Influence of Bison on Rock Movement at Konza Prairie

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Introduction

North America is home to the second largest grassland ecoregion of the world, the central great plains. Within this vast tallgrass prairie ecosystem lies the Flint Hills, stretching from the most northern part to the most southern part of the state of Kansas. In the early 1970s, the Konza Prairie Biological Station was established in the northern portion of the Flint Hills. The Konza Prairie is used as a large landscape-scale experimental manipulation of fire and grazing to understand the drivers that influence tallgrass prairie ecosystems (Nippert et al., 2022). Those predominantly responsible for the grazing that occurs within the Konza Prairie are hundreds of American bison. Bison were historically the primary grazers of the tallgrass prairies and were abundant components of the biota throughout the history of the Great Plains grasslands. Grazing is an extremely important ecological process, especially in the Konza Prairie. Both fire and the grazing of bison reduce the amount of dead biomass that would otherwise blanket the ground and limit productivity in the prairie. It is now evident that "the unique spatial and temporal complexities of bison grazing activities are critical to the successful maintenance of biotic diversity in this grassland" (Knapp et al., 1999). Aside from the keystone role they play by grazing in tallgrass prairie ecosystems, it has been questioned whether bison play a role in rock movement and geomorphic processes, specifically at Konza Prairie.

It is a known fact that bison often engage in "wallowing". This behavior, along with the movement of large herds, is a natural disturbance to prairie topography that erodes the topsoil of the landscape (Gibson, 1989). Although, the question still stands: do bison herds impact the movement of rocks on prairie landscapes? This question was answered by an undergraduate research team at Kansas State University. They conducted a study in which rocks on a chosen hillslope, where bison freely roam, were measured, recorded, and monitored over four weeks. By the end of their study, they found both numerical and photographic evidence that bison do have numerous interactions with rocks on the Konza Prairie and are very likely geomorphic agents of the prairie landscape (Barrios et al., 2022).

To expand on their findings, our research team continued to monitor the previous team's study site for an additional nine weeks. Our team also chose a second study site on a neighboring hillslope, with numerous differences, in which rocks were measured weekly for 7 weeks. The original site was located along a fenceline, faced a different direction, and had a lower overall elevation than the new site. In addition, there are differences in the time of year that these sites were analyzed, therefore causing variances in vegetation growth and precipitation. All of these differences allowed us to determine to what extent bison interact with rocks on the Konza Prairie and how varying conditions can impact the magnitude of the interactions. As proven in the previous study, bison do have an impact on the rock movement on the Konza Prairie, so, our research team set out to determine the significance of this impact.

Background

Study Area

The Konza Prairie is mostly made up of chert and flint-bearing limestone layers embedded with shale (Buchanan & McCauley, 2010). The ridges of these hills are flat with shallow, rocky soils which makes them an excellent area to study rock movement downslopes. Factors such as wind, water, biodiversities like tallgrasses, and the animals like the bison have certainly impacted the Konzas geomorphology (Stumpff, 2017). The rocks littered throughout the Konza create a natural armoring for the hillslopes which help contain the topsoil allowing for plant species to grow and for animals to thrive. Erosion of the geologic layers is caused by tributaries of the Kansas River, creating a landscape of dissected hills. Most soils in Konza Prairie are less than 1m thick, with the thickest soils located at the slopes' lower parts and valleys.

Despite its tranquil appearance, the Konza Prairie derives from dynamic processes from billions of years ago. Within the rocks in the prairie lies the story in which Konza was created and matured. The rocks at Konza are mostly sedimentary, the rock class that exhibits its history much more easily than the others. Limestone dominates the rock types at Konza are marine in origin. This is because the Konza area was at one point covered in shallow seas in which the underlying rocks were laid. Each subsequent geologic period was composed of events that played a role in the origin of the Konza prairie (Reichman, 1987). These events included episodic earthquakes, fault line shifts, nearby volcanic eruptions, etc. Also, there were the introductions of countless plant and animal species throughout time. In the last 60 million years, however, the major geologic force on Konza has been erosion rather than deposition. Following these major events, there were glacial episodes that brought forests and woodlands to North America. As time went on and these forests and woodlands began to disappear from the central plains, the vegetation started to change at a rapid pace (Axelrod, 1985). The region began to attract plants, especially grasses, and many animals who came to take advantage of the grasslands. Following the arrival of all the new species seeking the grasslands, some prehistoric people may have inhabited the region, according to anthropologists. More recently, however, the Pawnee tribe and then the Kansa tribe resided in the Konza Prairie hundreds of years ago before the Europeans arrived. From there, the Kansa tribe was deported, and the land eventually became what it is now (Reichman, 1987).

Following the great Chicago fire in 1871, Charles Paulson Dewey jumped at the opportunity to purchase a large amount of ruined real estate. This paid off as the city was rebuilt and one year later, he purchased land in Kansas. Later on, because of the severe effects of the winter of 1886-87, land prices decreased and the Deweys purchased over 5,000 acres of land in Riley County and Geary County. In Manhattan, the Deweys were involved in numerous businesses that allowed him to own and operate two ranches. The Deweys, in 1930, were forced to sell the ranch due to financial issues, and the Geary County portion was separated from the Riley County portion (Given, 2004). Then, in 1956, several faculty members from Kansas State University expressed a need for a prairie field station for ecological research. Dr. Lloyd C. Hulbert was among them. It was he, as the founder and first director, who was responsible for what Konza Prairie is today. Many potential sites were considered but it was the plot of 916 acres of the Geary County portion of the Dewey Ranch that was selected. This narrow strip of land was purchased for KSU by The Nature Conservancy, with funds from an anonymous donor that was later discovered to be Katherine Ordway. Beginning in 1972, it was decided that the prairie would be burned at prescribed intervals in watershed-sized units. This would become one of the first ways that the prairie would be utilized as not only a prairie reserve but also a laboratory for scientific research. Then The Nature Conservancy purchased the 7220-acre Riley County portion of the Dewey Ranch next to Konza in 1977. It wasn't until 1980 the Konza Prairie was officially dedicated in ceremonies (Hulbert, 1985).

