THESIS

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Characteristics of the level of disturbance of soil surface by rooting of wild boar *Sus scrofa* at Jane Goodall Tanösvény open ground in Hungary

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Chapter 1

1. Introduction

The wild boar is commonly known as wild swine, feral swine, or wild pig *Sus scrofa* Linnaeus, 1758 by wildlife managers, based on its ecological status can be considered as native or introduced (Keiter et al., 2016). It has a prehistoric status in Europe and is of great importance to humans (Rice, 1992; Sommer & Nadachowski, 2006) It exhibits a wide spectrum of behavior for its survival in the ecosystem this is supported by studies according to Erdtmann and Keuling (2020). Rooting or grubbing in wild boar is an important behavior that involves the use of the snout on the ground to remove the topsoil and leaves to expose the food sources on the ground in search of food and it occurs in selected sites based on a strong sense of smell and time that are considered safe to avoid predation (Graves, 1984). This activity occurs in the first half of the night and resting behavior occurs in the second half of the night (Boitani et al., 1994; Stolba & Wood-Gush, 1989). Experimental studies using domestic pigs have demonstrated that the quality of food has a direct influence on the frequency of site visits and the amount of time spent searching for the desired food (Held et al., 2005).

The major food searched for includes but is not strictly limited to plant matter, roots, seeds, bulbs, earthworms, and other invertebrates that constitute an important part of their diet. However, seasonal variation, energy requirements, geographical variation, and availability of food have an impact on the choice of diet by the wild boar (Ballari & Barrios-Garcia, 2013; Schley & Roper, 2003). Wild boars are also known to prey on snakes, frogs, rodents and birds that nest on the ground, which have been found in their digestive tract (Cao et al., 2023).

It is important to understand the pattern of foraging of wild boar, especially considering agricultural practices along forest edges (Thurfjell et al., 2009) among other damages that include soil disturbances and the introduction of non-native seeds that germinate and lead to unnatural competition with the native species (Barrios-Garcia & Ballari, 2012; Cuevas et al., 2012). The disturbances in the soil profile by the wild boar have been shown not to have an impact on the soil characteristics and hence the need to consider other abiotic factors as drivers of soil degradation and not as a result of effects caused by the wild boar (Pitta-Osses et al., 2022).

A study in central Europe indicates that wild boar has a significant effect of disturbing the topsoil and that the wild boar may selectively root soil surface more than once hence leading to variation in the intensity of excavation in terms of the depth and circumference (Sütő et al., 2020).

This study wishes to document the intensity and characteristics of disturbance caused by wild boar activity (rooting) at Jane Goodall tanösvény in Hungary. This study is important as other variables such as roads, and human settlements may influence the feeding behavior associated with rooting and compare the results with other studies conducted in relatively similar ecological characteristics (Bueno et al., 2009).

1.1. Study Questions

1. What is the total size of the disturbed soil surface in the study area?
2. How many rooted patches are included?
3. What is the size distribution of those patches?
4. How far those patches are from each other?

Chapter 2

2. Literature review

Rooting by wild boar is the act of removal of the upper soil layer that is caused by disturbing soil structure, this natural act can harm the environment (Massei & Genov, 2004). However, this act is beneficial to the wild boar as they do this in an attempt to obtain food from the underground, the food can be vegetation, ground-dwelling animals such as moles, snakes, rats worms, and insects (Ballari & Barrios-Garcia, 2013). The magnitude of rooted surfaces in terms of the depth of the hole created and perimeter varies depending on the frequency of rooting which is determined by the availability and palatability of food resources and their distance in a particular area of rooting (Bueno et al., 2009). In Hungary, this topic has been extensively studied and the dynamics of the behavior of rooting have been documented (Pitta-Osses et al., 2022; Sütő et al., 2020).

2.1 Food types searched by rooting

Wild boar mostly consume plant material origin and it composes of about 90% of their diet. However, wild boars are omnivores and are known to eat a wide variety of foods including roots, and tubers, fruits, nuts, and corn; the last is wild boars' favorite food with high fat and energy content (Ballari & Barrios-Garcia, 2013).

They are also known to be opportunistic omnivores that is they consume other animals such as insects, rodents, reptiles, and amphibians. As revealed by the recovery of the stomach content of sampled wild boar (Cao et al., 2023), however wild boar sometimes eat dead bodies of other animals. The food adaptability of wild boar have allowed them to distribute and survive almost every location where they've been introduced (Genov, 1981; Herrero et al., 2004; Villanua, 2004). Sometimes they eat inorganic materials like stones, mud, and plastic in some parts of their native environment (Katona & Heltai, 2018b; Barrios-Garcia & Ballari, 2012).

2.2 Daily activity and frequency of rooting

Wild boar and other ungulates tend to be more active during the crepuscular hours which means they are mostly likely to root around during the early morning and late afternoon (Handschuh et al., 2020; Sütő et al., 2020). Wild boars are also nocturnal so they can root during the night when the environment allows them to detect predator (Gordigiani et al., 2022). The nighttime activity of the wild boar is dominated by bright moonlight nights, the light should be at its highest, especially where natural predators are present. Wild boar can forage 6-12 hours a day (Gordigiani et al., 2022; Russo et al., 2010) and their activities sometimes change due to weather conditions such as hot-cold, or humidity. Usually wild boar can rest during the day. In case of any human being interacting with wild boar they root at nighttime to reduce interference (Handschuh et al., 2020; Keuling et al., 2013; Podgórski et al., 2013).

2.3 Rooting habitat preference

Wild boar possess high environmental adaptability and wide tolerance (Elledge et al., 2013; Thurfjell et al., 2009). The presence of woody species provides a good food source and hiding spot, together with shrub cover (Sütő et al., 2020). High-altitude, gently sloping ridge habitats were chosen by wild boar. The site's characteristics somewhat correlate with the spread of the forest type. Because of the rich potential food sources in these areas, possibly because of the high plant diversity, the wild boar exhibited feeding behavior primarily at higher elevations. The wild boar favored areas that were remote from forest roads and that many hikers frequented. However Kim et al. (2019) hypothesized that because they could avoid people and had a variety of food sources in these patches, wild boar favored large forest patches. Also, wild boar preferred easily dug, moist areas. If there is comparatively less dense vegetation, wild boar prefer it because it offers a safer and clearer view and a pathway to a higher elevation in case of emergency. Nowadays, *Sus scrofa* can be found in large European cities and towns, including Berlin, Rome, and Budapest, due to the presence of small forests and woody plants that provide the animals with food (Massei et al., 2015; Podgórski et al., 2013).

