JPPIPA 9(6) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Habitat Factors that Determine the Movement of Sumatran Elephants at Bukit Barisan Selatan National Park

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Received: April 12, 2023
Revised: June 8, 2023
Accepted: June 25, 2023
Published: June 30, 2023

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DOI: 10.29303/jppipa.v9i6.3633

Abstract: Until now, conflicts between elephants and the community are still occurring, one of which is in the Bukit Barisan Selatan National Park. This conflict has a negative impact on both elephants and society, so it is necessary to examine the habitat factors that determine the movement of Sumatran elephants. Therefore, the aim of this study is to determine the daily movement of the elephants and to analyze the habitat factors that influence elephant movement. Data was collected in the form of elephant movements in one period which were obtained from the Bukit Barisan Selatan National Park. 1-year results obtained from the GPS stated that there are two groups of elephants, the citra elephant group and the bunga elephant group. The results showed that groups of elephants in Bukit Barisan Selatan National Park have lengths that ranged from 63 – 137 kilometers, with linear, zigzag and circular trajectories, and the frequency of points used is 2-6 repetitions with the time needed per-kilometers ranging from 110 – 518 minutes. Factors that influence elephant movement are track length, frequency of point used, time spent per-kilometers, altitude, slope, distance to settlements, distance to water sources, availability of feed, and availability of scrubbing trees.

Keywords: Elephant's track; Habitat factors; Sumatera elephant

Introduction

Human-elephant conflict occurs when there is no balance between the welfare of humans and elephants, resulting in losses for both parties (Pratiwi et al., 2020). Bukit Barisan Selatan National Park is a location where human-elephant conflict often occurs due to forest destruction, which results in a narrowing of home ranges for elephants, resulting in conflict between elephants and local residents' settlements. According to (Hedges et al., 2005), based on the results of the elephant conflict identification carried out by the Wildlife Conservation Society (WCS) during 2000–2002, there were 340 incidents of agricultural crops destroyed in Bukit Barisan Selatan National Park. The area of plantations damaged by elephant disturbance was 30 ha in 2000 and 20 ha in 2001. In the TNBBS year-end report, it was recorded that from 2017 to 2021, there were 330 conflicts. The increasing conflict between humans and elephants makes people think that the existence of elephants is detrimental, so humans tend to be hostile towards them (Abdullah et al., 2017). People think wild elephants are plant pests for farmers around forest areas (Mustafa et al., 2019).

The impact of conflict between elephants and humans often causes losses, both for humans and elephants. The losses experienced by humans can be in the form of loss of property or lives. Property losses such as damage to gardens, agricultural crops, houses, and livestock According to the year-end report (TNBBS, 2021), the community's losses in 2021 will reach Rp. 66,050,000 million. Losses of life such as injuries, physical disabilities, and death. The impact of the conflict experienced by the elephants themselves included death, expulsion, and physical disability.

The natural habitat of elephants has been degraded by land cover change, resulting in conflicts between elephants and humans. This conflict has been going on for a long time since forest clearing in elephant habitat (Ikhsan, 2021). Areas that were originally elephant trails have now become open land or plantations (Nugraha et

How to Cite:
Hadinata, M.L., Santosa, Y., & Masy'ud, B. (2023). Habitat Factors that Determine the Movement of Sumatran Elephants at Bukit Barisan Selatan National Park. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4738–4746. https://doi.org/10.29303/jppipa.v9i6.3633

al., 2014). As a result, conflicts occur, mostly caused by the destruction of agricultural cultivation crops in areas adjacent to elephant habitat (Berliani et al., 2016). This habitat fragmentation causes elephants to be trapped in small blocks that are actually unable to support their home range and food needs (Nuryasin et al., 2014). Therefore, the highest conflicts occur in spaces shared by humans and elephants (Purwanuriski et al., 2022). The occurrence of disturbances to people's crops has led to efforts made to drive elephants both from managers, partners, government, and the community. Efforts to date have included the use of mercon, elephant trenches, fires, the use of tame elephants and GPS collar monitoring. Despite these efforts, conflicts continue to increase because the natural habitat of elephants is converted by the community so that elephants become accustomed to disturbances from the community.

The increase in human-elephant conflict has so far not found a clear spot. For this reason, efforts are needed to reduce elephant-human conflict, so elephants are brought back to the TNBBS area in ways that do not harm the Sumatran elephants. The solution that can be done is to know the "Determining Habitat Factors for the Movement of Sumatran Elephants in the Bukit Barisan Selatan National Park", with the aim of: (1) describing quantitatively the trajectory of the daily movement of the Sumatran elephant (*Elephas maximus sumatranus*) and (2) analyzing the habitat factors that affect the movement of Sumatran elephants (*Elephas maximus sumatranus*).

Method

Time and Place

This research was conducted in April-June 2022 in Bukit Barisan Selatan National Park, Lampung Province.