Konza has been, currently is, and will be home to numerous research projects. There are over 30 years of "accumulated data on a wide range of population, community, and ecosystem processes", (Konza Prairie Biological Station, 2014). Aside from that, there is a wide variety of individual research projects being conducted by a wide variety of researchers from not only the university but non-KSU scientists. The Konza Prairie is also home to over 200 bison thanks to the addition of the Dewey Ranch and the Thowe land since there was initially not enough room for native grazers. In 1992, cattle units were added to study the effects of native grazers as opposed to introduced grazers. There are also plans to reintroduce elk and pronghorn antelope in the future.

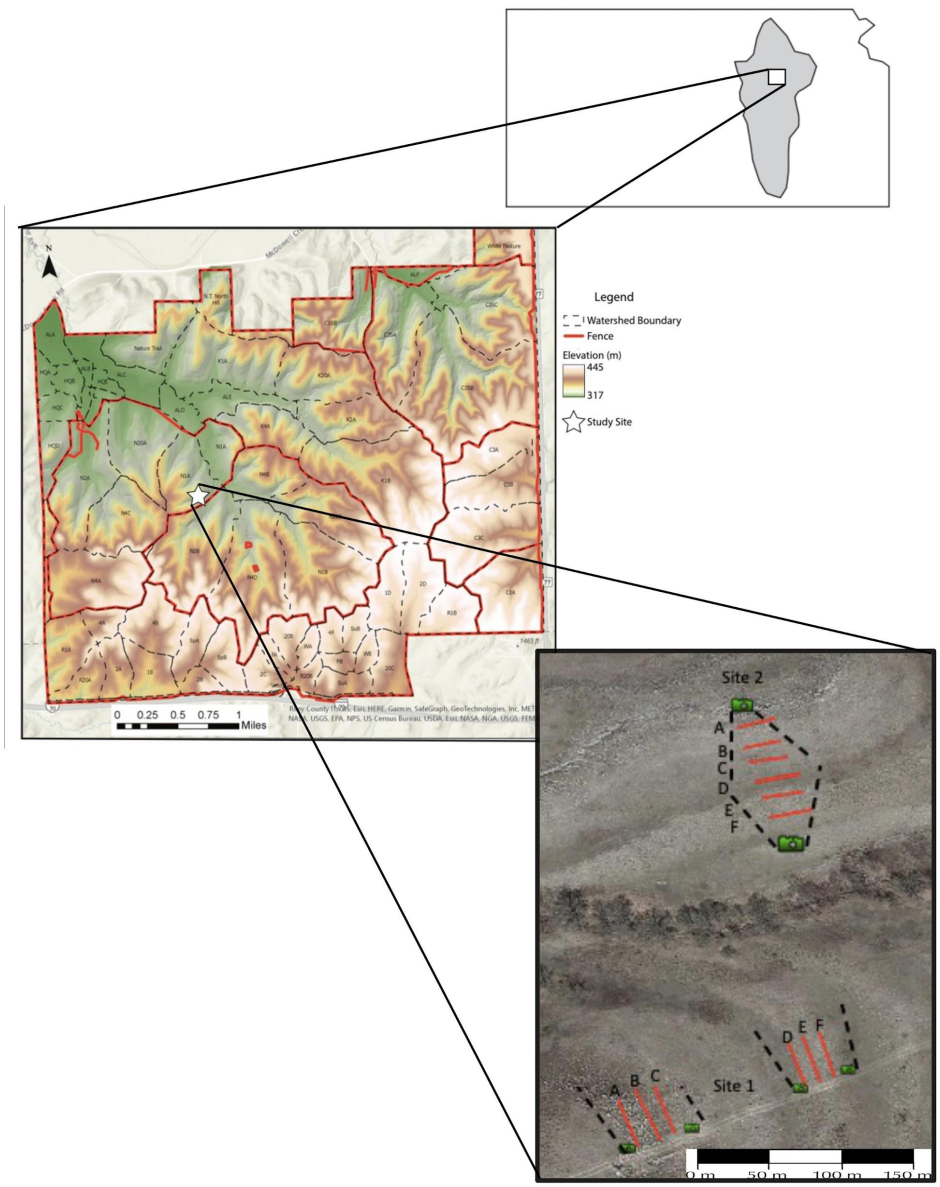


Figure 1. The top right is a map of Kansas with an outline of the flint hills and a black box surrounding the Konza Prairie. The map on the middle left is a map showing the Konza Prairie

outlining topography, fence lines, and watersheds. The star represents the location we had our study sites set up within the Konza Prairie Biological Research area. The image on the bottom right is an overhead satellite view of our research sites on the Konza Prairie. The map shows the location of site 1 as well as site 2 and labels the locations of our trail cameras and their field of view as well as our rock transect lines.

Rock Movement On Slopes

For years, research done by geologists and professors have found many different ways rocks move down slopes and how that movement impacts the geomorphology of a region. Many forces act on the Earth's surface to produce this landscape evolution which scientists have been able to quantify since the 1940s and 1950s largely because of the work of Horton, Strahler, and Leopold who advocated for a physical assessment of landforms (Stetler, 2014). The interactions between rocks, soils, and geomorphic landscapes have been tested and found very useful in providing a framework for studying a concentration of soil and rock movement across a lateral slope (Mirna et al., 2014). Some studies also include research-based models on how the shapes of rocks impact their ability to move down slopes. In a study done by Tímea Szabó and Gábor Domokos titled "A new classification system for pebble and crystal shapes based on static equilibrium points" (Zingg, 1935), they researched methods of classifying different shapes of pebbles and crystals using measurements of static equilibria instead of traditional measurements like the length.

The reason rocks move downslope is because of stressors. Stress in geology is the force exerted per unit area in a direction. When the applied stress is greater than the strength of the rock strain is a result causing the rock to deform. Strain can be an example of a rock changing in volume and/or shape, as well as fracturing. There are three types of stress tensional (stretching), compressional (shortening), and shear (tearing). Rocks move downslope from stress because of many factors, including shape, size, animal activity, gravity, weather, angle of slope, type of soil, and many others (Heather, 2012). We choose to record the shapes and sizes of the rocks in our experiment to see if these factors had any impact on how likely they are to move when exposed to large animal activity.