2.4 Positive impact of rooting

Sus scrofa rooting can typically identified by the surface soil disturbance (Sütő et al., 2020). Increased soil turnover can facilitate the cycling of nutrients, increasing their availability to other plants. Wild boar rooting helps minimize the direct flow of water downhill slopes and stability of water bodies and aquatic ecosystems by improving the diversity (richness) and distribution within an ecosystem, wild boar rooting promotes biodiversity (Pitta-Osses et al., 2022). Wild boar disturbances have the budding to create microhabitats that are valuable to specific plant and animal species. By rooting, wild boar can create small dents or wallows that can become habitats and provide water for other wildlife during dry spells. These characteristics may add to an ecosystem's total habitat diversity.

2.5. Negative impact of rooting

The disturbance caused by wild boar alters the structure and composition of plant communities, slows down the rate of decomposition, and encourages the establishment and growth of invasive plants. These effects are felt both at the community and ecosystem scales (Pitta-Osses et al., 2022) enhancing runoff and modifying the sedimentation process' trajectory. Genov (1981) states that wild boars can impact the quantity and diversity of plant species by directly consuming entire plants or their vegetative parts, including fruits, bulbs, and tubers. According to Bogdán and Heltai (2014) reports claimed that because of wild boars, the locals mostly children feel threatened by them. Conversely, wild boar caused damage to the vegetable garden and cultivated areas are destroyed, the fence is damaged, roots are damaged, and similarly, dogs are hostile (Csókás et al., 2020).

Chapter 3

3. Materials and methods

3.1.Study area

The study took place in Vöröskővár (47°33’14,84” N 18°58’34,68 E) around Budapest's second district. The place is bordered by urban areas. This area offers a variety of habitat types, such as grassland, shrubby, and wooded landscapes. It is located on the outskirts of Budapest, near a grassy disused airport field and surrounded by big woodland blocks (Hármashatárhegy).

The steep section of this location is part of a 0.8-kilometer-long out-back hiking track named after Dr. Jane Goodall, where our sampling was conducted. Because of the hiking route and the airport space, this region is popular as a training field for paragliding as well as walking, running, and cycling.

Figure 1. The picture shows the study area at the Jane Goodall nature trail.

This study was focused on wild boar rooting behavior in the grassland area and understand and document the dynamics of this unique characteristic of the wild boars. To study this behavior, sampling along predetermined transects in grid cells was conducted using a GPS.

Adjacent tows of 20m x 20m grid cells parallel to each other were designated for the study area. An area of 500m x 100m was designated on which a plain grassland and a hill were included, for a total of 125 grid cells.

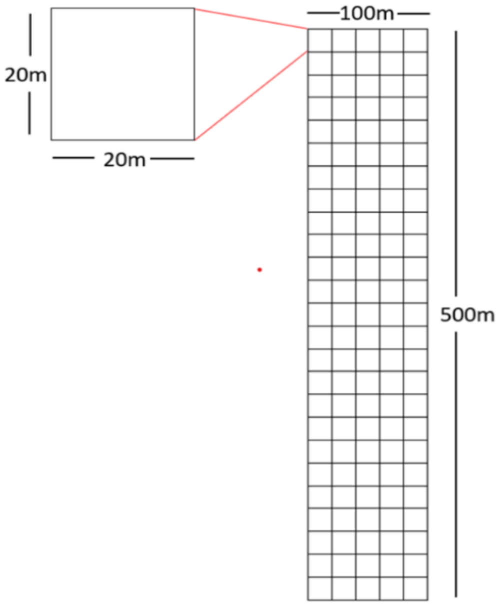

Figure 2. The measurements of distance covered and the size of cells of each grid

Data collection for wild boar rootings was conducted in the center of intermittent grid cells,

utilizing transect lines close to the longer extent of the region, Transects were utilized as a reference to walking through a representative area of the research.

