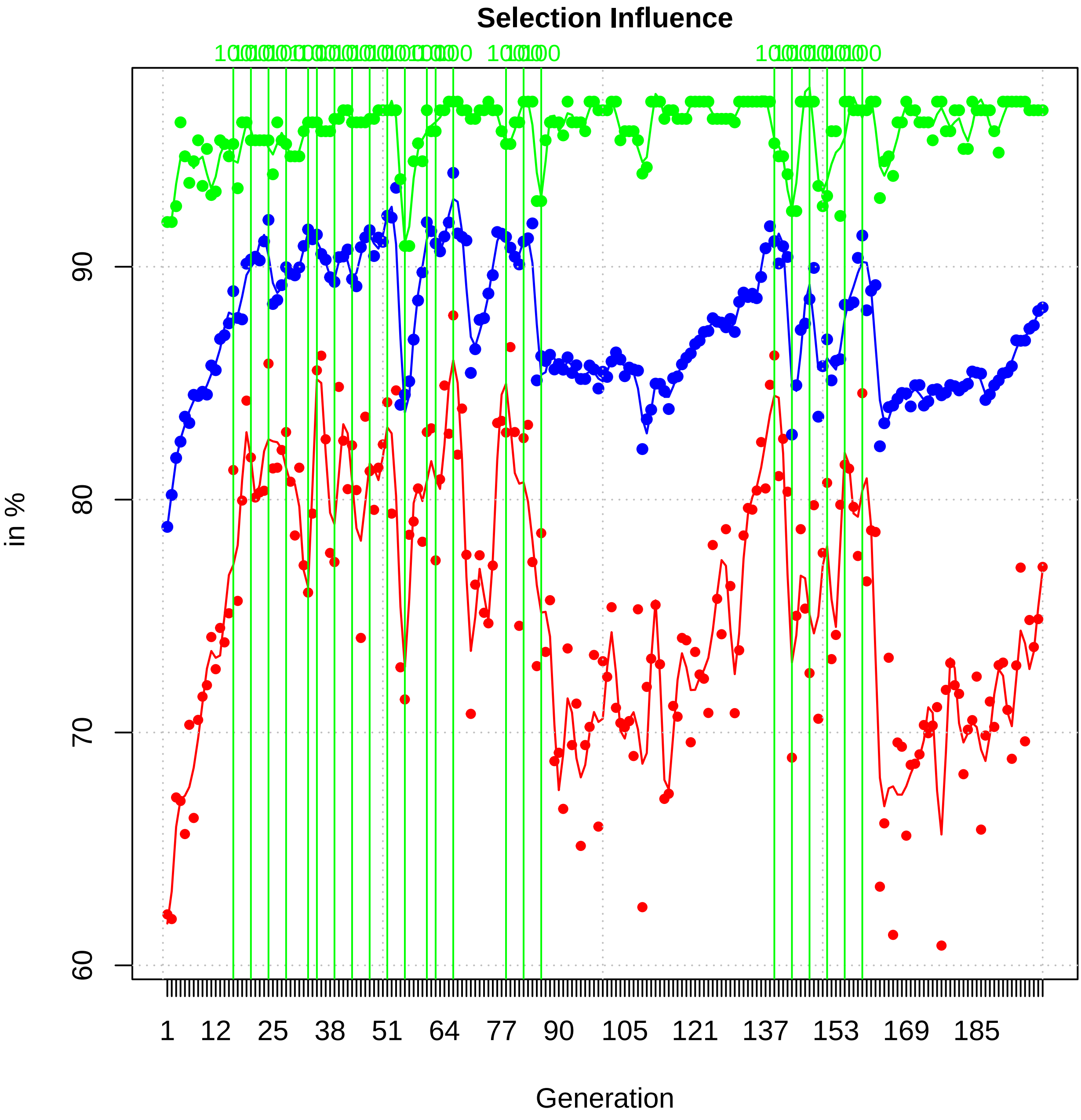

Population Size
Amount of Individuals in:
Fitness
Selection
Crossover
Amount of Individuals
Generation
0
100
200
300
400
1
12
25
38
51
64
77
90
105
122
139
156
173
190


Selection
Percentage
Generation
20
40
60
80
100
0
50
100
150
200

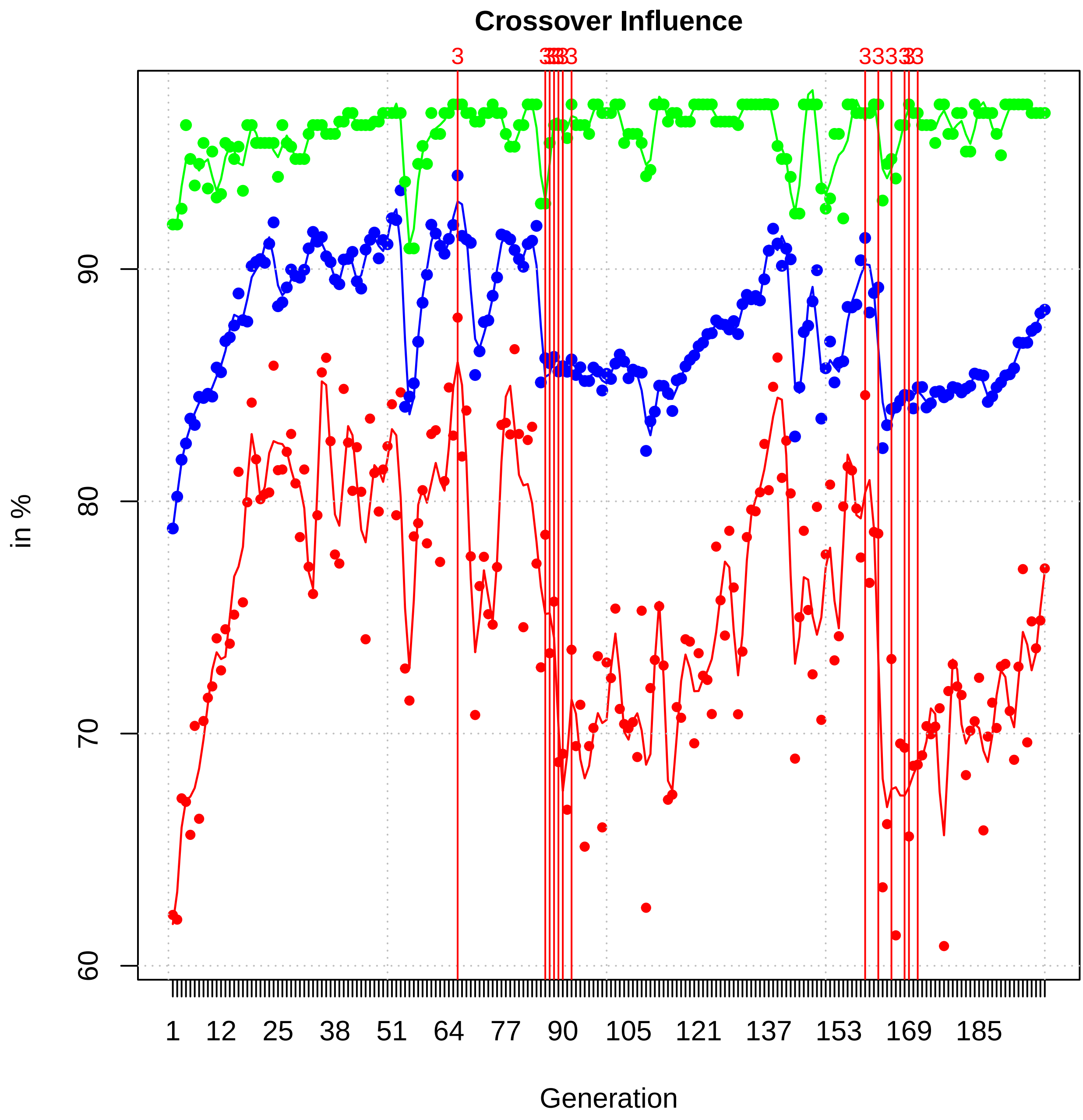

Crossover
Crossover Points
Generation
1
2
3
4
5
6
7
8
0
50
100
150
200
66



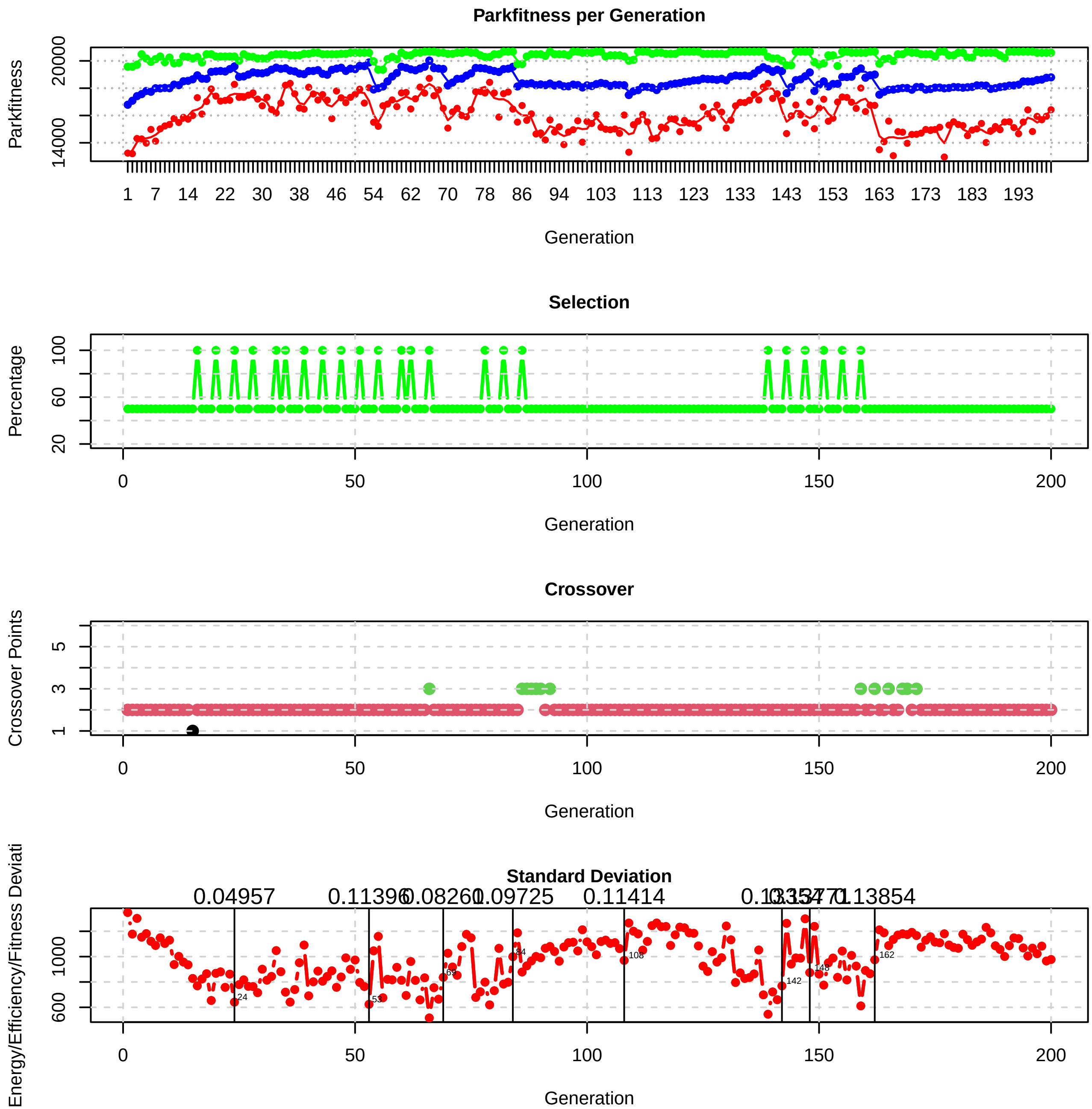
Mutation Influence
0.04957
0.11396
0.08261
0.09725
0.11414
0.13354
0.13471
0.13854
in %
60
70
80
90
1
12
25
38
51
64
77
90
105
121
137
153
169
185
Generation



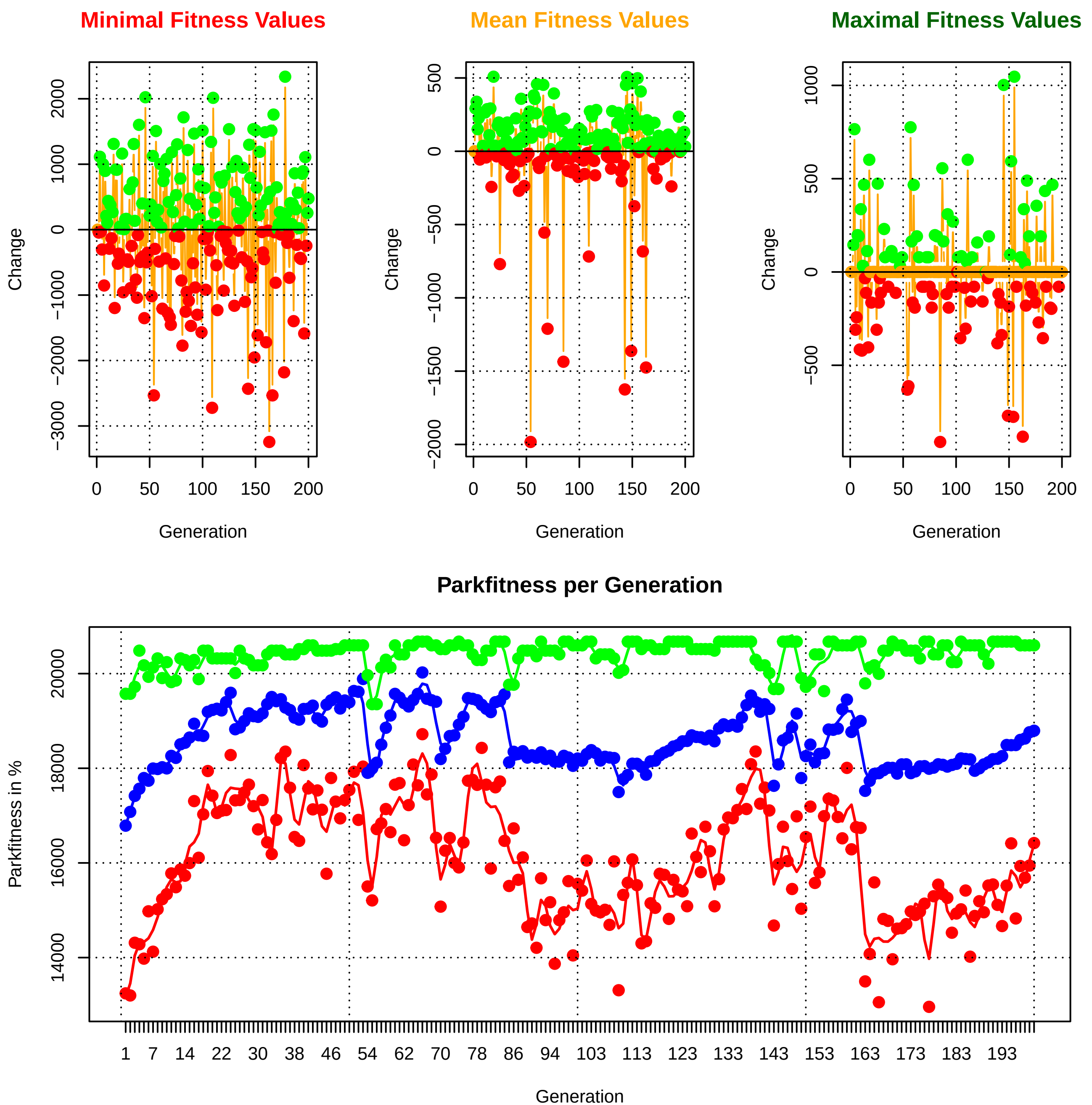
Selection Influence
in %
Generation
60
70
80
90
1
12
25
38
51
64
77
90
105
121
137
153
169
185



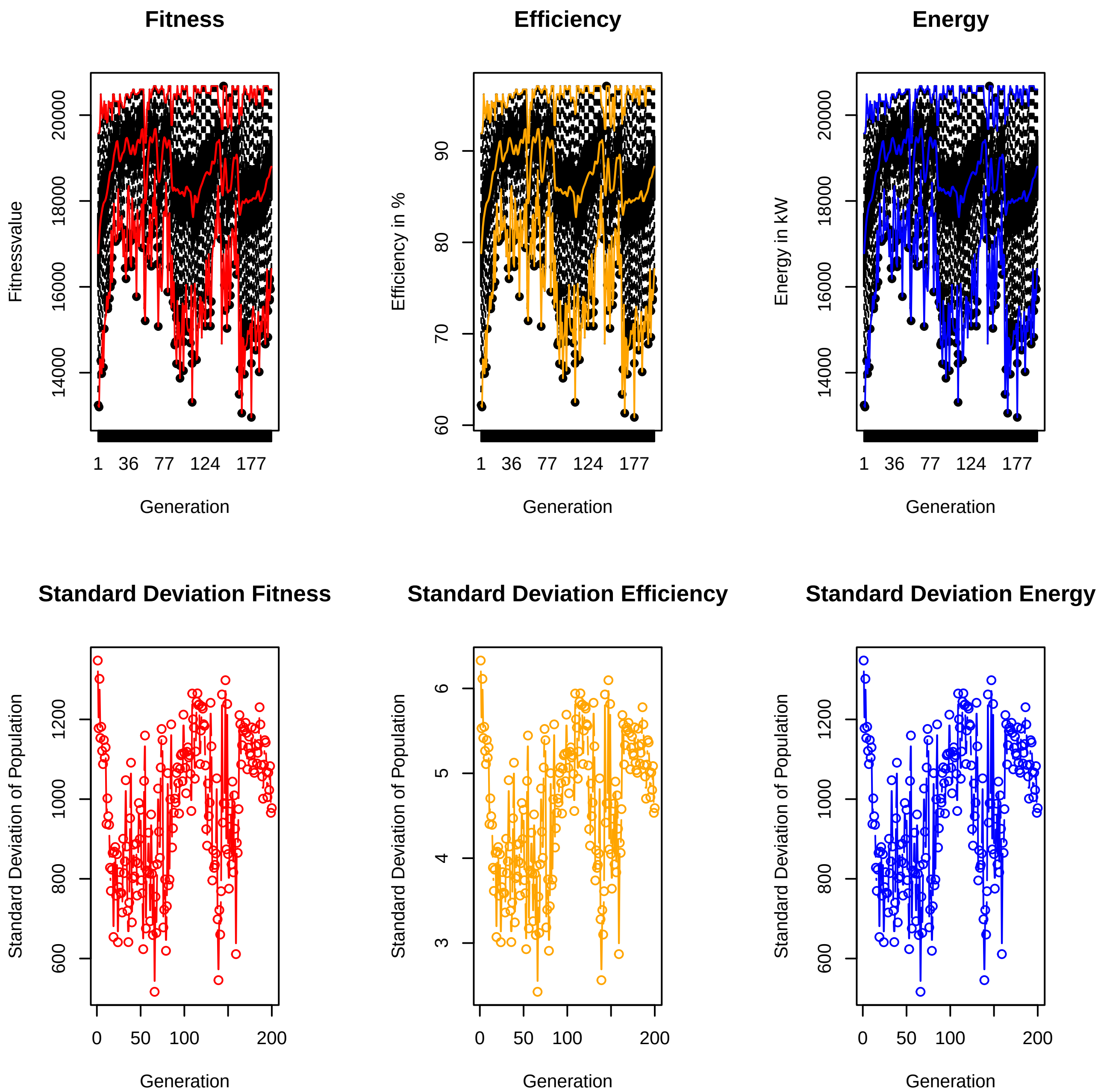
Crossover Influence
3
33333
333333
in %
60
70
80
90
1
12
25
38
51
64
77
90
105
121
137
153
169
185
Generation



Parkfitness per Generation
Parkfitness
14000
20000
Generation
Selection
Percentage
20
60
100
Generation
Crossover
Crossover Points
1
3
5
Generation
Standard Deviation
0.04957
0.11396
0.08261
0.09725
0.11414
0.13854
Energy/Efficiency/Fitness Deviati
600
1000
Generation

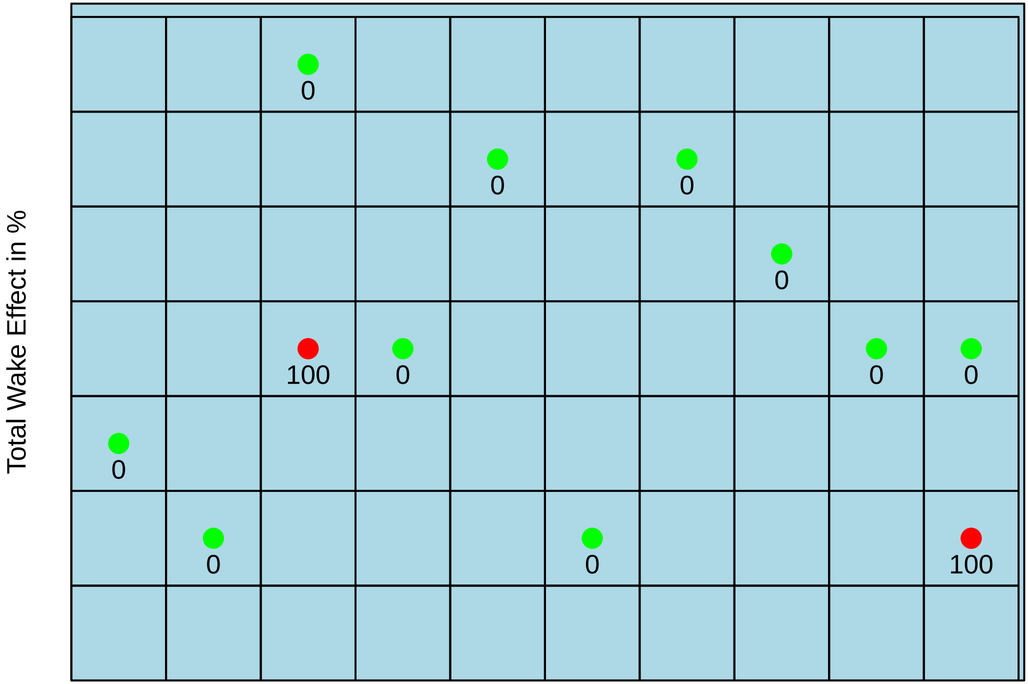


Minimal Fitness Values
Mean Fitness Values
Maximal Fitness Values
Change
Generation
Parkfitness per Generation
Parkfitness in %
Generation



Fitness
Fitnessvalue
14000
16000
18000
20000
1
36
77
124
177
Generation
Efficiency
Efficiency in %
60
70
80
90
1
36
77
124
177
Generation
Energy
Energy in kW
14000
16000
18000
20000
1
36
77
124
177
Generation
Standard Deviation Fitness
Standard Deviation of Population
600
800
1000
1200
0
50
100
200
Generation
Standard Deviation Efficiency
Standard Deviation of Population
3
4
5
6
0
50
100
200
Generation
Standard Deviation Energy
Standard Deviation of Population
600
800
1000
1200
0
50
100
200
Generation

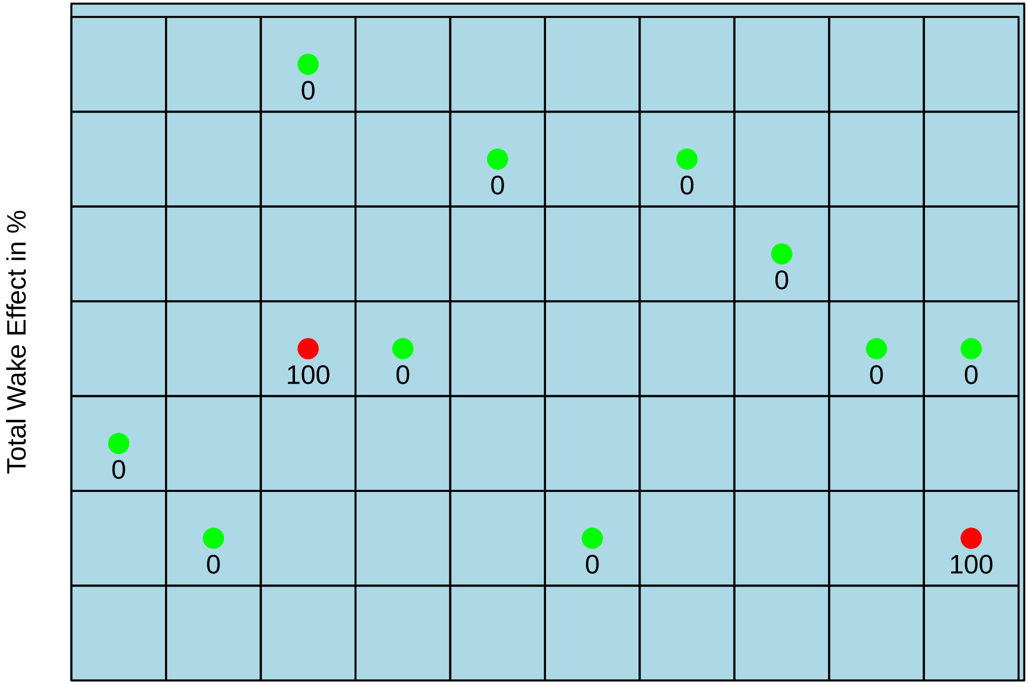
1 Best Energy Windfarm
Energy Output 19719.67 kW
Efficiency: 92.6 %



minimal Distance 150

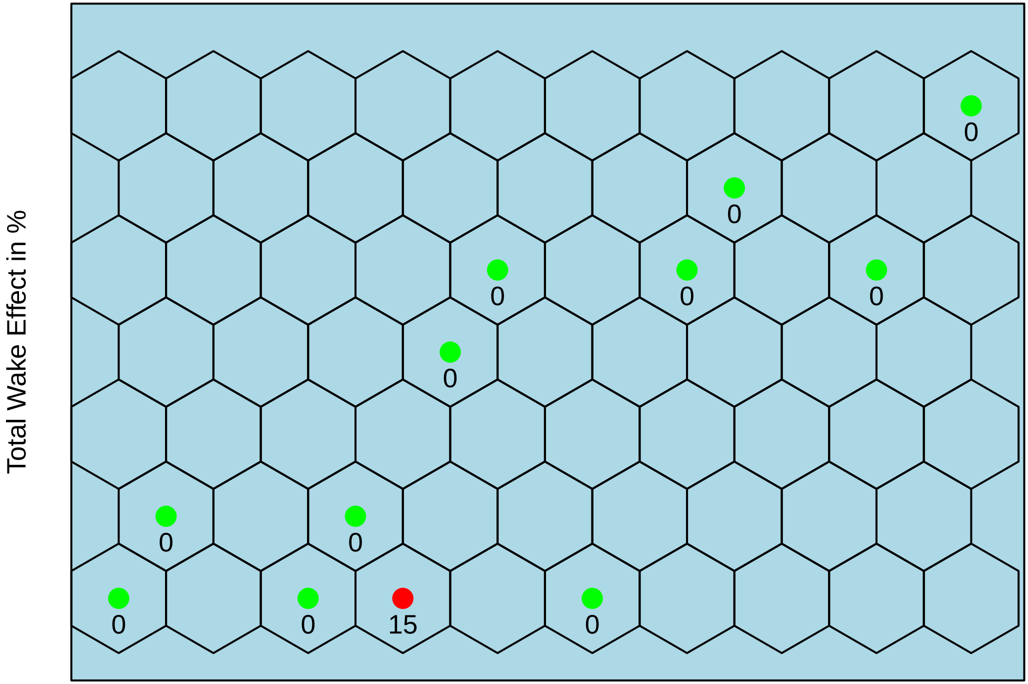
mean Distance 686.6

1 Best Energy Windfarm
Energy Output 19719.67 kW
Efficiency: 92.6 %



minimal Distance 150
mean Distance 686.6

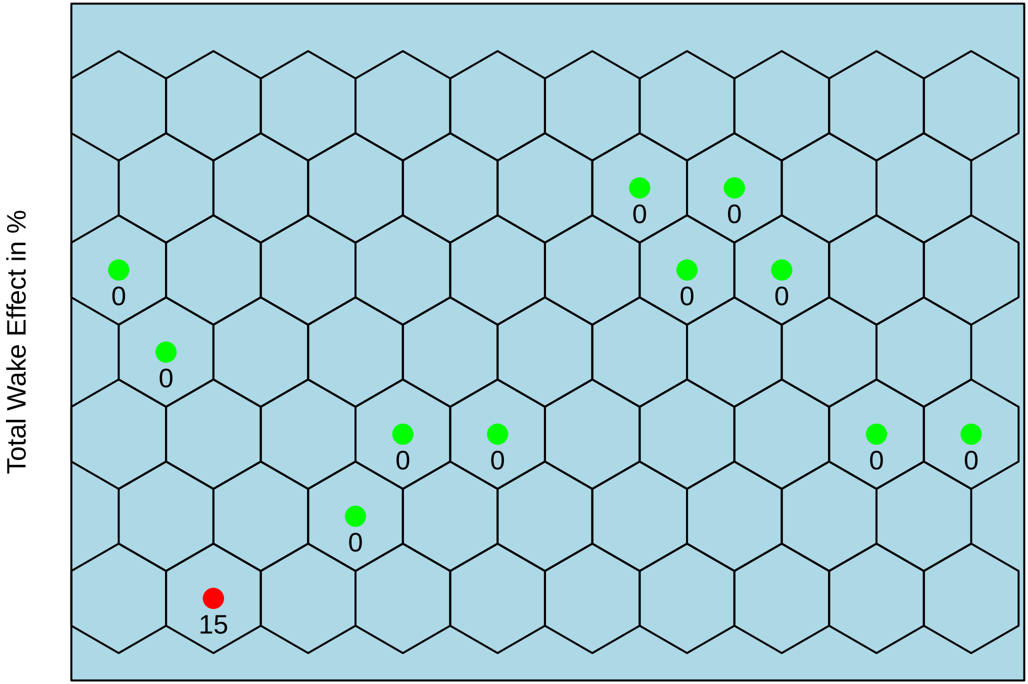
2 Best Energy Windfarm
Energy Output 21161.49 kW
Efficiency: 99.37 %