Previous Findings

In a previous study conducted at Konza Prairie, students from Kansas State University chose a hillslope in which bison were able to roam freely. On this hillslope, they divided the area of land into two portions and placed three transects among each section. This hillslope was located alongside a fence line where they set up trail cameras to monitor the interaction between the bison and several chosen rocks within the area being studied. The chosen rocks were marked and various measurements were recorded so that the students would be able to monitor their movement. The objective of their study was to determine whether bison herds have an impact on the movement of rock fragments. Initially, the bison frequently visited the site and grazed upon it but there was no interaction with the chosen rocks. In the final two weeks of their study, the interaction of bison and the placed rocks finally began to occur. They determined that out of the 60 rocks they had placed and marked, 32 of them had been altered in some way. This gave them a 54% rate of bison-rock interaction. Their results showed that rocks at both locations were either moved, flipped, and/or rotated. One of the most important pieces of evidence that were collected from this study was photographic proof that a bison had moved and rotated a rock the students had marked and placed. Based on their research and findings, they concluded that bison can act as geomorphic agents on the Konza Prairie (Barrios et al., 2022).

Figure 2. Photographic evidence from the previous study portrays the movement of a rock caused by a bison. “The picture on the right was captured 23 seconds after the left picture was taken and shows the red spray-painted rock in a different position. This is indicated by the blue circle, indicating direct contact between the bison and rock.” (Barrios et al., 2022)

Methods

While conducting our study we traveled to the field and visited our sites once a week and sometimes more depending on what time allowed. When we arrived at the field for the first time we took measurements at the site of the previous study that we had decided to continue observing. We evaluated and discussed what we had observed as well as set up the previously used site again to be able to continue the work that had been started by the original study group. We started this process by taking measurements of the rocks since they had not been measured in approximately 4 months and used these numbers as our base measurements. We had decided not to re-align the rocks to their starting positions because we wanted to be able to continue the original site and use it to show possible change over a longer period. The base measurements were calculated by using a string and tying it to a stake placed on the fence line and a stake placed on the opposite end of the rocks. These stakes had been in place by the previous team to show where the original straight line was located. We then measured each rock and the distance from the fence to the center of the rock, the distance from the original line up or down the slope, the color of the rock, and the orientation/angle of the lines on the rock using a compass. Each rock had a line painted on it, the top side having a red line while the bottom side having a green line. These lines were used to take our orientation measurements and as an easy indicator to tell if a rock had flipped over. We repeated our measuring process for all 6 rows of rocks on the original site. We took some of our time in the field the first time to also engrave the rocks so we would easily be able to identify which rock was which. Once we had measured and finished engraving most of the rocks, we discussed where might be the best places to put our trail cameras to catch wildlife activity on our rocks and potentially allow us to see a bison move a rock.

Selecting a Second Site

We selected 4 different spots on the original site for our camera that we felt would have the highest potential of showing if the bison were moving the rocks as well as how much wildlife that was present in our research site. Once we had set up the cameras and had all of the rocks measured and labeled, we looked for a sufficient spot to set up a second site where we would be able to set up an additional area of observation. We were unable to decide on a site during our first day in the field due to having a large amount of bison in the potential study area. Due to the bison being located where we wanted to set up site 2, we then looked at maps to see if that was where we wanted to set up our new site. We then came back a week later with plans to set up on a site that was away from a fence line and had a different-facing slope. These were decisions we made because we wanted to try and survey an area that had different land features from the original site to see if our results would line up. Site 2 was a hillslope that seemed to have frequent bison activity due to a freshwater spring that was located relatively close to the site. We did not have evidence that this is where the bison liked to drink from but we had seen that they were located on that slope in some of our pictures from the previous week's photos, as well as observations while previously in the field.

Setting Up Our Site

Before setting up the second site we discussed how we would set it up to receive the best results. We decided to keep the same amount of rows keeping it at 6. We decided that we wanted our numbers to be easier to keep track of so we placed rocks that were randomly selected in rows of 20, placing a rock every meter so that we could tell easier if there was movement. When setting the lines we placed steaks on either side of the row and tied our tape measure from one to the other and used this as a straight line to place the rocks. Before placing the rocks we repeated the same processes of painting a red line on one side and a green line on the other so we could use this to tell azimuth as well as if a rock had flipped over. We repeated the random sampling and placement of the rocks until all 120 rocks had been placed in rows.

Placing Cameras

We spent time discussing where the most optimal camera placement would be for this second site due to it not being on a fence line. On site 1 we utilized the fence line to place our cameras on, this was a safe spot where they would not get bumped and we would not have to worry about trying to stake them in a field of rocks. On our new site, we had to decide if we wanted a side view like the original site or if would we want a top-down/bottom-up view. We ended up selecting the top-down and the bottom-up views. This decision was made so that we would be able to better protect the camera and not have to fear the wildlife knocking them over or affecting our images as much.

Image Analysis

To keep track of the bison on our sites the team decided on using trail cameras. After looking at our site's topography we decided that it would be best to have two cameras at each site. We set the two cameras to cover the top part and the bottom part of site 1, all of the cameras were set on fence posts that are on the fence line.

As we set up site 2 we realized that there was more change in elevation than we originally anticipated. The group decided to place a camera at the top of the site looking down and the second camera at the bottom looking up the slope. This would give us the best chance of catching all of the animals interacting with our site.

When counting Bison in the photos we only counted the bison that were within our site. if they were in the background of the photo they were not added to our bison counts. If there was a bison that walked through our site, extended the camera, and then turned around to walk back through that bison would be counted twice for the day. It did not have to be the same bison interaction within our site; we wanted to know how much it interacted. Knowing the number of bison passing through would make it easier to correlate with bison interaction and rock movement.