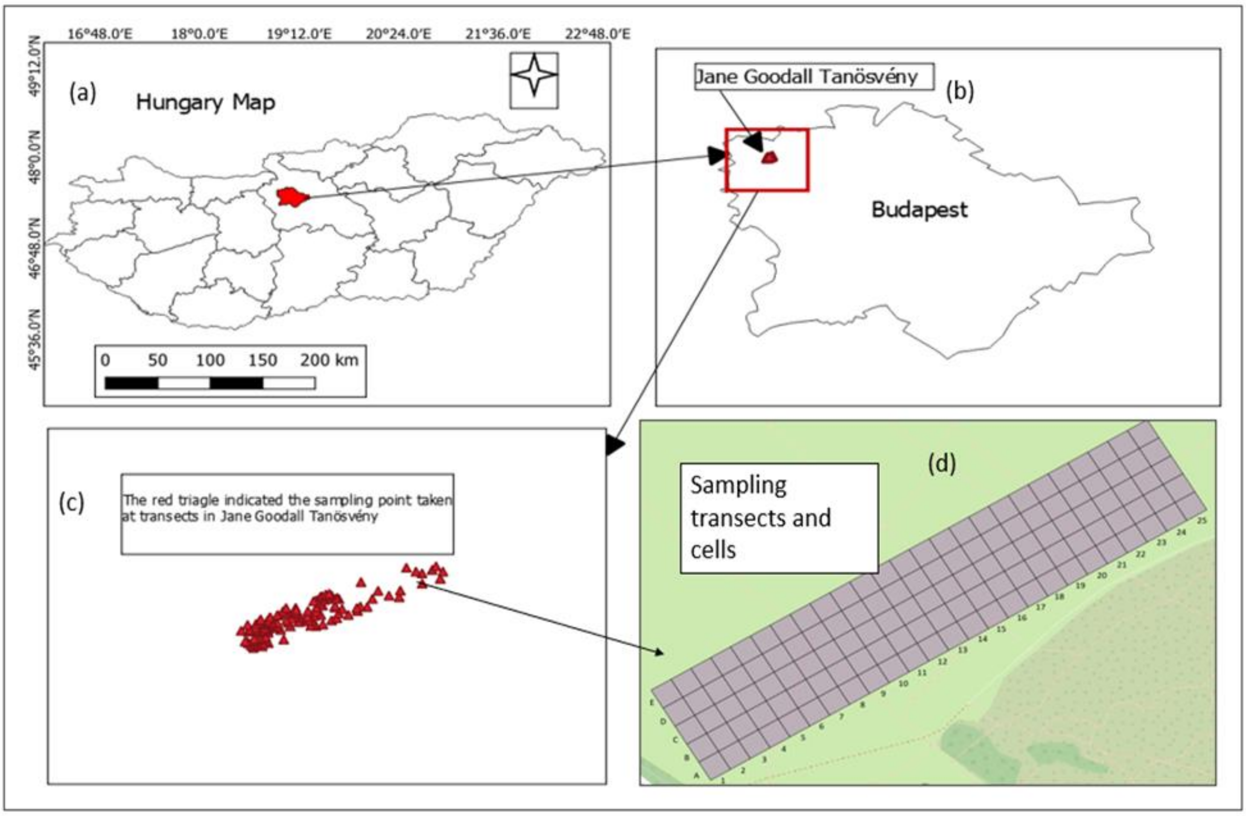

Figure 3. The map showing the study (a) Hungary map (b) Jane Goodall Tanösvény

in Budapest (c) sampling point (d) sampling transects and cells

3.2. Field method and data collection

To investigate the temporal changes in the quantity and distribution of rootings caused by wild boar we conducted observational surveys from 11 am to 5 pm every two days per week for 2 months (April -May 2023), meaning 16 sampling days.

By recording the coordinates of the rooted area's entry point and exit point in a single direction parallel to the transect, we were able to measure the length of each rooted patch. This allowed us to create a line segment that would give the rooted area's length in meters (m). A Garmin GPS unit captured the location points. To ensure accuracy in sampling the rootings within each cell, a 20m string with a nail attached to it was used. The nail was pinned to the very beginning of the middle transect line and the string was pulled over it and laid on the ground to sign the overlapping edge of the two neighboring cells. After finishing data collection in the two cells, this procedure was repeated passing along the transect ensuring cell separation.

We considered a patch as rooted by wild boar when the disturbed site heavily differed from the undisturbed surroundings, meaning that on a large surface, the herbaceous vegetation was exposing just the soil. Only fresh rooting was mapped with no vegetation inside.

Figure 4. A wild boar-rooted area.

Rooting by wild boar involves the act of removal of the surface vegetation and excavation of soil that leads to characteristic holes that range between 5 and 15 cm (Kotanen, 1995).

The rootings were identified due to a noticeable disturbance in the soil characteristics of the depth (shallow vs. deep roots) (Welander, 2000).

3.3 Data analysis

We were able to scan 125 grid cells' root points. In the field, observational data was collected using a datasheet, which was subsequently recorded into an Excel spreadsheet. Using a separate Excel spreadsheet, the data was organized and analyzed in Microsoft Excel before being interpreted in various graphics based on the research questions.

To determine the overall size of the affected region, it is assumed to be a circular shape. The formula used to compute the area is πr^2, where r represents the radius of the disturbed surface (d/2; i.e. half of the length of the rooted section). After we converted the distance estimate from kilometers to meters. The Haversine formula, a mathematical equation employed to determine the most direct distance between two locations on a spherical surface, has been utilized to compute the distance (d) between two given points, as seen in equation (i). Distances were computed for all 124 rooted sites, and the area was determined for each of these places.

Distance d =ACOS(a+b+c)*6370 kilometers …………(i)

Where c = SIN(lat entry*π/180)*SIN(lat exit*π/180)

And b = COS(lat entry*π/180)*SIN(long entry*π/180)*COS(lat exit*π/180)*SIN(long exit*π/180)

And a = COS(lat entry*π/180)*COS(lat exit*π/180)*COS(long entry*π/180)*COS(long exit*π/180)

The numerical value of π is roughly 3.14, whereas the Earth's radius is estimated to be around 6370 km. This function is employed to convert the angular distance calculated by the Haversine formula into the equivalent distance on the Earth's surface. The trigonometric functions ACOS, COS, and SIN are used in spherical geometry to calculate angles and distances for latitude and longitude coordinates. The variable "d" specifies the distance between the two locations where the entry and exit take place, as demonstrated in Appendix 2.

Chapter 4

4. Results and discussion

4.1 What is the total size of the disturbed surface?

Compared to our estimation, the study revealed that the total area affected was calculated to be 1565.2 m^2 out of the whole area. The measured area covered a total of 50,000 m^2. The undisturbed area included 48,434.2 m^2, which represents a small proportion of the total area, as seen in Figure 5.

We observed that the percentage of disturbed regions appears to be lower than expected. This could be due to insufficient sunshine or incorrect watering may also lead to the tiny size of the wild boar rooting area in cells. Low nutrients in the soil might be the cause of the rooting area's small size. Furthermore, competition from other species or human activity may limit the boars' access to broader places for consumption. This is similar to Pitta-Osses et al. (2022) who reported an increase in rooting activity throughout the autumn and winter months, followed by a progressive decline in rooting activity in the spring and summer. This might be related to a decrease in the availability of green vegetation throughout the winter, as well as the necessity to seek acorns, seeds, and roots underground. As a result, wild boar eating habits vary with time and place, but it may be viewed as a continual disturbance component in forest soil.

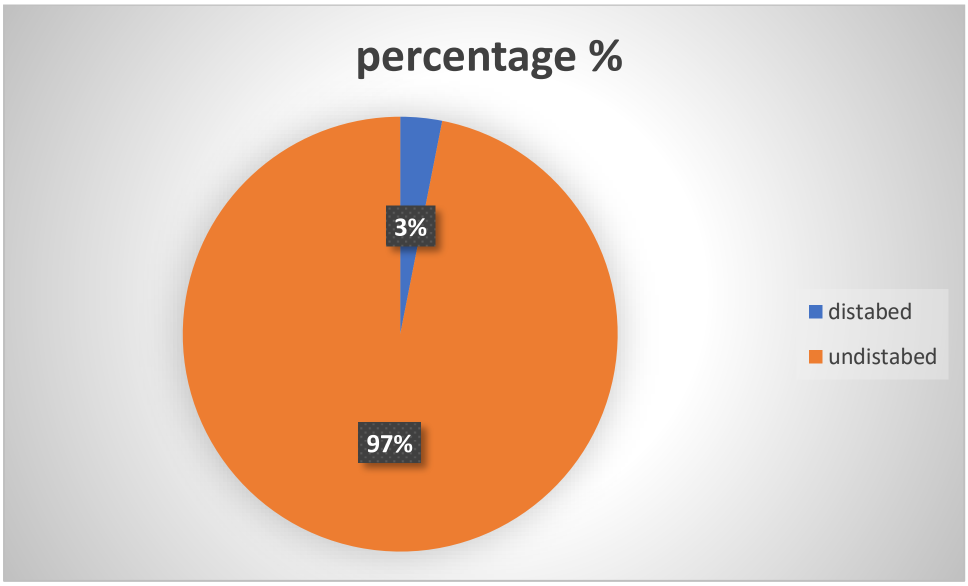

Figure 5. The percentage (%) of the size of the disturbed and undisturbed area.