Tools and Material

The research tools and objects used are GPS, cameras, area maps, tally sheets, GIS, and SPSS applications. The research object used in this study was a group of elephants paired with GPS and the habitat where the Sumatran elephant moves in the Bukit Barisan Selatan National Park.

Method of Collecting Data

The scope of data and variables (parameters) that are measured or collected, as well as the data collection and analysis methods used in this study are presented in Table 1.

Table 1. Objectives, Types of Variables, Data Analysis Methods and Formulas

Objective	Variable Type	Data collection	Data analysis
Describe the characteristics of the elephant's movement trajectory	• The shape of each track • The length of each track • Point usage frequency • Time required per kilometers • Topography • Land Cover	• The data is taken from the monitoring results of groups of elephants that are installed with GPS • Elephant movement data from 2020-2021 • The citra elephant group and the bunga elephant group	• Descriptive statistics • $\bar{x} = \frac{x_1+x_2+x_3+\cdots x_n}{n}$
Habitat factors that affect the frequency of point use and the time required per km	Dependent variable: • Point usage frequency • The time required per km Independent variables: • Height • Tilt • Temperature • Humidity • Settlement distance • Distance to water source • Availability of feed • Availability of body rub trees	• The data was taken from the Bukit Barisan Selatan National Park Office • Observation • Study literature	• *Multiple Regression Analysis* (MRA): • $Y = b_1X_1 + b_2X_2 + \cdots b_nX_n + c + e$

Data Analysis

Multiple regression analysis is a statistical technique that analyzes the relationship between two or more variables and uses that information to estimate the value of the dependent variable. In the case of the Sumatran elephant, the movement pattern of the elephant may change due to changing habitat conditions. The data that will be taken from the elephant's movement is the number of tracks, the length of each track, the shape of the track, the time per kilometer, the frequency of point use, then it will be linked to the variables from the habitat factor of the

Sumatran elephant in the form of distance to settlements, distance to water sources, topography, slope, and Land cover. Each parameter of the elephant's movement pattern will later be related to all variables from the habitat factor of the elephant using the equation of multiple regression analysis (Supranto, 2004).

$$Y = b_1X_1 + b_2X_2 + \cdots b_nX_n + c + e \quad (1)$$

Information:
Y = Variable that you want to predict
b = Regression coefficient
c = Constant
e = Wind
After carrying out multiple linear regression analysis, the next step is testing the model using the F test, T test, and the coefficient of determination.

F-Test

The F-test was carried out with the aim of showing whether all the independent variables included in the regression model have a joint effect on the dependent variables (Kuncoro, 2009), with the hypothesis:
H0: All independent variables have no significant effect on the dependent variables together.
H1: All variables have a significant effect on the dependent variables together.
Results used: accept H0 if the significance value is > 0.05, and reject H0 if the significance value is <0.05.

T-Test

The t-test aims to test how far the influence of the independent variables on the dependent variables is partially (Widarjono, 2015), with the hypothesis:
H0: The independent variable partially has no significant effect on the dependent variable.
H1: The independent variables partially have a significant influence on the independent variables.
Results used: accept H0 if the significance value is > 0.05, and Reject H0, if the significance value is <0.05.

The coefficient of determination describes the variation in the effect of the independent variables on the dependent variables, it can also be said to be the proportion of the influence of all independent variables on the dependent variables. The coefficient of determination is carried out to determine the best level of accuracy in the regression analysis, which is expressed with a value between zero to one. A zero value on the coefficient of determination means that the independent variable has absolutely no effect on the dependent variable. Conversely, if the coefficient of determination has a value close to one, it means that the independent variable has an effect on the dependent variable.

Result and Discussion

Description of Elephant Tracks

Bukit barisan selatan national park has two groups of elephants that are fitted with GPS collars, named the citra elephant group and the flower elephant group. The movement trajectory is obtained from the monitoring results of the GPS collar installed in both elephant group, the data is collected in the form of movement points that are updated once an hour. The calculation of elephant trajectories in this study is different in general, namely the calculation of one elephant trajectory is obtained from the summation of movement points for 24 hours for one year. The calculation of elephant trajectories is applied to the calculation of trajectory length, trajectory shape, time required per kilometer, topography and land cover type. In the calculation of movement points obtained from updating GPS collar data in one hour for one year in each elephant group, data that can be processed using movement points is the frequency of use of the point.

Length of Track

The track traversed by the Sumatran elephant for one year shows that in the track, the elephant has a length that varies each month. The following is the result of calculating the length of the table for each month in one year for the citra elephant group and the bunga elephant group. Following are the results of the acquisition of the track length of elephant groups in the Bukit Barisan Selatan National Park:

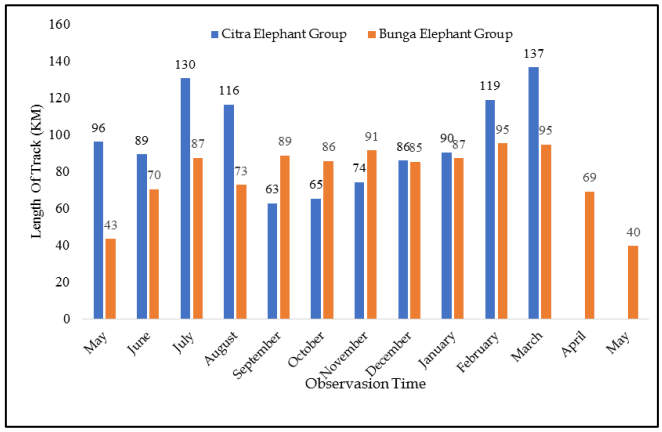

Figure 1. Elephants track length

The maximum track length used by the Citra Elephant Group is 137 km in March, and the minimum track length is 63 km in September. The average monthly track length used by the Citra elephant group is 107 km. In the bunga elephant group, the maximum track length obtained is 95 km in February and March, and the minimum track length for the bunga elephant group is 40 km in May 2021. The average track length obtained

from bunga elephant groups is 84 km. The average length of passes obtained from flower clusters was 84 km, with mobile flower clusters occupying primary, secondary and agricultural land cover. The length of each track ranged from 1-2 km and the total length was 213.20 km (Pla-Ard et al., 2020).

The results above show that the trajectory of the Citra elephant group is longer than that of the Bunga elephant group; this is due to the herding that is carried out when the elephant group approaches the community plantations to look for food; this makes the Citra elephant group perform a lot of movement. This is in accordance with what was stated. According (Nugraha et al., 2014) the length of an elephant's track is caused by the presence of food trees and air sources.

Track Shape

The shape of the trajectory obtained from the movement of the elephant group is in the form of Linear, Zigzag and circular. The following is the result of the trajectory shape obtained from the citra elephant group and the bunga elephant group in a one-year period:

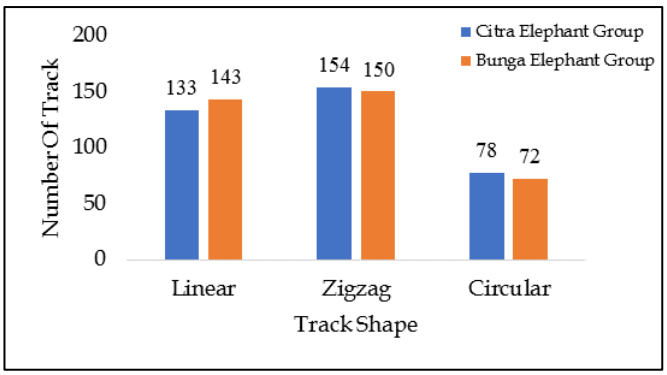

Figure 2. Elephant track shape

The shape of the trajectory of the citra elephant group that is often used is in the form of a zigzag with a number of 155 paths found and a presentation used for 43%, then linear with a number of 132 paths found and a presentation used for 36%. A path form that is rarely used is circular, with a total of 78 tracks and a presentation used for 21%. The shape of the path in the bunga elephant group that is most often used is zigzag with a total of 150 paths and presentation used 41%, then the shape of the path used is linear with the number found 142 paths and presentation used 39%, and the shape of the path that is rarely used is circular with the number found 72 tracks and presentation used 20%.

The linear form of movement is caused by a lack of food resources and the sloping topography, so groups of elephants keep walking to find food and water needs, while groups of elephants carry out zigzag movements because groups of elephants choose a more sloping topography to be traversed in search of food and resources. According to (Abdullah et al., 2012), in the flat topography class, the Sumatran elephant will move more easily. However, there are some locations where the elephant group only circles in that location because the location has a water source as well as feed and the land cover elephants need.

Point Usage Frequency

The frequency of using a point is how often the point is passed by a group of elephants; the point in question is the presence of a group of elephants in one hour, while the track is a collection of points connected in one day. The following is the calculation result for the frequency of point use by the two groups of elephants:

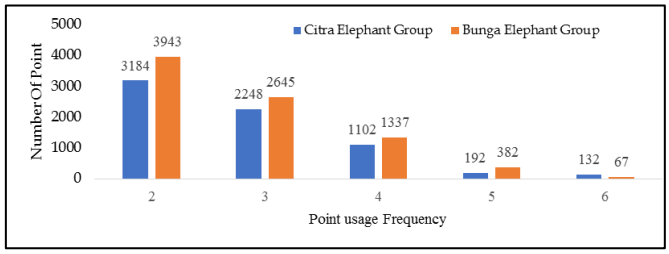

Figure 3. Frequency of use of elephant group points

The frequency of point use in Citra elephant groups varied from 2–6 times being skipped. The group of citra elephants passed 132 points six times, 192 points five times, 1102 points four times, 2248 points three times, and 3184 points twice. Whereas in the bunga elephant group, 67 points were passed six times, 192 points five times, 1102 points four times,2248 points three times, and 3943 points two times.