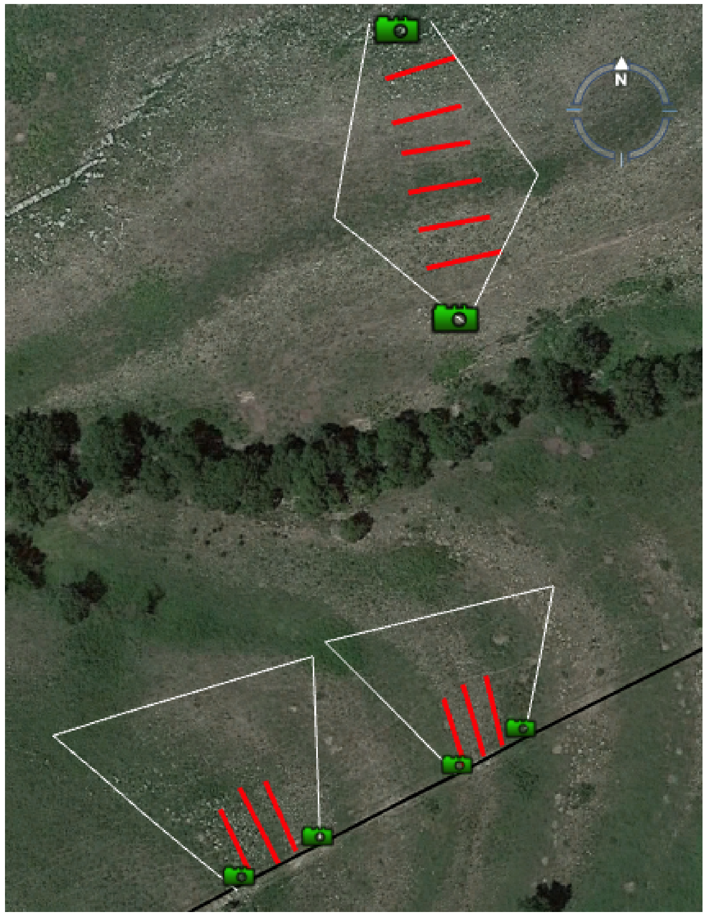
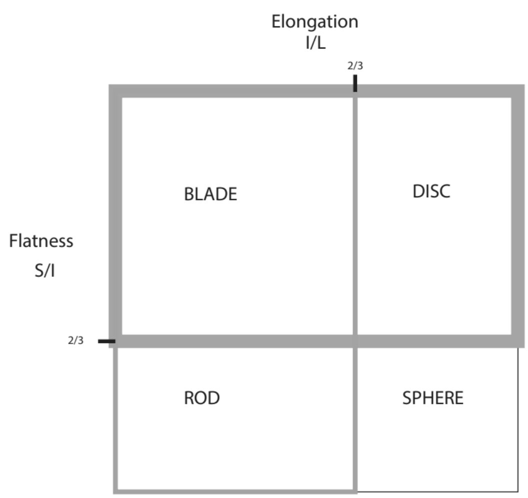


Figure 3. The angles at which the cameras' view can reach the transects of each site. The bottom six transects, divided into two groups of three, are site 1 and used four cameras. The upper six transects are site 2 and used two cameras. (Google, n.d.)

The next week after pulling the SD cards the group quickly realized that there were going to be lots of pictures to go through. To keep all of the data on a user-friendly platform we used excel. We went through the photos keeping track of the bison that had entered the site. Keeping in mind that we were looking for bison interaction with the rocks, we set up some rules when counting. If the bison were not within the boundaries of the research area and were in the photo we did not add them to the bison count. If the Bison passed through the site and re-entered the research area then we counted them as two bison. The cameras also caught other animals that were not originally targeted to rock movement. This led to a discussion if we should also add the data from them. As the team decided that the information was valuable we added columns in our excel list to add the activity of deer and elk.

Rock Classification

We decided to use the Zingg method (1935) to classify the rocks that we observed to determine if rock shape had any impact on their ability to move down the hillslope. We used the Zingg diagram because it is simple, uses four shape classifications, and provides a more even distribution of the shape continuum than other diagrams.



Index	Formula
First-order indices	
$\frac{S}{I}$ **(flatness)**	$\frac{S}{I}$
$\frac{I}{L}$ **(elongation)**	$\frac{I}{L}$
$\frac{S}{L}$ **(equancy)**	$\frac{S}{L}$

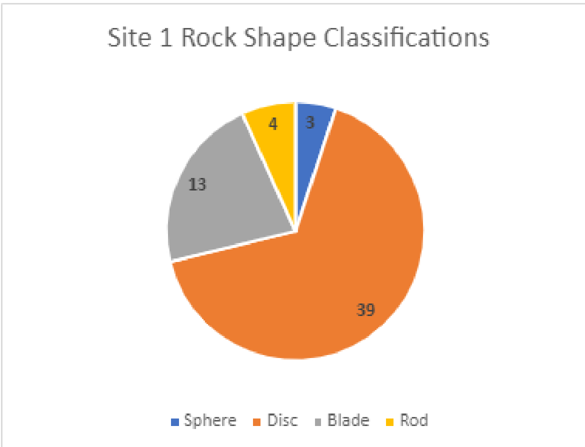
(a) 4 classes of Zingg diagram (b) Zingg index and formulas

Figure 4. Zingg diagram with 4 classes: Disc, Sphere, Blade, Rod
L= Longest dimension, I= Intermediate dimension, S= Smallest dimension
⅔ = Optimal universal parameter to separate the 4 classes.

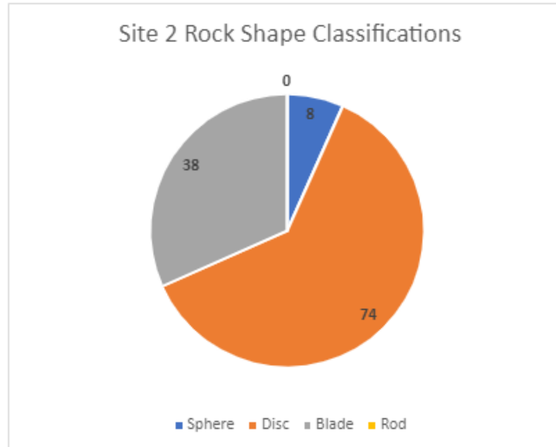
Results

Rock Shape Distribution

According to the Zingg method a majority of the rocks that were randomly sampled in our experiment were classified as discs and the second most classified were blades. This was a consistent finding for both site 1 and site 2. In figure 5, we charted the classifications for each observed rock from site 1 and site 2 into separate pie charts to compare.



(a) Site 1 rock shape classifications



(b) Site 2 rock shape classifications

Figure 5. Rock shape classifications of both sites.