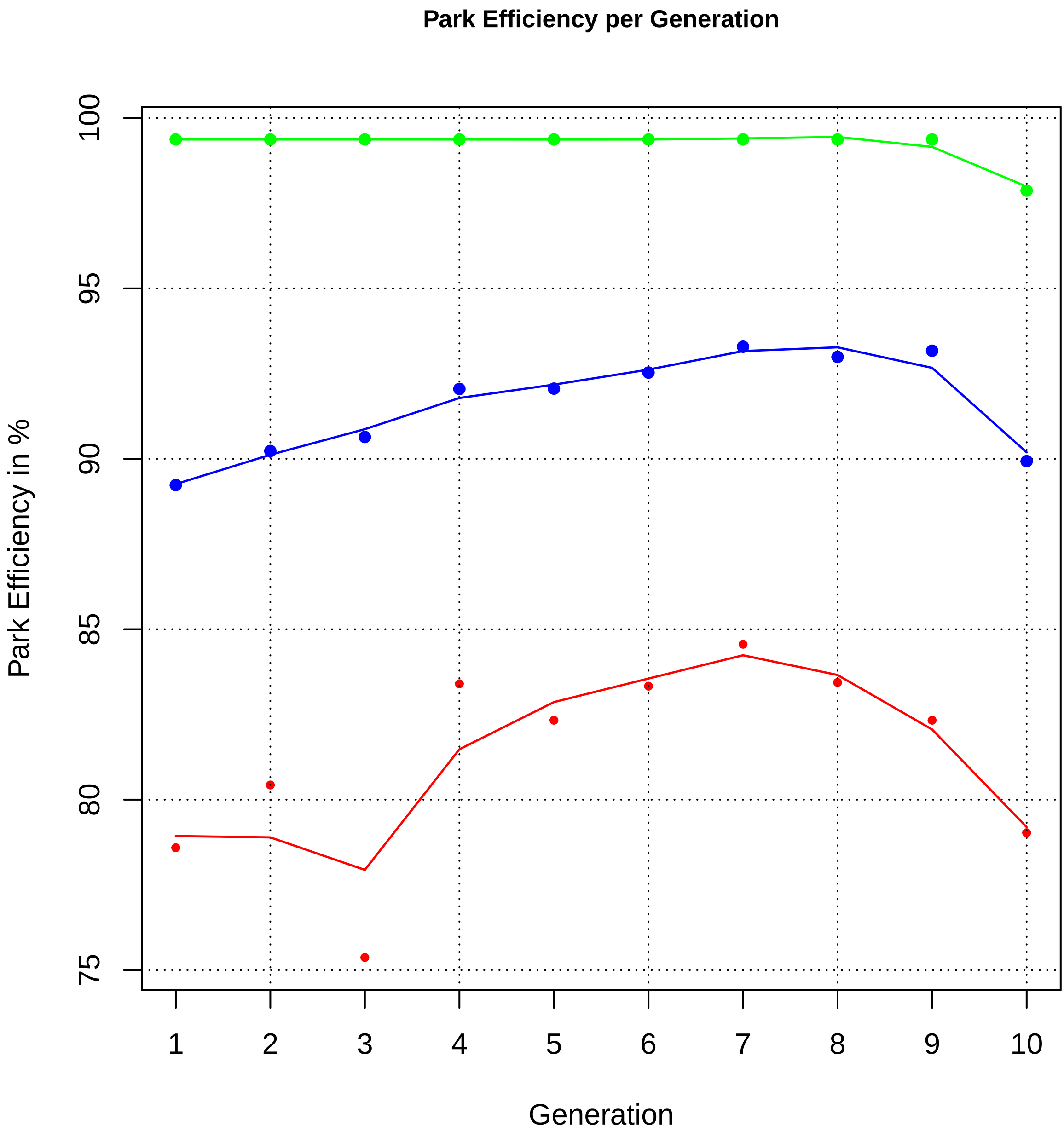
minimal Distance 150

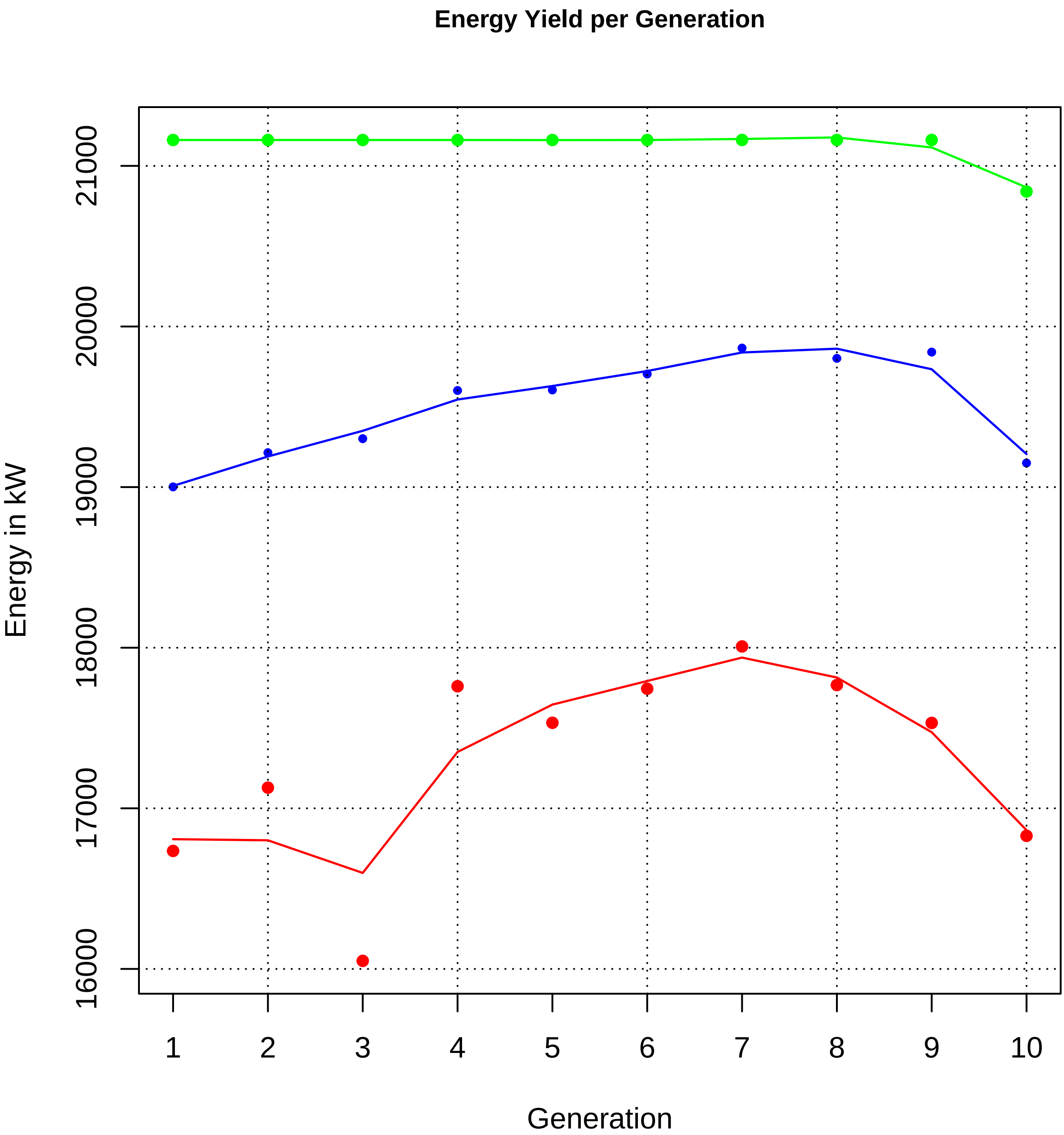
mean Distance 637.95

1 Best Energy Windfarm
Energy Output 21161.49 kW
Efficiency: 99.37 %

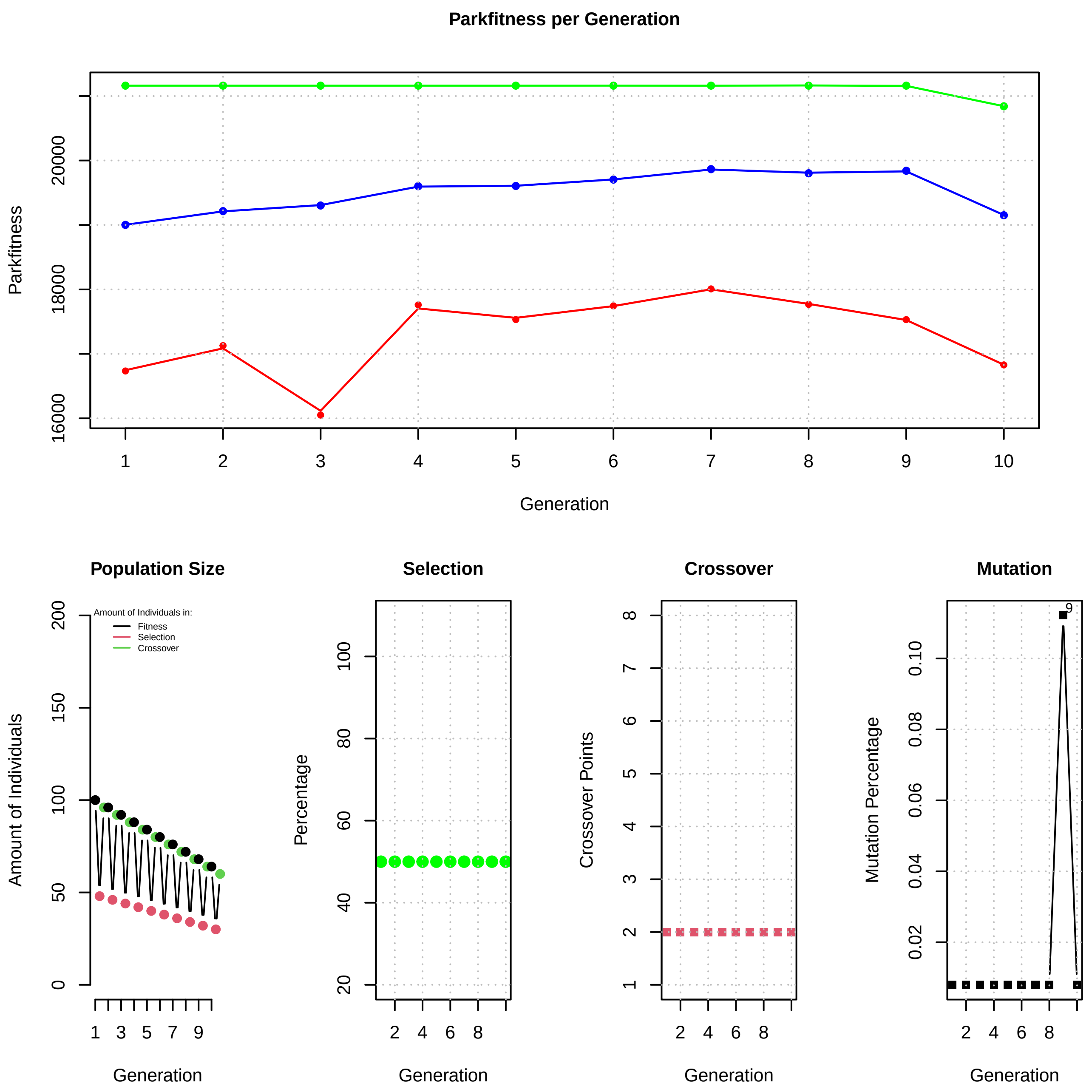


minimal Distance 150
mean Distance 627.61

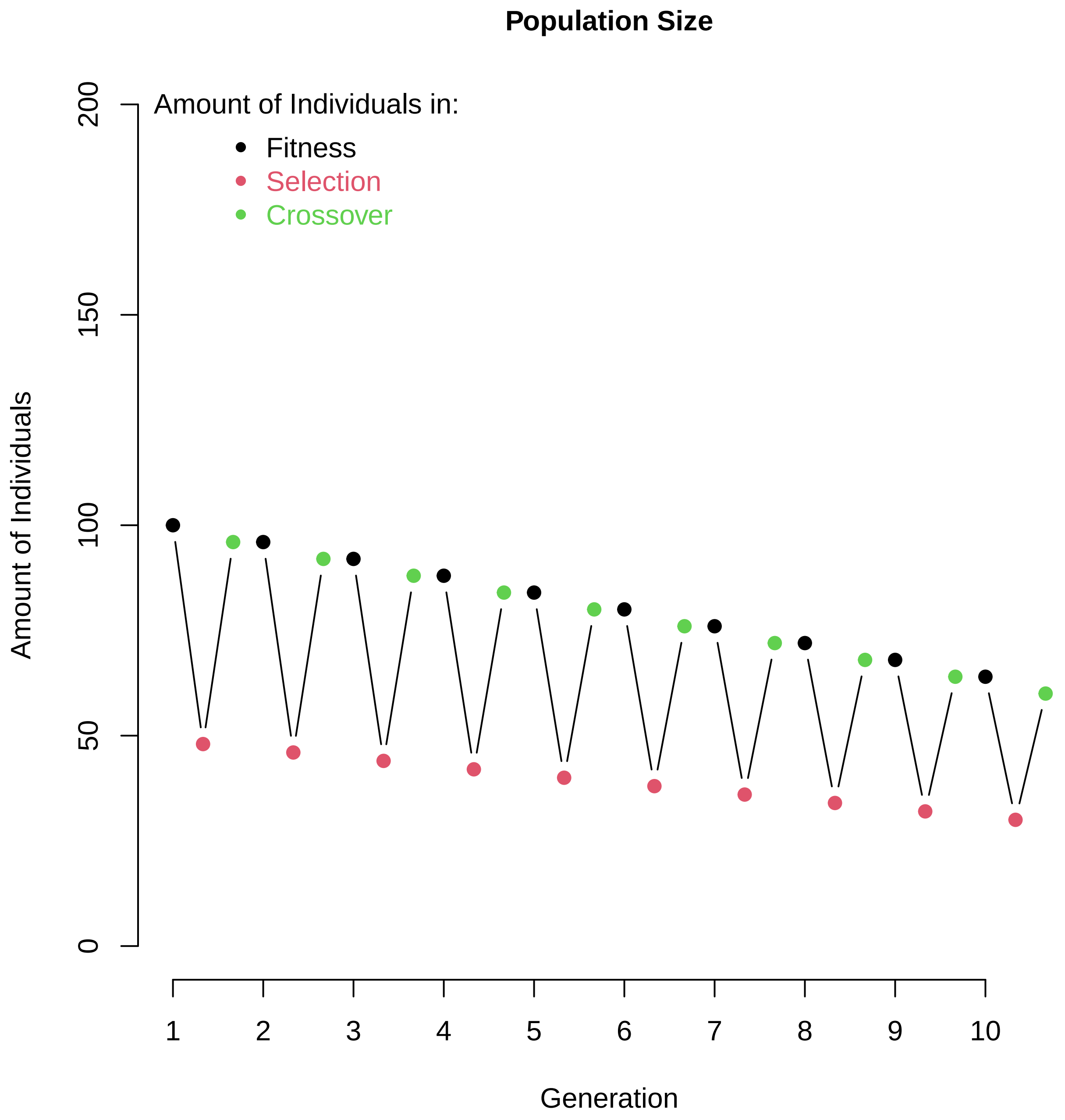

Park Efficiency per Generation
Park Efficiency in %
100
95
90
85
80
75
1
2
3
4
5
6
7
8
9
10
Generation

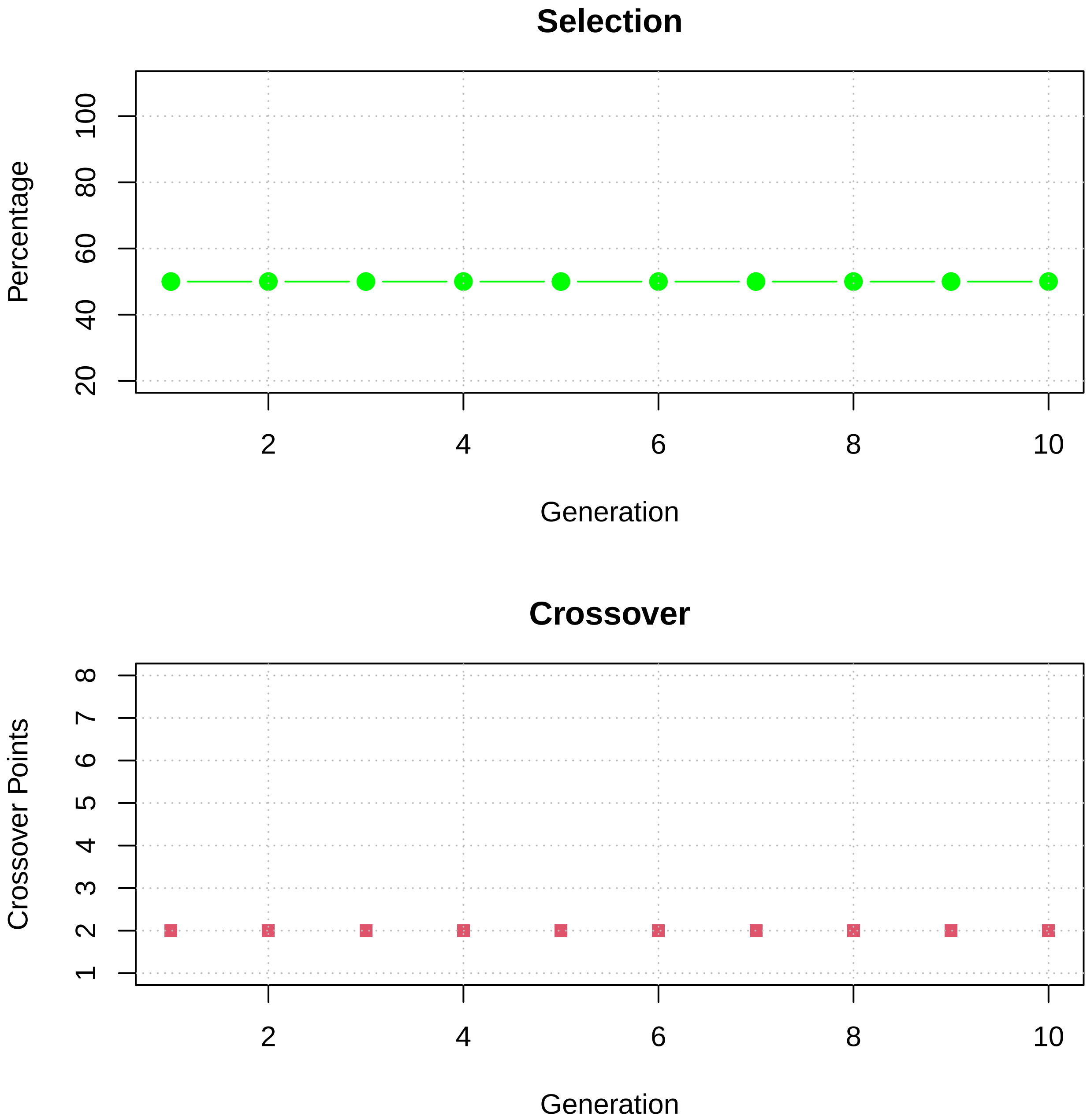


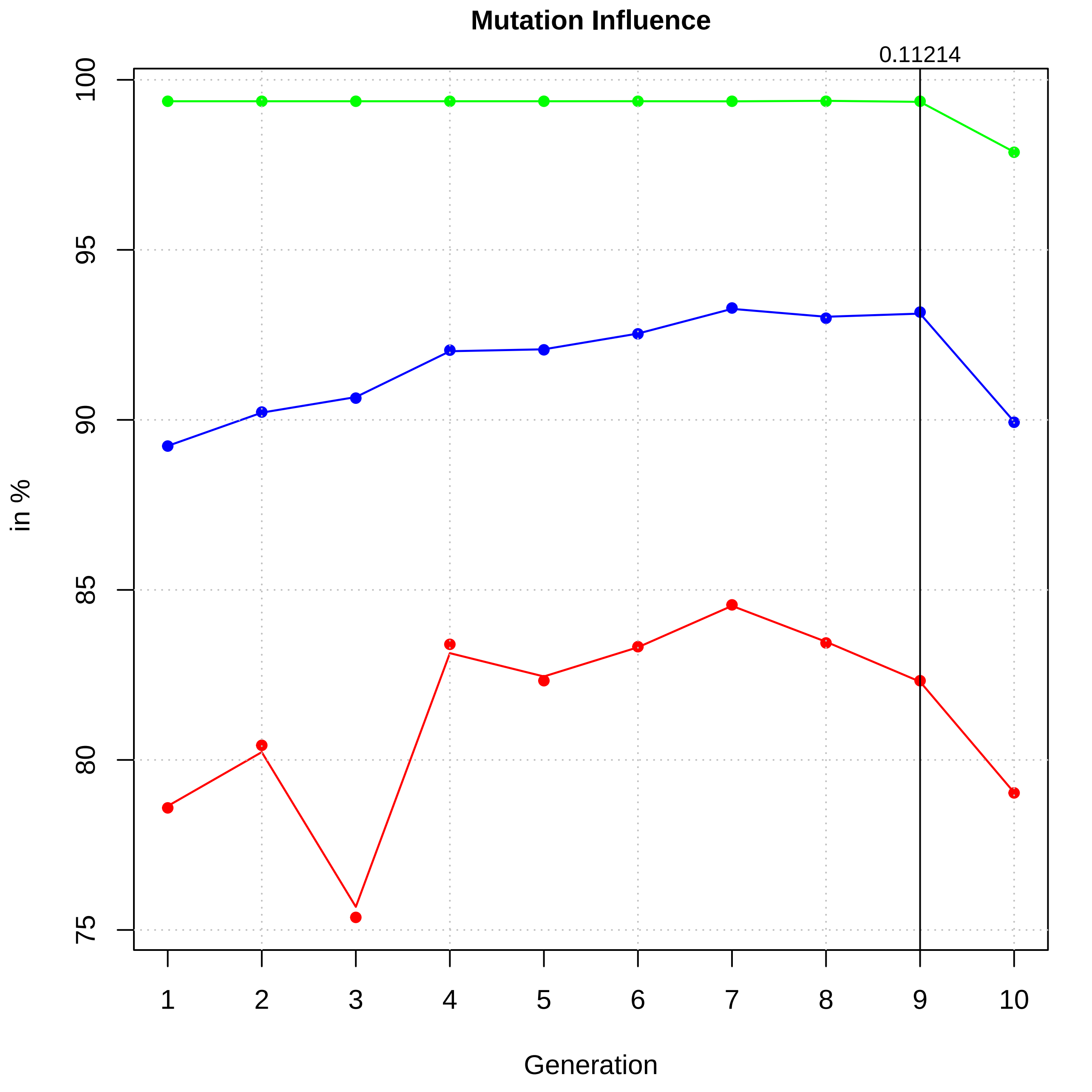
Energy Yield per Generation
Energy in kW
21000
20000
19000
18000
17000
16000
1
2
3
4
5
6
7
8
9
10
Generation



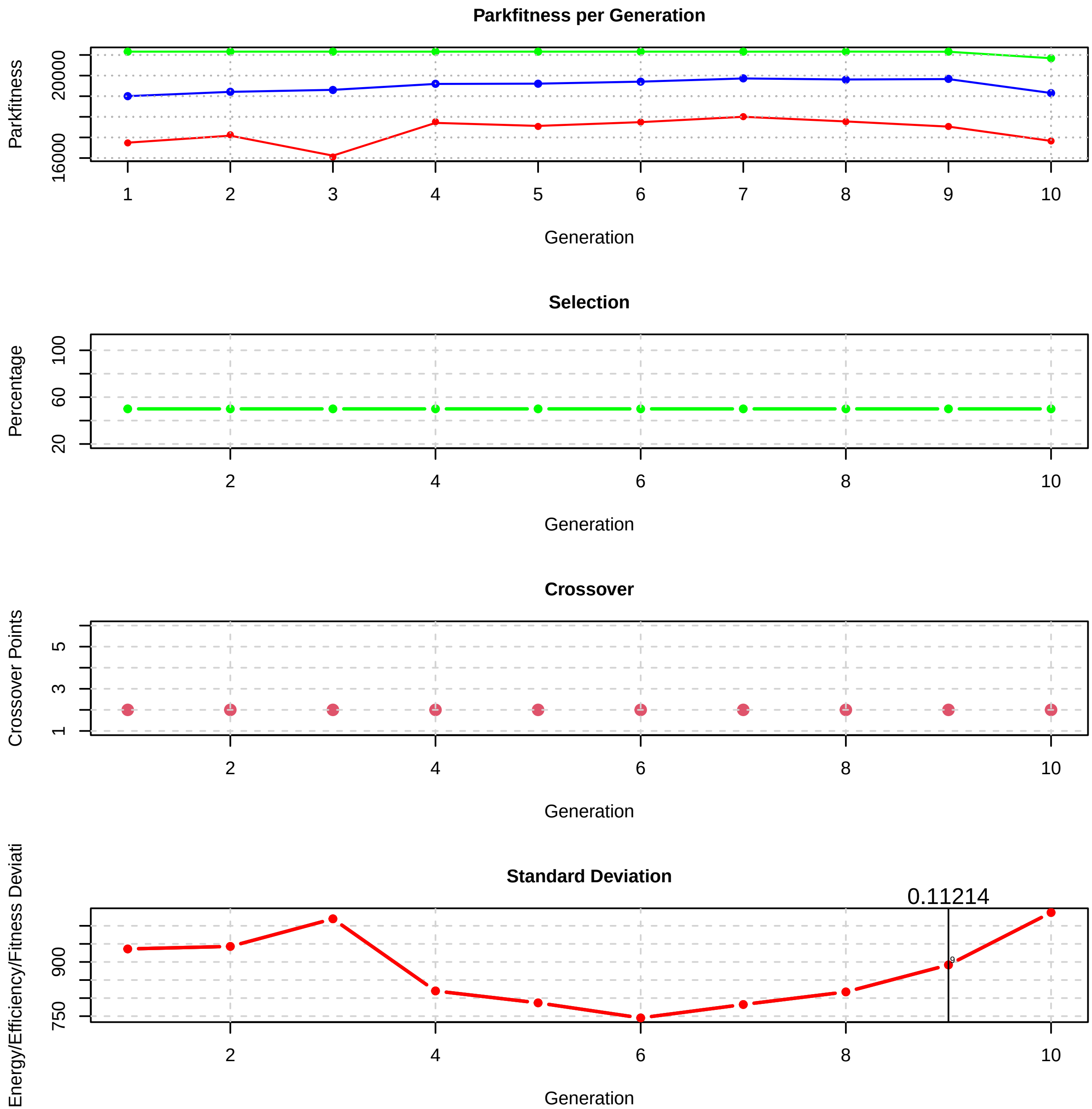
Parkfitness per Generation
Parkfitness
16000
18000
20000
1
2
3
4
5
6
7
8
9
10
Generation
Population Size
Amount of Individuals
Amount of Individuals in:
Fitness
Selection
Crossover
0
50
100
150
200
1
3
5
7
9
Generation
Selection
Percentage
20
40
60
80
100
2
4
6
8
Generation
Crossover
Crossover Points
1
2
3
4
5
6
7
8
2
4
6
8
Generation
Mutation
Mutation Percentage
0.02
0.04
0.06
0.08
0.10
9
2
4
6
8
Generation

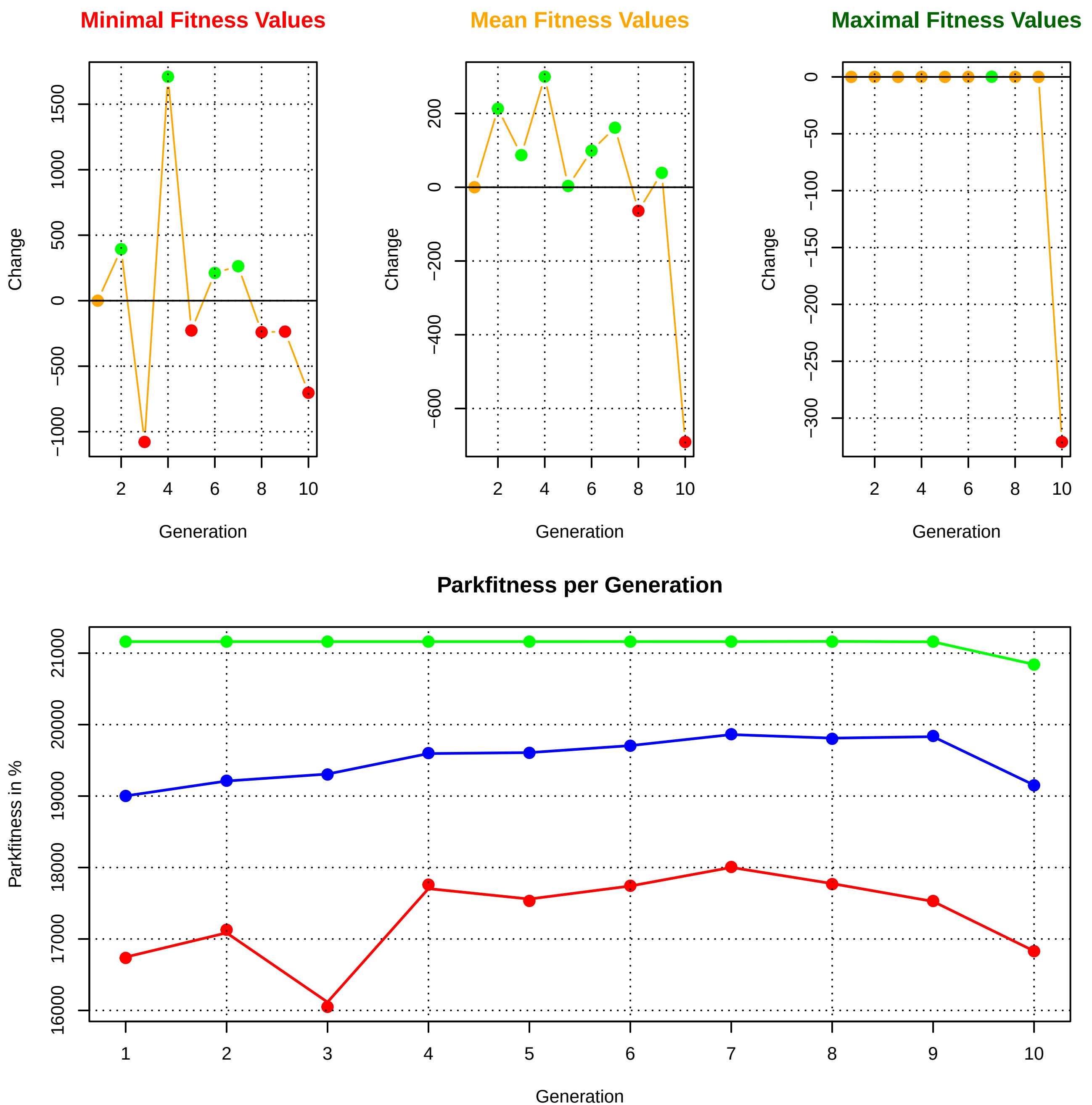

Population Size
Amount of Individuals in:
Fitness
Selection
Crossover
Amount of Individuals
0
50
100
150
200
Generation
1
2
3
4
5
6
7
8
9
10


Selection
Percentage
20
40
60
80
100
2
4
6
8
10
Generation
Crossover
Crossover Points
1
2
3
4
5
6
7
8
2
4
6
8
10
Generation