The frequency of point use in the Citra elephant group is higher due to the group's location in hilly areas, which causes them to move a lot for activities such as looking for food and water sources. The frequency in bunga elephant groups is lower because there is rarely a change in location by bunga elephant groups so that fewer crossed points are found. This is because the locations occupied by bunga elephant groups have more abundant food available in agriculture and secondary forests, which provide elephant feed enrichment, and are close to a water source. According to (Afrizal et al., 2018), elephants move from one place to another according to the food and water sources available in that place.

Time Required an Kilometer

Based on the results of the point GPS collar data obtained in hourly time, for daily data, as many as 24 points were obtained. The time needed per km is generated by the group of elephants, which is calculated based on the length of time the group of elephants travels a distance of one km. The following is the

calculation result of the time per kilometer traveled by a group of elephants:

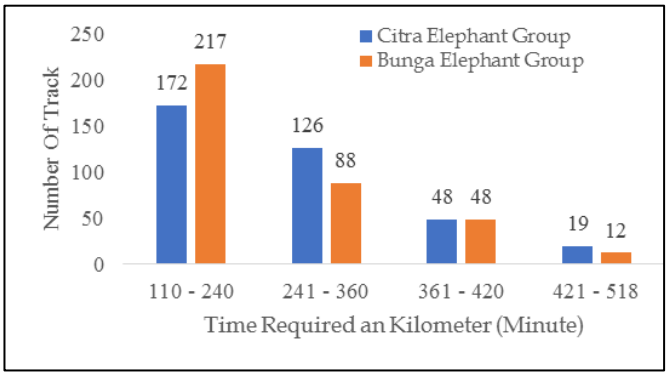

Figure 4. Time spent per kilometer

The time required per kilometer for the citra elephant group was found to be 19 tracks with a travel time of 421–518 minutes, 48 tracks with a time of 361-420 minutes, 126 tracks with a time of 241-360 minutes, and 172 tracks with a time of 110–240 minutes. Whereas in the group of bunga elephants, the travel time of 421–518 minutes found 12 tracks, 361-420 minutes found 48 tracks, 241–360 minutes found 88 tracks, and 110–240 minutes found 217 tracks.

The longer the elephant group spends on the track, it means that on the track there are habitat factors that meet the needs of the elephant group, both from the availability of food, water sources, and places to rest. The shorter the time the elephant group spends on the track, the more it means that the elephant group continues to move in search of habitats that can meet their daily needs. According to Nyhus et al. (2004), elephants conduct daily roaming in their home ranges; Sumatran elephants choose locations and determine the right time to eat, which is influenced by various limiting factors in the habitat so that it will affect composition, distribution, and productivity.

Topography

Topography is one of the determinants of habitat selection for elephant groups. Several types of slope classification are based on Permenhut P.12/Menhut-II/2021: 8% flat, 8–15% gentle, 16–25% rather steep, 24%–40% steep, and >40% very steep. The following is a topographical class that is used as the habitat of the Citra and Bunga elephant groups. The following is the result of the topographic calculation of the elephant group shown in Figure 5.

The topography that is often used in the Citra Elephant Group is in a steep location, namely 26-40% for 183 tracks, and the topography that is rarely used is in a flat location, namely 8% for 1 track. Whereas in the group of elephants, the topographic imagery that is often used is in a flat location, namely 8%, with 214 tracks found, and the topography that is rarely used is in a steep location, namely 26-40%, with 23 tracks.

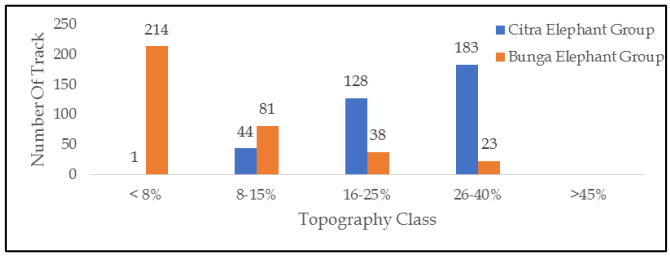

Figure 5. Number of elephant group points based on topography

The difference in the topography occupied by the citra group and the bunga elephant group is because the citra group occupies the highest classification in the steep topography. According to research Anggrita et al. (2017), the large area that has a very high slope class can cause large mammals to have difficulty in occupying their habitat space. This is because the location has sufficient food availability to cause the citra group to stay, while the bunga elephant group moves to a more sloping area. The bunga elephant group occupies an area with a flat classification; elephants will look for flat and sloping habitats to make it easier to move; this is in accordance with the results of previous studies, namely (Rohman et al., 2019). Elephants are more likely to be in the 2–7% slope class, where the land has a gentle slope.