4.2 How many rooted patches are included?

The findings indicate that deep, shallow, or even partial rootings were present in at least 90% of the grid cells. Of 125 total cells, 120 were rooted, while only 5 were left undisturbed. There might be other causes for this. This involves the presence of obstacles that hinder the establishment of roots in particular areas. The availability of trails for human use may potentially play a role in promoting or inhibiting root development in particular regions. To identify the exact reasons behind the absence of roots in these particular cells, more investigation is required.

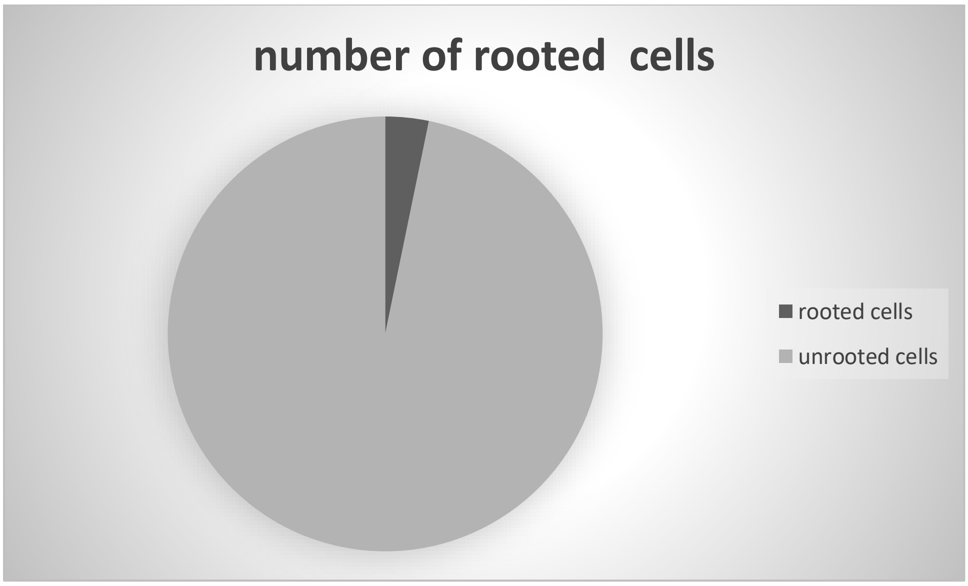

Figure 6. The number of rooted and unrooted grid cells

4.3 What is the size distribution of those patches?

The results of the study were analyzed and calculated using Excel by computing the standard deviation and mean. The average area of 12.6 m^2 was calculated by dividing the entire sum of areas for all rooting points (1565.2 m^2) by the number of rooting points (124). The standard deviation was 17.3m^2 this was calculated using the STDEV() function in Excel. The area is commonly conceptualized as a circular zone, and its size is determined using the formula πr^2, where r denotes the radius of the affected surface (d/2). After calculating each grid cell, the value of r was converted into square meters, as shown in Figure 7.

The study discovered that the area of soil disturbed by wild boar was relatively small, This accounts for less than 3% of the total area and suggests that the impact is limited. Moreover, due to the predominantly shallow nature of roots, the impact of wild boars on the soil may be swamped by other variables. It is worth mentioning that the amount of soil moved by wild boar can have lasting impacts on soil properties. Hancock et al. (2016) recognize that wild boar rooting leads to permanent problems for forest ecosystems. It becomes clear that the dispersed and changing distribution of the rooted areas would eventually cover most of the ground in a relatively short period, playing a vital role in the processes that contribute to soil formation. Our findings are in line with those of the Bradley & Lockaby (2021) exhibiting a seasonal pattern that is consistent with our observation, more marked from mid-autumn to spring. In the areas where the wild boar has been introduced, where the ecosystems may be less resistant to its impacts, some writers documented that more substantial disruptions were caused by the soil being redistributed by the animals' rooting formation.

Wild boar roots can help slow down flow and trap silt. Their digging movements cause little cavities in the ground's surface, which can assist conserve water while avoiding erosion. Furthermore, the damage generated by their roots could stimulate new plant development and boost biodiversity in the ecosystem. While wild boar rooting is considered detrimental in some cases, it can also have beneficial ecological effects when handled properly. Bruinderink & Hazebroek (1996) published a study that examines the impact of wild boar roots on forest regeneration in the Netherlands.