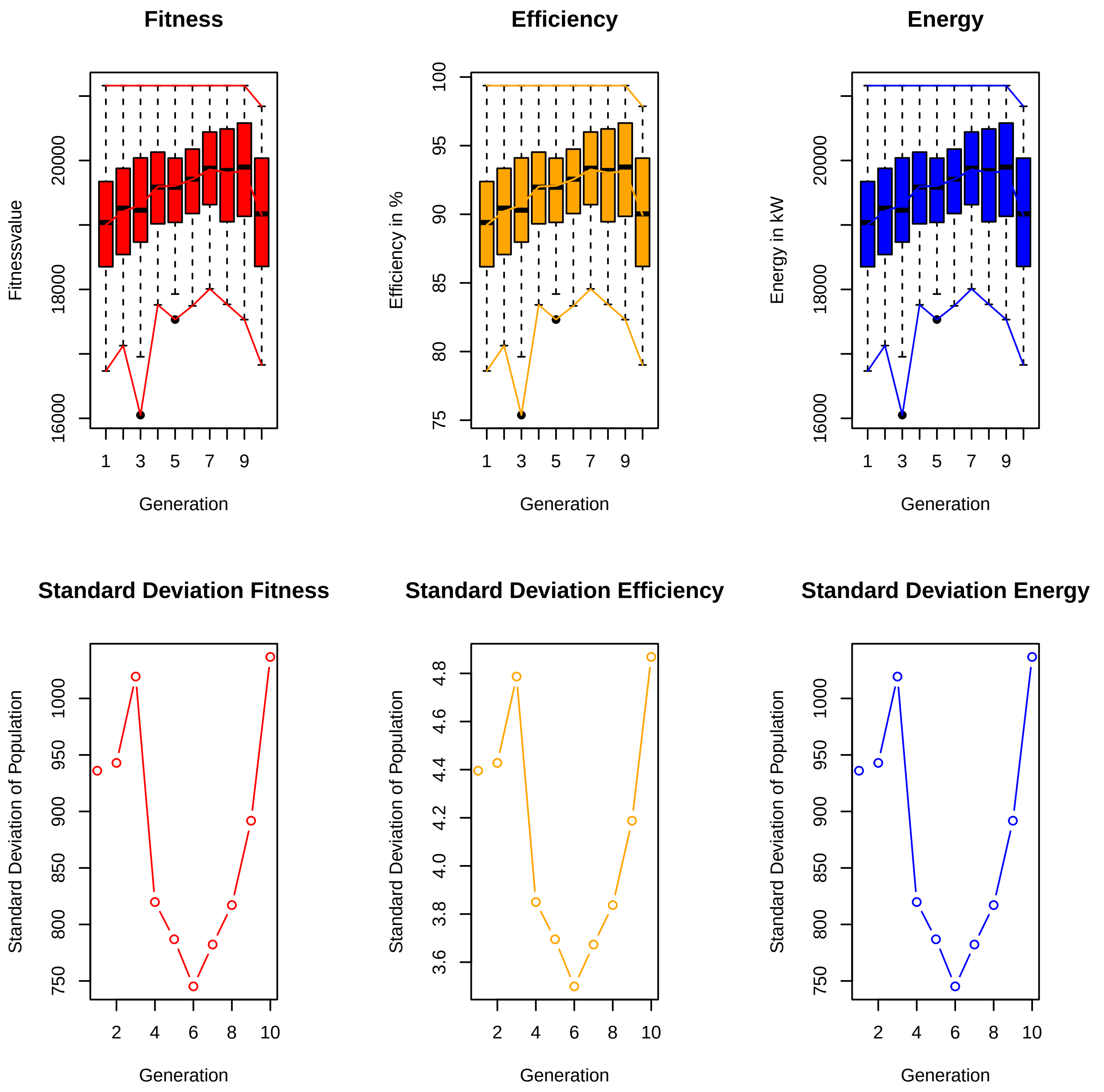


Mutation Influence
0.11214
100
95
90
85
80
75
in %
1
2
3
4
5
6
7
8
9
10
Generation

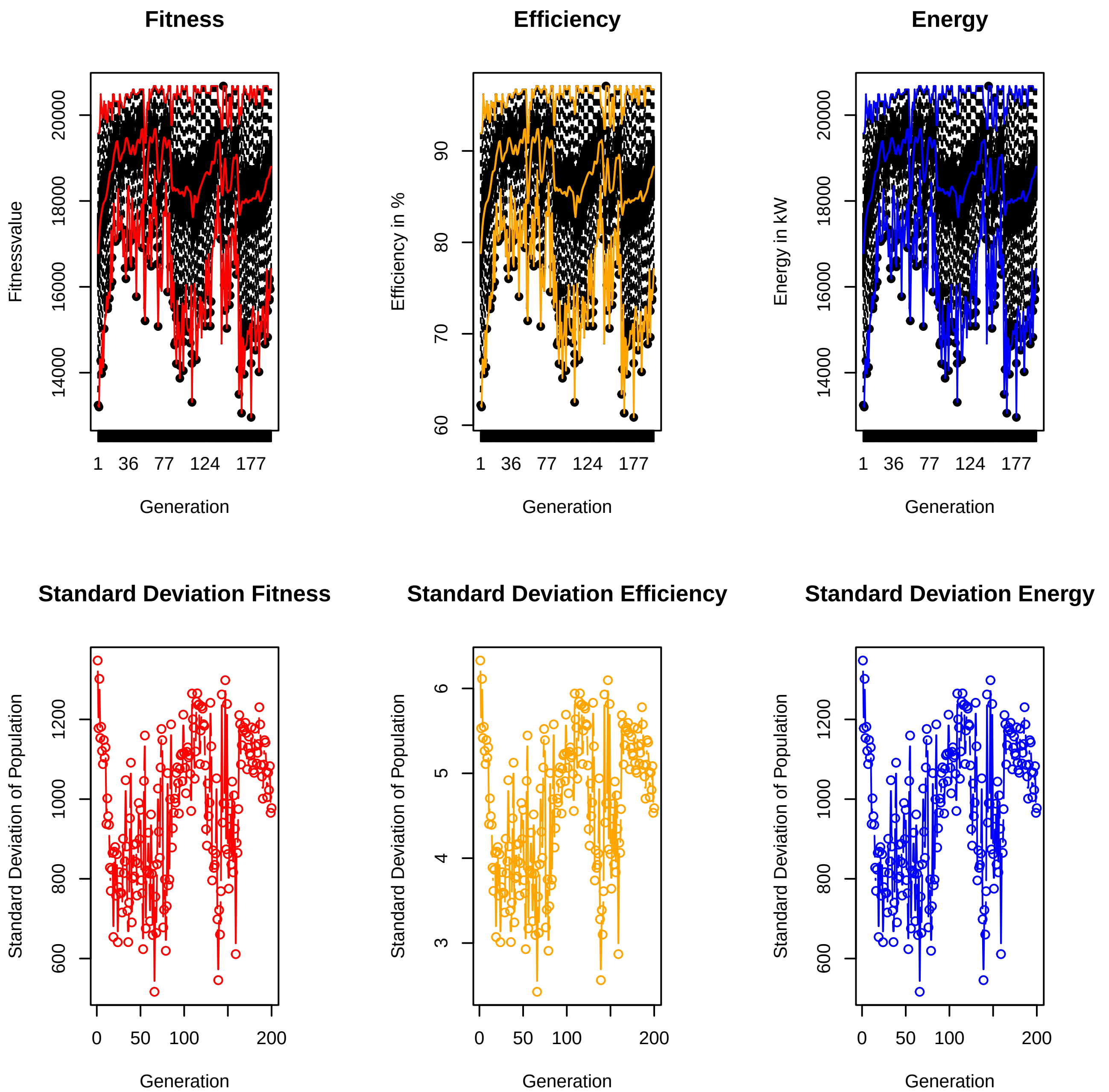

Parkfitness per Generation
Parkfitness
16000
60
20
20000
Generation
Selection
Percentage
20
60
100
Crossover
Crossover Points
1
3
5
Standard Deviation
Energy/Efficiency/Fitness Deviati
750
900
0.11214
2
4
6
8
10

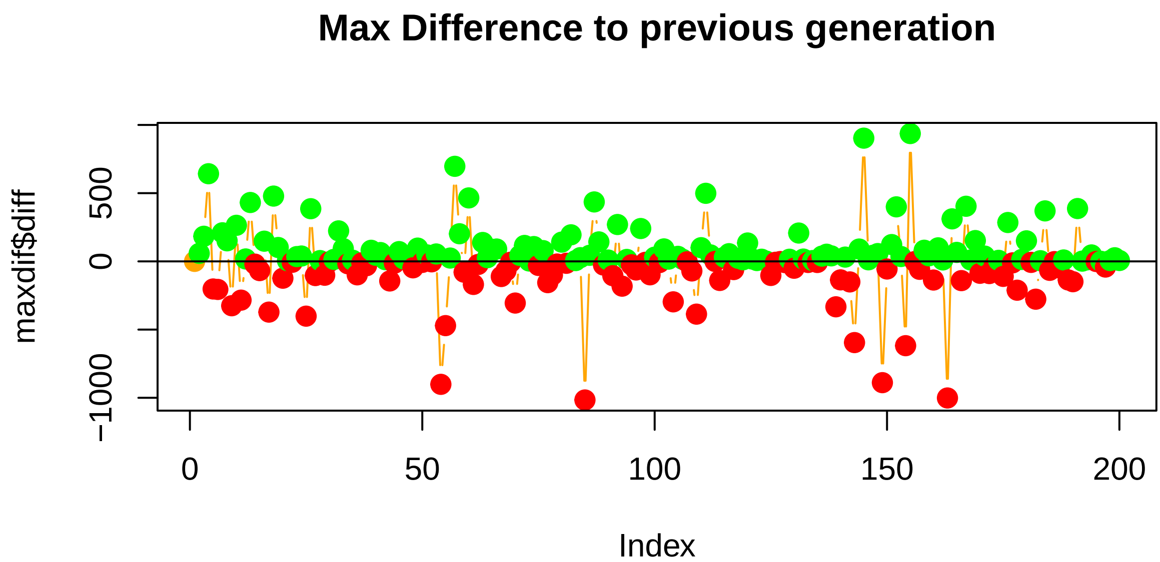


Minimal Fitness Values
Mean Fitness Values
Maximal Fitness Values
Change
Generation
Parkfitness per Generation
Parkfitness in %

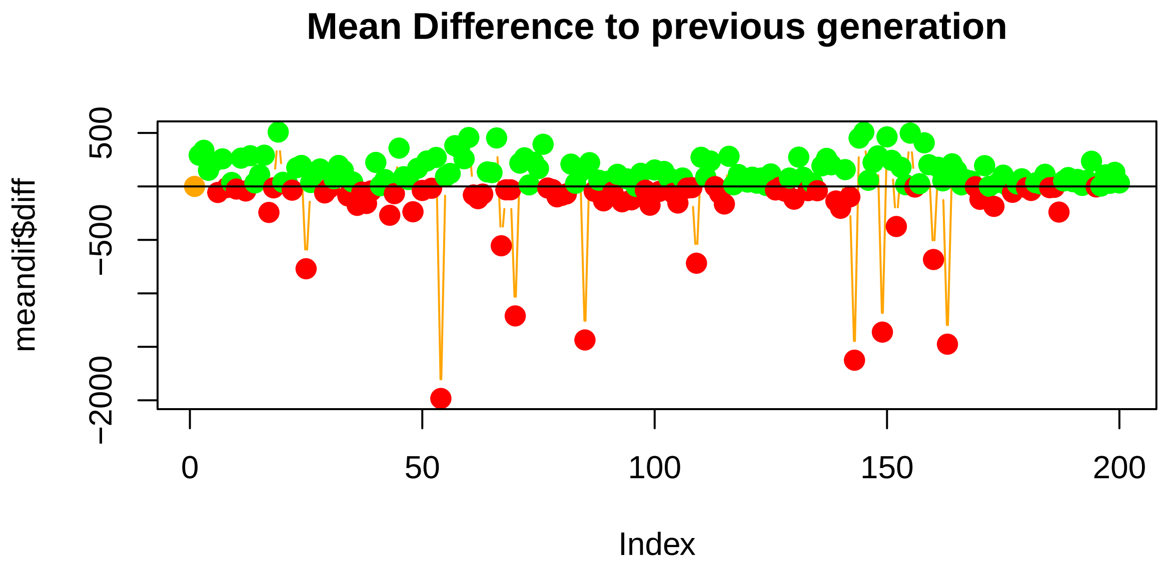


Fitness
Fitnessvalue
16000
18000
20000
1
3
5
7
9
Generation
Efficiency
Efficiency in %
75
80
85
90
95
100
1
3
5
7
9
Generation
Energy
Energy in kW
16000
18000
20000
1
3
5
7
9
Generation
Standard Deviation Fitness
Standard Deviation of Population
750
800
850
900
950
1000
2
4
6
8
10
Generation
Standard Deviation Efficiency
Standard Deviation of Population
3.6
3.8
4.0
4.2
4.4
4.6
4.8
2
4
6
8
10
Generation
Standard Deviation Energy
Standard Deviation of Population
750
800
850
900
950
1000
2
4
6
8
10
Generation

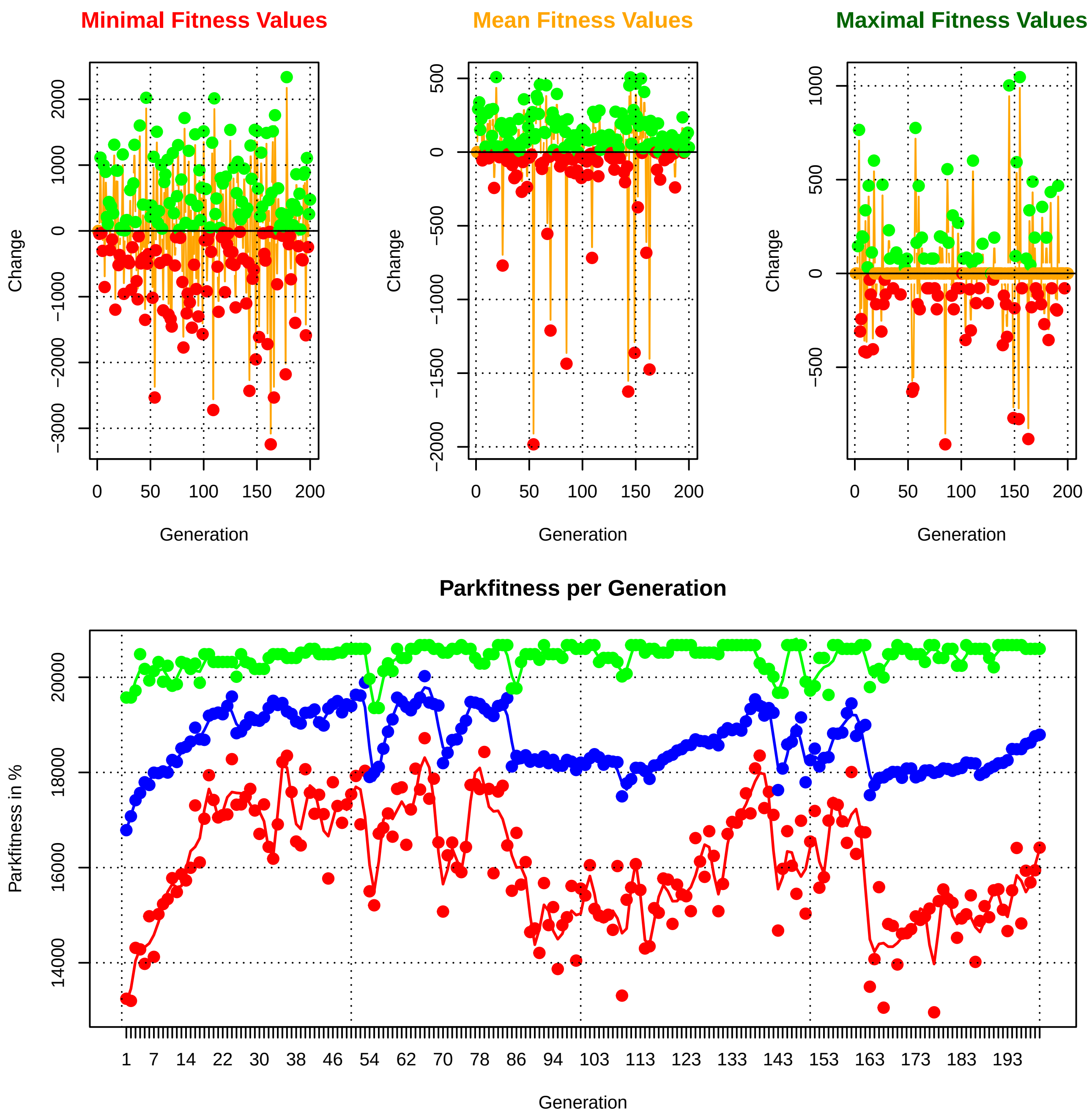

Fitness
Fitnessvalue
14000
16000
18000
20000
1
36
77
124
177
Generation
Efficiency
Efficiency in %
60
70
80
90
1
36
77
124
177
Generation
Energy
Energy in kW
14000
16000
18000
20000
1
36
77
124
177
Generation
Standard Deviation Fitness
Standard Deviation of Population
600
800
1000
1200
0
50
100
200
Generation
Standard Deviation Efficiency
Standard Deviation of Population
3
4
5
6
0
50
100
200
Generation
Standard Deviation Energy
Standard Deviation of Population
600
800
1000
1200
0
50
100
200
Generation



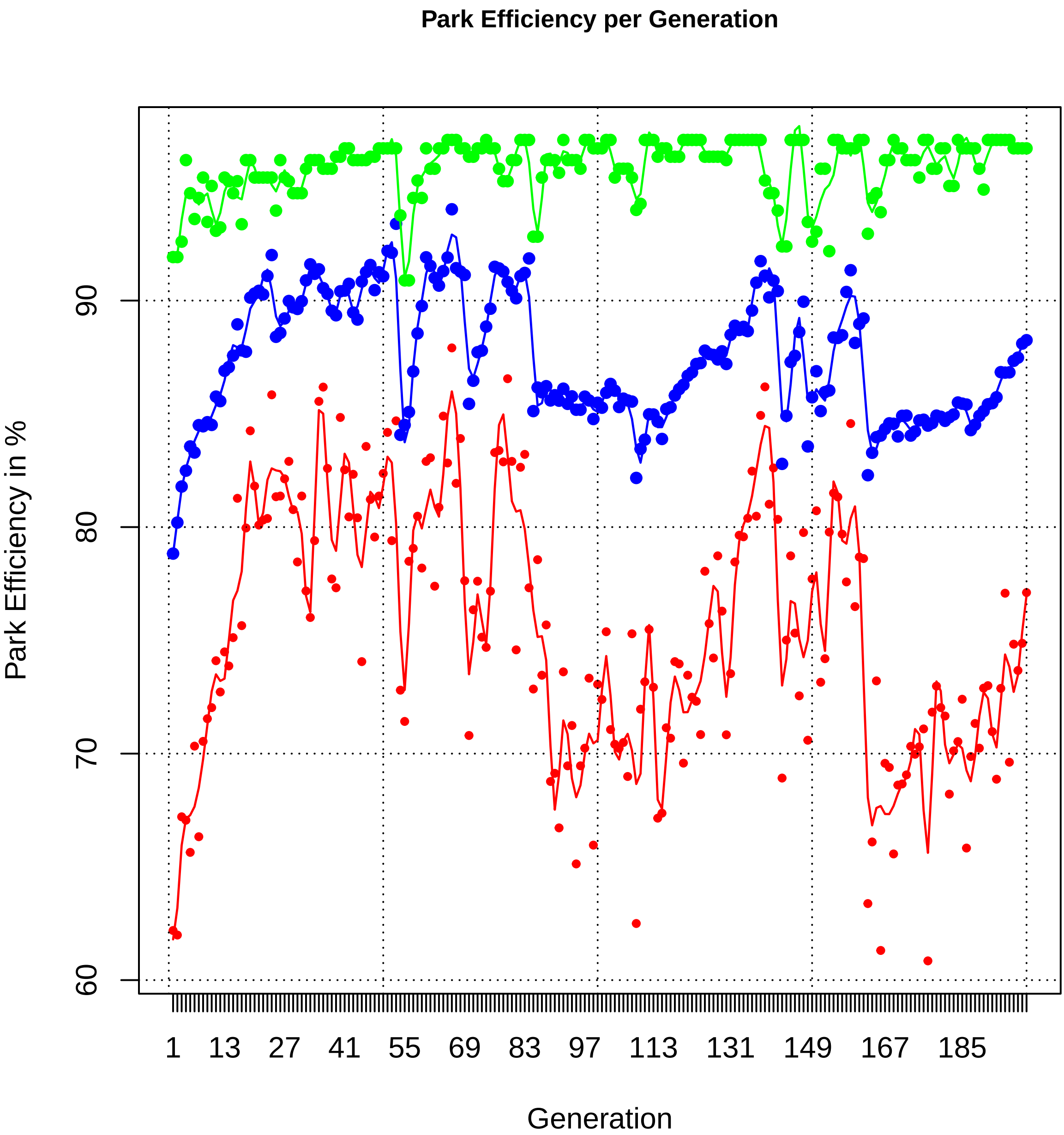
Max Difference to previous generation
maxdif$diff
−1000
0
500
0
50
100
150
200
Index



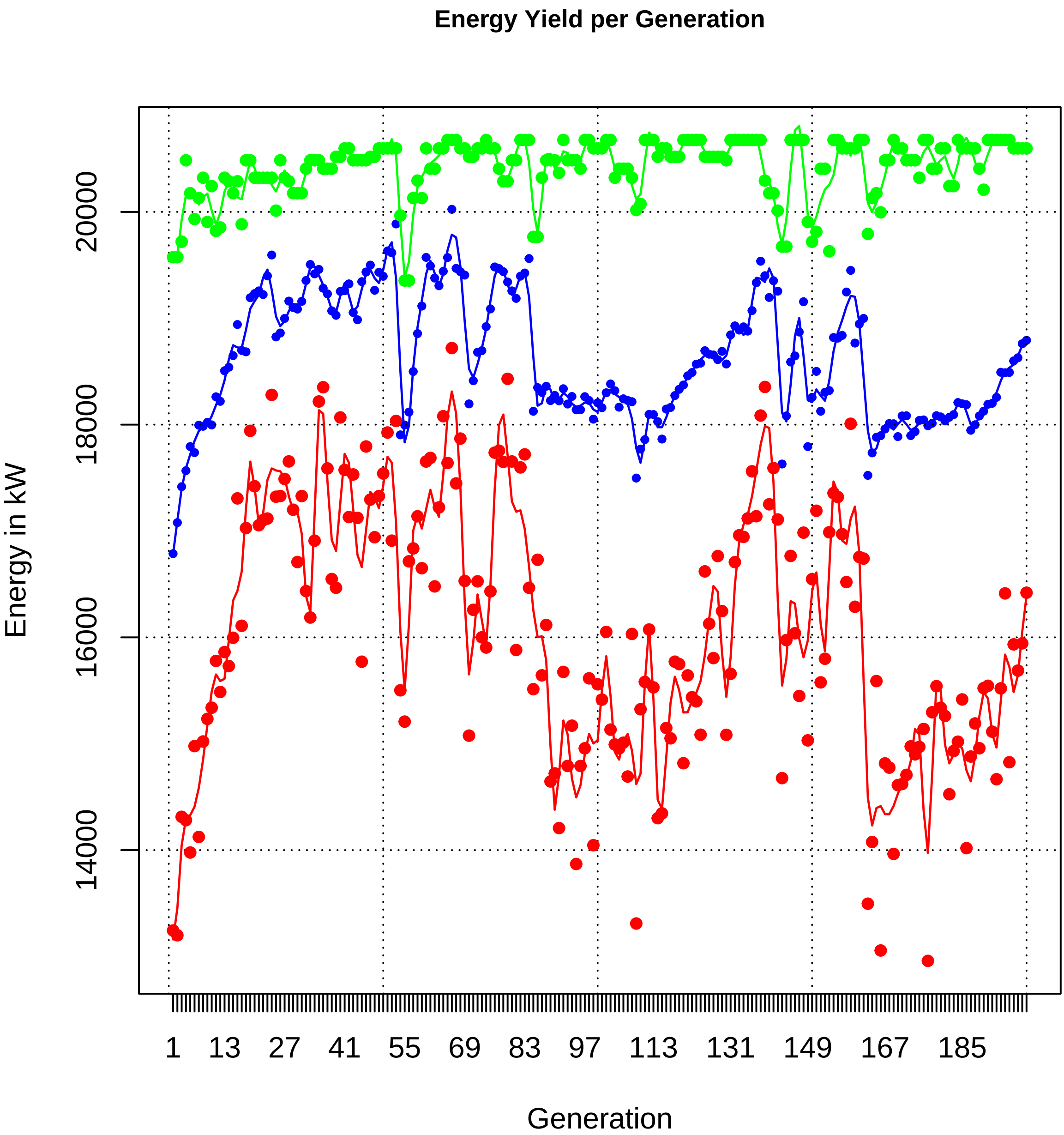
Mean Difference to previous generation
meandif$diff
−2000
−500
500
0
50
100
150
200
Index

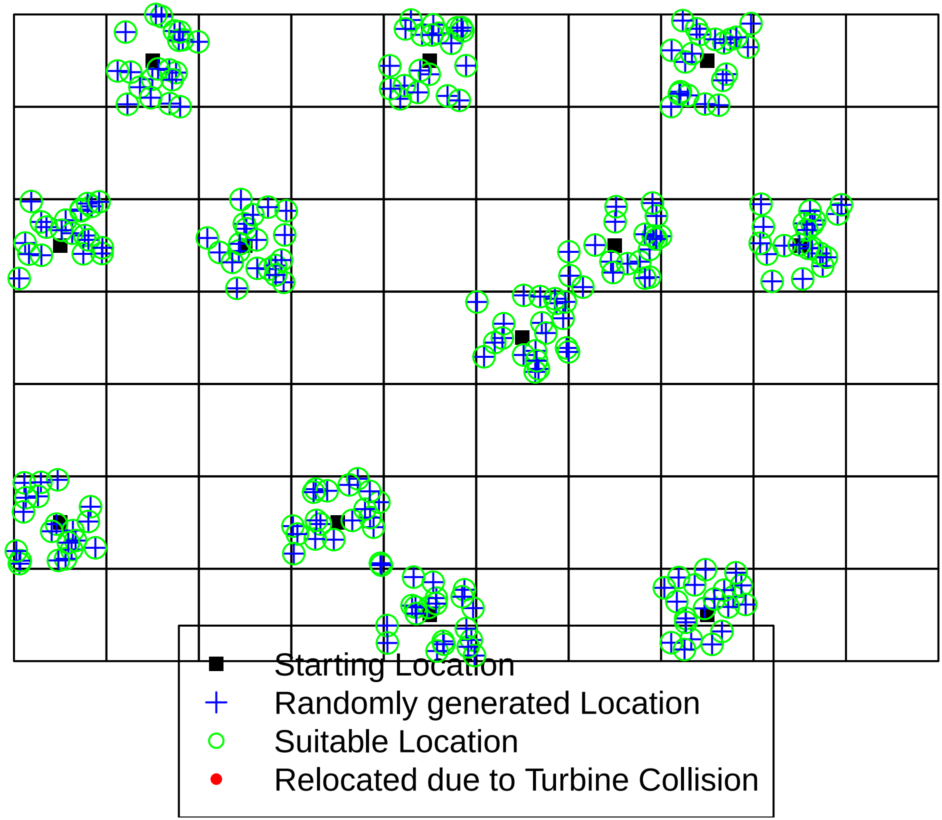


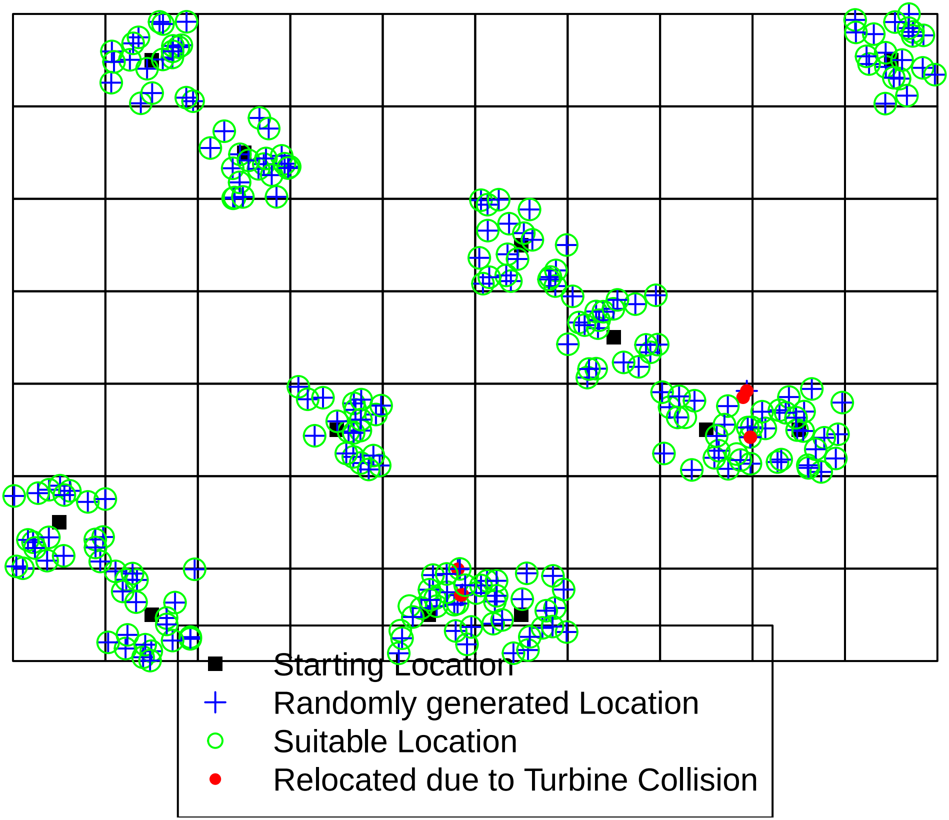
Minimal Fitness Values
Mean Fitness Values
Maximal Fitness Values
Change
Generation
Parkfitness per Generation
Parkfitness in %
Generation



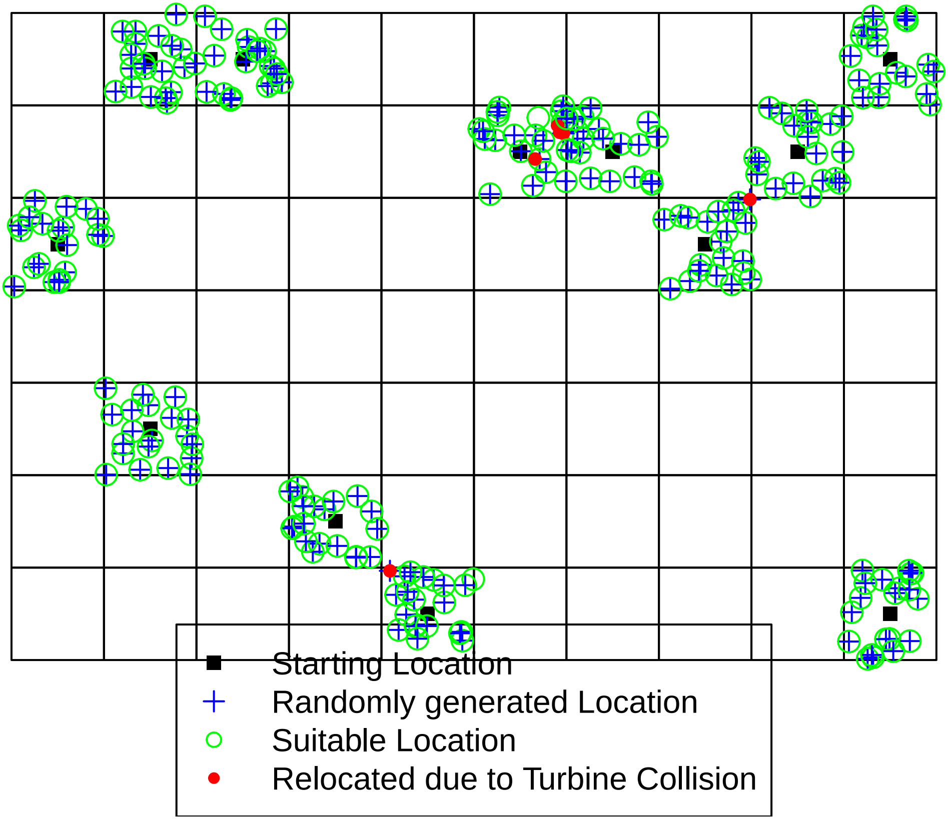
Park Efficiency per Generation
Park Efficiency in %
60
70
80
90
1
13
27
41
55
69
83
97
113
131
149
167
185
Generation