Land Cover

The selection of land cover by the elephant group is based on the availability of daily needs such as food, water sources, trees for rubbing the body, and resting. Land cover used by groups of elephants in the Bukit Barisan Selatan National Park area is primary, secondary, weedy, and agricultural. The following is the use of land cover by groups of elephants:

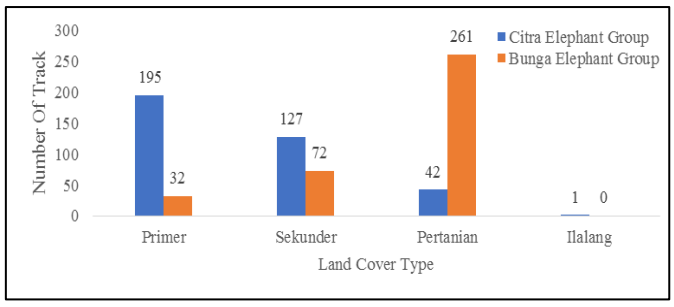

Figure 6. Number of elephant group points based on land cover

From the results above, the group of citra elephants occupied primary land cover with 195 tracks, secondary land cover with 127 tracks, agricultural land with 42 tracks, and weeds with 1 track. Meanwhile, the bunga elephant group occupied primary land cover with

32 tracks, secondary land cover with 72 tracks, and agricultural land with 261 tracks. The bunga elephant group did not find any tracks on thatch land cover.

In the citra elephant group, the use of the primary land cover type was the highest due to the availability of forage trees, scrub trees, and adequate shelter. It can be assumed that the forest land cover is used as cover by Sumatran elephants on their daily roaming, both as protection from direct sunlight and as protection from disturbances or threats (Rohman et al., 2019). Bunga elephant groups using different land cover types in one period are most often used in agricultural land cover types. This is because in this land cover there is a source of food for elephants from community plants, and the proximity to water sources causes the presence of groups often found in this land cover, (Bohrer et al., 2014) Elephants migrate from lowlands to higher elevations because there is less green vegetation in the lowlands. According to Sitompul et al. (2013) elephants tend to use medium canopy and open canopy where closed canopy is often used by elephants at night. According to Abdullah et al. (2012), elephants use secondary forests as foraging areas and use primary forests as a place to shelter, rest and mate.

Analysis of the Relationship between Habitat Factors and the Frequency of Using Points and Time Used Per Kilometer

The relationship analysis uses multiple regression analysis calculations that are processed based on the movement point data found from the GPS collar. Factors are calculated both from the frequency of point use and the time required per kilometer. Habitat factors are altitude, slope, temperature, humidity, distance from settlements, distance from water sources, availability of food, availability of body rub trees. The overall aspect of this relationship analysis uses movement points for one hour in one year.

Frequency of Point Use with Habitat Factor

Result of *Multiple Regression Analysis* shows that there are habitat factors that are closely related to the frequency of point use, altitude, slope, temperature, humidity, distance to settlements, distance to water sources, availability of feed and availability of scrubbing trees. The following is the result of calculating the habitat factor with the frequency of point use.

Table 2. Results of the analysis of the frequency of use of elephant group points

Elephant Group	Regression Equation	T Test (P Value)	F Test (P Value)	Coefficient of Determination
Citra	Y1 (Point Usage Frequency): - 0.189 X1 + 0.001 X2 - 0.014 X3 - 0.067 X4 - 0.003 X5 + 9.269E-5X6 - 9.627E-5 X7 + 0.011 X8 - 0.005 X9	0.000	X1 = 0.000 X2 = 0.000 X3 = 0.000 X6 = 0.000 X7 = 0.000 Other variables show values > α	96.42 %
Bunga	Y1 (Point Usage Frequency): - 0.136 X1 + 0.004 X2 - 0.071 X3 - 0.019 X4 + 1.157 X5 + 6.928E-6 X6 + 2.268E-5 X7 + 0.852 X8 + 0.080 X9	0.000	X1 = 0.000 X2 = 0.000 X3 = 0.000 X8 = 0.000 X9 = 0.000 Other variables show values > α	93.71 %

Description: X1(time per kilometers) X2 (altitude), X3 (slope), X4 (temperature), X5 (humidity), X6 (settlement distance), X7 (distance to water sources), X8 (availability feed), X9 (availability of body rub trees).

From the results obtained, a significant effect on the citra elephant group is X1 (time per km) the longer the elephant uses the track, the more the elephant group crosses that point, X2 (height) the elephant will often cross points that are on the plateau, X3 (slope) groups of elephants will often cross points that are on a gentle slope. According to Abdullah et al. (2012), habitat factors that determine habitat selection are gentle slopes (0-20º) and land elevations in the range of 0-400m are conditions favored by Sumtera Elephants. The next significant effect is that X6 (settlement distance) elephant groups will choose a habitat where disturbance from the community is rare, so that groups of elephants often cross points that are far from human settlements, Animal species that are sensitive to human presence will tend to avoid encounters with humans, and move away from sources of disturbance when exploiting resources (Imron et al., 2013). X7 (distance to water sources) water sources are a habitat factor that is needed daily by groups of elephants so that groups of elephants will often cross habitats that have water availability, Water sources commonly used by image groups are rivers that are close to settlements, even so elephant groups will still go to water sources because they meet their daily

needs, Water sources are also strong predictors of elephant movement and distribution (Alfred et al., 2006; Ndaimani et al., 2017; Wato et al., 2018). This is in accordance with Abdullah et al. (2012) which states that the most activity traces are found in areas close to water sources with a distance of 0-500m.