Rock Size Distribution

Rock sizes were measured on three separate axes to determine their length, width, and depth. For the largest length of the rocks we labeled them "A", for the second largest length of the rocks we labeled them as "B", and for the smallest length of the rocks we labeled them as "C". We decided to chart the B axis for all of the rocks for both site 1 and site 2 because it best represented the size distributions for all of the rocks included in the experiment. The overall rock size distributions for site 1 and site 2 are depicted in Figure 6 and Figure 7 and the cumulative frequencies of the rock sizes for site 1 and site 2 are depicted in Figure 8 and Figure 9.

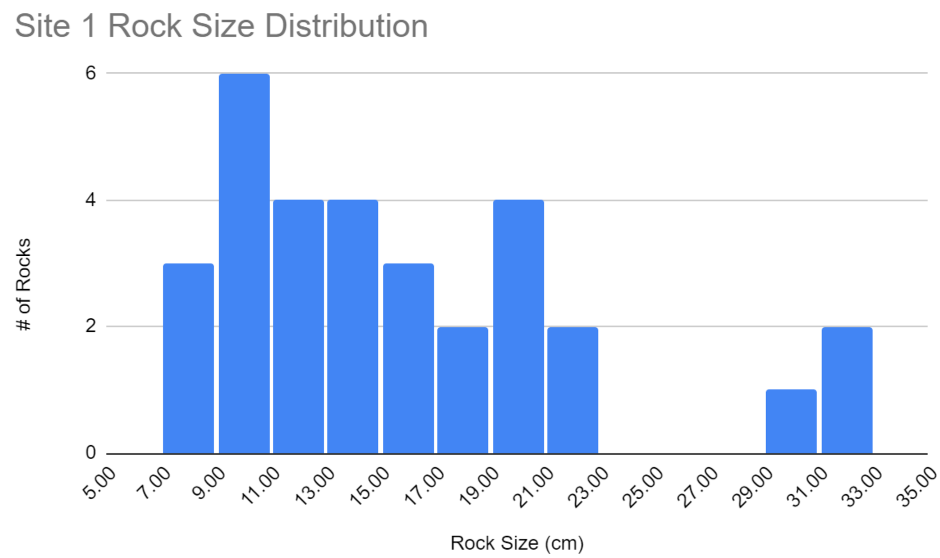


Figure 6. Rock size distribution for site 1 based on the B-axis measurements (second largest axis) of the rocks used for the experiment.

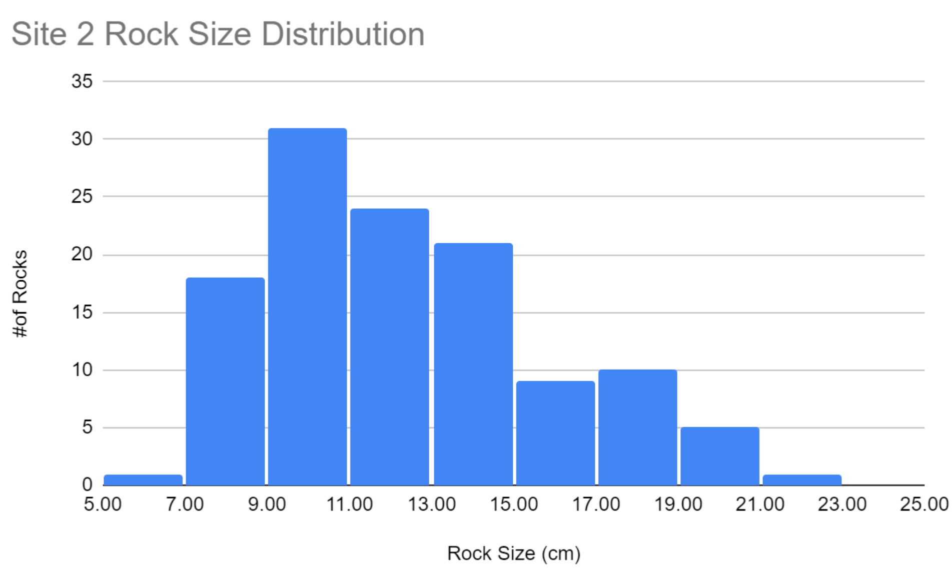


Figure 7: This figure shows rock size distribution for site 2 based on the B-axis measurements of the rocks used for the experiment.

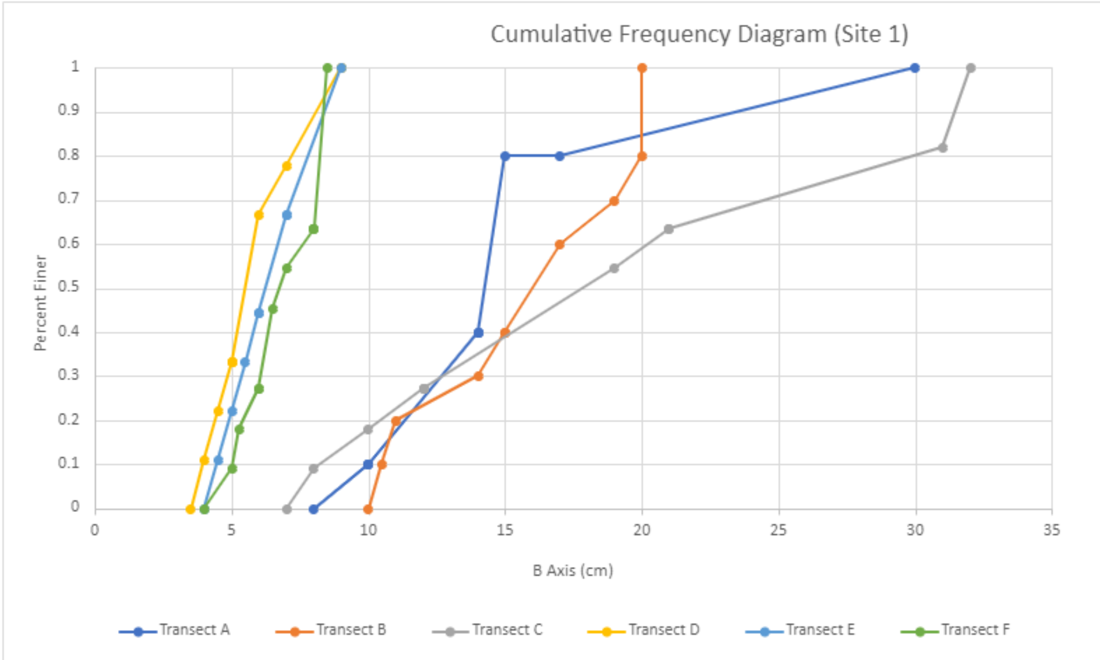


Figure 8: Cumulative frequency of rock size distribution for Site 1 based on the B-axis measurements of the rocks used for the experiment.