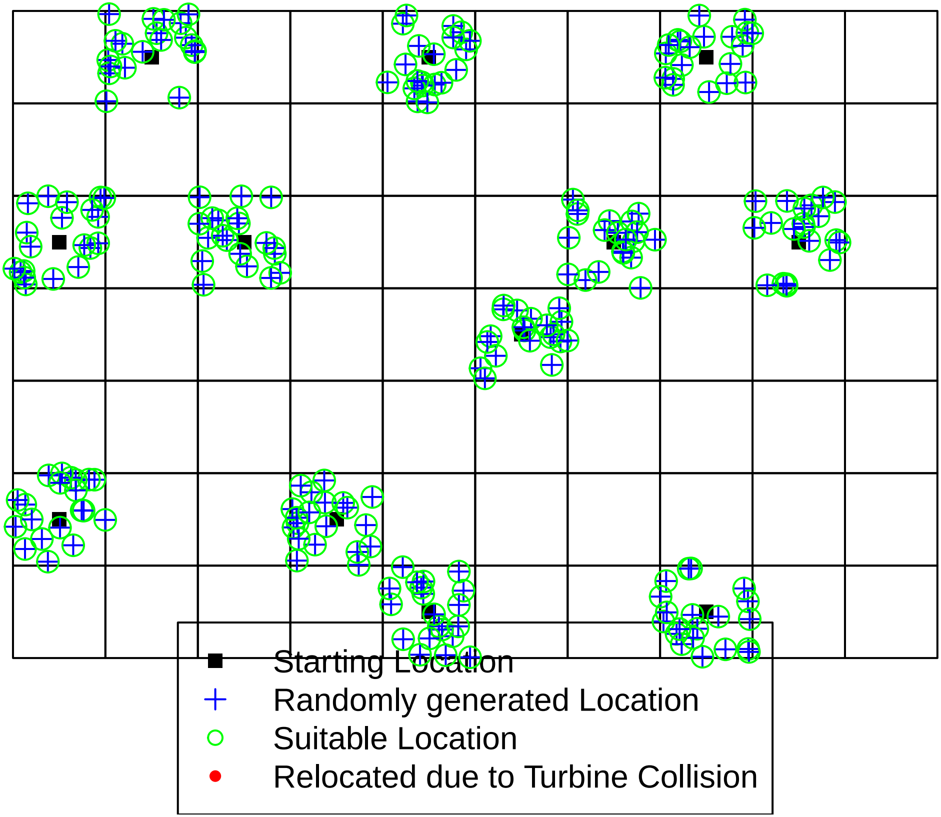

Energy Yield per Generation
Energy in kW
14000
16000
18000
20000
Generation
1
13
27
41
55
69
83
97
113
131
149
167
185

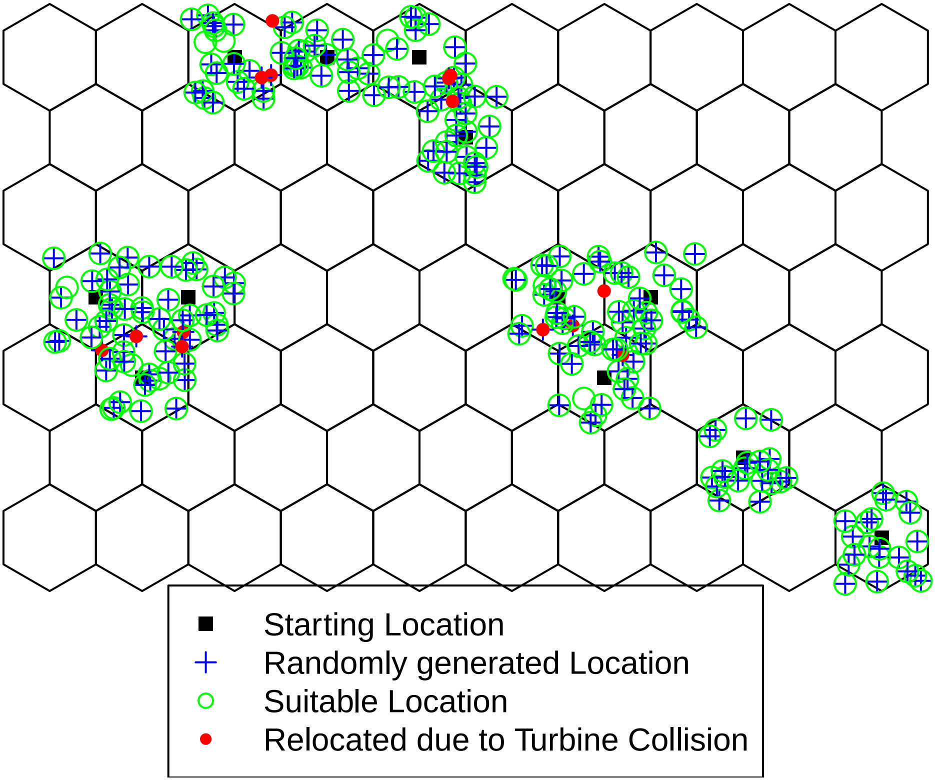

Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision



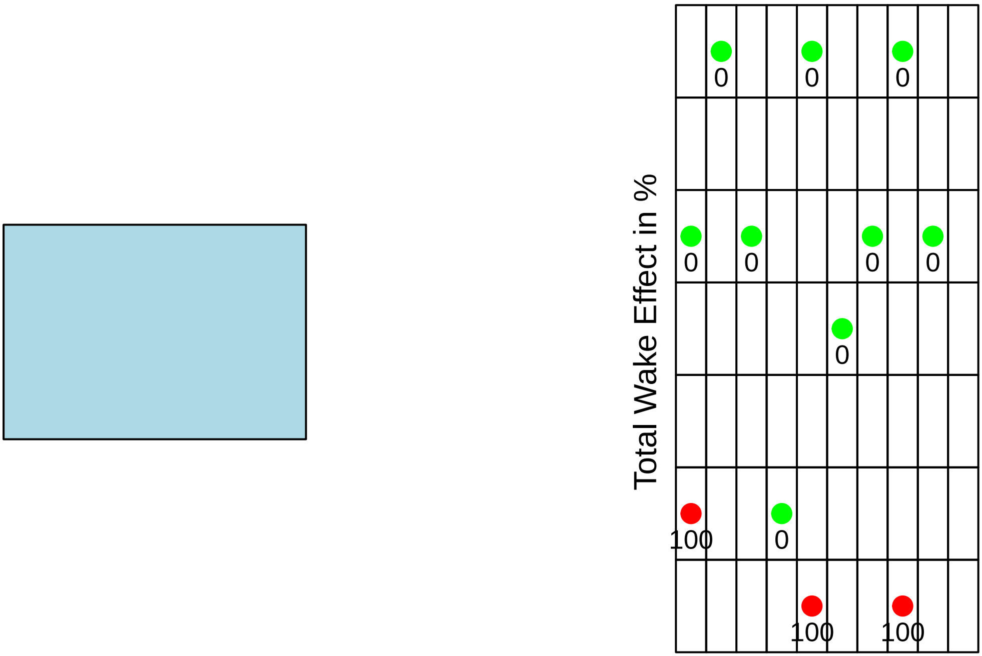
Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision


Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision


Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision

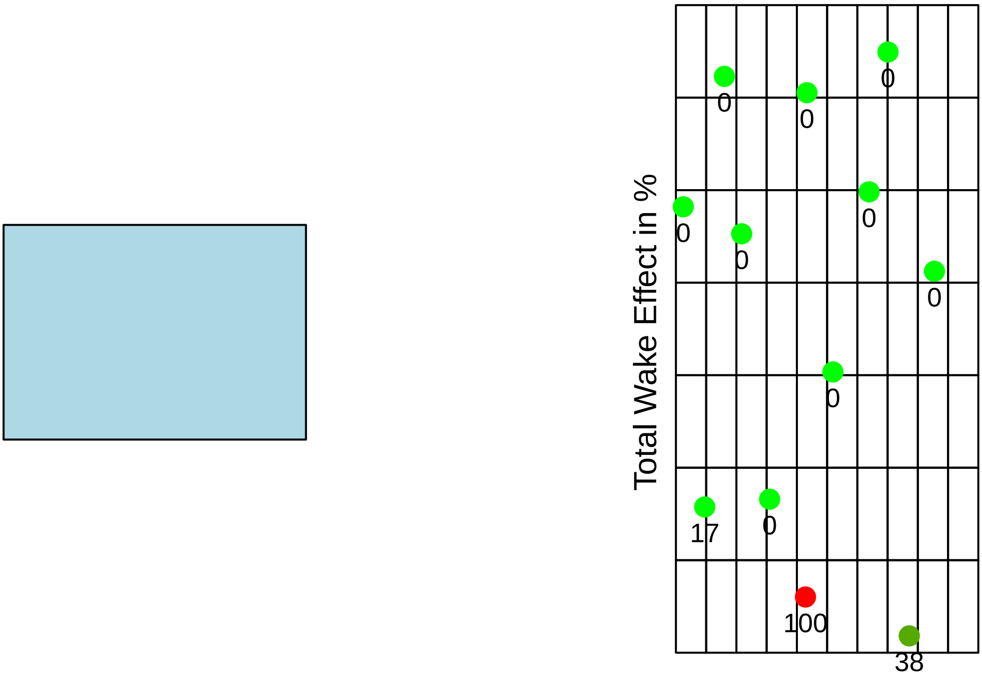

Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision

Original − Best Energy: 1
Energy Output 20011.7 kW
Efficiency: 93.97

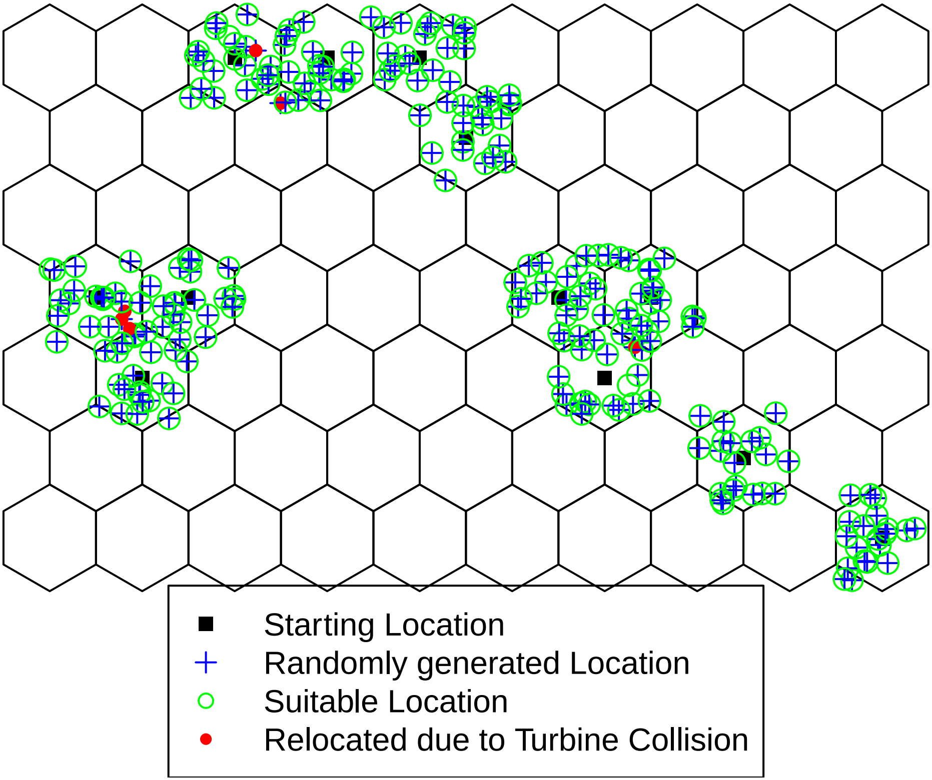


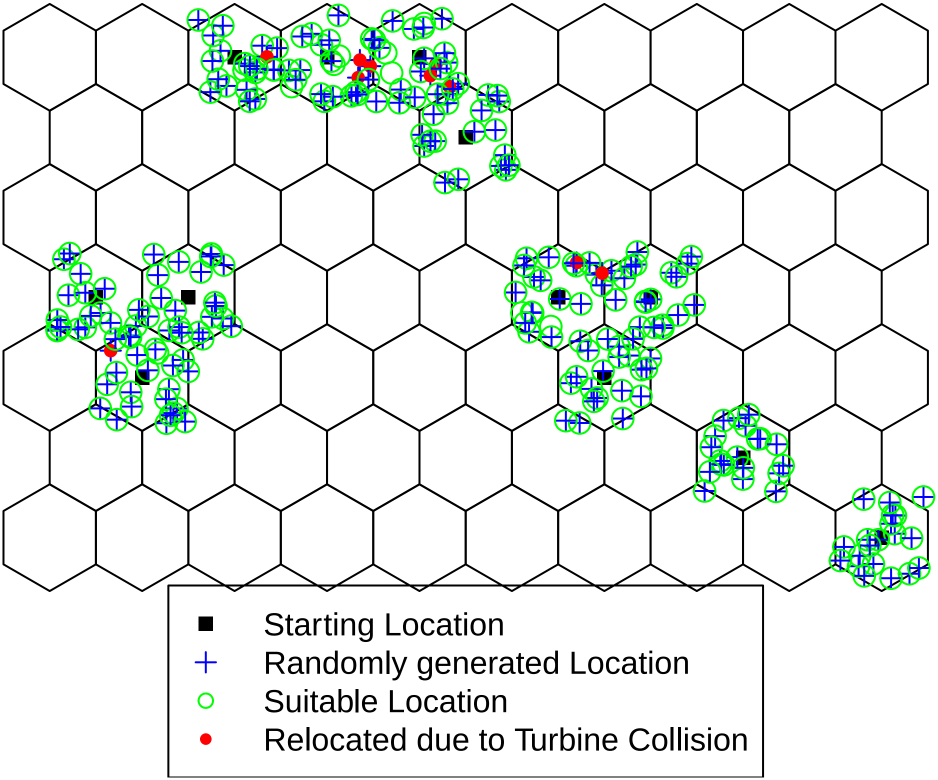
minimal Distance 212.13
mean Distance 707.05

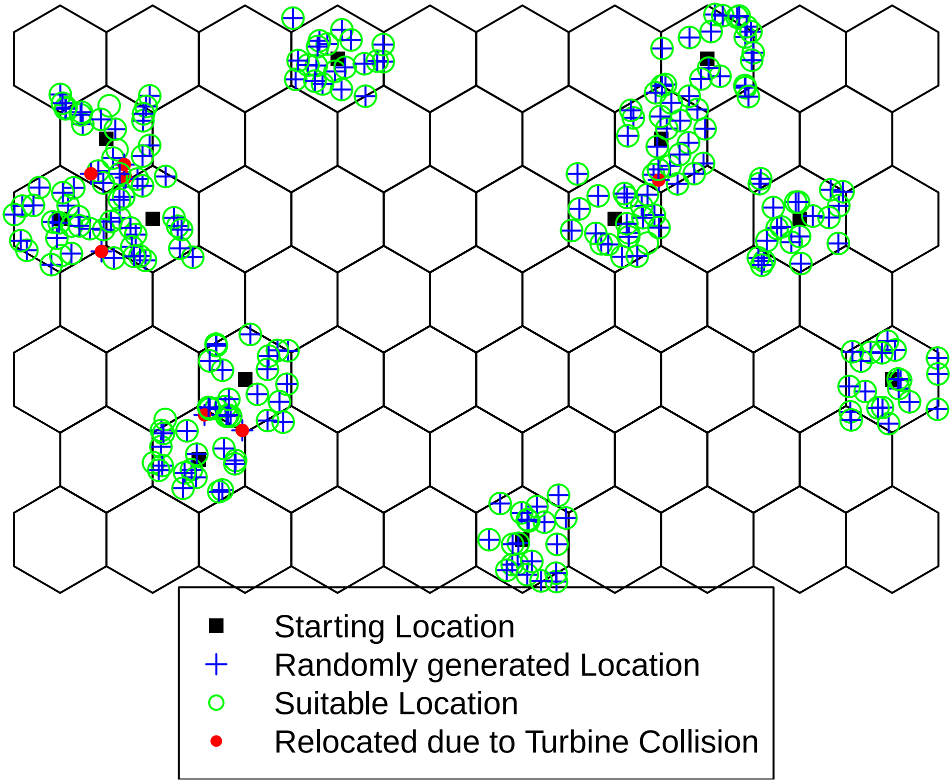
Random Search − Best Energy: 1
Energy Output 20754.85 kW
Efficiency: 97.46



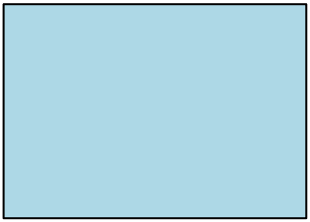
minimal Distance 238.16
mean Distance 697.38

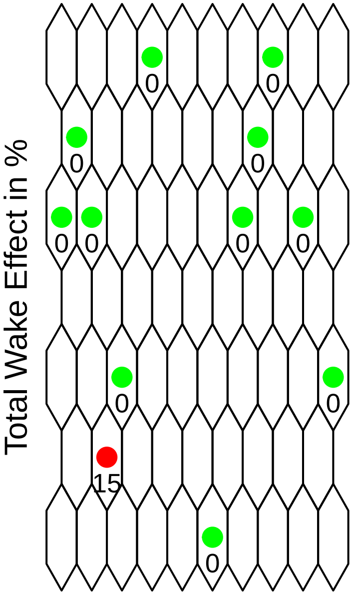

Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision


Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision


Starting Location
Randomly generated Location
Suitable Location
Relocated due to Turbine Collision

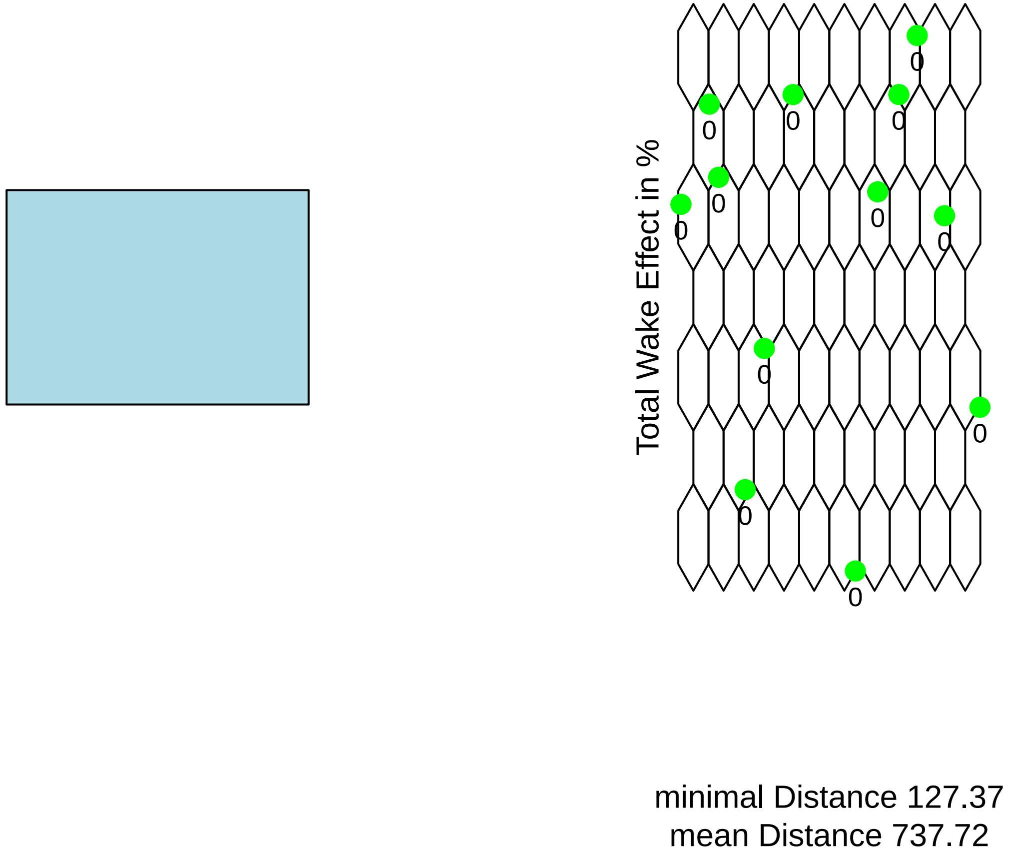
Original − Best Energy: 1
Energy Output 21161.31 kW
Efficiency: 99.37



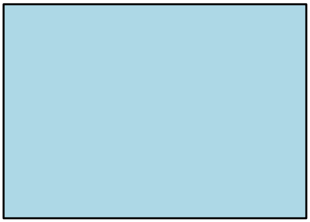


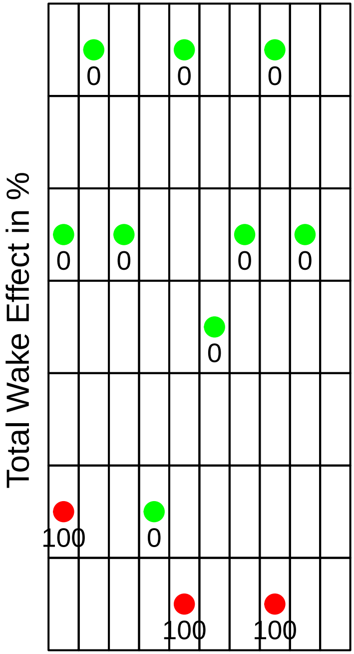
minimal Distance 150
mean Distance 686.57

Random Search − Best Energy: 1
Energy Output 21295.03 kW
Efficiency: 100

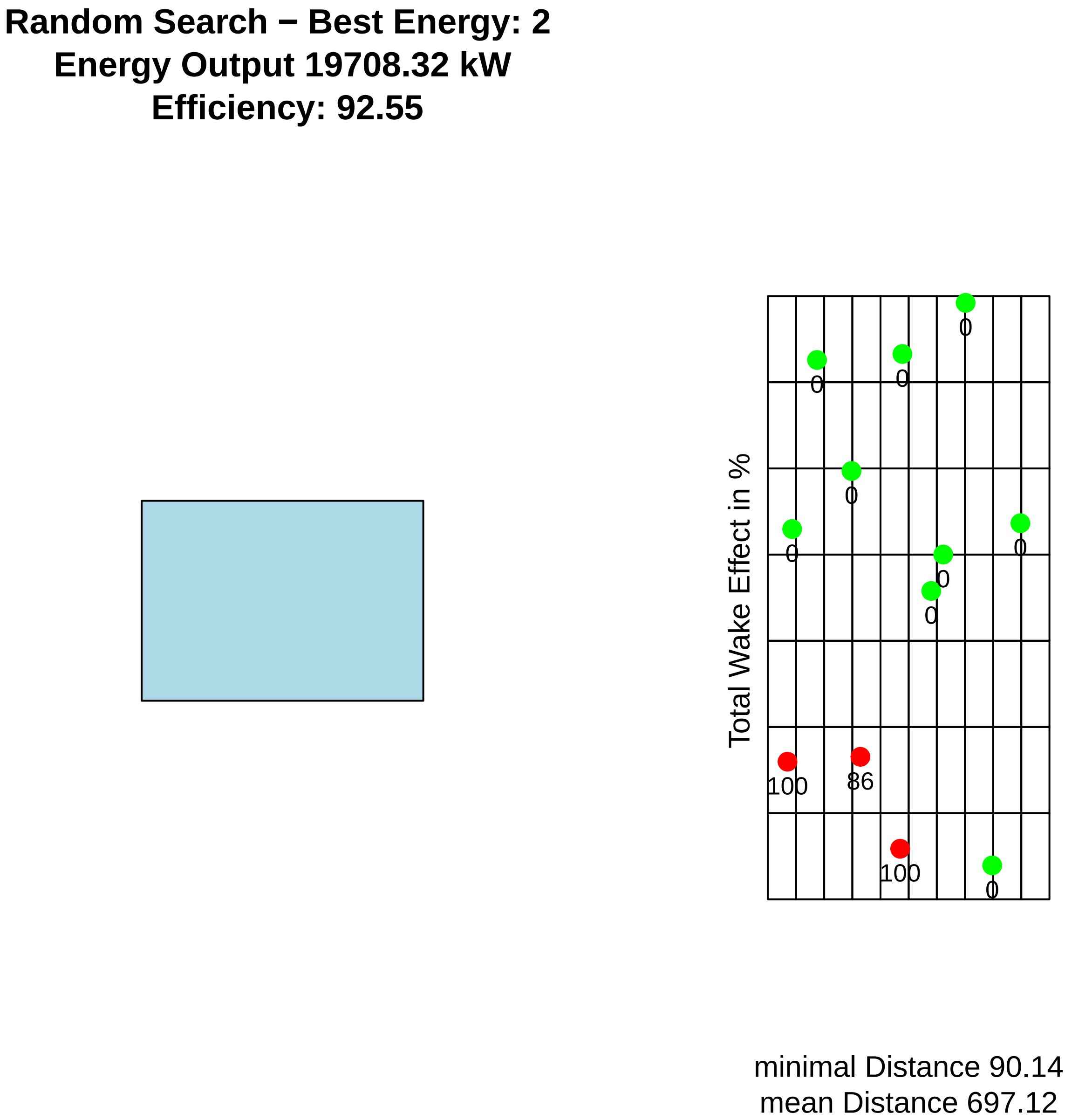


Original − Best Energy: 2
Energy Output 20011.7 kW
Efficiency: 93.97

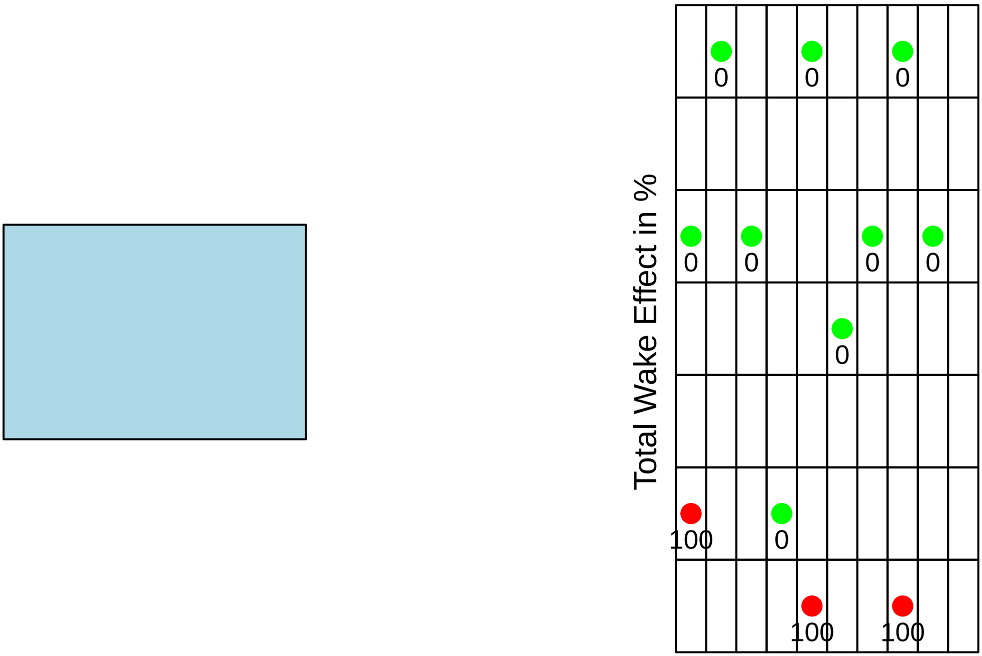




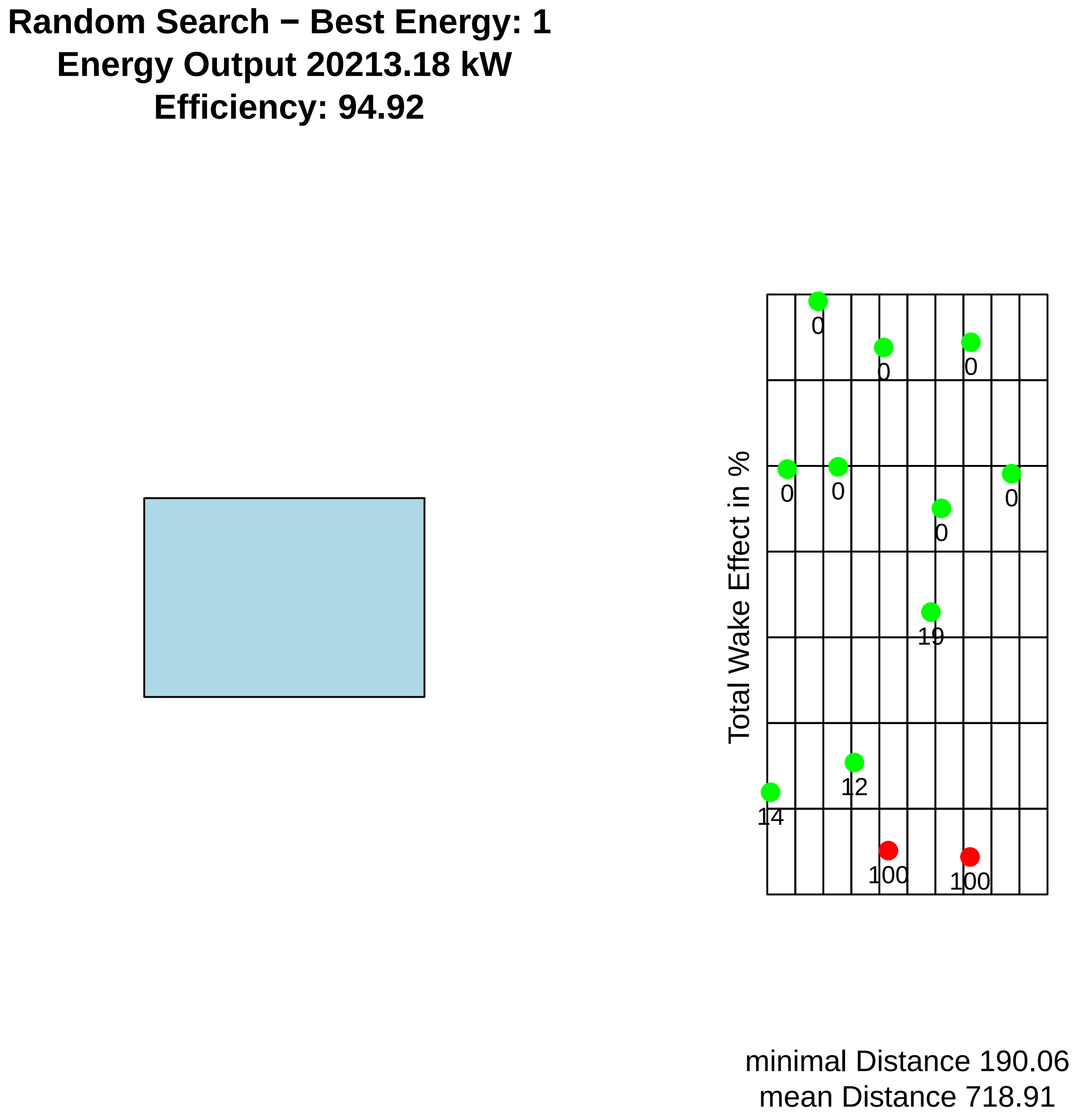
minimal Distance 212.13
mean Distance 707.05


Random Search − Best Energy: 2
Energy Output 19708.32 kW
Efficiency: 92.55
Total Wake Effect in %
0
0
0
0
0
0
0
0
0
100
86
100
0
minimal Distance 90.14
mean Distance 697.12