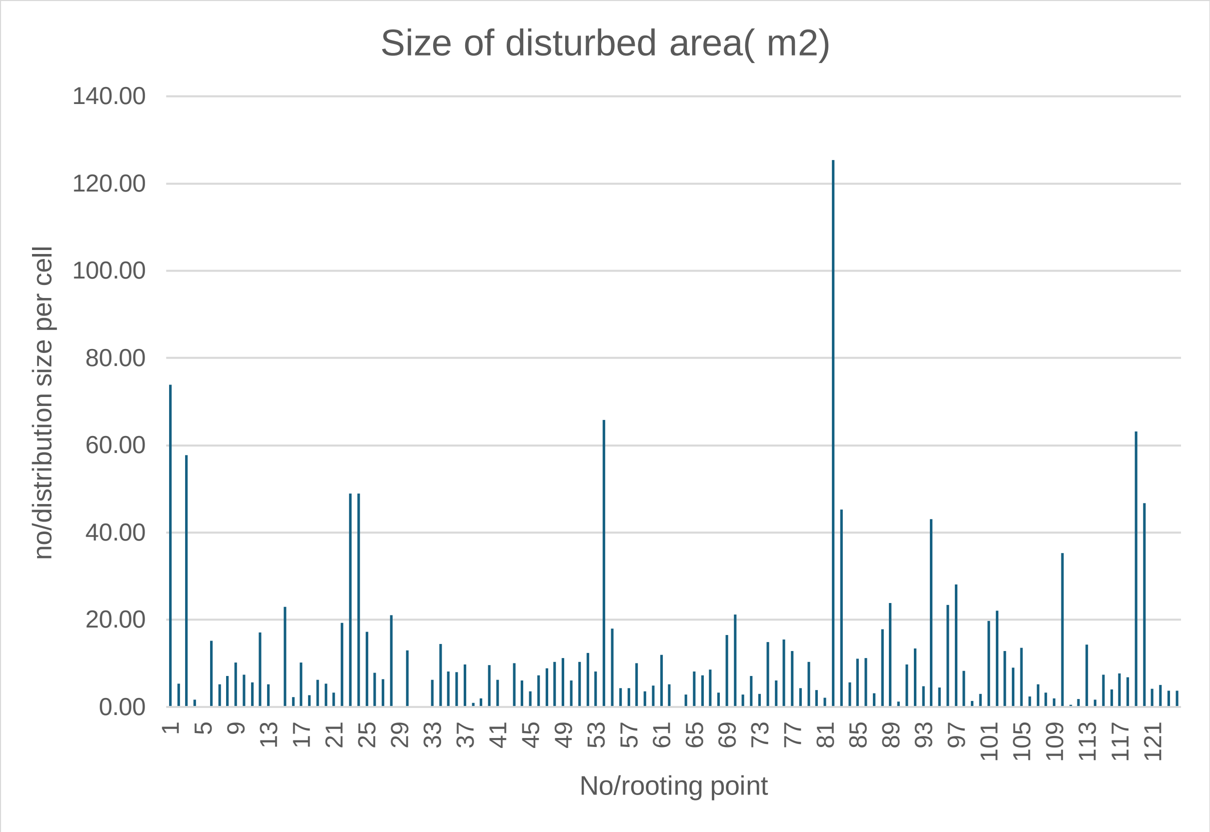

Figure 7. The size distribution (m^2) against number of rooting point

4.4 How far the rooted patches are from each other?

The minimum, maximum, and average distances were calculated as shown in Figure 8. for all rooting points. For example, for rooting point R1, its exit coordinate points (longitude and latitude) were used to calculate the distance with all other 123 entry rooting points and the calculations continued for R2 up to R124 as shown in Annex 1, using the equation (i). Then the MIN, MAX, and AVERAGE functions were used to calculate the minimum, maximum, and average distance as shown in Figure 8. a Figure 8. b, and Figure 8. c, respectively. Subsequently, the data were examined to ascertain the comprehensive distribution of distances as shown in Appendix 2. The results exhibited a Gaussian distribution of distances. The roots were near one other. Initially, at the start of the transect, the distances were rather consistent. However, as the transect progressed, the distances started to exhibit greater variability, see Figure 8. c.

The minimum outcome indicates that the first portion of the transect exhibited extensive root growth, as seen in Figure 8. a, whereas the latter portion had noticeably reduced root development. This disparity may be attributed to human activities in the vicinity. Activities such as hiking, dog work, riding, and other recreational activities are comparable to the study conducted by Sütő et al. (2020) who examined the quality and utilization of habitat patches by wild boar over an urban gradient and revealed similar findings.

Our findings indicate that the area with a high concentration of roots was near human habitation. This may be attributed to the dietary choice of wild boars. The proximity of food supplies to human settlements likely enticed the wild boar population to the densely vegetated region. This proximity to human settlement might potentially enhance the probability of human-wildlife confrontations. Wild boars in built-up areas of Hungary primarily consume natural food sources and show a lower dependence on human-made food sources, as observed in studies by Katona et al. (2018), but differs from other places where leftovers are the main food source for wild boars as reported by Stillfred et al. (2017b). In addition to providing protection sufficient and native flora in urban areas is the preferred food source, to which wild boars have adapted through their foraging habits and digestive systems (Bogdán and Heltai 2014).

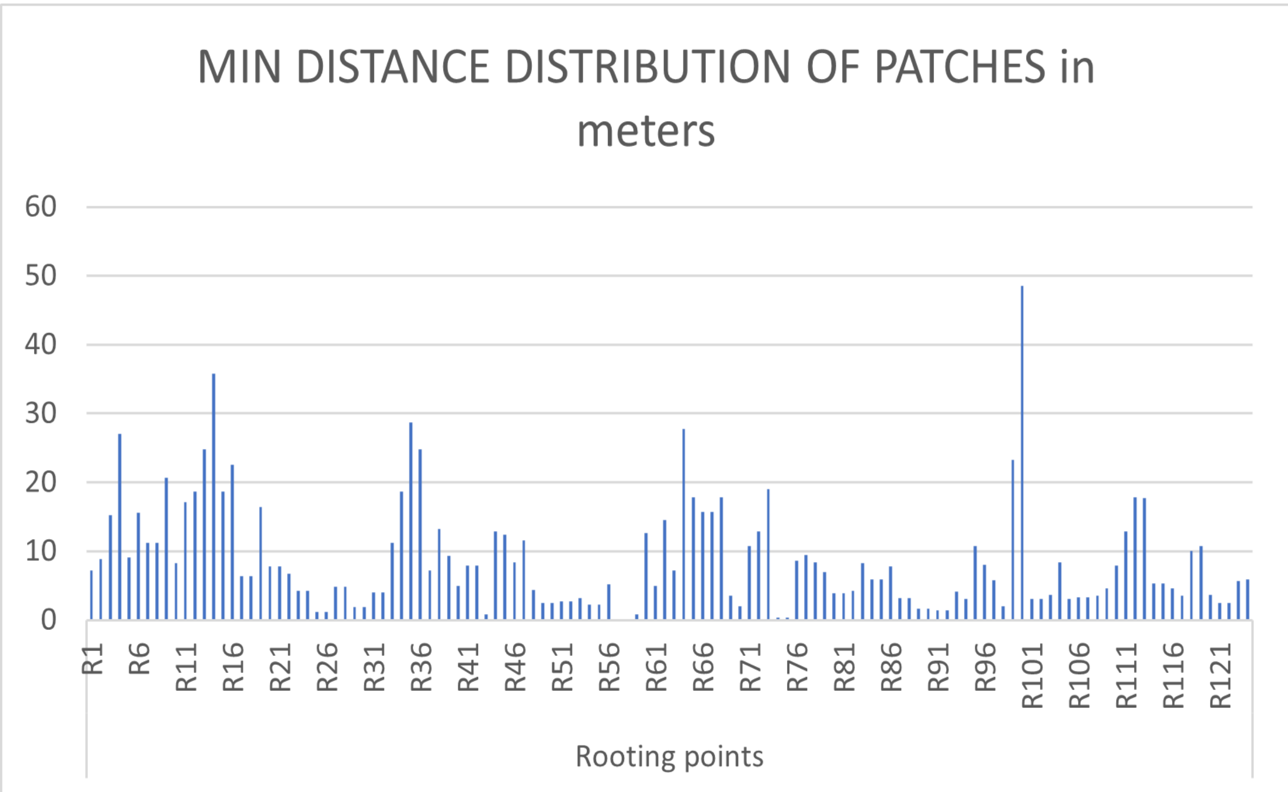

Figure 8a. Minimum distance distribution of rooted patches from each other.