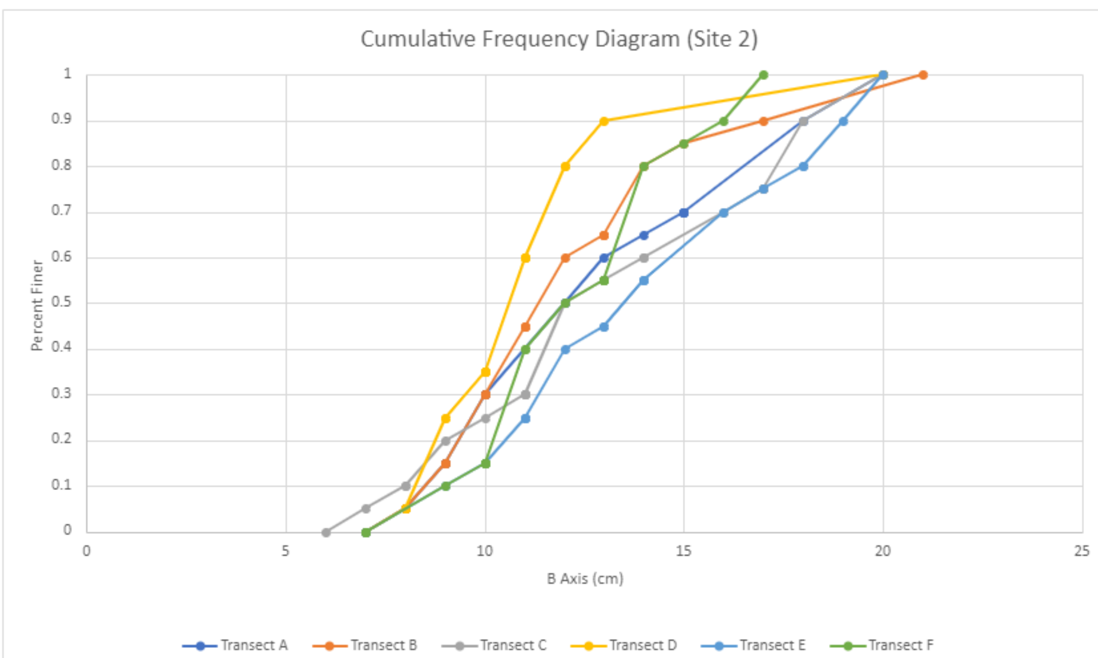


Figure 9: Cumulative frequency of rock size distribution for Site 2 based on the B-axis measurements of the rocks used for the experiment.

Rock Movement

Over a nine week period, the 60 rocks on site one were measured essentially weekly. The lateral, horizontal, and rotational movements were recorded, if any. The following table depicts the rocks that showed movement and the way in which they moved. Among the rocks in site 1, 9 rocks of varying shapes showed movement in varying ways. This gave us a 15% rock movement rate for site 1.

Table 1. Site 1 Rock Movement

Rock Name	Rock Movement	Rock Shape
A5	Shifted 50cm horizontally	Blade
A7	Shifted 95cm horizontally	Disc
A8	Rotated 47°	Disc
A9	Flipped, Rotated 87°, 36cm Downslope Shift	Blade
C3	Rotated 79°	Disc
C6	Rotated 87°	Disc
D3	10cm Downslope Shift	Disc
D7	Flipped	Rod
D8	Rotated 26°	Blade

Table 1. The recorded rock movement over nine weeks at the original site. Rock name, rotational movement, lateral and horizontal movement (cm) from the initial position, if the rock flipped, and rock shape are included for the rocks that exhibited definitive movement.

As for site 2, 120 rocks were measured essentially weekly over a seven week period. The lateral, horizontal, and rotational movements for this site were also recorded, if any. The following table depicts the rocks that showed movement and the way in which they moved. Among the rocks in site 2, 19 rocks of varying shapes showed movement in varying ways. This gave us a 16.67% rock movement rate for site 2.

Table 2. Site 2 Rock Movement		
Rock Name	Rock Movement	Rock Shape
A6	Rotated 98°	Disc
A7	Rotated 49°	Blade
A11	Rotated 21°	Disc
A13	Flipped & Rotated (46°,72°)	Disc
B3	Rotated 28°	Disc
B15	8cm Downslope Shift	Disc
B17	Rotated 15°	Disc
C5	Rotated 37°	Disc
C9	Rotated 44°	Disc
C10	Rotated 76°	Blade
C13	Flipped & Rotated 68°	Blade
D1	16cm Upslope Shift	Sphere
D5	Rotated 19°	Disc
D8	Rotated 38°	Disc
D11	Flipped & Rotated 41°	Disc
D14	Half Flipped	Disc
F3	Half Flipped	Disc
F11	Flipped	Blade
F14	Rotated 40°	Blade

Table 2. The recorded rock movement over seven weeks at the new site. Rock name, rotational movement, lateral and horizontal movement (cm) from the initial position, if the rock flipped, and rock shape are included for the rocks that exhibited definitive movement.

Bison Activity

This research study is specifically on bison's interaction with the rock movement. As some of our research suggested, most of the time when bison were passing through they were in herds of 20 to 30 bison. They would walk through slowly and looked to be selectively grazing, looking for new growth in the limited forage that was available this year due to the lack of precipitation. We also saw the occasional satellite bull which is a single male that was kicked out of the herd. As the bison walked through our observation site they would selectively graze plants. We were not able to capture a photo of any bison wallowing in the bison wallow that was within the bounds of the site. However, there was a bison that bedded down in the wallowed area for over 30 mins. This makes us wonder if there is another wallow sight that they prefer or if there is less wallowing activity in the fall or in dry months. Wallowing is an action that is specific to bison and this could be an attribute that would move rocks. Without any bison wallowing on our sight this can not be concluded in our research.