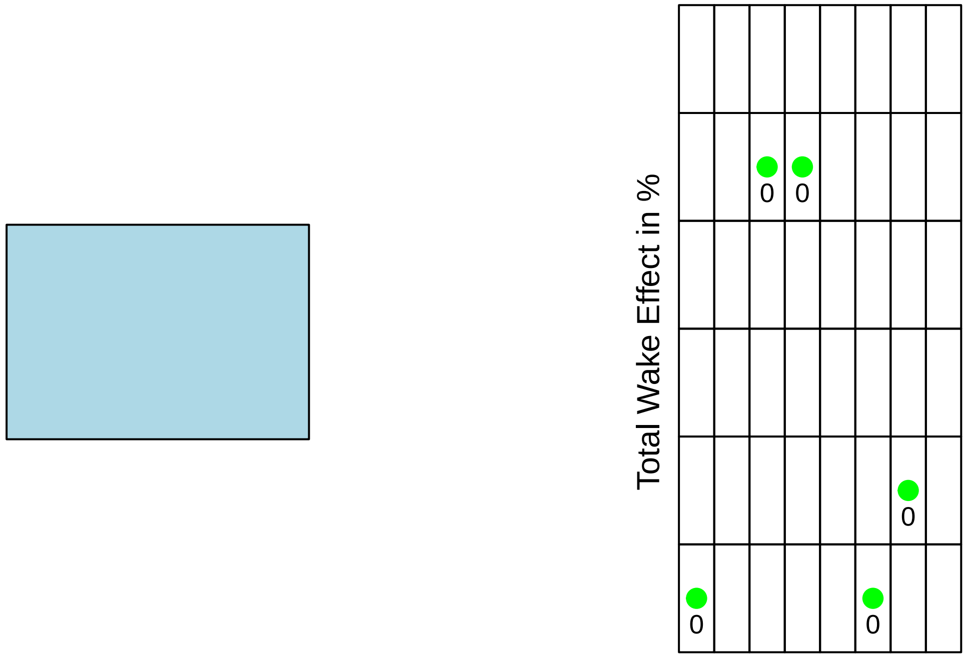
Original − Best Energy: 1
Energy Output 20011.7 kW
Efficiency: 93.97



minimal Distance 212.13
mean Distance 707.05

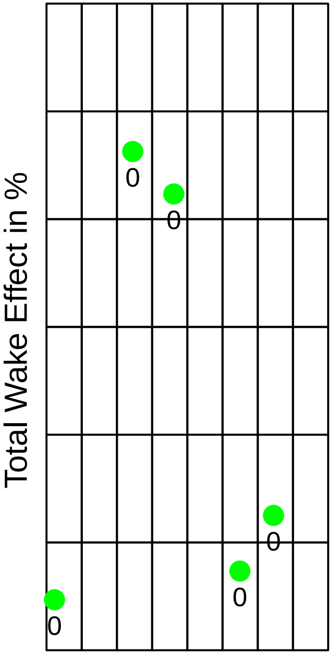

Random Search − Best Energy: 1
Energy Output 20213.18 kW
Efficiency: 94.92
Total Wake Effect in %
0
0
0
0
0
0
0
19
12
14
100
100
minimal Distance 190.06
mean Distance 718.91

Original − Best Energy: 2
Energy Output 12077.04 kW
Efficiency: 100

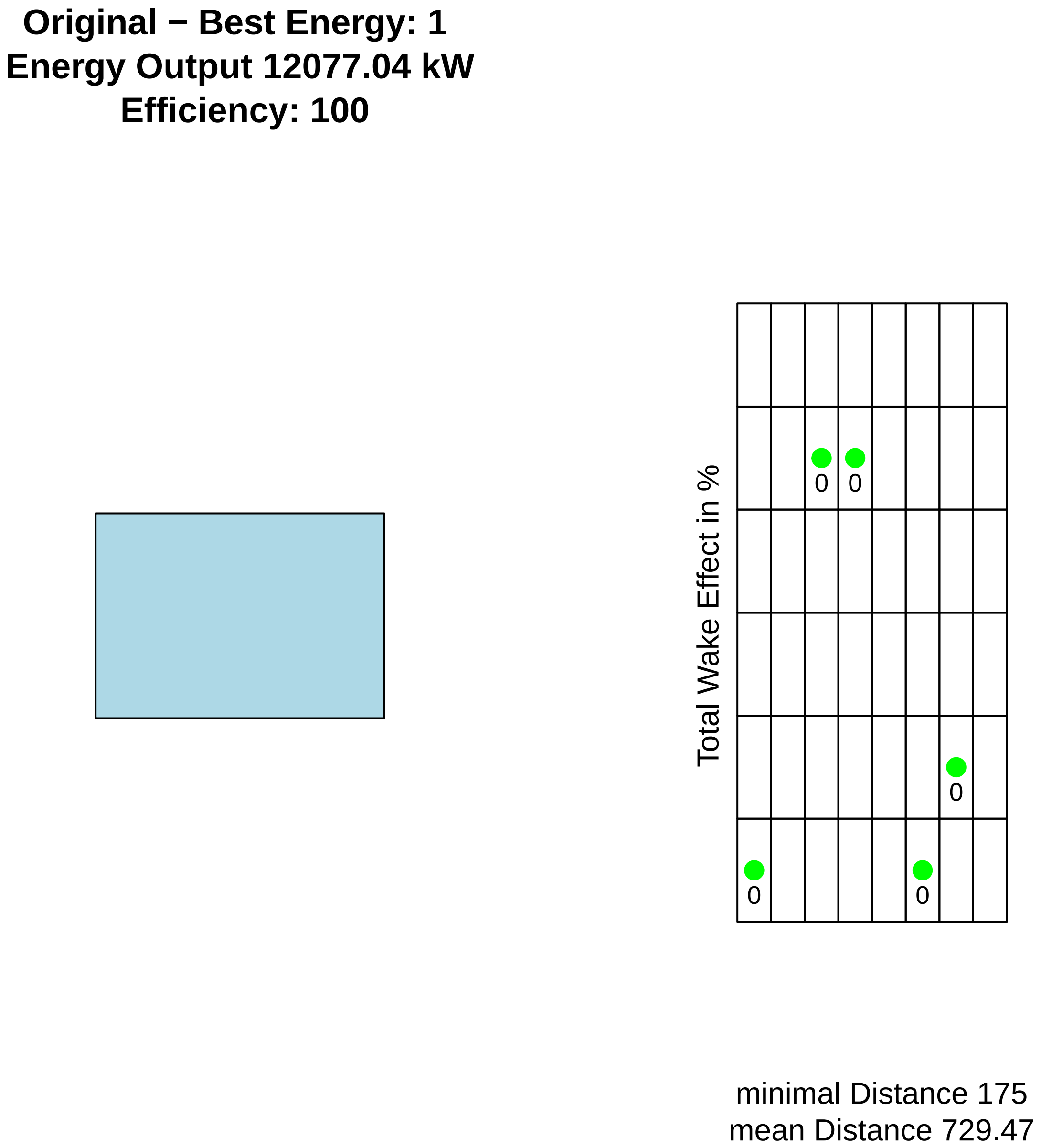


minimal Distance 175
mean Distance 729.47

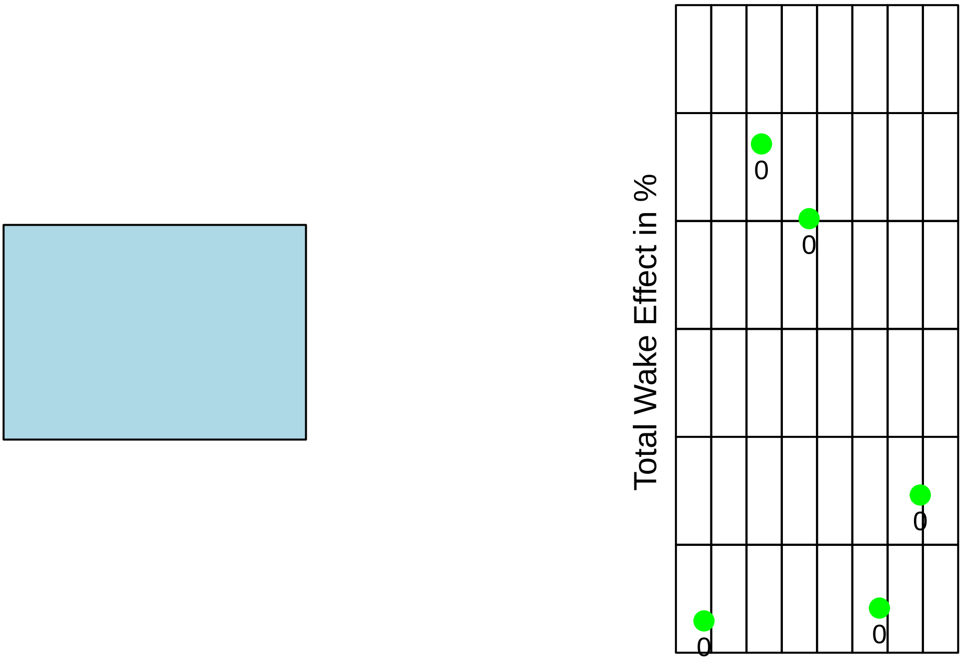
Random Search − Best Energy: 2
Energy Output 12077.04 kW
Efficiency: 100



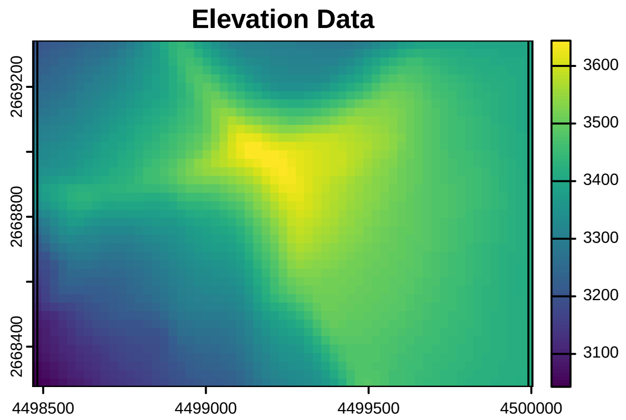
minimal Distance 190.01
mean Distance 733.19

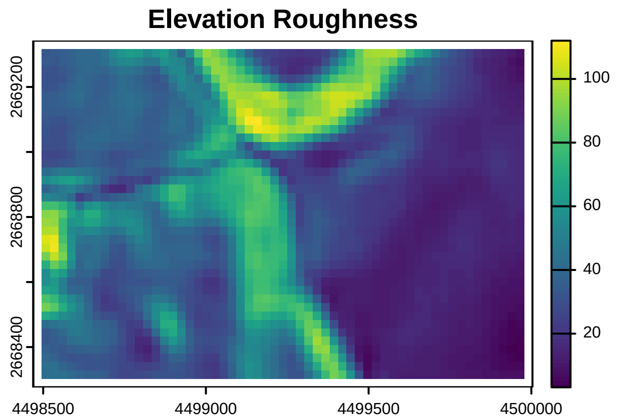

Original − Best Energy: 1
Energy Output 12077.04 kW
Efficiency: 100
Total Wake Effect in %
0
0
0
0
0
minimal Distance 175
mean Distance 729.47

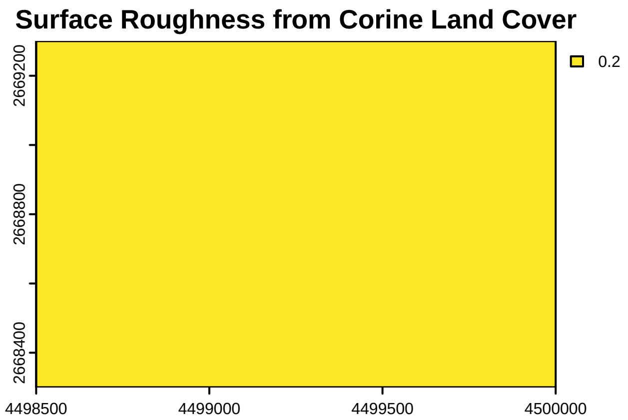
Random Search − Best Energy: 1
Energy Output 12077.04 kW
Efficiency: 100

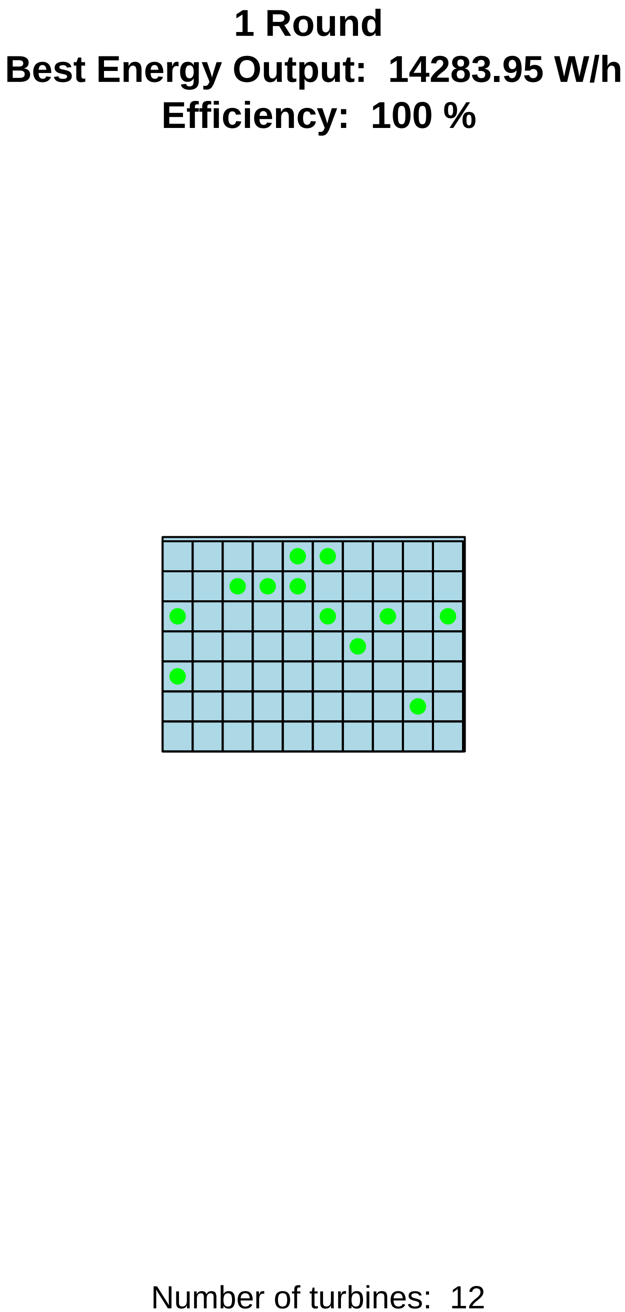


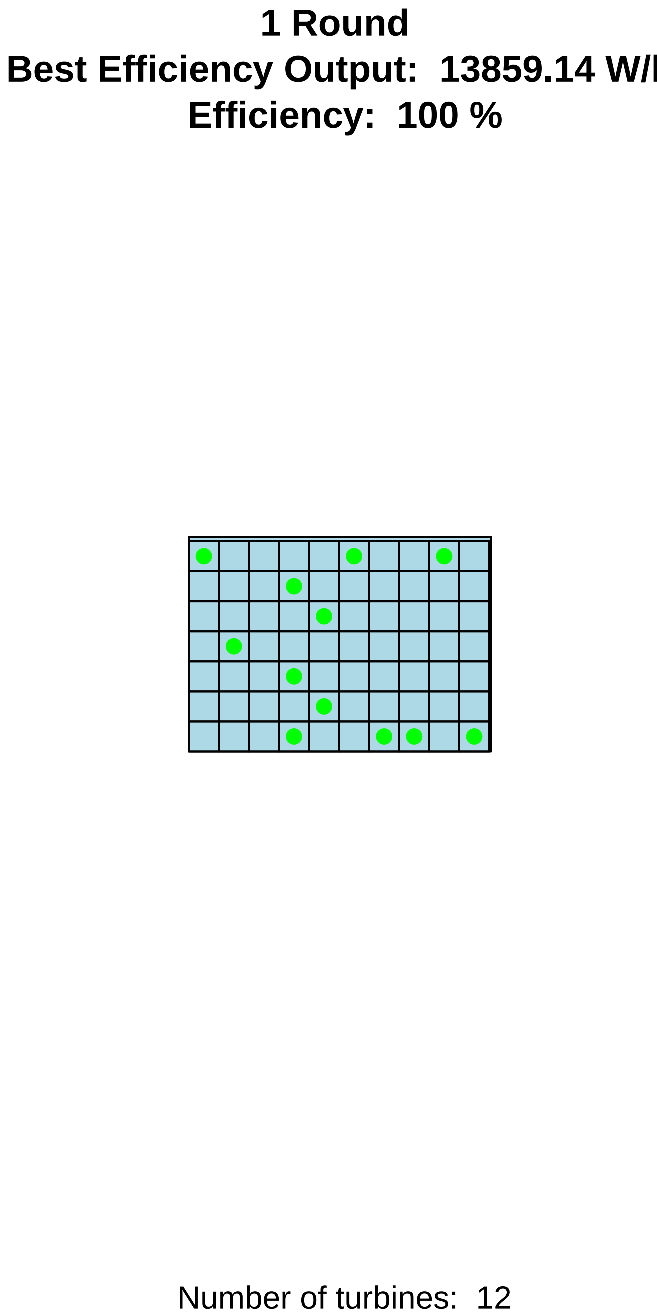
minimal Distance 265.61
mean Distance 751.82


Elevation Data
2669200
2668800
2668400
4498500
4499000
4499500
4500000
3600
3500
3400
3300
3200
3100

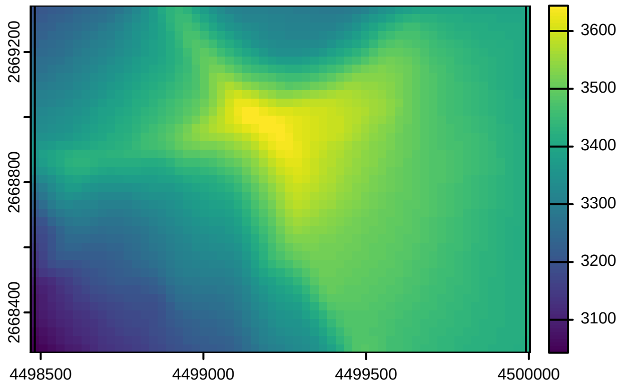

Elevation Roughness
2669200
2668800
2668400
4498500
4499000
4499500
4500000
100
80
60
40
20


Surface Roughness from Corine Land Cover
2669200
2668800
2668400
4498500
4499000
4499500
4500000
0.2

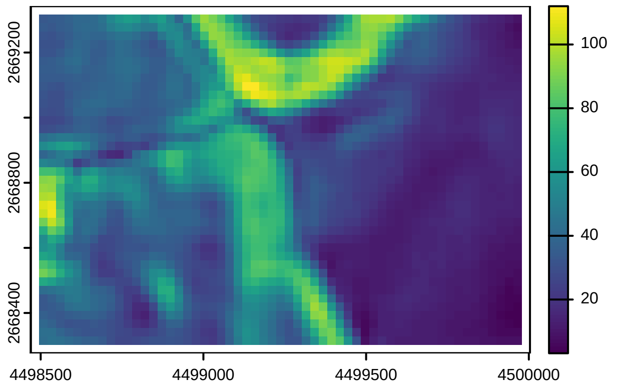

1 Round
Best Energy Output: 14283.95 W/h
Efficiency: 100 %
Number of turbines: 12


1 Round
Best Efficiency Output: 13859.14 W/
Efficiency: 100 %
Number of turbines: 12

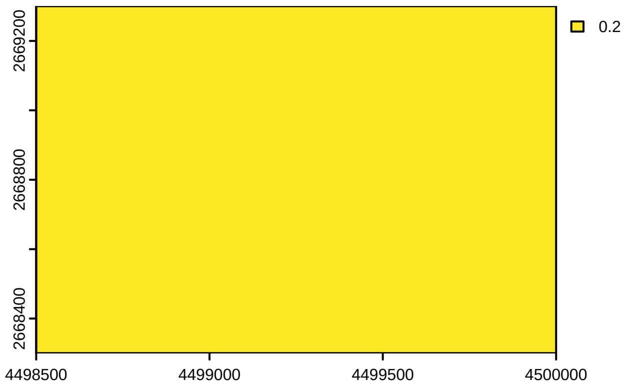
Elevation Data



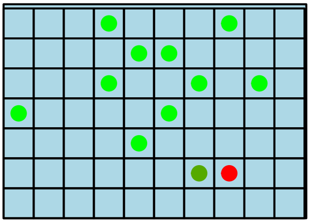
Elevation Roughness



Surface Roughness from Corine Land Cover

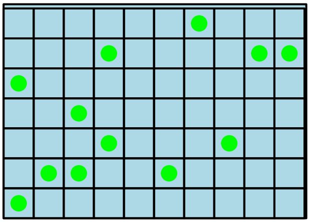


1 Round
Best Energy Output: 14466.17 W/h
Efficiency: 97.36 %



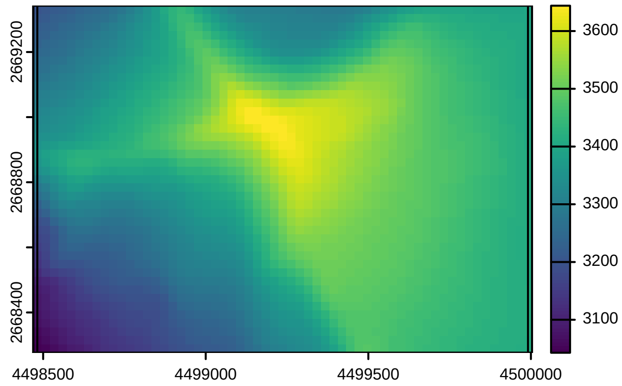
Number of turbines: 12

1 Round
Best Efficiency Output: 13476.59 W/h
Efficiency: 100 %

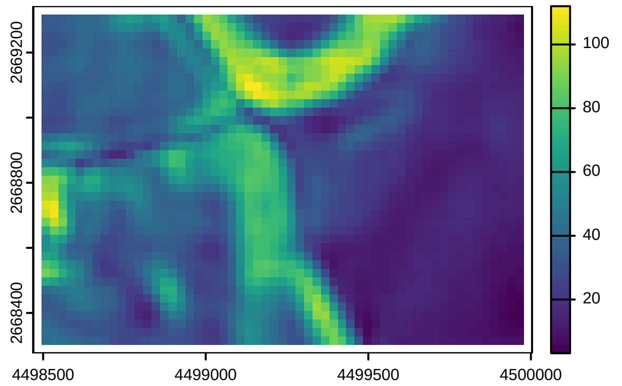


Number of turbines: 12

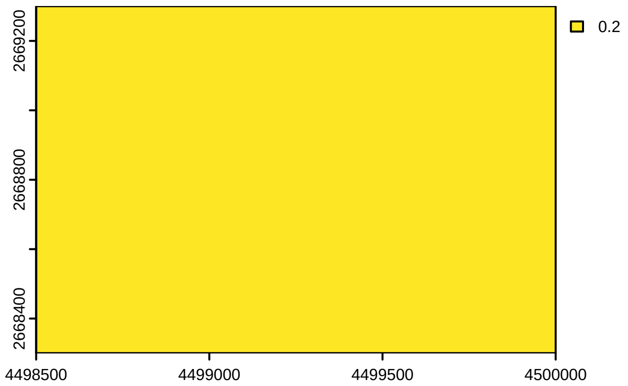
Elevation Data

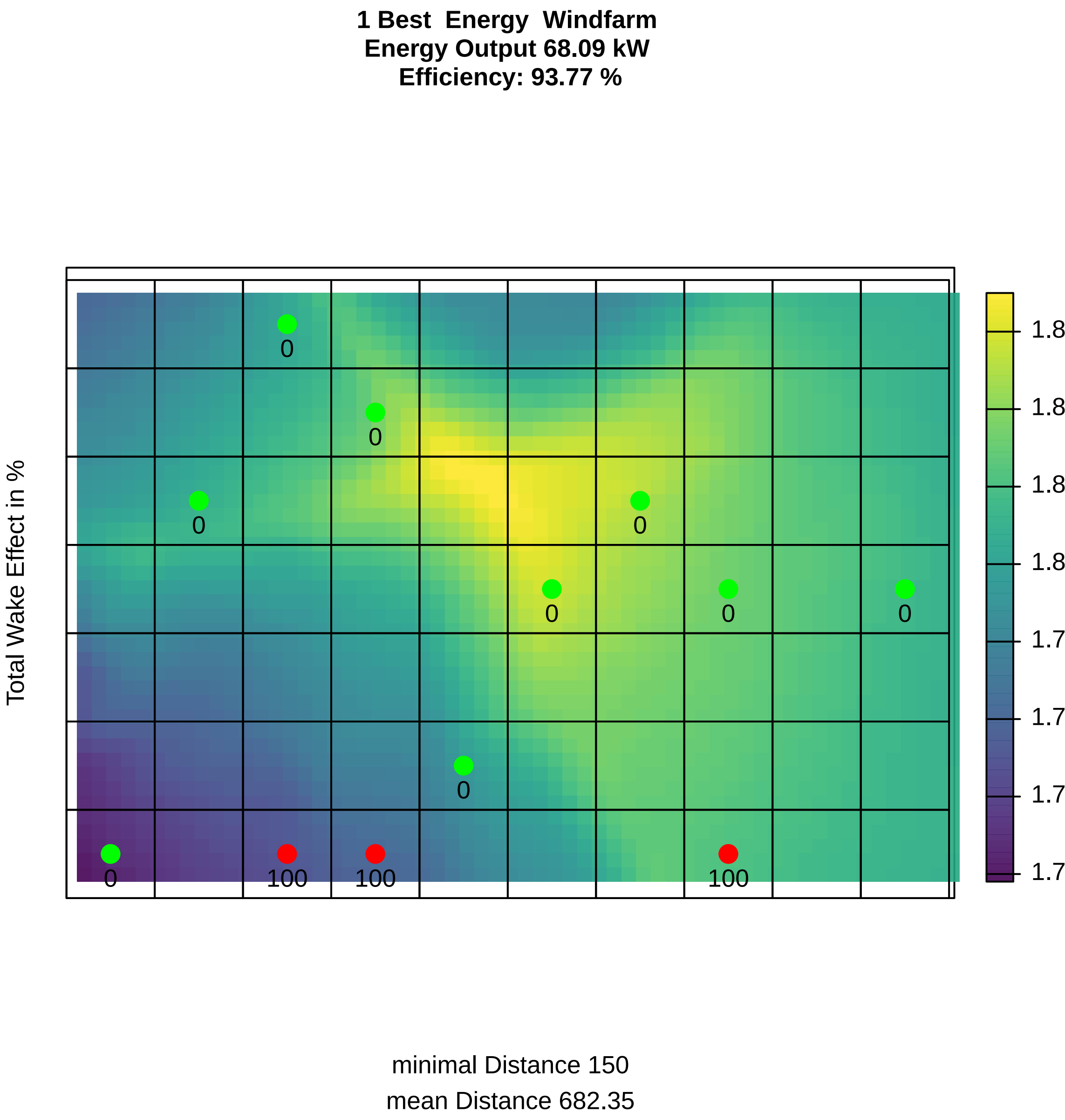


Elevation Roughness

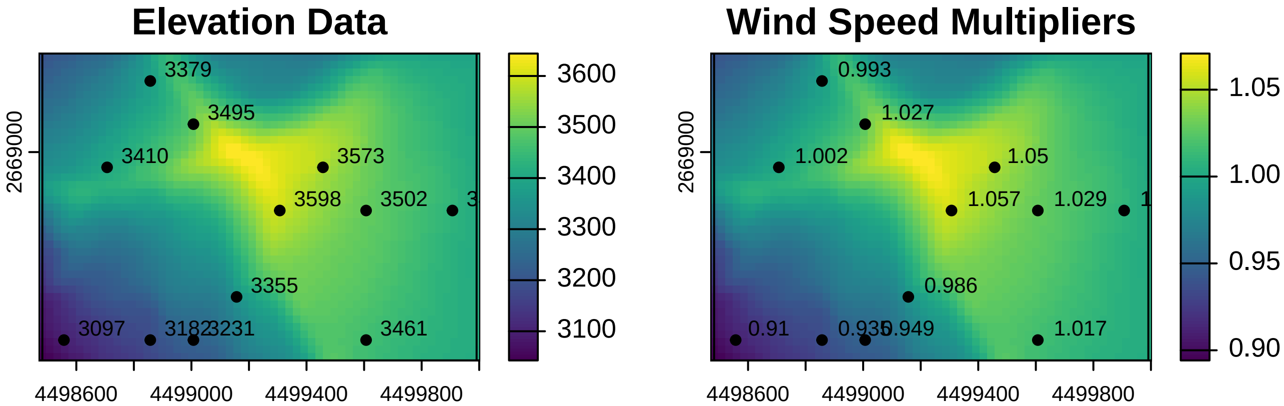


Surface Roughness from Corine Land Cover

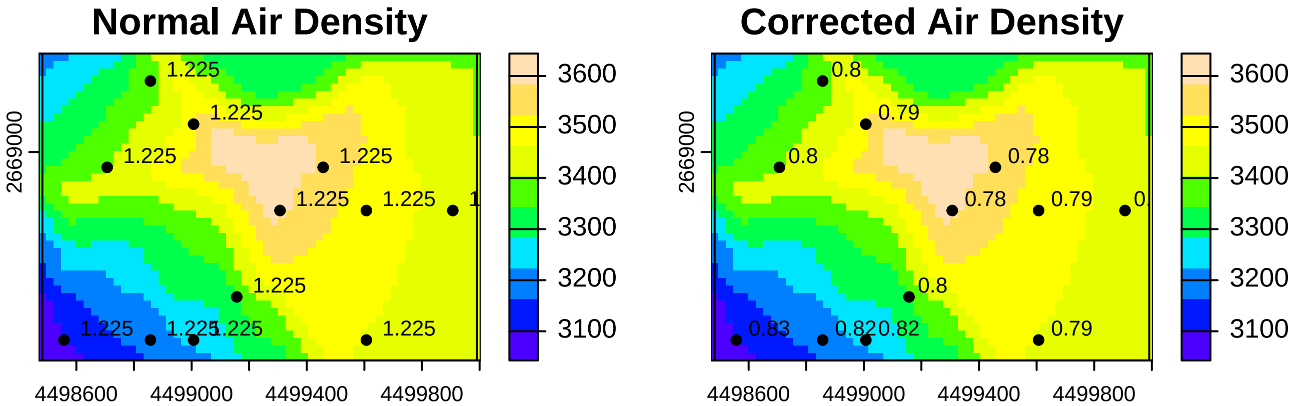


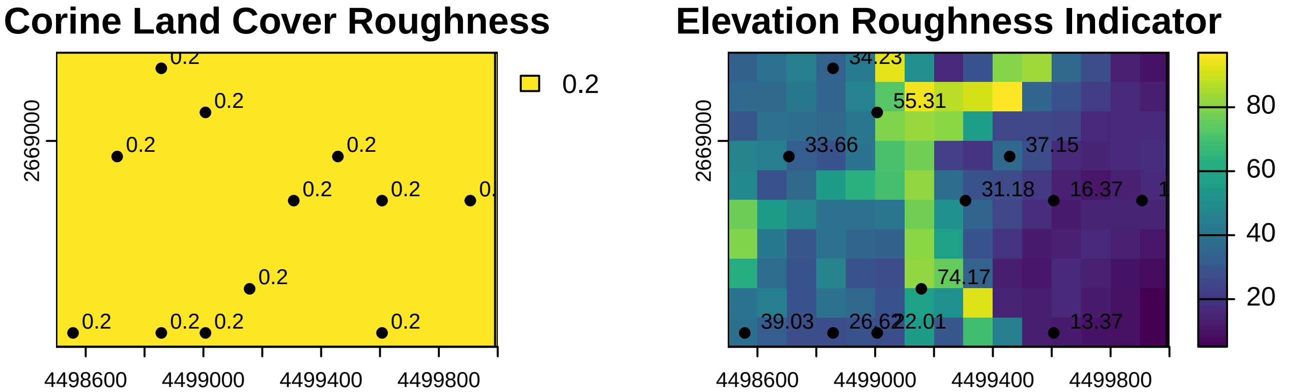


1 Best Energy Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %
Total Wake Effect in %
0
0
0
0
0
0
0
0
0
100
100
100
1.8
1.8
1.8
1.8
1.7
1.7
1.7
1.7
minimal Distance 150
mean Distance 682.35