A different significant effect on the bunga elephant group is X8 (*availability of feed*). The abundance of forage plants due to the enrichment of elephant feed in secondary land cover causes elephants to frequently cross points at this location because they can meet their food needs. This result is in accordance with the results of research Alfred et al. (2006) which shows that elephants utilize mixed secondary forests more than intact primary forests, because of the abundant food available in mixed secondary forests (Suba et al., 2017), because to meet the food and drinking needs of one group is very sufficient, therefore the Bunga group did not move to another location. According to Abdullah et al. (2012) the availability of plenty of food (75%) is a condition favored by elephants. In the variable X9 (availability of body rub trees) flower elephant groups will often pass points that have availability of body rub trees, one of which is on secondary land which has trees with large diameters. According to Abdullah et al. (2013), the availability of body rubbing trees with a sparse amount is a condition favored by Sumatran elephants, the tree where the body rubs is used to clean the ectoparasites attached to the body. The regression equations X8 and X9 have values of +0.852 and +0.080, which means that the more food available and the availability of scrubbing trees, the more often the frequency of groups of elephants on the track is traversed.in line with the statement (Ofrinaldi et al., 2020) that the movements carried out by elephants are carried out in search of food to meet their daily consumption needs.

Time Taken Per Kilometer with Habitat Factor

Result of Multiple Regression Analysis shows that there are habitat factors that are closely related to the time needed per km, namely altitude, slope, temperature, humidity, distance to settlements, distance to water sources, availability of feed and availability of scrubbing trees. The following is the result of calculating the habitat factor with time per kilometer.

Table 3 Results of the Analysis of the Time Needed per Kilometer in the Elephant Group

Elephant Group	Regression Equation	T Test (P Value)	F Test (P Value)	Coefficient of Determination
Citra	Y1 (Time Required an Kilometer): - 0.832 X1 -0.000 0.001 X2 + 0.006 X3 + 0.085 X4 +0.032 X5 + 0.000 X6 - 0.000 X7 + 0.105 X8 + 0.082 X9		X1 = 0.000 X6 = 0.000 X7 = 0.000 X8 = 0.004 X9 = 0.000 Other variables show values > α	91.49 %
Bunga	Y1 (Time Required an Kilometer): - 0.758 X1 0.000 + 0.003 X2 - 0.070 X3 - 0.132 X4 - 0.431 X5 + 0.000 X6 - 0.000 X7 - 0.277 X8 - 0.074 X9		X1 = 0.000 X2 = 0.003 X3 = 0.000 X6 = 0.000 X7 = 0.000 Other variables show values > α	97.84 %

Description: X1 (Point Usage Frequency) X2 (altitude), X3 (slope), X4 (temperature), X5 (humidity), X6 (settlement distance), X7 (distance to water sources), X8 (availability feed), X9 (availability of body rub trees)

A significant effect on the citra group is X1 (frequency of point use) the more often the citra group occupies one location, the more time it takes to occupy that location, X6 (settlement distance) elephant groups prefer habitat that is far from human settlements because it reduces disturbance from the community, so the time needed is getting longer (Nugraha et al., 2014) also showed that Sumatran elephants prefer habitat away from settlements. X7 (distance to water sources) the distance to water sources, elephants chose this route because it is easier to reach access to water sources, so it takes a long time to use the route. According to Abdullah et al. (2013), distance from water sources is a very significant condition for elephants because the activities of these large organisms require water to drink after eating. The next effect is X8 and X9 the availability of food and the availability of body scrubbing trees, the location occupied has abundant food resources causing elephant groups to choose this location because it meets their daily needs, according to Abdullah et al. (2013), distance from water sources is a very significant condition for elephants because the activities of these large organisms require water to drink after eating. With dense cover the availability of large trees that are used

as body scrubbing trees so that in that location group of elephants takes a long time.

The significant effect is different on the bunga elephant group of interest X2 (height), the elephant group will take a long time to per kilometer in the highlands. X3 (slope) in habitats that have a steep slope, groups of elephants will look for a gentler trajectory, causing it to take longer. The regression equations X3 and X4 have values of +0.003 and -0.070, meaning that the higher the location of the track used, the longer the elephant group spends on the track and the lower the slope of the track used, the more time it takes per km on the track. As pointed out by Gazeli et al. (2018). The slope of elephant habitat in natural forest ranges from 1-5%, which means the area is flat, this is in accordance with the nature of elephants who like flat areas to carry out their activities.

Conclusion

Based on the results of the research, several conclusions can be obtained as follows: The average track length per month in the citra elephant group is 107 km and in the bunga elephant group is 84 km, with the shape of each track being linear, zigzag, and circular, and the frequency of using points is 2-6 repetitions with the time needed per km ranging from 110 – 518 minutes for each group of elephants. Habitat factors that affect the frequency of use of points and the time needed per km for elephants, namely altitude, slope, distance to settlements, distance to water sources, availability of feed, and availability of scrubbing trees

Acknowledgments
The author is very grateful for the involvement and assistance provided by the Bukit Barisan Selatan National Park.