Other animals that were caught on camera in our sites were deer, coyote, elk, raccoon, skunk, and opossum. Once this observation was made that there were more than just bison present in our sites we realized that they too could be moving the rocks or rotating. In the case of the skunk, we saw that there were holes dug next to some of the rocks and that there was a possibility they could rotate smaller rock samples. Regarding deer and elk present it is worth noting that with the amount of activity recorded there is a high probability that they contributed to part of the rock movement. The graphs of bison activity based on sightings and dates are shown below.

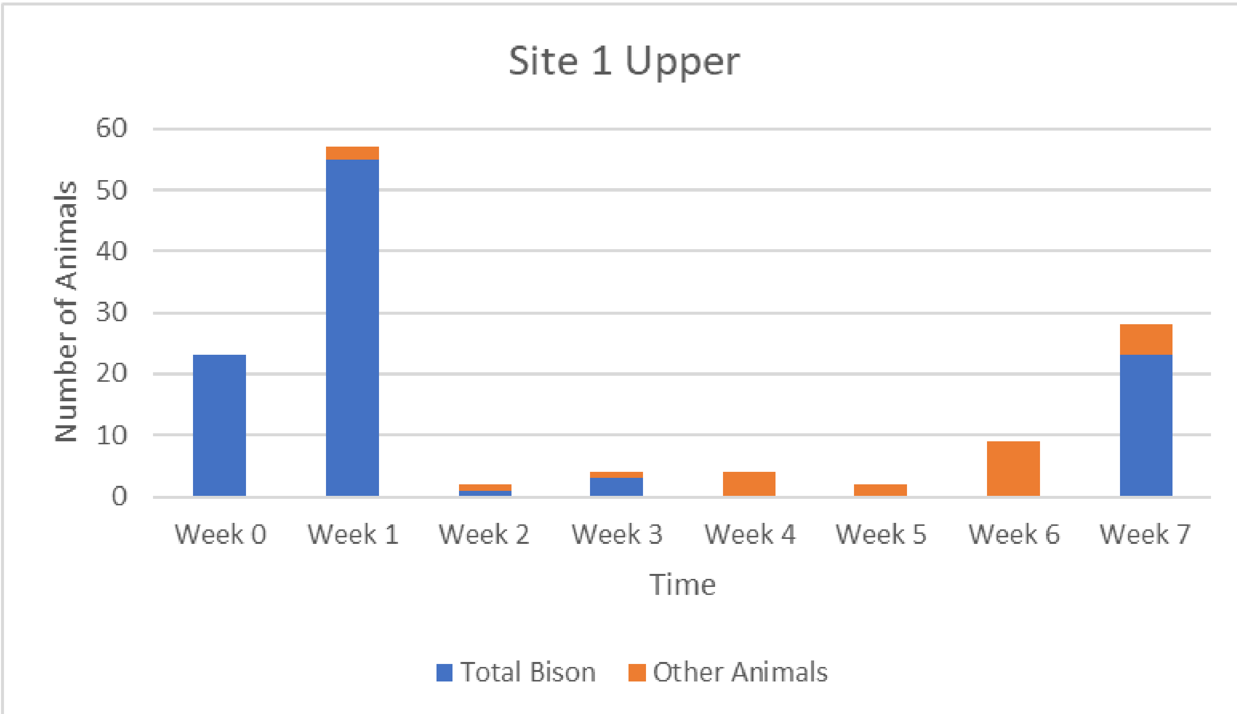


Figure 10: Bison totals over the weeks of our observation period in site 1 upper section.

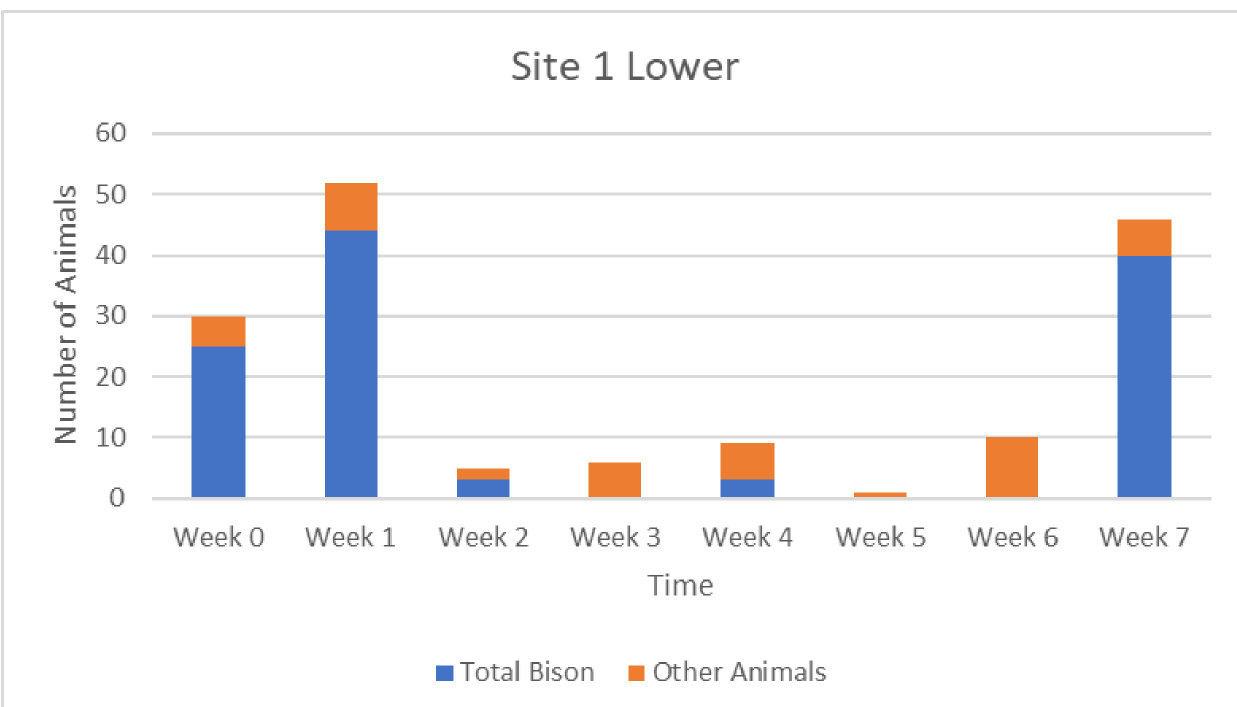


Figure 11: Bison totals over the weeks of our observation period in site 1 lower section.