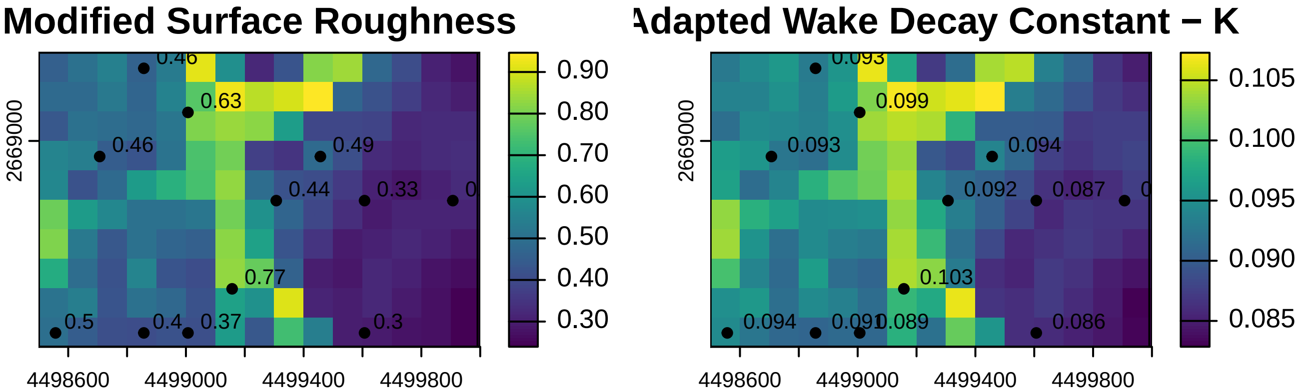


Elevation Data
3379
3495
3410
3573
3598
3502
3
3355
3097
3182
3231
3461
2669000
4498600
4499000
4499400
4499800
3600
3500
3400
3300
3200
3100
Wind Speed Multipliers
0.993
1.027
1.002
1.05
1.057
1.029
1
0.986
0.91
0.935
0.949
1.017
2669000
4498600
4499000
4499400
4499800
1.05
1.00
0.95
0.90


Normal Air Density
Corrected Air Density
2669000
4498600
4499000
4499400
4499800
3100
3200
3300
3400
3500
3600
1.225
0.8
0.79
0.78
0.83
0.82

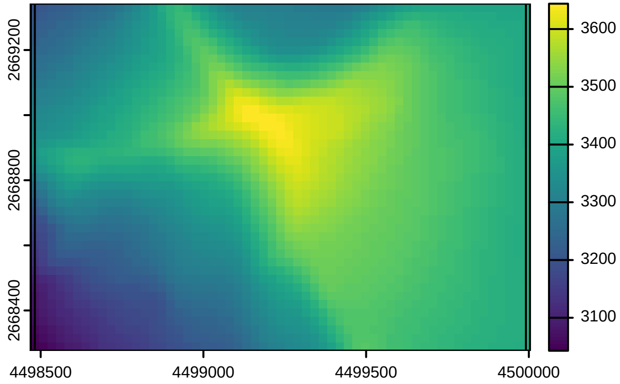


Corine Land Cover Roughness
0.2
2669000
4498600
4499000
4499400
4499800
Elevation Roughness Indicator
34.23
55.31
33.66
37.15
31.18
16.37
74.17
39.03
26.62
22.01
13.37
80
60
40
20
2669000
4498600
4499000
4499400
4499800

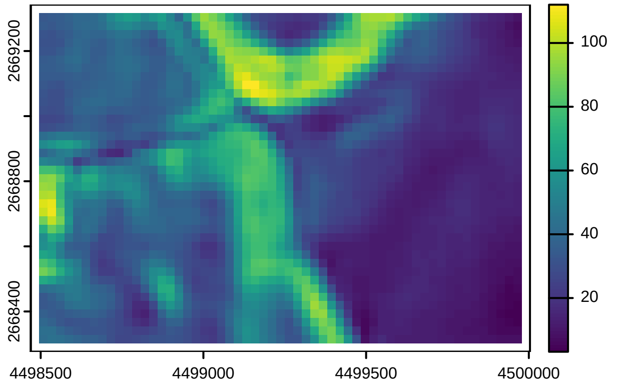


Modified Surface Roughness
Adapted Wake Decay Constant − K
2669000
4498600
4499000
4499400
4499800
0.46
0.63
0.46
0.49
0.44
0.33
0.77
0.5
0.4
0.37
0.3
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.093
0.099
0.093
0.094
0.092
0.087
0.103
0.094
0.091
0.089
0.086
0.105
0.100
0.095
0.090
0.085

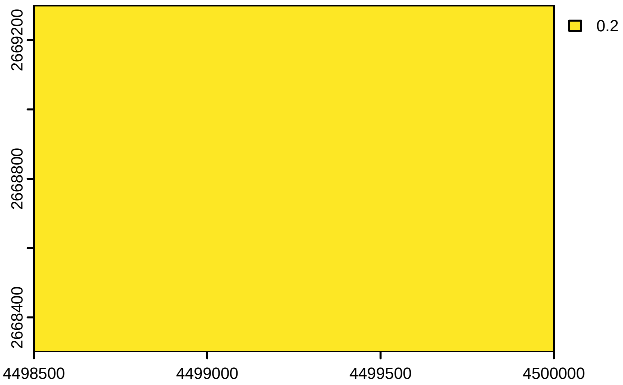
Elevation Data

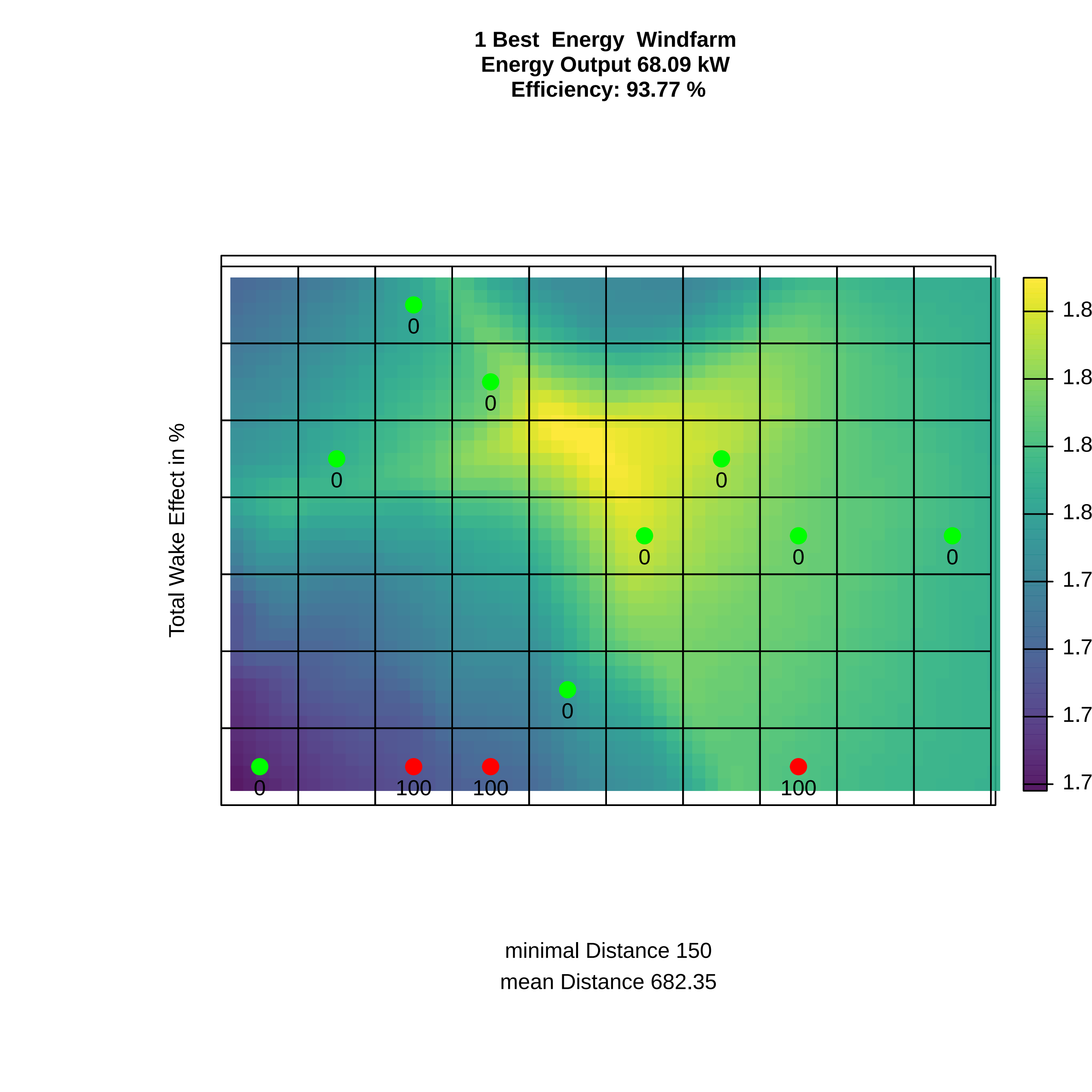


Elevation Roughness

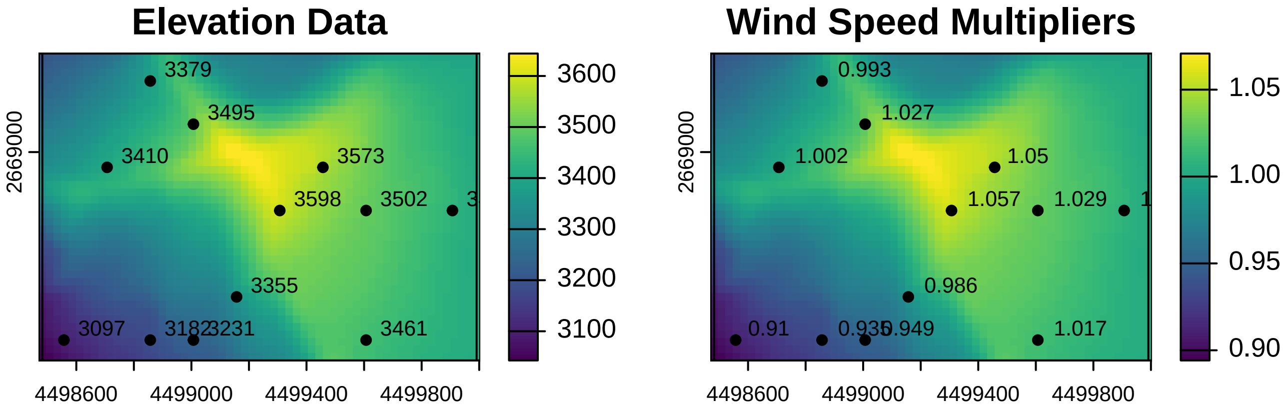


Surface Roughness from Corine Land Cover

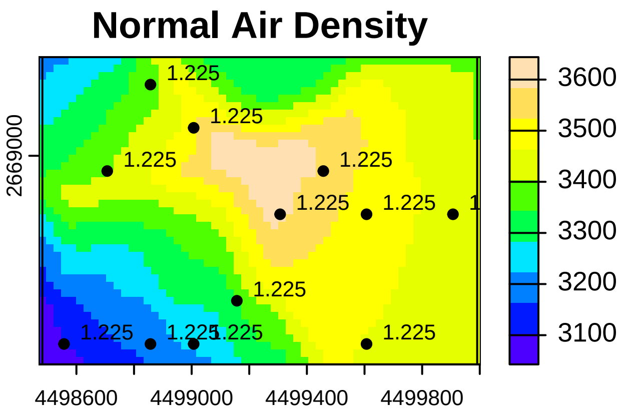




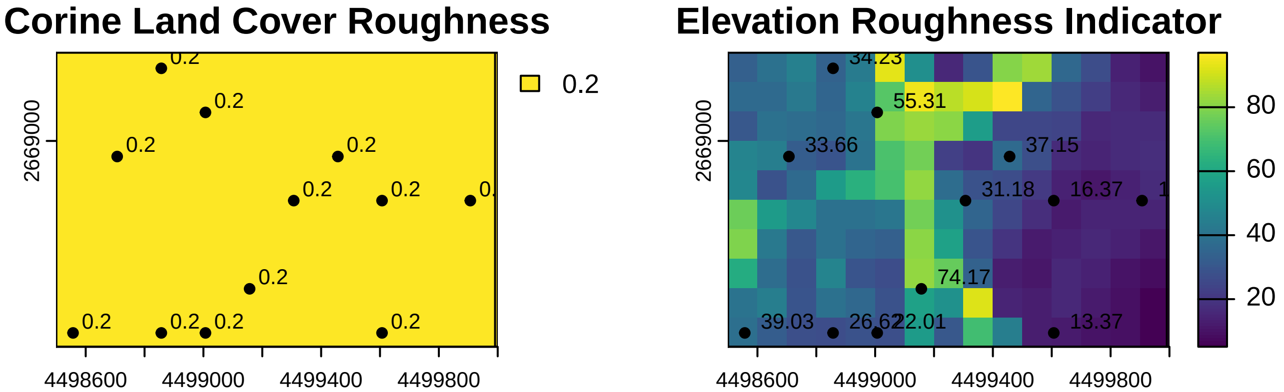
1 Best Energy Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %
Total Wake Effect in %
0
0
0
0
0
0
0
0
0
100
100
100
1.8
1.8
1.8
1.8
1.7
1.7
1.7
1.7
minimal Distance 150
mean Distance 682.35

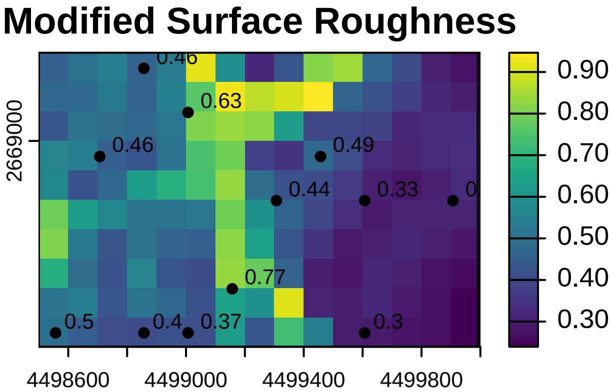


Elevation Data
3379
3495
3410
3573
3598
3502
3
3355
3097
3182
3231
3461
3600
3500
3400
3300
3200
3100
2669000
4498600
4499000
4499400
4499800
Wind Speed Multipliers
0.993
1.027
1.002
1.05
1.057
1.029
1
0.986
0.91
0.935
0.949
1.017
1.05
1.00
0.95
0.90
2669000
4498600
4499000
4499400
4499800

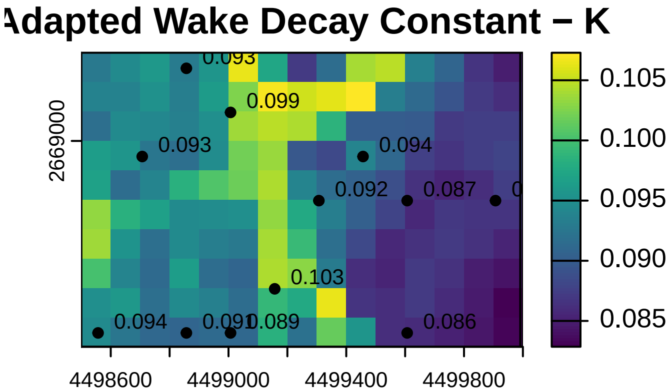


Normal Air Density
Corrected Air Density
1.225
0.8
0.79
0.78
0.83
0.82
3600
3500
3400
3300
3200
3100
2669000
4498600
4499000
4499400
4499800

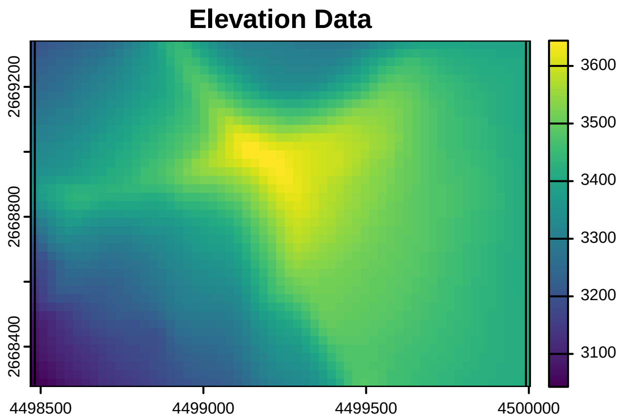

Corine Land Cover Roughness
Elevation Roughness Indicator
0.2
2669000
4498600
4499000
4499400
4499800
34.23
55.31
33.66
37.15
31.18
16.37
74.17
39.03
26.62
22.01
13.37
80
60
40
20

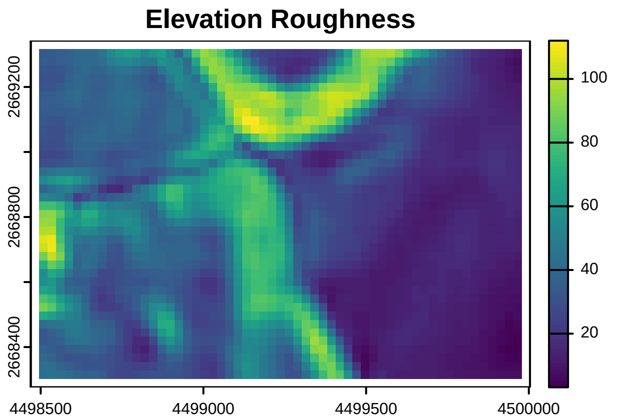


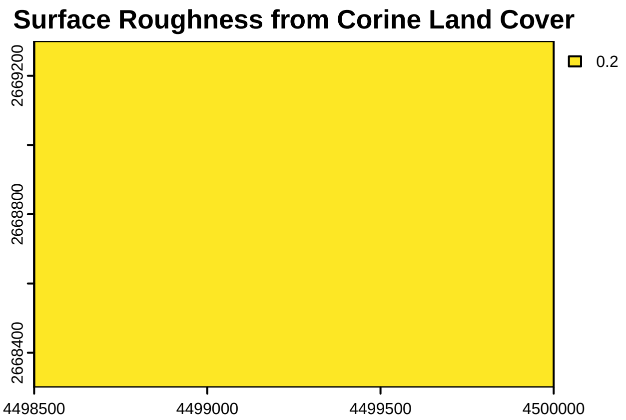
Modified Surface Roughness
2669000
4498600
4499000
4499400
4499800
0.46
0.63
0.46
0.49
0.44
0.33
0.77
0.5
0.4
0.37
0.3
0.90
0.80
0.70
0.60
0.50
0.40
0.30



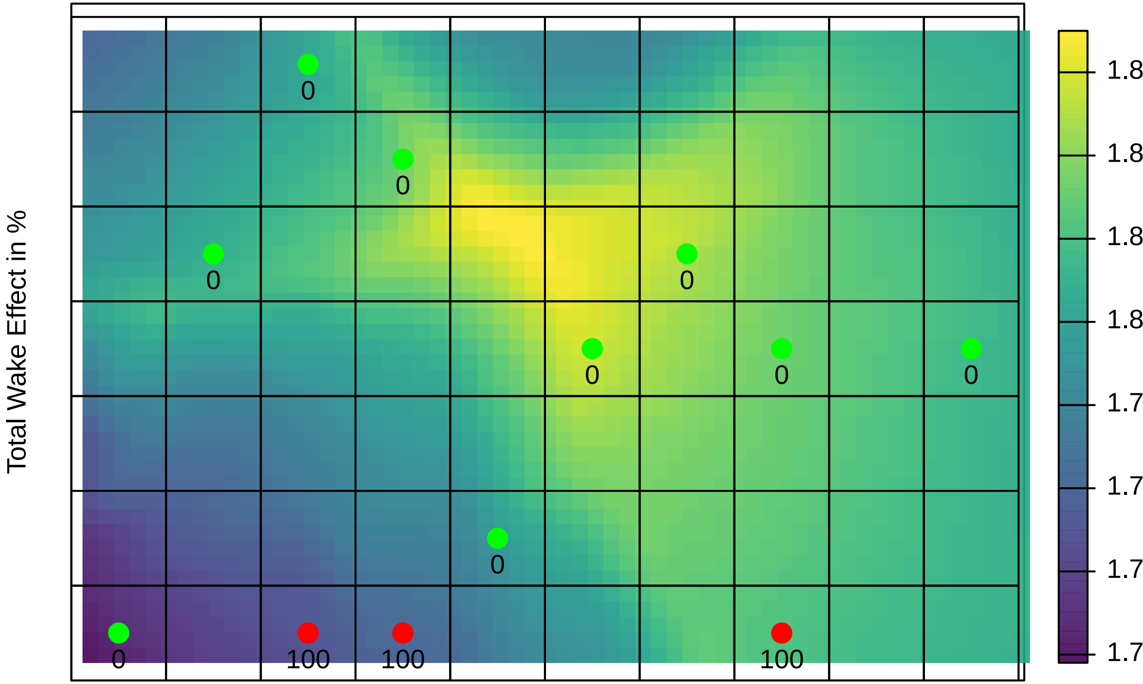
Adapted Wake Decay Constant − K
2669000
4498600
4499000
4499400
4499800
0.093
0.099
0.093
0.094
0.092
0.087
0.103
0.094
0.091
0.089
0.086
0.105
0.100
0.095
0.090
0.085


Elevation Data
2669200
2668800
2668400
4498500
4499000
4499500
4500000
3600
3500
3400
3300
3200
3100

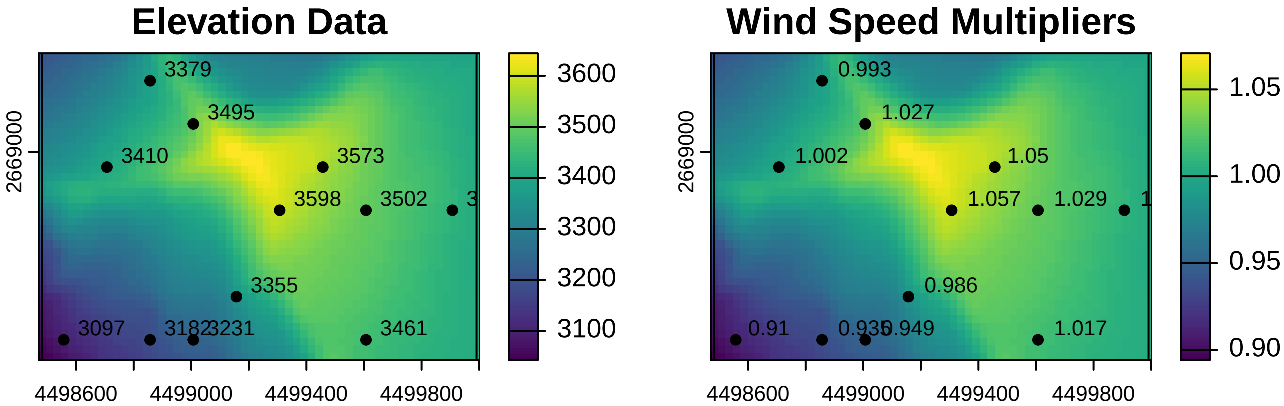

Elevation Roughness
2669200
2668800
2668400
4498500
4499000
4499500
4500000
100
80
60
40
20

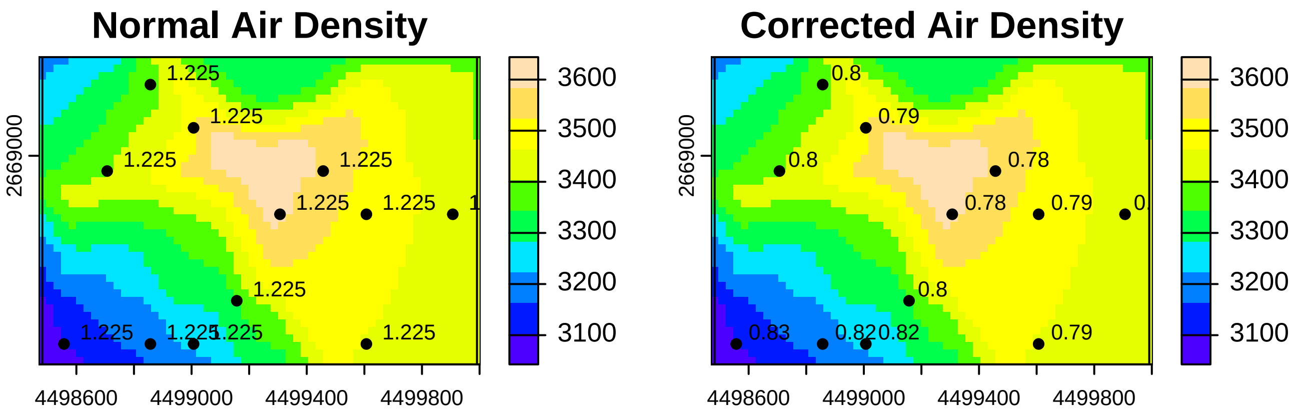

Surface Roughness from Corine Land Cover
2669200
2668800
2668400
4498500
4499000
4499500
4500000
0.2

1 Best Energy Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %



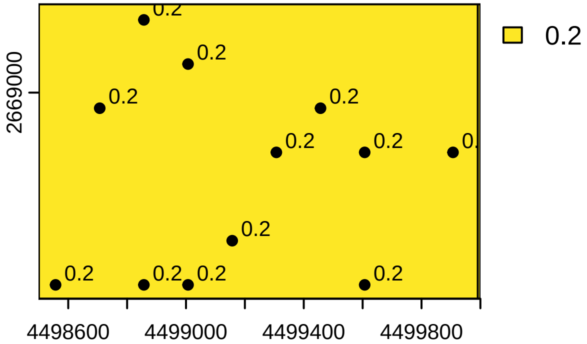
minimal Distance 150
mean Distance 682.35


Elevation Data
3379
3495
3410
3573
3598
3502
3355
3097
3182
3231
3461
3600
3500
3400
3300
3200
3100
2669000
4498600
4499000
4499400
4499800
Wind Speed Multipliers
0.993
1.027
1.002
1.05
1.057
1.029
0.986
0.91
0.949
1.017
1.05
1.00
0.95
0.90
2669000
4498600
4499000
4499400
4499800

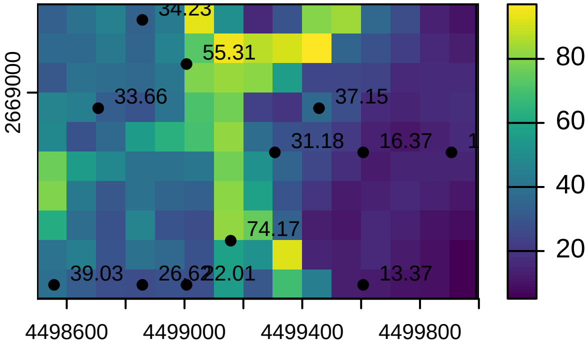


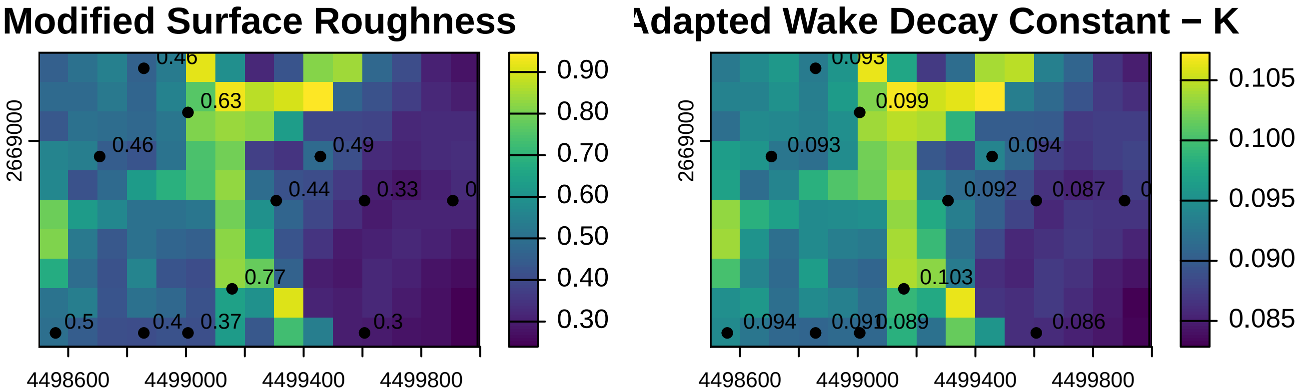
Normal Air Density
Corrected Air Density
2669000
4498600
4499000
4499400
4499800
3100
3200
3300
3400
3500
3600
1.225
0.8
0.79
0.78
0.83
0.82