Author Contribution
The main author, M.Latif Hadinata, contributed to designing research, conducting research, and writing research articles. The second author Yanto Santosa, contributed to assisted in the data collection process and guiding writing of the article. The third author Burhanuddin Mas'ud contributed to guiding the writing of the article.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Abdullah, A., & Japisa, T. (2013). Karakteristik Habitat Gajah Sumatera (Elephas maximus sumatranus Temminck) pada Habitat Terganggu di Ekosistem Hutan Seulawah. *Jurnal Edubio Tropika*, *1*(1), 1–60. Retrieved from https://jurnal.usk.ac.id/JET/article/view/5224

Abdullah, Ali S., M., & Hilmayanti, P. (2017). Persepsi masyarakat sekitar kawasan konflik gajah dengan manusia terhadap konservasi gajah dan habitatnya di Kecamatan Lembah Seulawah , Aceh Besar. *Jurnal Biologi Edukasi*, *9*(1), 16–19. Retrieved from https://jurnal.usk.ac.id/JBE/article/download/10156/8027

Abdullah, Asiah, & Japisa, T. (2012). Karakteristik Habitat Gajah Sumatera (Elephas maximus sumatranus) di Kawasan Ekosistem Seulawah Kabupaten Aceh Besar. *Jurnal Ilmiah Pendidikan Biologi, Biologi Edukasi Volume*, *4*(1), 41–45. Retrieved from https://jurnal.usk.ac.id/index.php/JBE/article/view/476

Afrizal, D., Rustiati, E. L., & Syahri, B. F. (2018). Teknik Pengamatan Pola Pergerakan Gajah Sumatera (Elephas maximus sumatranus) dengan Teknologi GPS Collar Di Hutan Lindung Register 39 KPH IX Kota Agung Utara. *Seminar Nasional Hasil-Hasil Penelitian*. Retrieved from http://repository.lppm.unila.ac.id/10283/

Alfred, R., Williams, A. C., Vertefeuille, J., Payne, J., Andau, P., Ambu, L., Sipangkui, S., & Lim, A. (2006). *Satellite Tracking of Borneo ' s Pygmy Elephants Table of Contents* (Issue June 2005). WWF International, Washington DC. Retrieved from https://awsassets.panda.org/downloads/stpe_1wwf.pdf

Berliani, K., Alikodra, H. S., Masy'ud, B., & Dikari Kusrini, M. (2016). Social, Economic, Cultural and Community Perception on Sumatran Elephant (Elephas maximus sumatranus) Conflict Areas in Aceh Province. *International Journal of Sciences: Basic and Applied Research (IJSBAR) International Journal of Sciences: Basic and Applied Research*, *27*(2), 170–181. Retrieved from http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Bohrer, G., Beck, P. S. A., Ngene, S. M., Skidmore, A. K., & Douglas-Hamilton, I. (2014). Elephant movement closely tracks precipitation-driven vegetation dynamics in a Kenyan forest-savanna landscape. *Movement Ecology*, *2*(1), 1–12. https://doi.org/10.1186/2051-3933-2-2

Gazeli, B. parta, Yoza, D., & Qomar, N. (2018). Karakteristik Habitat Gajah Sumatera (Elephas maximus sumatranus Temminck.) di Taman Nasional Tesso Nilo dan Sekitarnya, Provinsi Riau. *Jom Faperta*, *5 Edisi 2*, 1–9. Retrieved from https://jom.unri.ac.id/index.php/JOMFAPERTA/article/view/22492

Hedges, S., Tyson, M. J., Sitompul, A. F., Kinnaird, M. F., Gunaryadi, D., & Aslan. (2005). Distribution, status, and conservation needs of Asian elephants (Elephas maximus) in Lampung Province, Sumatra, Indonesia. *Biological Conservation*, *124*(1), 35–48. https://doi.org/10.1016/j.biocon.2005.01.004

Ikhsan, M. (2021). *Mitigasi Konflik Manusia Dan Gajah Di Kawasan Sampoiniet Aceh Jaya* [UIN Ar-Raniry Banda Aceh]. Retrieved from https://repository.ar-raniry.ac.id/id/eprint/17845/

Imron, M. A. L. I., & Sinaga, J. O. (2013). Aktivitas Manusia dan Distribusi Banteng (Bos Javanicus D'alton 1832) di Taman Nasional Alas Purwo. *Jurnal Ilmu Kehutanan*, *1*(2), 30–38. https://doi.org/10.22146/jik.1553

Kuncoro, M. (2009). *Metode riset untuk bisnis & ekonomi edisi 3: bagaimana meneliti dan menulis tesis* (3rd ed.). Erlangga.