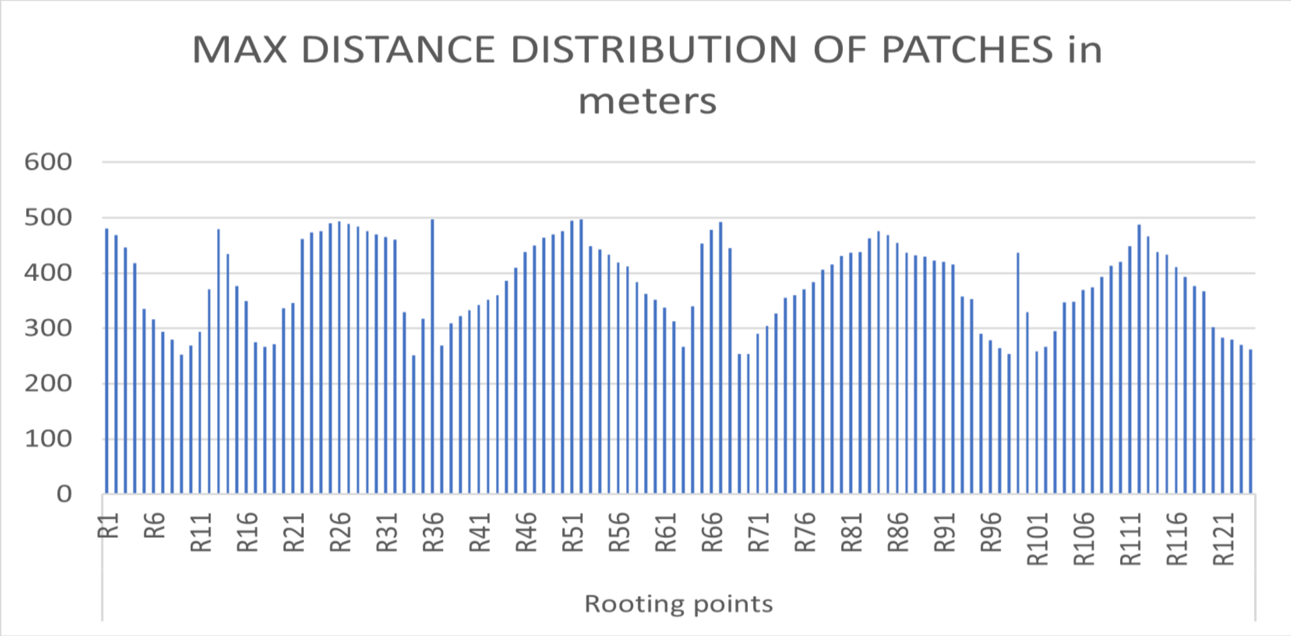

Figure 8b. Maximum distance distribution of rooted patches from each other.

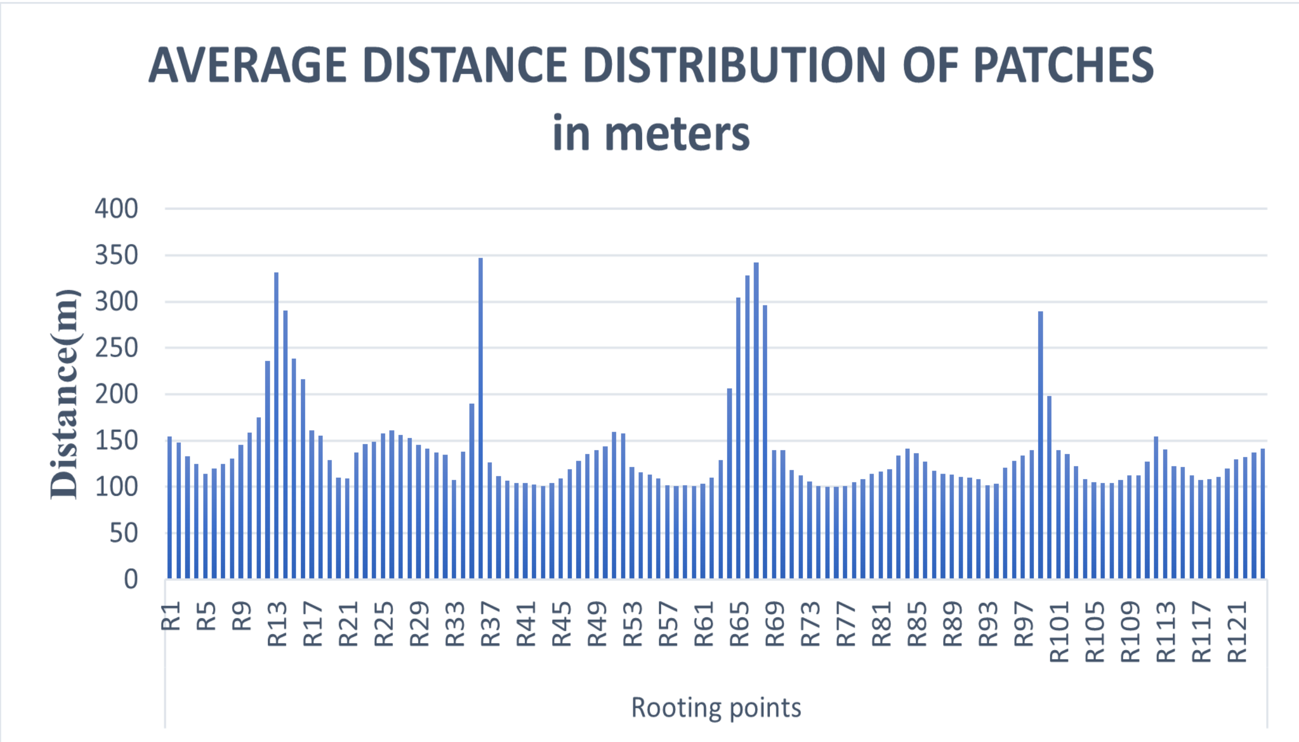

Figure 8c. Average distance distribution of rooted patches from each other

The diagram below (Figure 8d) represents the movement of wild boars over our transect cells and demonstrates the distance between the roots in Annex 2. The values for the maximum, minimum, and average are displayed collectively.