Corine Land Cover Roughness

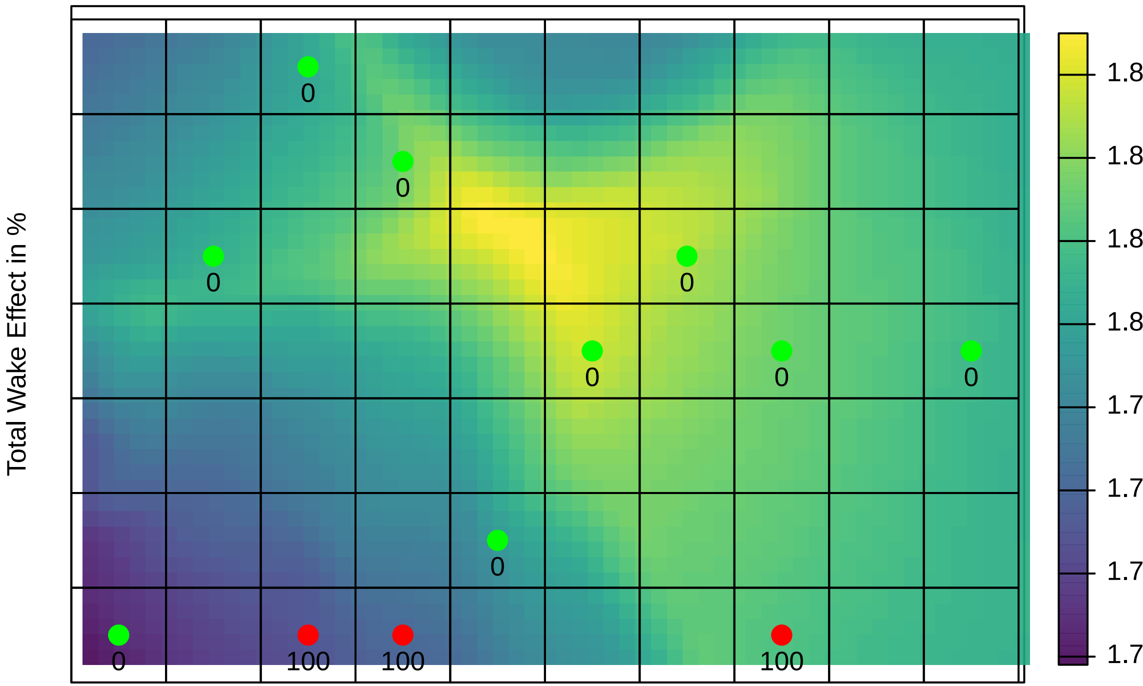


Elevation Roughness Indicator



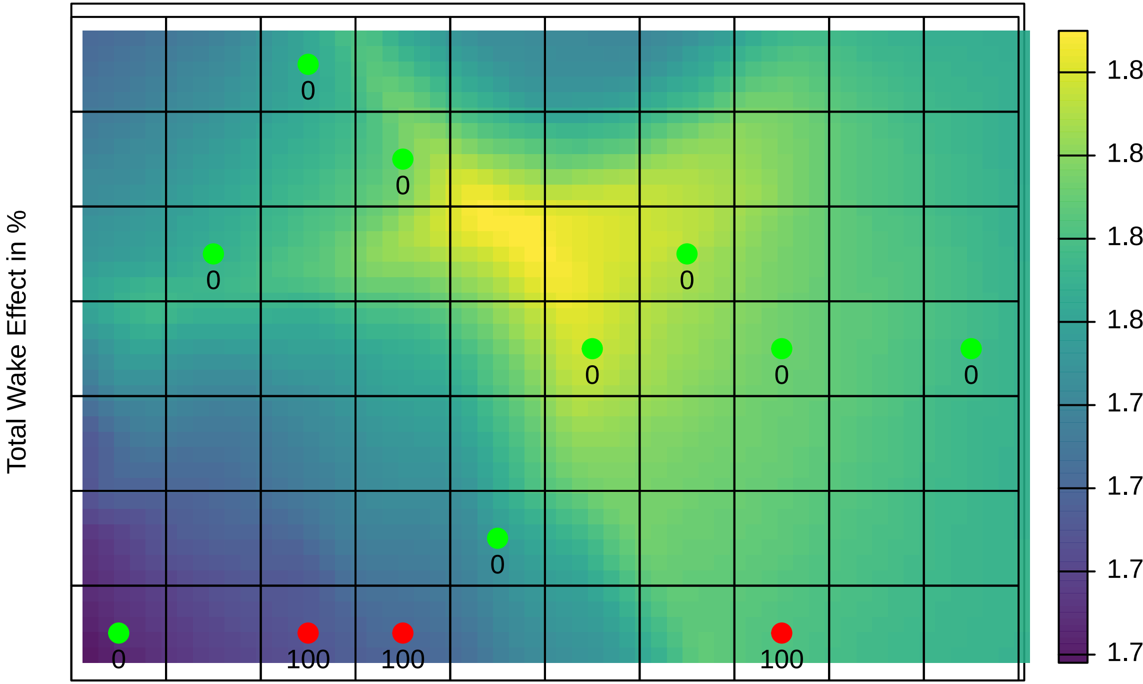

Modified Surface Roughness
Adapted Wake Decay Constant − K
0.46
0.63
0.46
0.49
0.44
0.33
0.77
0.5
0.4
0.37
0.3
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.093
0.099
0.093
0.094
0.092
0.087
0.103
0.094
0.091
0.089
0.086
0.105
0.100
0.095
0.090
0.085
2669000
4498600
4499000
4499400
4499800

1 Best Energy Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %



minimal Distance 150
mean Distance 682.35

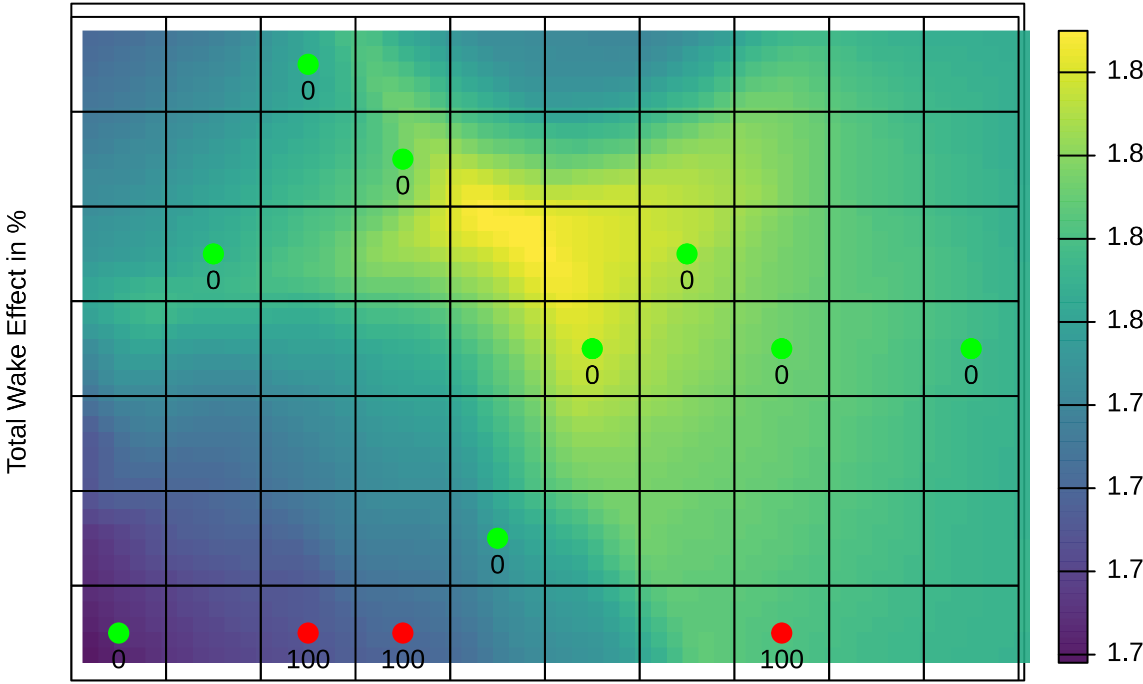
1 Best Energy Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %



minimal Distance 150

mean Distance 682.35

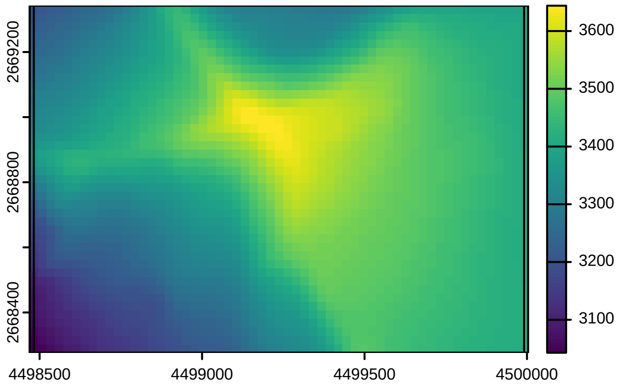
1 Best Efficiency Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %



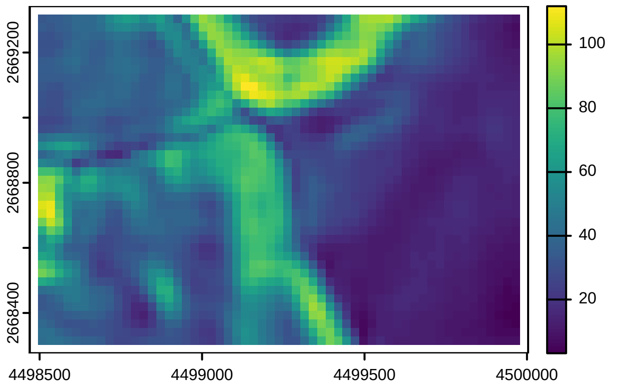
minimal Distance 150

mean Distance 682.35

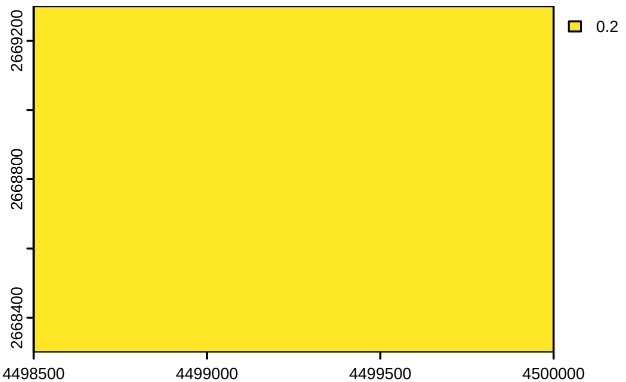
Elevation Data

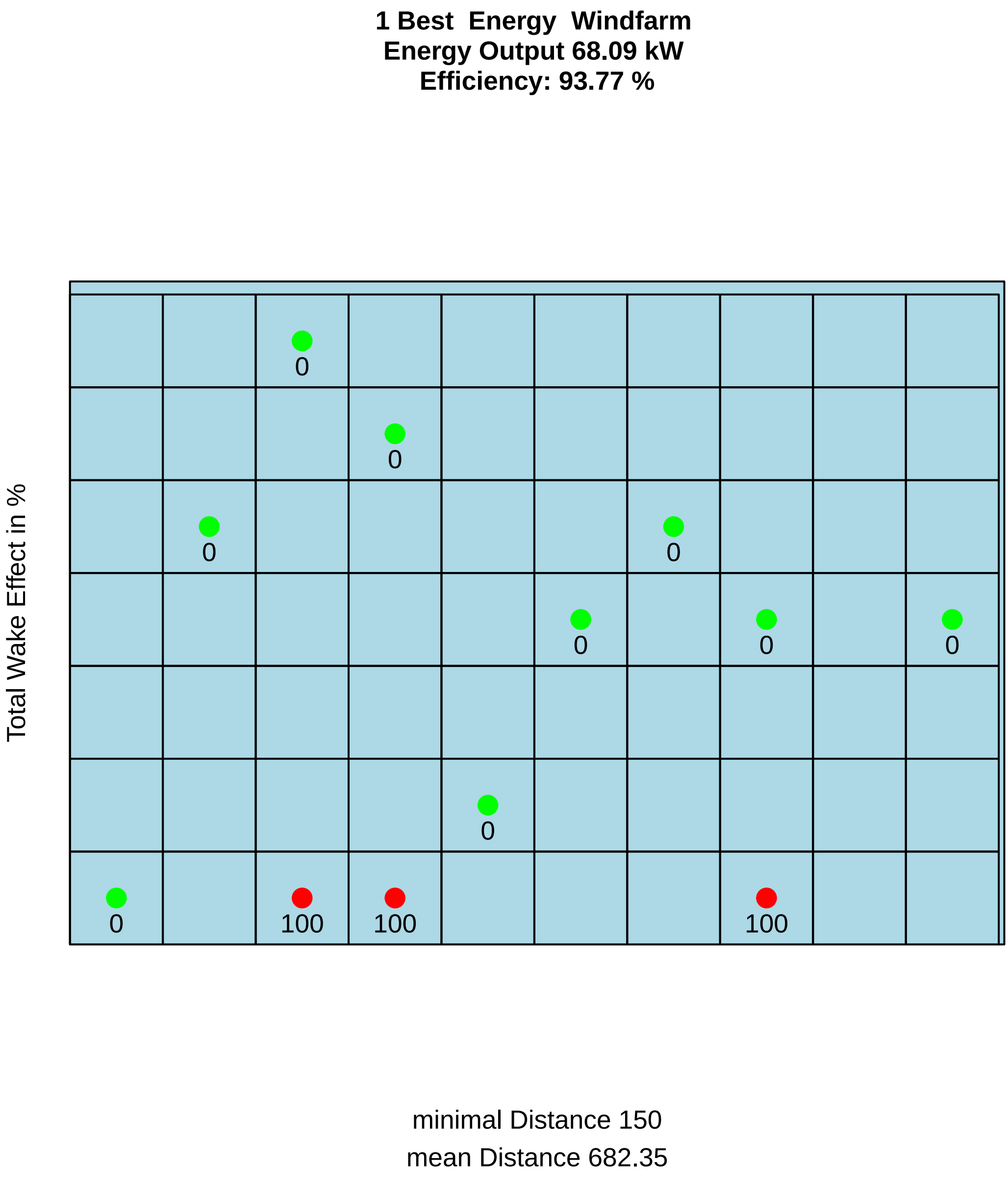


Elevation Roughness

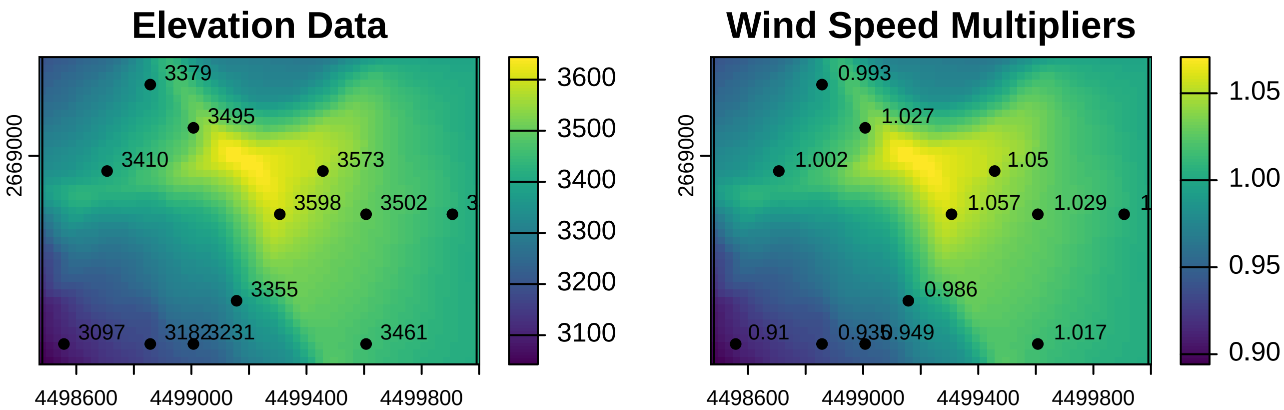


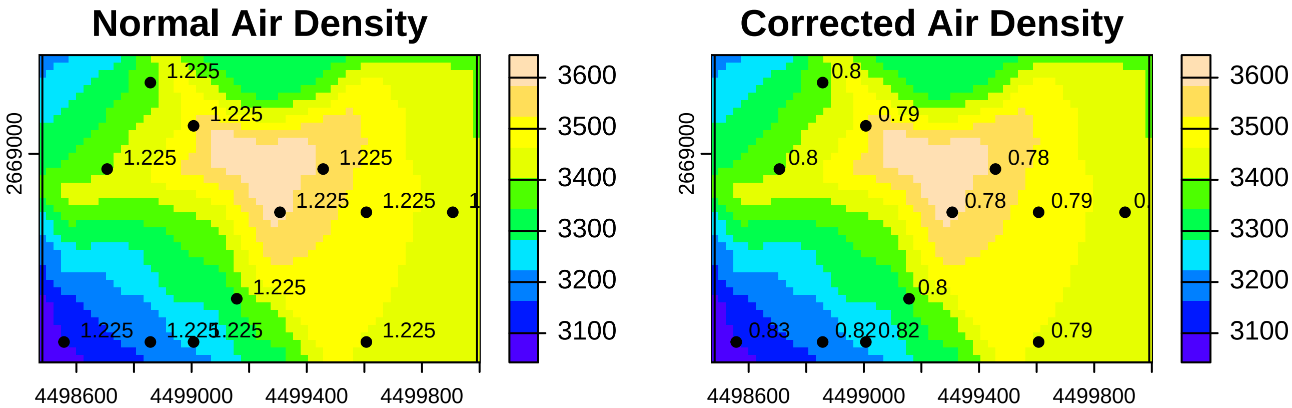
Surface Roughness from Corine Land Cover

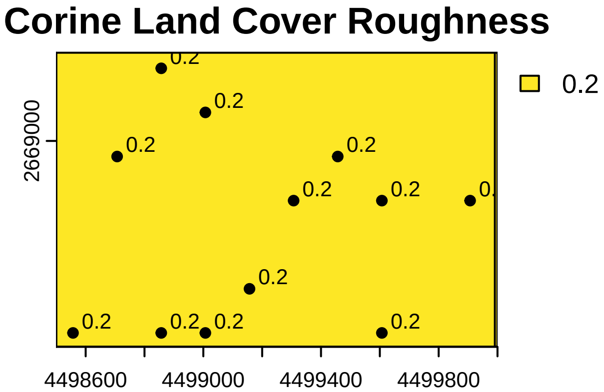


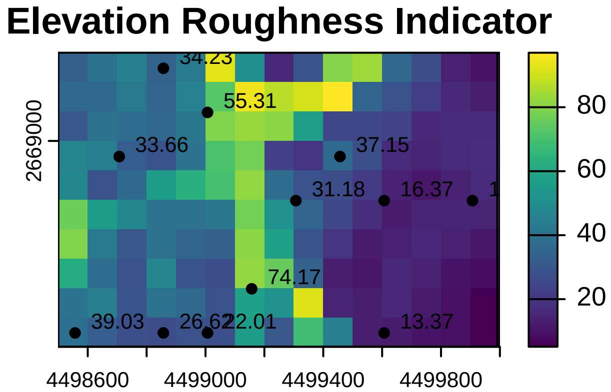


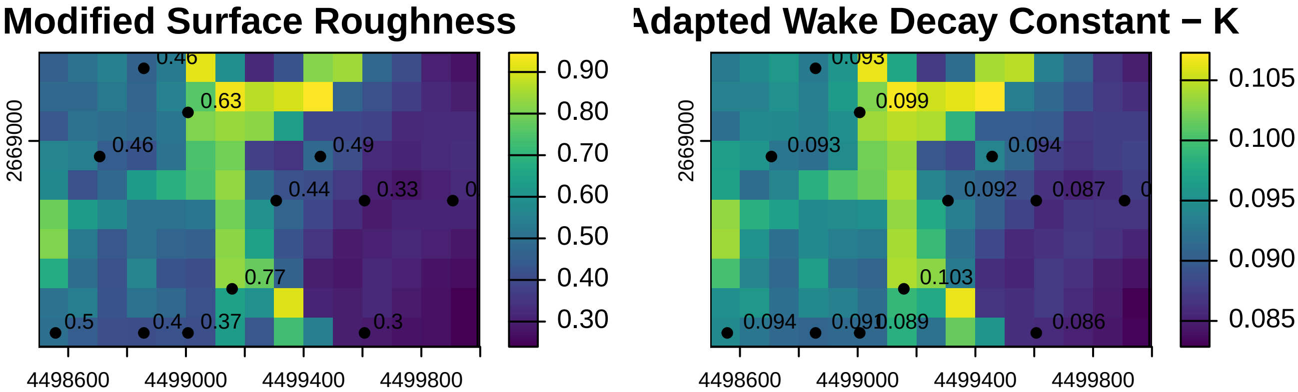
1 Best Energy Windfarm
Energy Output 68.09 kW
Efficiency: 93.77 %
Total Wake Effect in %
0
0
0
0
0
0
0
0
0
100
100
100
minimal Distance 150
mean Distance 682.35


Elevation Data
3379
3495
3410
3573
3598
3502
3
3355
3097
3182
3231
3461
2669000
4498600
4499000
4499400
4499800
3600
3500
3400
3300
3200
3100
Wind Speed Multipliers
0.993
1.027
1.002
1.05
1.057
1.029
1
0.986
0.91
0.935
0.949
1.017
2669000
4498600
4499000
4499400
4499800
1.05
1.00
0.95
0.90

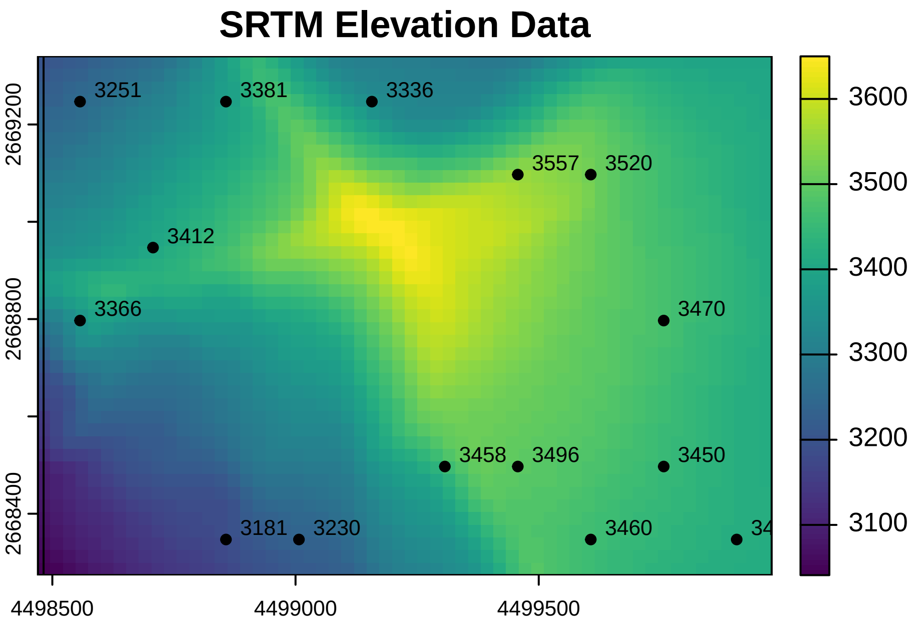

Normal Air Density
Corrected Air Density
1.225
0.8
0.79
0.78
0.83
0.82
3600
3500
3400
3300
3200
3100
2669000
4498600
4499000
4499400
4499800

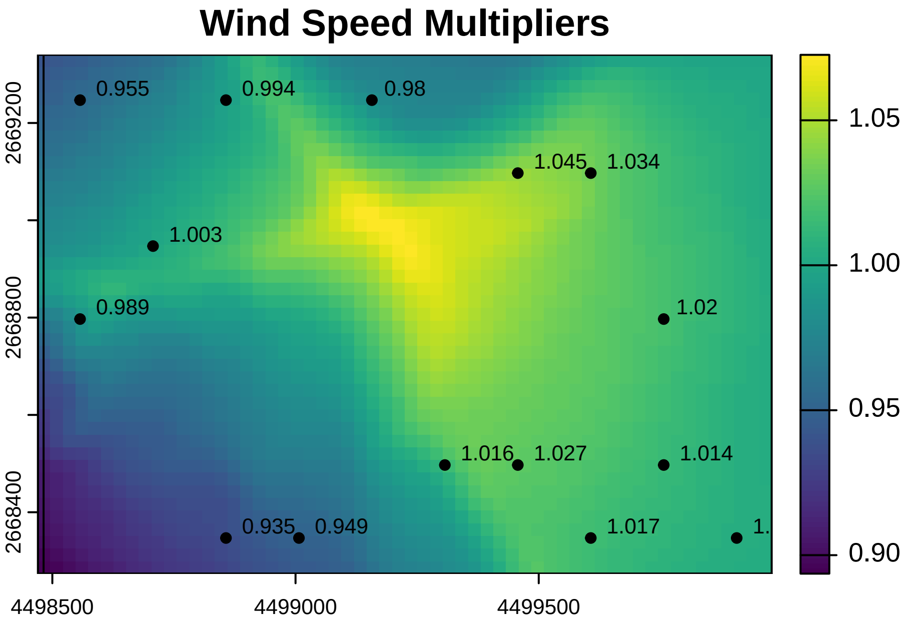

Corine Land Cover Roughness
0.2
2669000
4498600
4499000
4499400
4499800

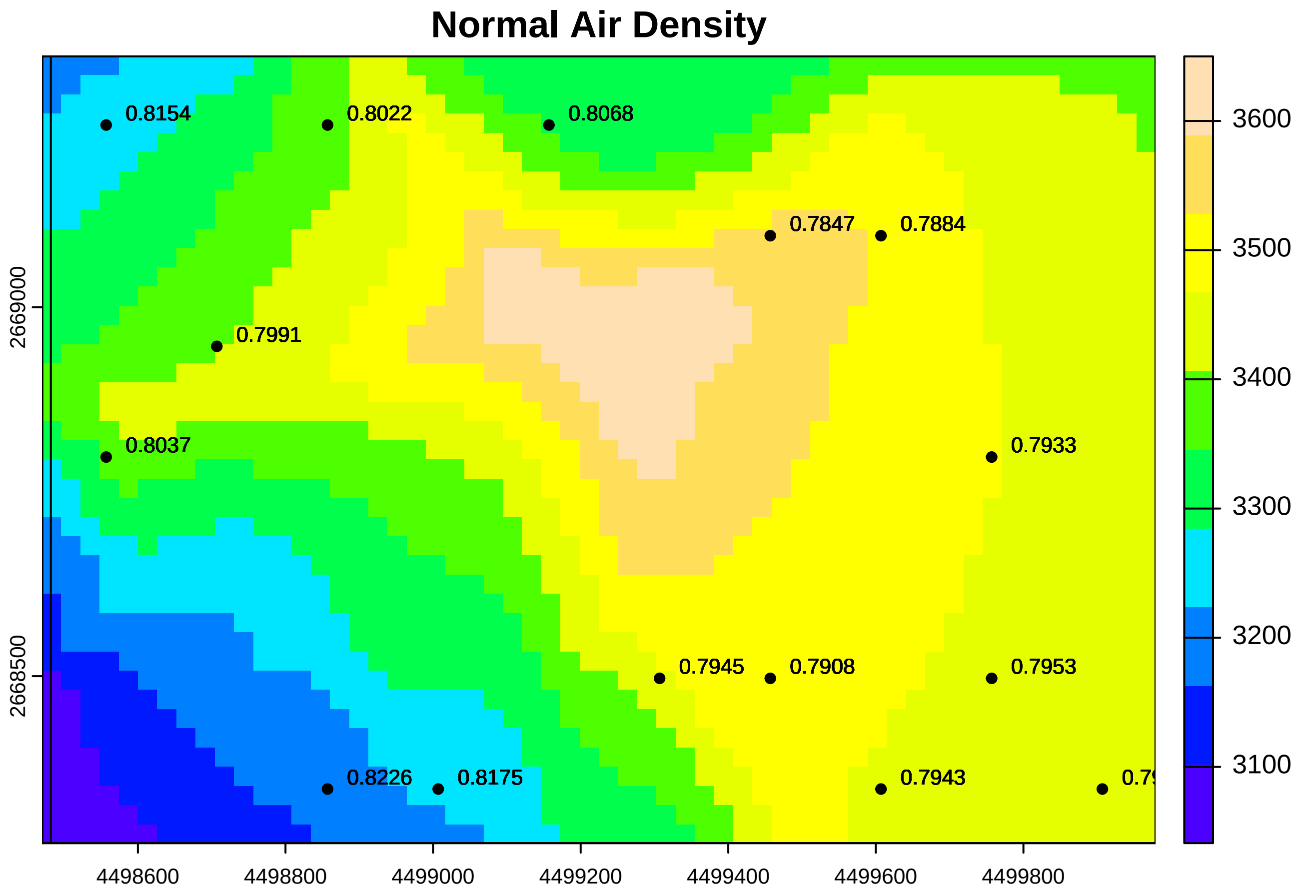

Elevation Roughness Indicator
34.23
55.31
33.66
37.15
31.18
16.37
74.17
39.03
26.62
22.01
13.37
80
60
40
20
2669000
4498600
4499000
4499400
4499800



Modified Surface Roughness
2669000
4498600
4499000
4499400
4499800
0.46
0.63
0.46
0.49
0.44
0.33
0.77
0.5
0.4
0.37
0.3
0.90
0.80
0.70
0.60
0.50
0.40
0.30
Adapted Wake Decay Constant − K
0.093
0.099
0.093
0.094
0.092
0.087
0.103
0.094
0.091
0.089
0.086
0.105
0.100
0.095
0.090
0.085

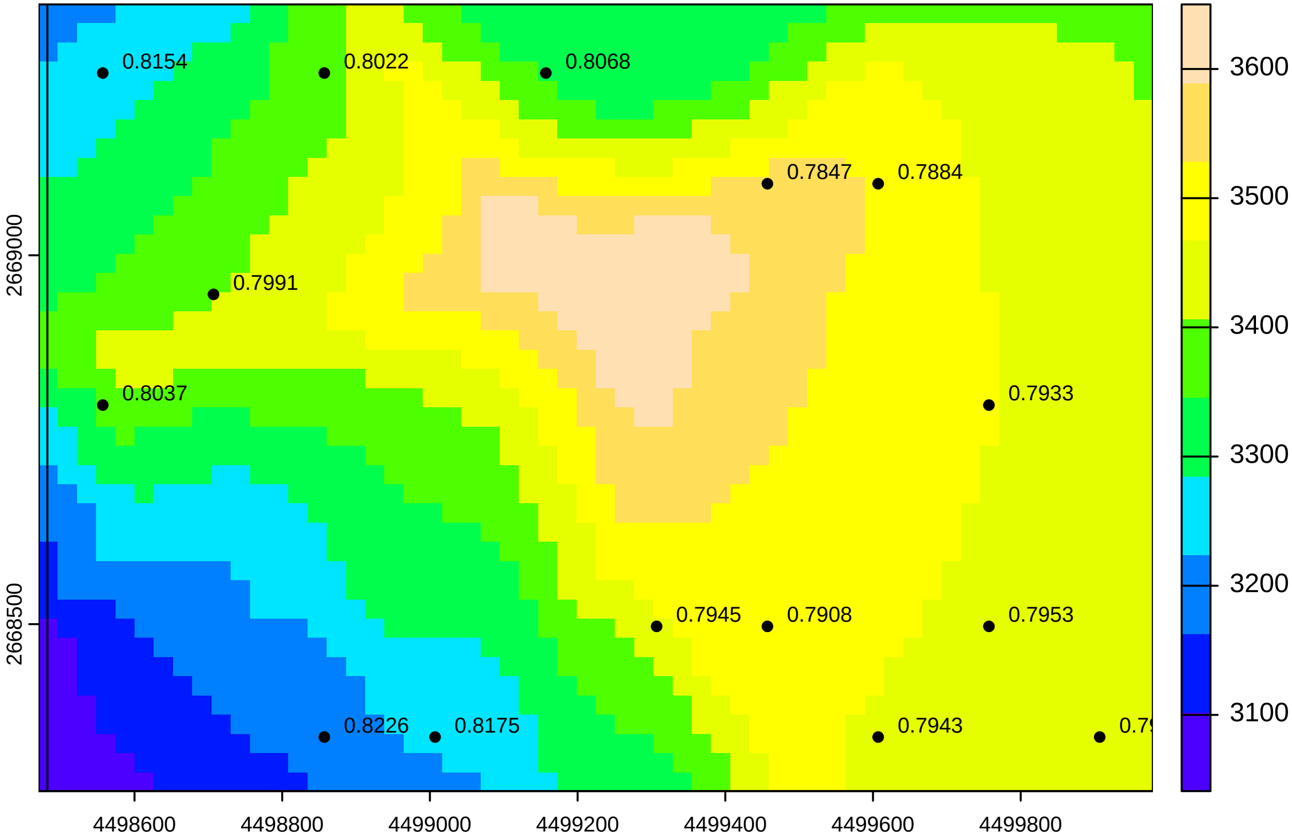

SRTM Elevation Data
3251
3381
3336
3557
3520
3412
3366
3470
3458
3496
3450
3181
3230
3460
34
2669200
2668800
2668400
4498500
4499000
4499500
3600
3500
3400
3300
3200
3100

