Introduction

Animal behavior is an important component of conservation science. The data utilized in this project includes three species; the endangered African savanna elephant *(Loxodonta africana)*, the critically endangered black rhino *(Diceros bicornis),* and the near threatened white rhino *(Ceratotherium simum)*. Habitat management is an important component of conservation strategies. For example, when asked why black rhinos tend not to venture outside of Kenya's Ngulia Sanctuary-excluding the presence of the physical barrier of a light fencing - officials responded that since food and water were plenty within the sanctuary, individuals did not usually leave the area. This meant that individuals were naturally inclined to reside in areas with heavier protection against poachers. In this case, incentives of steady water and food sources were used to keep black rhinos under Ngulia's protection.

The focus of this project is a study analyzing waterhole usage patterns of the African savanna elephant, black rhino and white rhino within the context of Olifants West Nature Reserve (OWNR) located within southern Africa. By tracking species waterhole preference, especially in drought-prone areas, wildlife officials can make informed habitat management decisions that have the potential to incentivize targeted species to remain in better protected areas, reducing poaching pressures.

Smith, Brown, and Barrett created a comprehensive report tracking waterhole usage patterns by African savanna elephants, black rhinos and white rhinos. Camera traps monitored four different types of artificial waterholes; earth dams, concrete pans, reservoirs and troughs, 24/7 from January to December of 2013. Population densities were not available to the authors of this study due to high poaching risks.

This project will focus on three variables tracked by Smith, Brown and Barrett; species, waterhole type, and duration (minutes). Since population densities are unknown and the spatial layout of waterholes in regards to such densities are unclear, a simple count of individual visits to waterholes per species is not sufficient in itself. Therefore, it is necessary to pair it with recorded duration to track usage per species in the most simplistic form possible. This information should be placed within the contexts of previously established species behavior regarding water and social interactions.

Materials and Methods

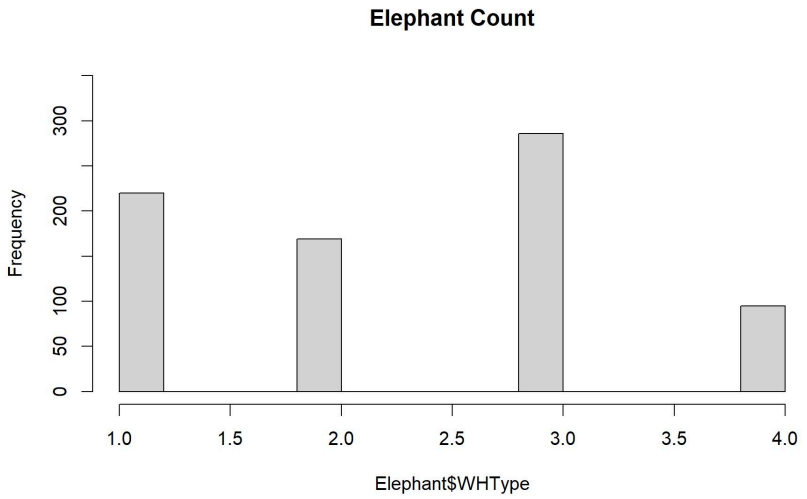
The original study conducted by Smith, Brown and Barrett, and its data, was collected from PLOS One. The authors of this study used camera traps for the 24/7 monitoring of four different types of artificial watering holes - earth dams, concrete pans, reservoirs, and troughs - for the year 2013. Multiple camera trap brands were used, but all brands were reported to have similar specifications with standardized settings to take photos every 1.2 seconds once movement was detected. All cameras had infrared capabilities to capture data at night. Dates and times were synchronised and field-of-views overlapped to ensure individuals were not double counted or missed. Prior to the start of data collection, camera traps were placed in their positions for