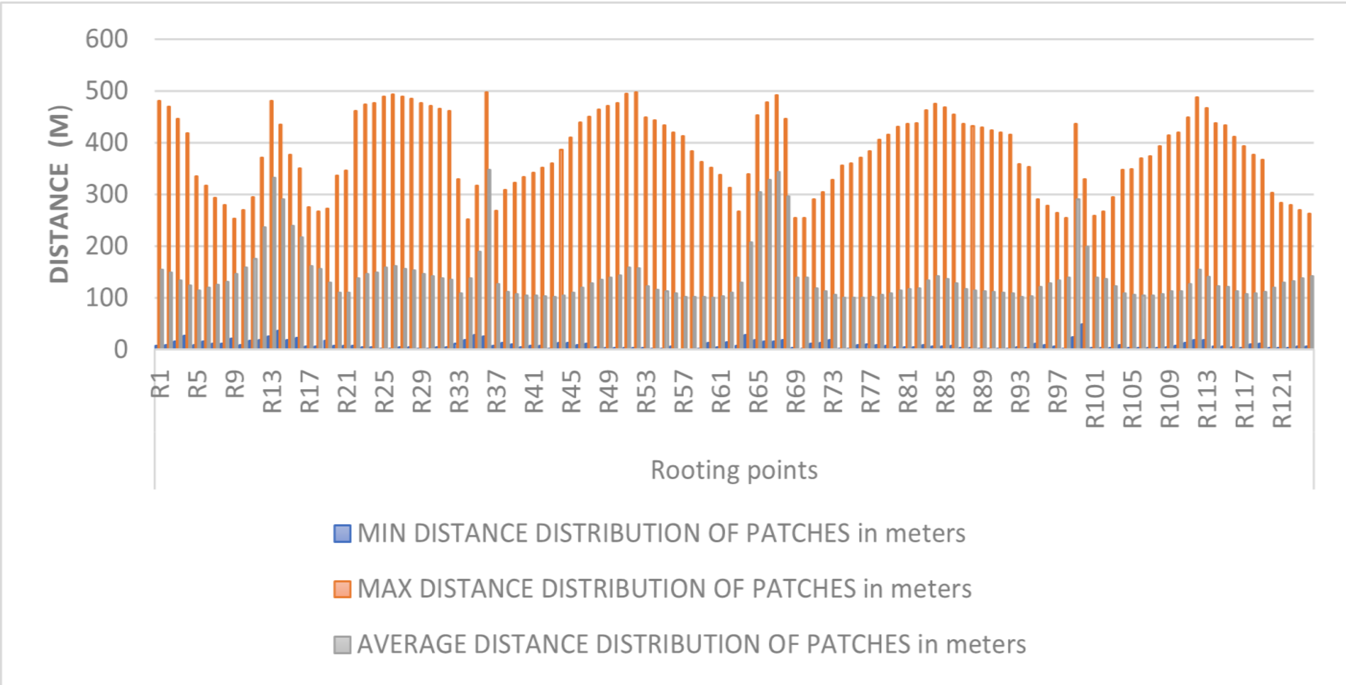

Figure 8d. The distribution for minimum, maximum, and average distance of rooted patches from each other.

Chapter 5

5. Conclusions and Recommendation

Management of recreational and protected natural areas should balance the need between outdoor pleasure, sustainable usage, and conservation. Decades of study have proven that outdoor activity, such as hiking, cross-country skiing, and riding vehicles, may be harmful to animals. The most obvious indicators are behavioral changes: animals may flee from approaching humans, feed less frequently, and leave nests or dens.

Other impacts are less visible, but they can have major ramifications for the health and survival of animals. When wild animals recognize people, they may undergo physiological changes such as higher heart rates and stress hormone levels. to protect these areas Management of such areas should invest in creating awareness for the animals on the hiking and nature trail, for example suggesting that cyclists should ride at a minimum speed of 5km/hr limitations and visitor management may put in place to allow minimal disturbance of wild animals on nature trails.

Furthermore, man-made structures such as trails near the area being studied may have an even bigger impact on the alterations in soil characteristics compared to the impacts caused by wild boar. Human-made infrastructure can cause soil compaction, pollution from automobile emissions, and disruption of natural vegetation. These variables have the potential to modify the arrangement of soil particles, the concentration of nutrients, and the activity of microorganisms, eventually impacting the overall well-being and productivity of the soil. Therefore, land managers need to consider the impacts of both human activities and wildlife when assessing and managing soil health in a given area.

According to our investigation, the study area lacked water supplies for wild animals, which could have contributed movement of wild animals toward human settlement. The presence of wild animals near human settlements can increase the risk of conflicts and potential dangers for both humans and animals. Finding sustainable solutions to provide water sources for wildlife in the area could help mitigate these issues and create a more harmonious coexistence between humans and wildlife. Either lack of water sources may have also impacted the overall ecosystem in the region, as animals would have been forced to travel further distances in search of water. We expect that these approaches will enhance our understanding of the impacts and behaviors of wild boar rooting in forests, as well as enable us to discover the beneficial patterns of wild boar disturbances in ecosystems. By comprehending the behaviors and implications of wild boars, we may formulate more efficient management measures that minimize their adverse effects on the forest ecosystem.

Chapter 6

6. Acknowledgement

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Chapter 7

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Chapter 8

8. Appendices

8.1 Data below shows the entry and exit rooting point (raw data)

Rooting points	Entry Longitude	Entry Lattitude			Exit Longitude	Exit Latitude
1	18.97084	47.5557		1	18.97095	47.55574
2	18.97109	47.55575		2	18.97113	47.55575
3	18.97127	47.55585		3	18.97137	47.55588
4	18.97171	47.55596		4	18.97173	47.55597
5	18.97265	47.55639		5	18.97265	47.55639
6	18.97284	47.55644		6	18.9729	47.55644
7	18.9731	47.55657		7	18.97312	47.55658
8	18.97325	47.55663		8	18.97329	47.55664
9	18.97358	47.55674		9	18.97363	47.55675
10	18.97385	47.55686		10	18.97387	47.55689
11	18.97413	47.55699		11	18.97416	47.557
12	18.97505	47.5573		12	18.97506	47.55734
13	18.97624	47.55788		13	18.97628	47.55788
14	18.97572	47.55773		14	18.97572	47.55773
15	18.97508	47.55751		15	18.97501	47.5575
16	18.97476	47.55735		16	18.97473	47.55734
17	18.97393	47.55701		17	18.97389	47.55699
18	18.97382	47.55695		18	18.9738	47.55694
19	18.9733	47.55679		19	18.97327	47.55678
20	18.9726	47.55646		20	18.97257	47.55645
21	18.97249	47.5564		21	18.97247	47.55639
22	18.97117	47.55591		22	18.97111	47.55589
23	18.97111	47.55583		23	18.97102	47.5558
24	18.97096	47.55581		24	18.97096	47.55581
25	18.97086	47.55577		25	18.9708	47.55576
26	18.97078	47.55576		26	18.97074	47.55576
27	18.97068	47.55586		27	18.97072	47.55587
28	18.97074	47.55583		28	18.97079	47.55586
29	18.97088	47.5559		29	18.97088	47.5559
30	18.97091	47.5559		30	18.97095	47.55593
31	18.97102	47.55595		31	18.97102	47.55595
32	18.97107	47.55596		32	18.97107	47.55596
33	18.97254	47.55656		33	18.97257	47.55655
34	18.9734	47.55692		34	18.97346	47.55693
35	18.97428	47.55725		35	18.97432	47.55725