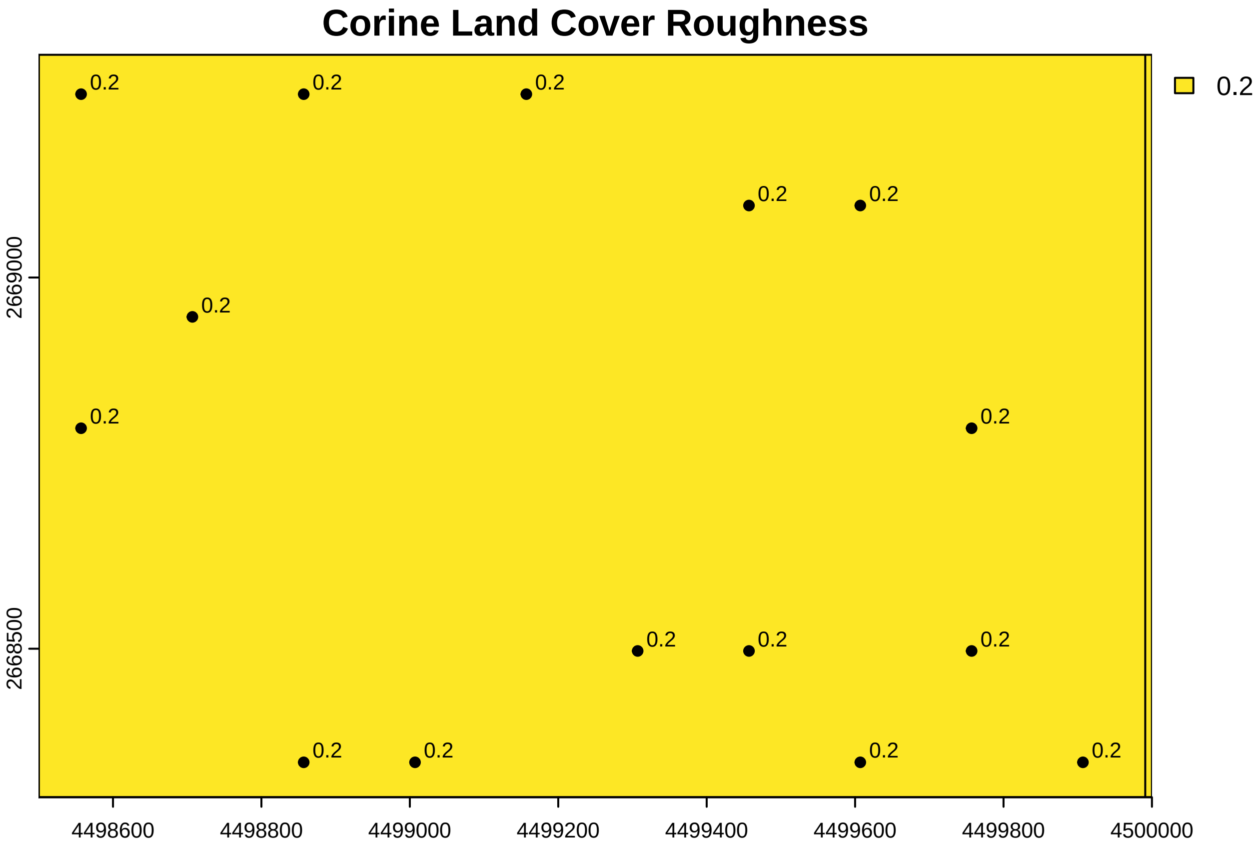

Wind Speed Multipliers
0.955
0.994
0.98
1.045
1.034
1.003
0.989
1.02
1.016
1.027
1.014
0.935
0.949
1.017
1.
2669200
2668800
2668400
4498500
4499000
4499500
1.05
1.00
0.95
0.90

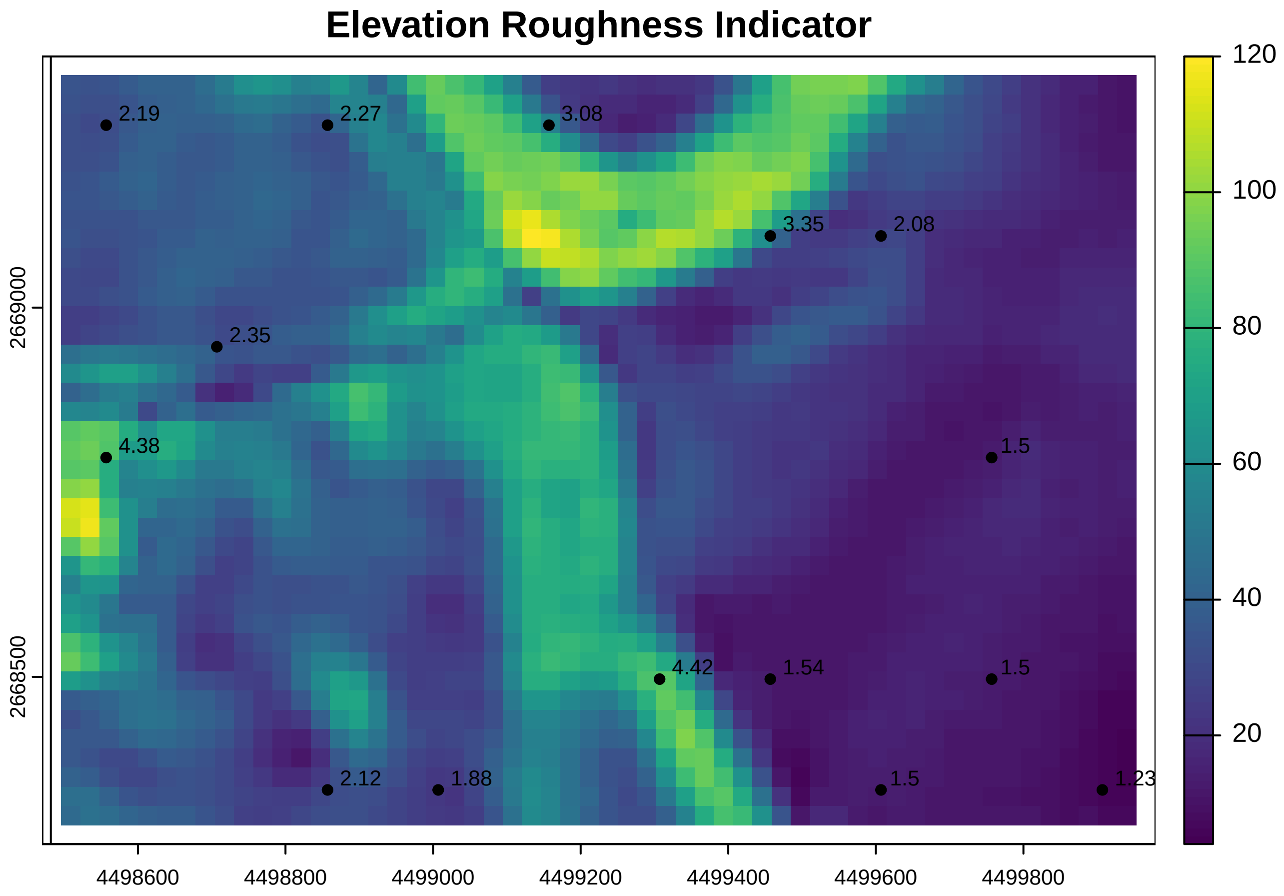


Normal Air Density
0.8154
0.8022
0.8068
0.7847
0.7884
0.7991
0.8037
0.7933
0.7945
0.7908
0.7953
0.8226
0.8175
0.7943
4498600
4498800
4499000
4499200
4499400
4499600
4499800
2669000
2668500
3600
3500
3400
3300
3200
3100

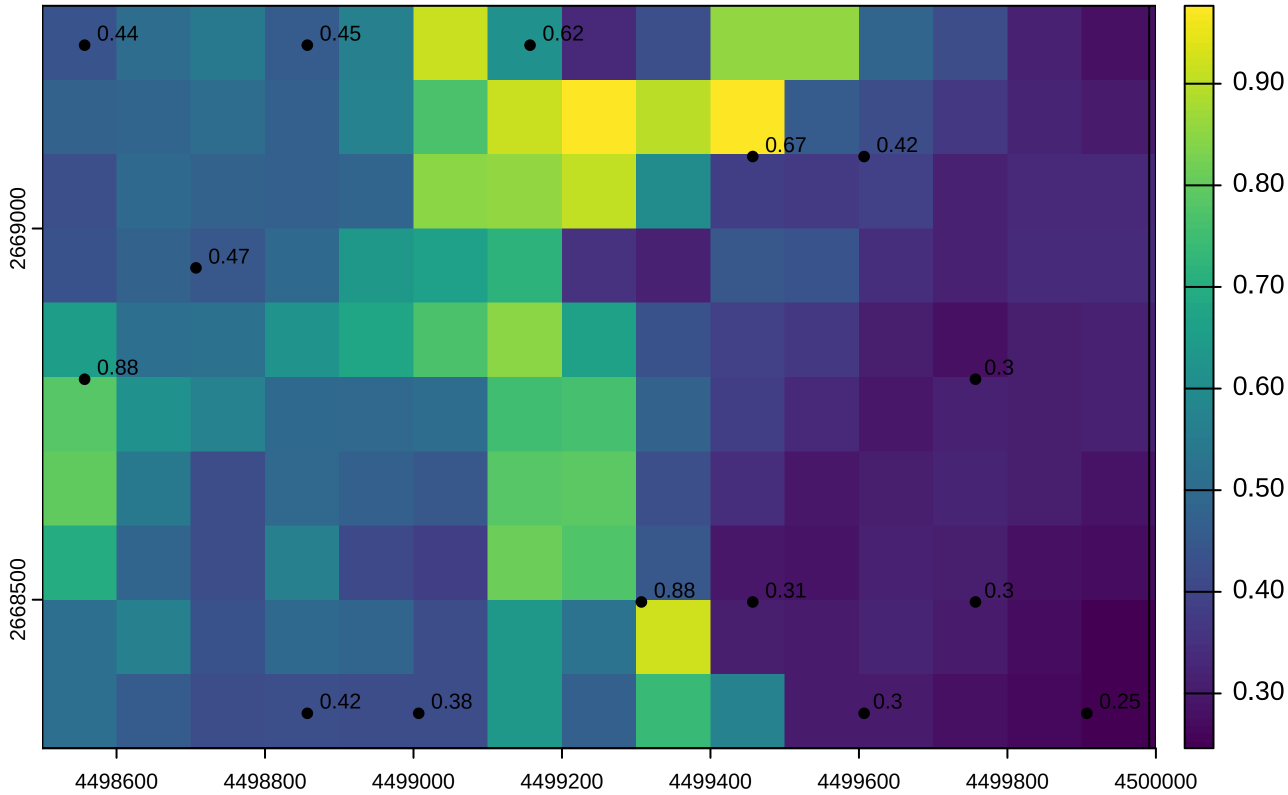
Corrected Air Density

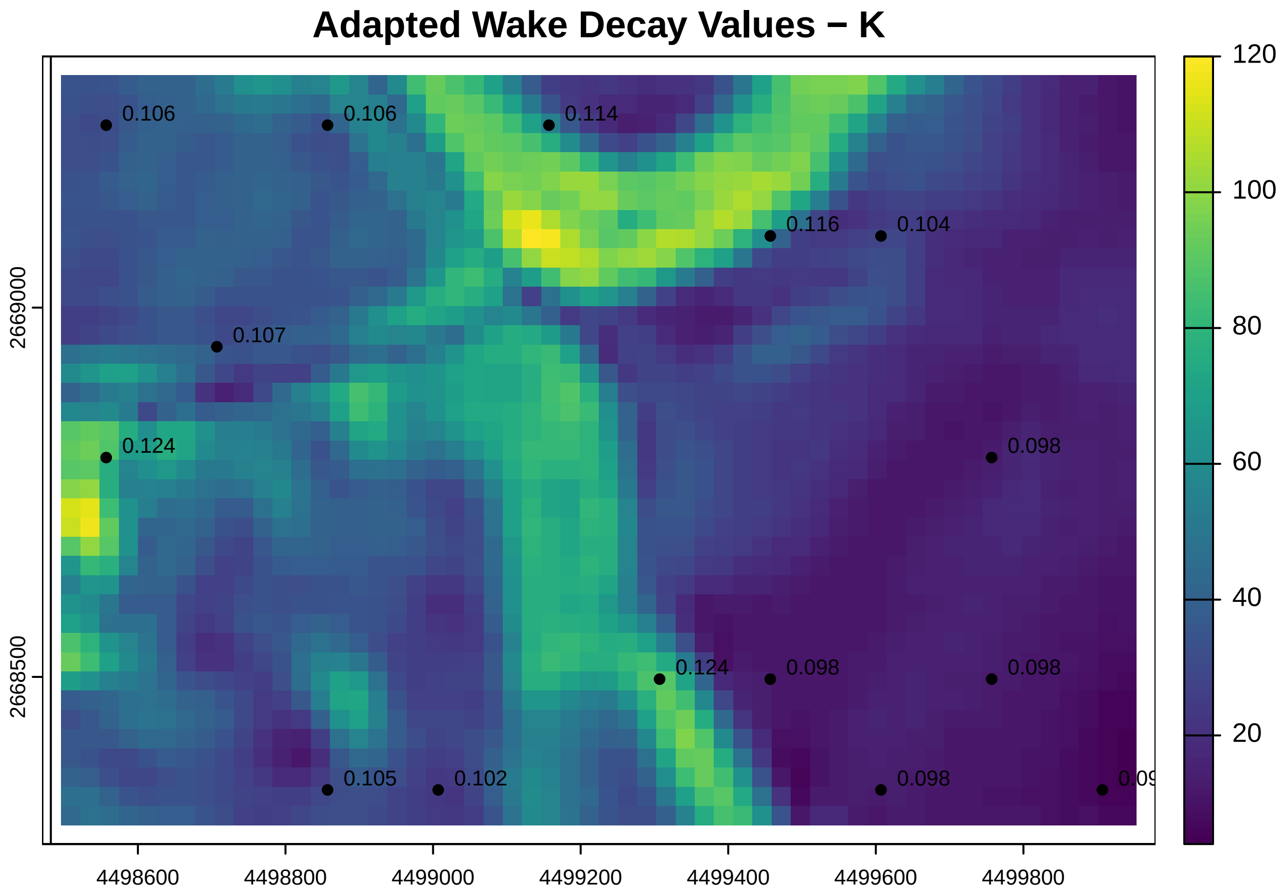



Corine Land Cover Roughness
0.2
4498600
4498800
4499000
4499200
4499400
4499600
4499800
4500000
2668500
2669000


Elevation Roughness Indicator
2.19
2.27
3.08
3.35
2.08
2.35
4.38
1.5
4.42
1.54
1.5
2.12
1.88
1.5
1.23
2669000
2668500
4498600
4498800
4499000
4499200
4499400
4499600
4499800
120
100
80
60
40
20

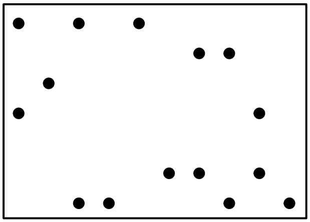
Modified Surface Roughness



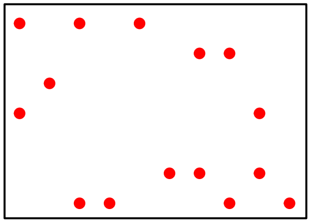


Adapted Wake Decay Values − K
0.106
0.106
0.114
0.116
0.104
0.107
0.124
0.098
0.124
0.098
0.098
0.105
0.102
0.098
0.09
2669000
2668500
4498600
4498800
4499000
4499200
4499400
4499600
4499800
120
100
80
60
40
20

Shape at angle 0

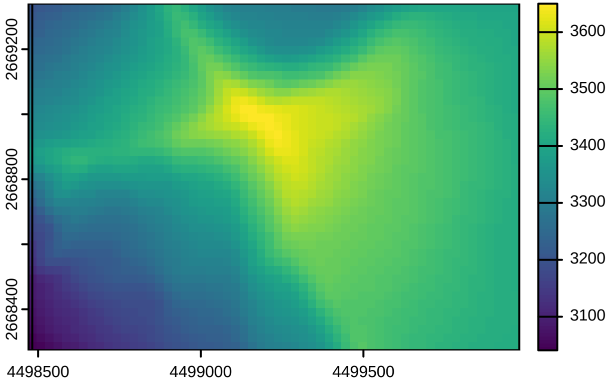


Shape at angle: 0

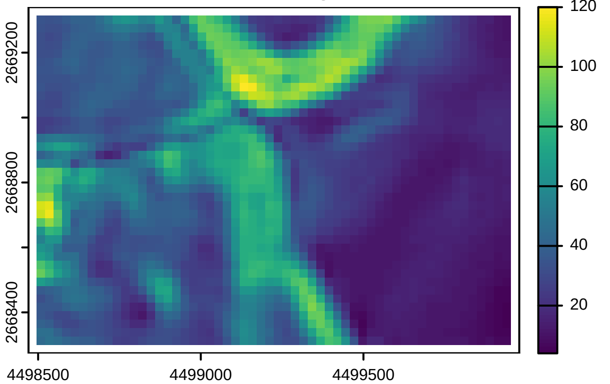


Direction: 1
from total: 1

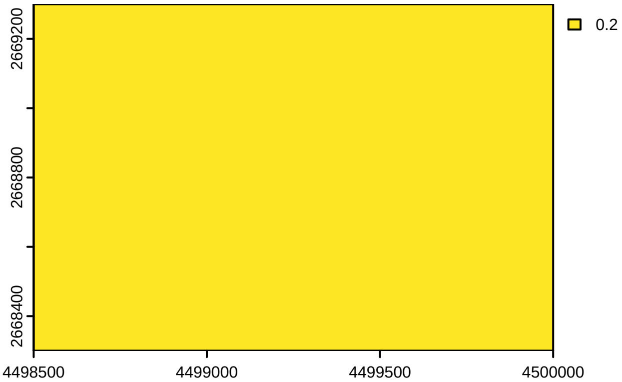
Elevation Data



Elevation Roughness



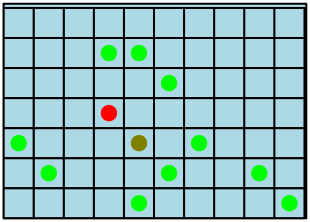
Surface Roughness from Corine Land Cover



1 Round

Best Energy Output: 14123.59 W/h

Efficiency: 99.92 %

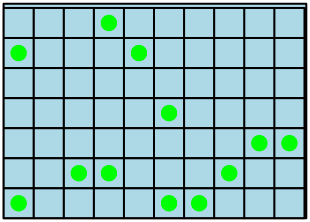


Number of turbines: 12

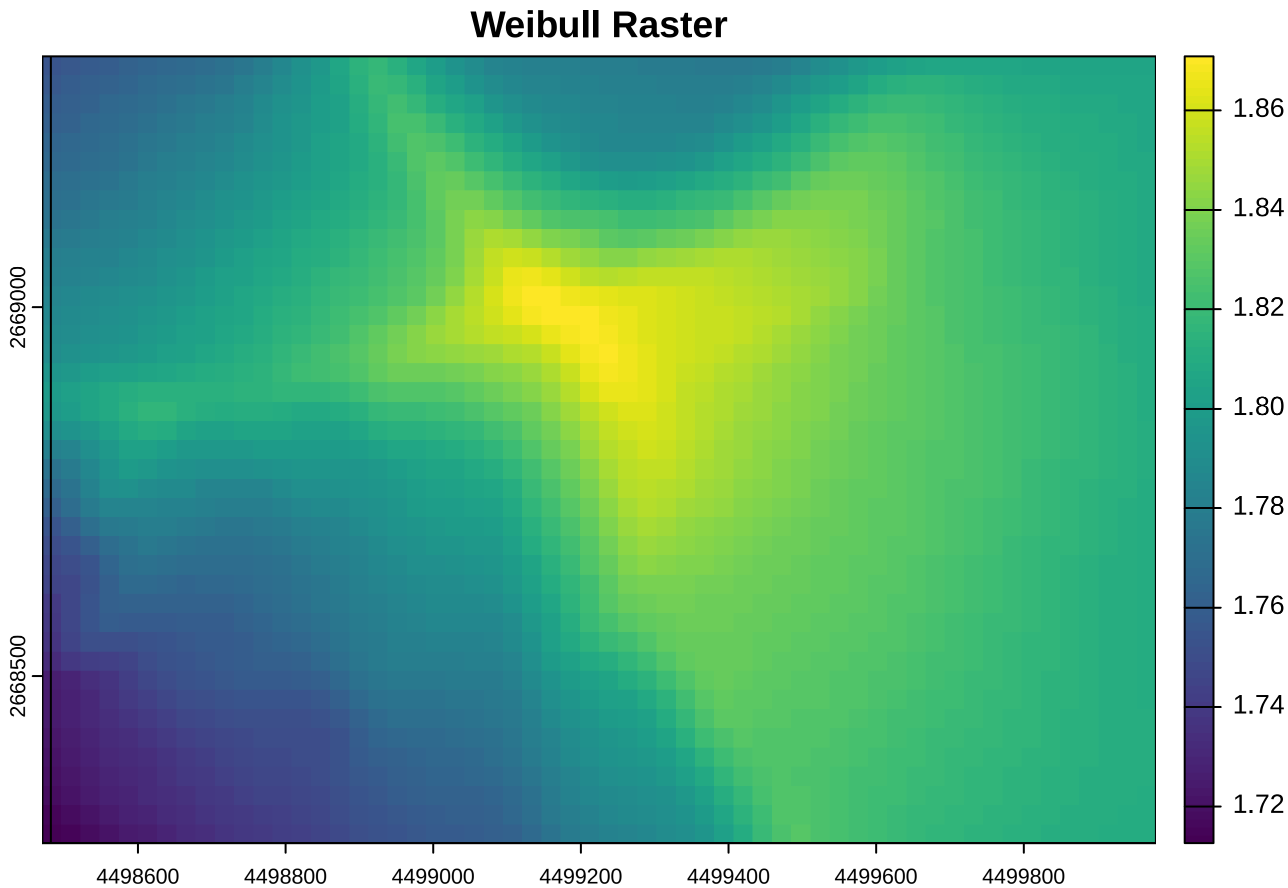
1 Round

Best Efficiency Output: 13814.09 W/h

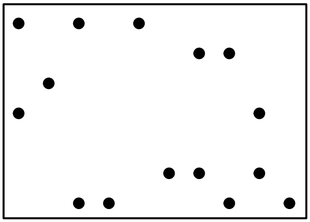
Efficiency: 100 %



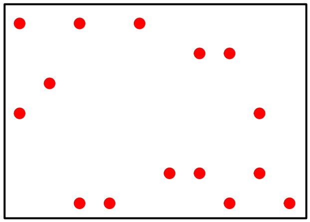
Number of turbines: 12


Weibull Raster
2669000
2668500
4498600
4498800
4499000
4499200
4499400
4499600
4499800
1.86
1.84
1.82
1.80
1.78
1.76
1.74
1.72

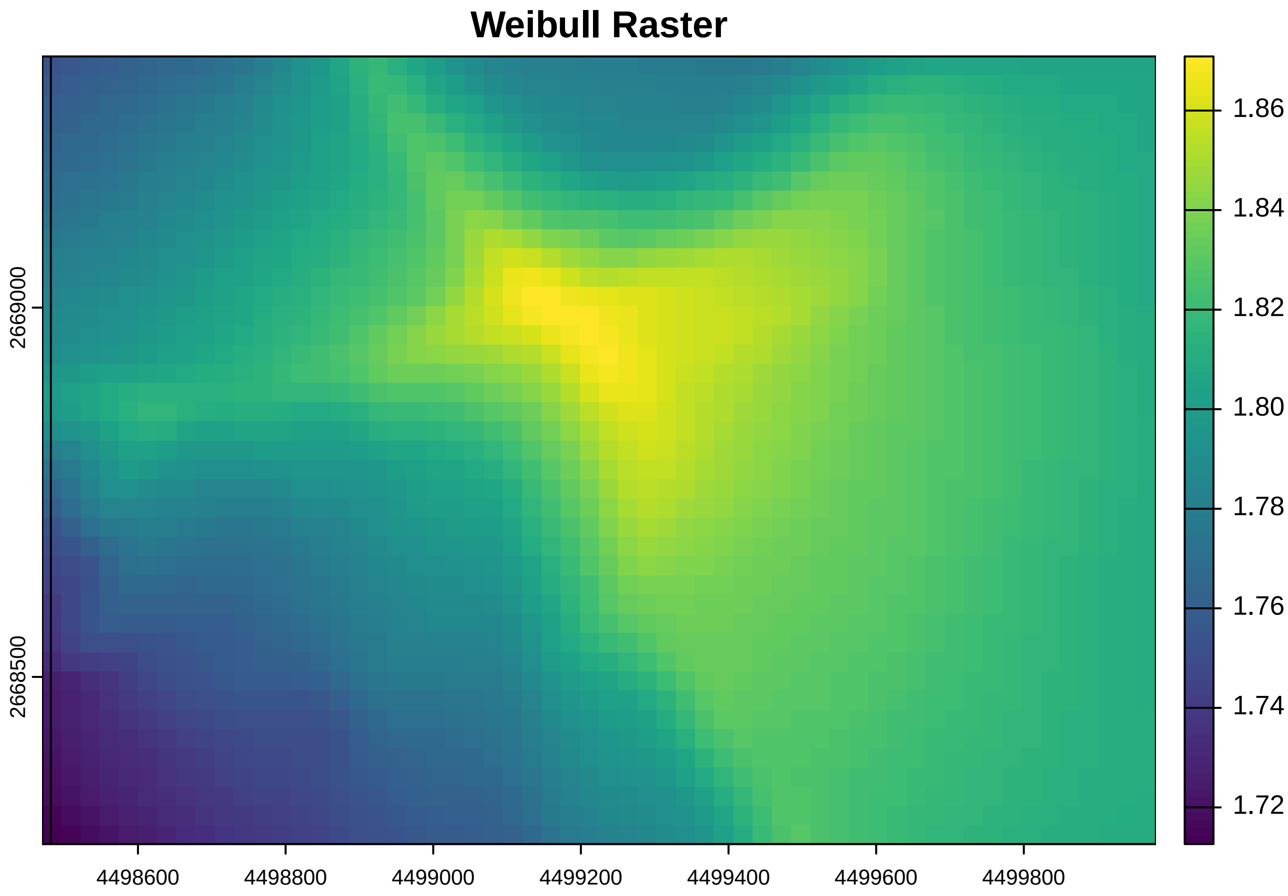
Shape at angle 0



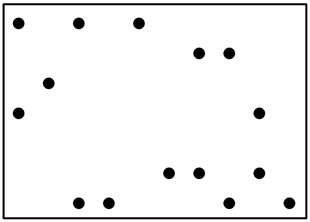
Shape at angle: 0



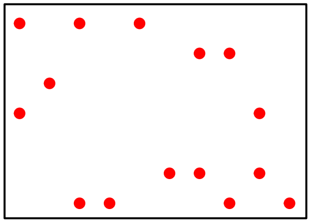
Direction: 1
from total: 1


Weibull Raster
2669000
2668500
4498600
4498800
4499000
4499200
4499400
4499600
4499800
1.86
1.84
1.82
1.80
1.78
1.76
1.74
1.72

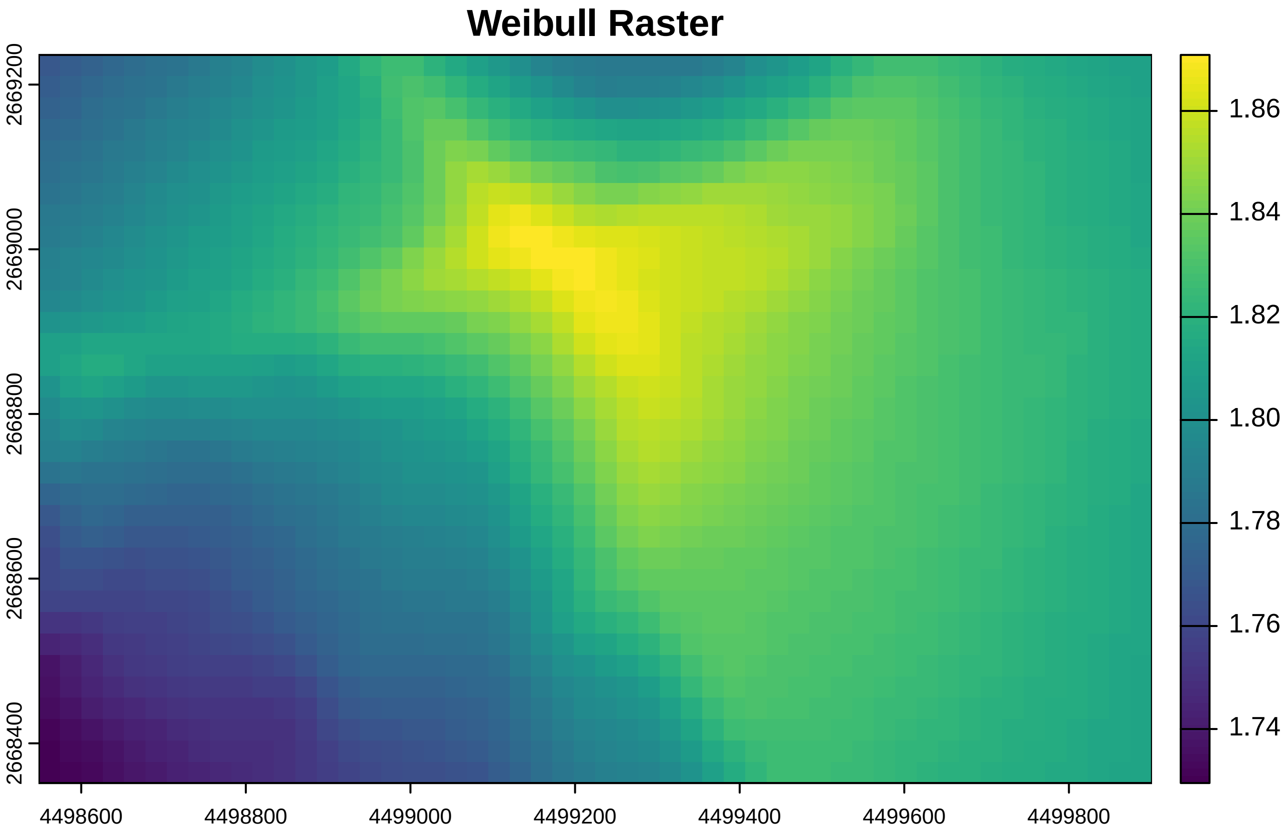
Shape at angle 0



Shape at angle:
0

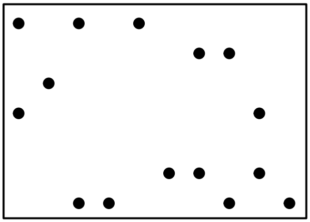


Direction: 1
from total: 1

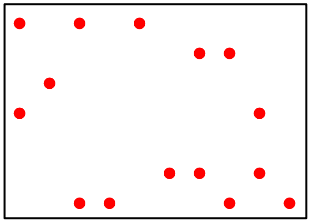


Weibull Raster
2669200
2669000
2668800
2668600
2668400
4498600
4498800
4499000
4499200
4499400
4499600
4499800
1.86
1.84
1.82
1.80
1.78
1.76
1.74

Shape at angle 0



Shape at angle: 0



Direction: 1
from total: 1