Mustafa, T., Abdullah, A., & Khairil, K. (2019). Analisis Habitat Gajah Sumatera (Elephas maximus sumatranus) berdasarkan software smart di Kecamatan Peunaron Kabupaten Aceh Timur. *BIOTIK: Jurnal Ilmiah Biologi Teknologi Dan Kependidikan*, *6*(1), 1. https://doi.org/10.22373/biotik.v6i1.4041

Ndaimani, H., Murwira, A., Masocha, M., & Zengeya, F. M. (2017). Elephant (Loxodonta africana) GPS collar data show multiple peaks of occurrence farther from water sources. *Cogent Environmental Science*, *3*(1), 1–11. https://doi.org/10.1080/23311843.2017.1420364

Nugraha, D., H, G., & Khairijon. (2014). Pola Pergerakan dan Wilayah Jelajah Gajah Sumatra (Elephas maximus sumatranus Temminck, 1874) dengan menggunakan GPS Radio Collar di kawasan Tesso Nilo, Riau. *Jom Fmipa*, *1*(2), 607–612. Retrieved from https://jom.unri.ac.id/index.php/JOMFMIPA/article/view/4033

Nuryasin, Yoza, D., & Kausar. (2014). Dinamika dan Resolusi Konflik Gajah Sumatera (Elephas maximus sumatranus) terhadap Manusia di Kecamatan Mandau Kabupaten Bengkalis. *Jom Faperta*, *1*(2). Retrieved from https://jom.unri.ac.id/index.php/JOMFAPERTA/article/view/3628

Nyhus, P., & Tilson, R. (2004). Agroforestry, elephants, and tigers: Balancing conservation theory and practice in human-dominated landscapes of Southeast Asia. *Agriculture, Ecosystems and Environment*, *104*(1), 87–97. https://doi.org/10.1016/j.agee.2004.01.009

Ofrinaldi, Yoza, D., & Arlita, T. (2020). The Eating Behavior of Sumatran Elephants (Elephas maximus sumatranus Temminck.) at The Team Flying Squad in the Tesso Nilo National Park (TNNP). *Jom Faperta*, *7*(2), 9–19. Retrieved from https://jom.unri.ac.id/index.php/JOMFAPERTA/article/view/9569

Pla-Ard, M., Sukmasuang, R., & Srinopawan, K. (2020). Population characteristics and habitat suitability of Asian elephants (Elephas maximus Linnaeus, 1758) in the Khao Yai National Park, Thailand. *European Journal of Ecology*, *5*(2), 62–71. https://doi.org/10.2478/eje-2019-0012

Pratiwi, P., Rahayu, P. S., Rizaldi, A., Iswandaru, D., & Winarno, G. D. (2020). Community Perception on the Conflict between Human and Sumatran Elephant (Elephas maximus sumatranus Temminck 1847) in Way Kambas National Park. *Jurnal Sylva Lestari*, *8*(1), 98. https://doi.org/10.23960/jsl1898-108

Purwanuriski, L., Darmawan, A., Winarno, G. D., Febryano, I. G., Ismanto, I., & Sugiharti, T. (2022). Analisis Mitigasi Konflik Gajah Sumatra (Elephas maximus sumatranus, Temmick 1874) di Taman Nasional Bukit Barisan Selatan. *Jurnal Belantara*, *5*(2). https://doi.org/10.29303/jbl.v5i1.865

Rohman, W. A., Darmawan, A., Wulandari, C., & Dewi, B. S. (2019). Preferensi Jelajah Harian Gajah Sumatera (Elephas maximus sumatranus) di Taman Nasional Bukit Barisan Selatan. *Jurnal Sylva Lestari*, *7*(3), 309. https://doi.org/10.23960/jsl37309-320

Sitompul, A. F., Griffin, C. R., Rayl, N. D., & Fuller, T. K. (2013). Spatial and temporal habitat use of an Asian elephant in Sumatra. *Animals*, *3*(3), 670–679. https://doi.org/10.3390/ani3030670

Suba, R. B., van der Ploeg, J., van't Zelfde, M., Lau, Y. W., Wissingh, T. F., Kustiawan, W., de Snoo, G. R., & de Iongh, H. H. (2017). Rapid expansion of oil palm is leading to human–elephant conflicts in north Kalimantan province of Indonesia. *Tropical Conservation Science*, *10*. https://doi.org/10.1177/1940082917703508

Supranto. (2004). *Analisis Multivariat Arti dan Interpretasi*. Rineka Cipta.

TNBBS. (2021). *Laporan Tahunan 2021*.

Wato, Y. A., Prins, H. H. T., Heitkönig, I. M. A., Wahungu, G. M., Ngene, S. M., Njumbi, S., & van Langevelde, F. (2018). Movement patterns of African Elephants (Loxodonta africana) in a Semi-arid Savanna suggest that they have information on the location of dispersed water sources. *Frontiers in Ecology and Evolution*, *6*(OCT), 1–8. https://doi.org/10.3389/fevo.2018.00167

Widarjono, A. (2015). *Analisis multivariat terapan* (Edisi I, F). UPP STIM YKPN.