36	18.97632	47.55811	36	18.97636	47.55811
37	18.9732	47.55698	37	18.97315	47.55696
38	18.97279	47.55673	38	18.97277	47.55673
39	18.9726	47.55671	39	18.97258	47.5567
40	18.97247	47.55666	40	18.97243	47.55664
41	18.97242	47.55656	41	18.97239	47.55655
42	18.97228	47.55654	42	18.97228	47.55654
43	18.97218	47.55652	43	18.97213	47.55652
44	18.9719	47.55638	44	18.97186	47.55638
45	18.97162	47.55627	45	18.9716	47.55626
46	18.97126	47.55618	46	18.97123	47.55617
47	18.9712	47.55604	47	18.97117	47.55602
48	18.97101	47.55601	48	18.97099	47.55599
49	18.97093	47.556	49	18.97089	47.55598
50	18.97085	47.55598	50	18.97082	47.55597
51	18.97065	47.55589	51	18.97061	47.55588
52	18.9706	47.5559	52	18.97064	47.55592
53	18.97109	47.55621	53	18.97113	47.55621
54	18.97116	47.55623	54	18.97123	47.55629
55	18.97126	47.55628	55	18.97131	47.55631
56	18.97144	47.55633	56	18.97147	47.55633
57	18.97152	47.55636	57	18.97185	47.55649
58	18.97185	47.55649	58	18.97189	47.55651
59	18.97214	47.55652	59	18.97217	47.55652
60	18.9722	47.55664	60	18.97223	47.55666
61	18.9724	47.55668	61	18.97245	47.55669
62	18.97265	47.55683	62	18.97268	47.55684
63	18.9732	47.55702	63	18.9732	47.55702
64	18.97444	47.5575	64	18.97446	47.55751
65	18.97572	47.55805	65	18.97575	47.55803
66	18.97601	47.55816	66	18.97604	47.55814
67	18.97612	47.55827	67	18.97616	47.55829
68	18.97554	47.55811	68	18.97551	47.55811
69	18.97331	47.55724	69	18.97325	47.55723
70	18.97327	47.55727	70	18.9732	47.55726

71	18.97284	47.55703		71	18.97281	47.55703
72	18.97266	47.55698		72	18.97262	47.55699
73	18.97241	47.55686		73	18.97239	47.55686
74	18.97208	47.55673		74	18.97204	47.5567
75	18.97204	47.55669		75	18.97201	47.55669
76	18.97194	47.55662		76	18.97188	47.55663
77	18.97179	47.55657		77	18.97174	47.55655
78	18.97153	47.55648		78	18.9715	47.55648
79	18.97141	47.55644		79	18.97136	47.55643
80	18.97122	47.55638		80	18.97119	47.55638
81	18.97115	47.55636		81	18.97114	47.55635
82	18.97116	47.55632		82	18.97099	47.55631
83	18.97086	47.55623		83	18.97079	47.55619
84	18.97069	47.55621		84	18.97072	47.55622
85	18.97075	47.55627		85	18.97079	47.55629
86	18.9709	47.55634		86	18.97095	47.55633
87	18.97111	47.55642		87	18.97113	47.55642
88	18.97117	47.55643		88	18.97123	47.55643
89	18.97118	47.55646		89	18.97125	47.55648
90	18.97127	47.55647		90	18.97128	47.55648
91	18.97131	47.55649		91	18.97135	47.5565
92	18.97137	47.5565		92	18.97142	47.55651
93	18.97201	47.55678		93	18.97203	47.5568
94	18.97206	47.55683		94	18.97211	47.55689
95	18.97278	47.55712		95	18.97281	47.55713
96	18.9729	47.55721		96	18.97297	47.55722
97	18.97308	47.55724		97	18.97315	47.55724
98	18.97322	47.55726		98	18.97326	47.55727
99	18.97526	47.55823		99	18.97524	47.55823
100	18.97395	47.55777		100	18.97393	47.55776
101	18.97309	47.55736		101	18.97303	47.55735
102	18.97299	47.55734		102	18.97292	47.55733

	103	18.97266	47.55721		103	18.97261	47.5572
	104	18.97206	47.55696		104	18.97201	47.55696
	105	18.97208	47.5569		105	18.97202	47.55691
	106	18.97183	47.55681		106	18.97182	47.5568
	107	18.97178	47.55678		107	18.97174	47.55678
	108	18.97155	47.55672		108	18.97153	47.55671
	109	18.9713	47.55664		109	18.97128	47.55664
	110	18.97125	47.55657		110	18.97116	47.55655
	111	18.97091	47.55645		111	18.9709	47.55645
	112	18.97048	47.55624		112	18.97047	47.55623
	113	18.97067	47.55642		113	18.97071	47.55645
	114	18.97101	47.55654		114	18.97103	47.55654
	115	18.97105	47.55659		115	18.97109	47.5566
	116	18.97132	47.55667		116	18.97134	47.55668
	117	18.97153	47.55674		117	18.97155	47.55676
	118	18.97169	47.55686		118	18.97173	47.55687
	119	18.97178	47.55696		119	18.97186	47.55702
	120	18.97258	47.55717		120	18.97266	47.55721
	121	18.97277	47.5573		121	18.9728	47.55732
	122	18.97282	47.55733		122	18.97284	47.55735
	123	18.97293	47.55738		123	18.97295	47.55739
	124	18.97303	47.55741		124	18.97305	47.55741

8.2 The data below shows how the size of the disturbed area was calculated

Longitude entry y	Lattitude entry x	Longitude exit y	Latitude entry x	a	b	c	distance (kilometers)	r=d/2	r in meters	area=r2(Pi) in meters square
18.970838	47.555695	18.970947	47.555742	0.40774205	0.04813051	0.54412744	0.00970326	0.004852	4.851630243	73.9
18.971091	47.555749	18.971125	47.555754	0.407740483	0.048131503	0.544128013	0.002609879	0.001305	1.30493971	5.3

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