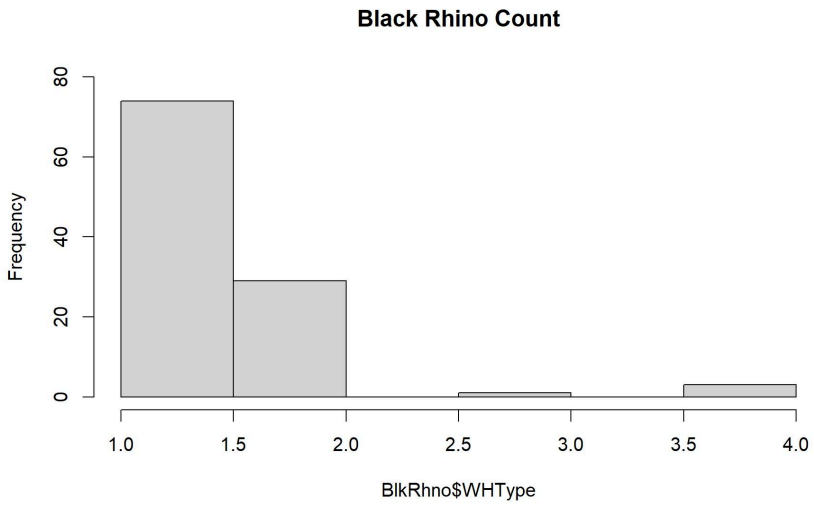
two-weeks to both check effectiveness and to desensitize animals to their presence. All waterholes were within the confines of OWNR. The authors of the study collected multiple variables, all of which were relevant to evaluating waterhole usage within the context of each species. These variables included, but are not limited to, potential for intra and inter-species interactions, climate data, season, surrounding woody vegetation, date, ground access, and waterhole characteristics. Additional data that would have been interesting to collect would have been water quality tests, especially those in regards to fecal type and amount as well as interaction type (drinking, wallowing, swimming, etc.).

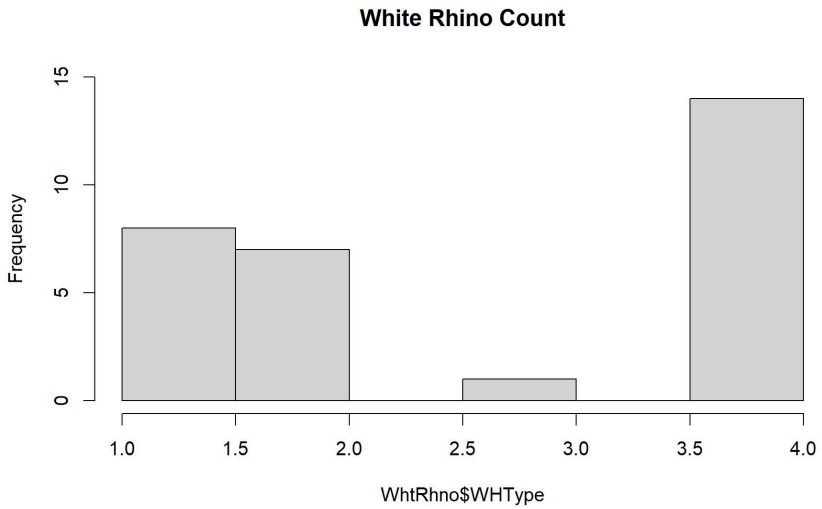
Within the context of this project, three variables from the original study were used; species, waterhole type, and duration. Four datasets were loaded into RStudio (R Core Team). Waterhole_Data was the complete set of data across all three species. Since population densities were not available, and therefore cannot be assumed equal, the original data was broken into three sets based on species it covered. Waterhole_Data 1 only included elephant data. Waterhole_Data 2 only tracked black rhinos and Waterhole_Data 3 only recorded white rhinos. These datasets required the readxl package (Wickham) to load into RStudio. Since the authors of the original study translated their data to fit Poisson General Linear Models, multiple variables required a class change from “numeric” to "integer". Once classes were confirmed to be correct, the plot and hist functions were used to analyze the provided data.

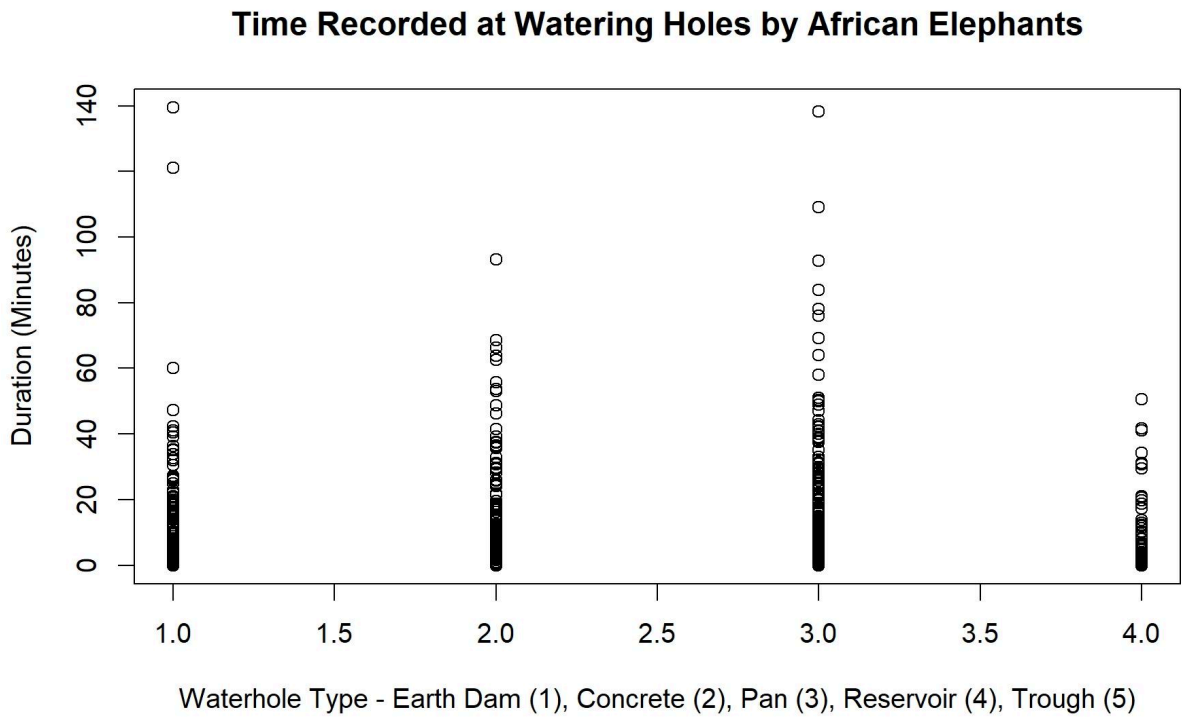
Results

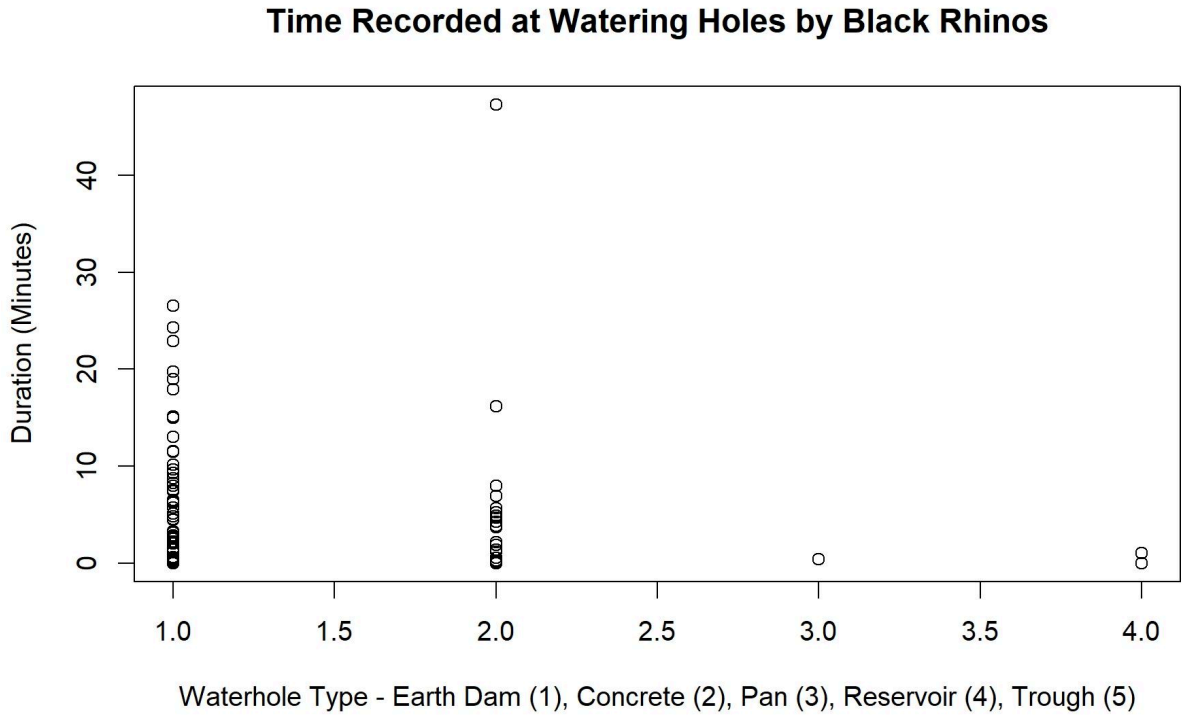
The top three figures show the frequency of sightings based on the three tracked species: elephants, black rhinos and white rhinos divided among the different artificial waterhole types. Please note the differences in y-axis limits between these figures. Elephants had the largest sample size, and white rhinos the smallest. The last three figures show the duration in minutes of individuals of each species at each watering hole, organized by watering hole type. African elephants were found to have a presence at all waterhole types but troughs, with most data points pooling between the 0 and 40 minute duration marks. Elephants appeared to typically spend longer periods of time at pans. Black rhinos were recorded at all waterhole types but troughs, although had the most sightings recorded at earth dams. On average the most amount of time appears to be spent at earth dams although there is a singular data point of an individual spending over 40 minutes at a concrete waterhole, the longest amount of time recorded at any waterhole included in the study for black rhinos. White rhinos were once again recorded at every waterhole but troughs and appeared to spend the longest amounts of time at concrete waterholes. Pan waterhole only has one data point, suggesting that white rhinos prefer earth dams, concrete, and reservoir artificial waterholes to pan and trough artificial waterholes. From these figures, an argument could be made that the preferred artificial waterhole type for African elephants are pans, the preferred artificial waterhole types for black rhinos are earth dams and concrete and the preferred artificial waterhole types for white rhinos are concrete and reservoirs.

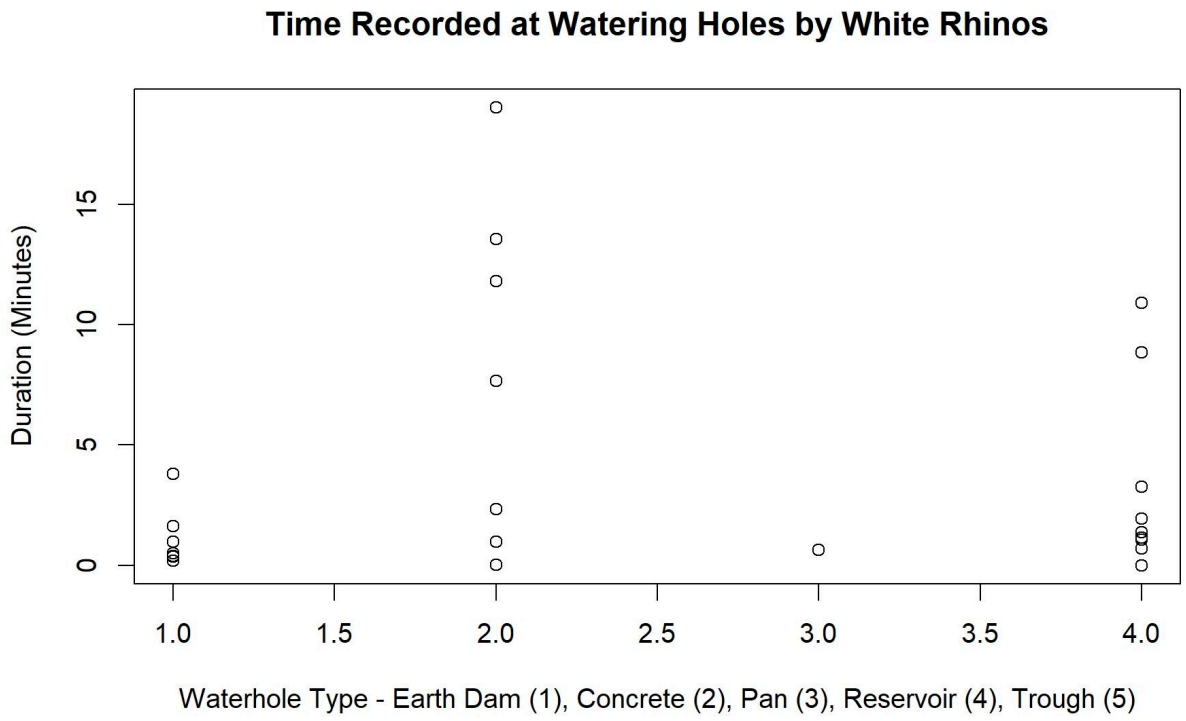

Elephant Count
Frequency
0
50
100
200
300
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Elephant$WHType


Black Rhino Count
Frequency
0
20
40
60
80
1.0
1.5
2.0
2.5
3.0
3.5
4.0
BlkRhno$WHType


White Rhino Count
Frequency
0
5
10
15
1.0
1.5
2.0
2.5
3.0
3.5
4.0
WhtRhno$WHType


Time Recorded at Watering Holes by African Elephants
Duration (Minutes)
0
20
40
60
80
100
140
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Waterhole Type - Earth Dam (1), Concrete (2), Pan (3), Reservoir (4), Trough (5)


Time Recorded at Watering Holes by Black Rhinos
Duration (Minutes)
0
10
20
30
40
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Waterhole Type - Earth Dam (1), Concrete (2), Pan (3), Reservoir (4), Trough (5)


Time Recorded at Watering Holes by White Rhinos
Duration (Minutes)
0
5
10
15
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Waterhole Type - Earth Dam (1), Concrete (2), Pan (3), Reservoir (4), Trough (5)

References

Gobush, K.S., Edwards, C.T.T, Balfour, D., Wittemyer, G., Maisels, F. & Taylor, R.D. 2022. *Loxodonta africana* (amended version of 2021 assessment). *The IUCN Red List of Threatened Species* 2022: e.T181008073A223031019. https://dx.doi.org/10.2305/IUCN.UK.2022-2.RLTS.T181008073A223031019.en. Accessed on 15 October 2025.

Emslie, R. 2020. *Ceratotherium simum*. *The IUCN Red List of Threatened Species* 2020: e.T4185A45813880. https://dx.doi.org/10.2305/IUCN.UK.2020-1.RLTS.T4185A45813880.en. Accessed on 15 October 2025.

Emslie, R. 2020. *Diceros bicornis*. *The IUCN Red List of Threatened Species* 2020: e.T6557A152728945. https://dx.doi.org/10.2305/IUCN.UK.2020-1.RLTS.T6557A152728945.en. Accessed on 15 October 2025.

Wickham H, Bryan J (2025). _readxl: Read Excel Files_. doi:10.32614/CRAN.package.readxl <https://doi.org/10.32614/CRAN.package.readxl >, R package version 1.4.5, <https://CRAN.R-project.org/package=readxl>.

R Core Team (2025). _R: A Language and Environment for Statistical Computing_. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

Wickham H, Hester J, Bryan J (2024). _readr: Read Rectangular Text Data_. doi:10.32614/CRAN.package.readr <https://doi.org/10.32614/CRAN.package.readr>, R package version 2.1.5, <https://CRAN.R-project.org/package=readr>.

Smith E, Brown LR, Barrett AS (2024) Insights into artificial waterhole utilization patterns by elephants and rhinos: Lessons from a South African Nature Reserve. PLoS ONE 19(10): e0312158. https://doi.org/10.1371/journal.pone.0312158