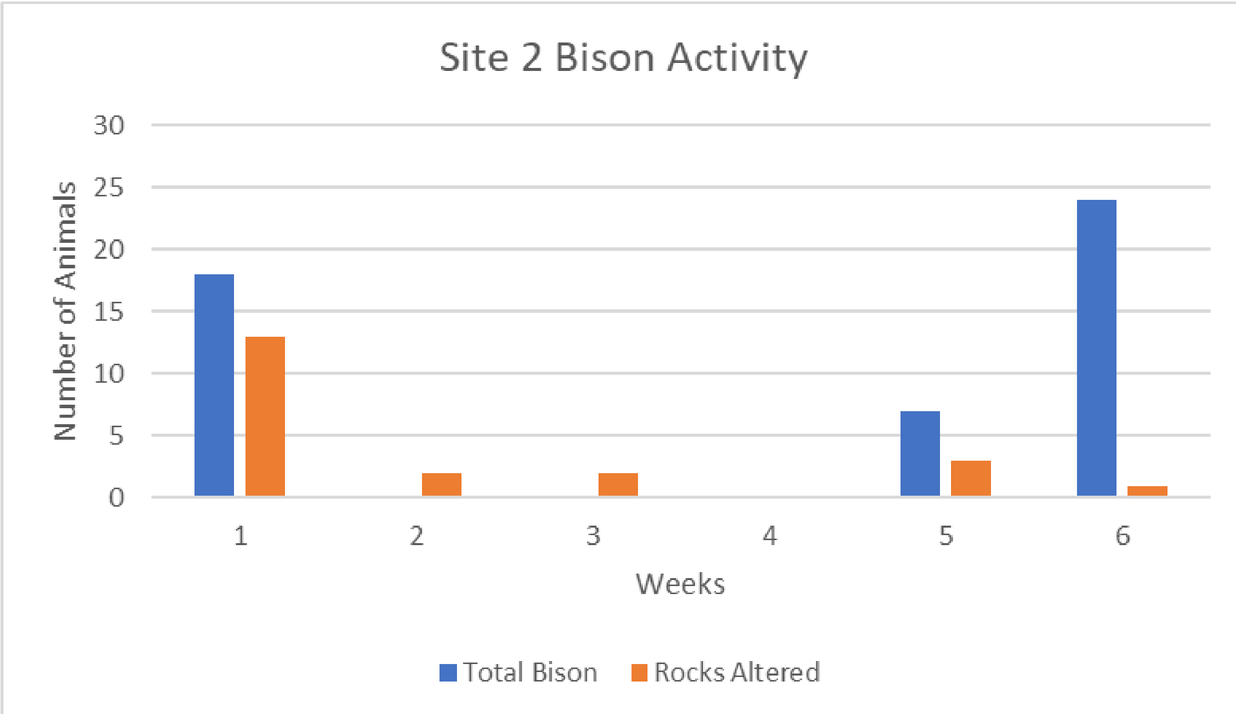


Figure 12: Bison totals over the weeks of our observation period in site 2.

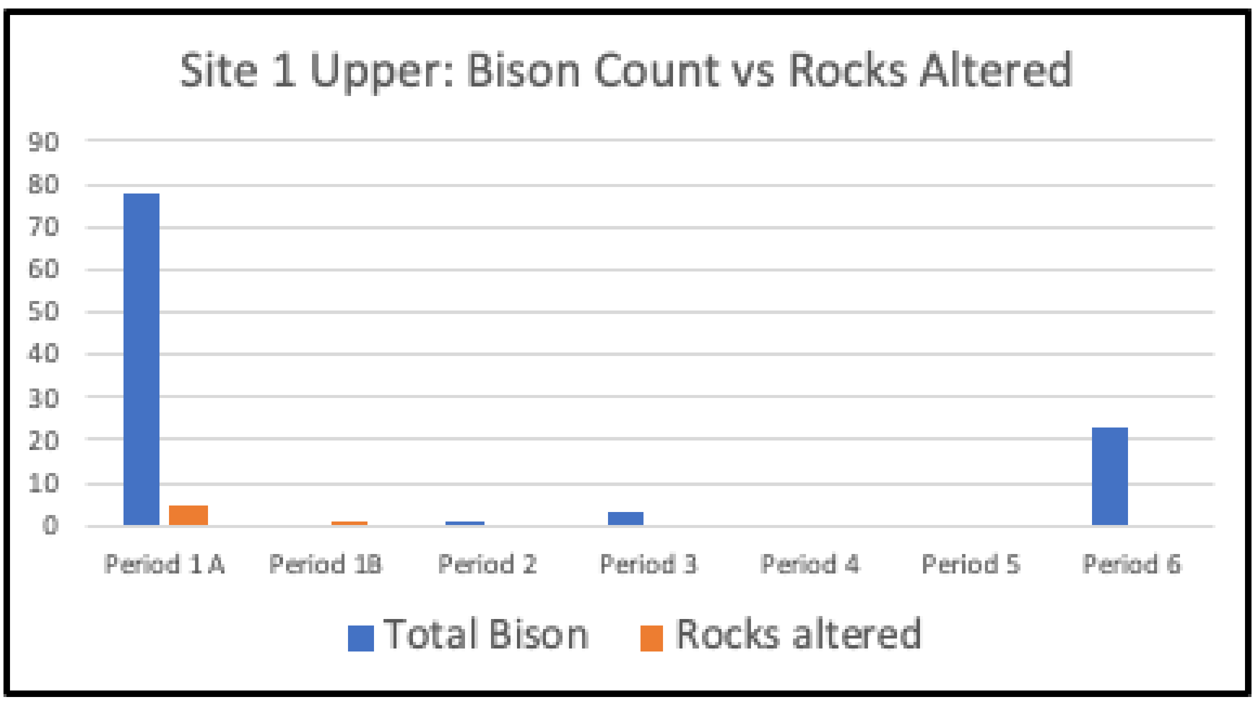


Figure 13: Bison activity relative to rock movement site 1 upper section.

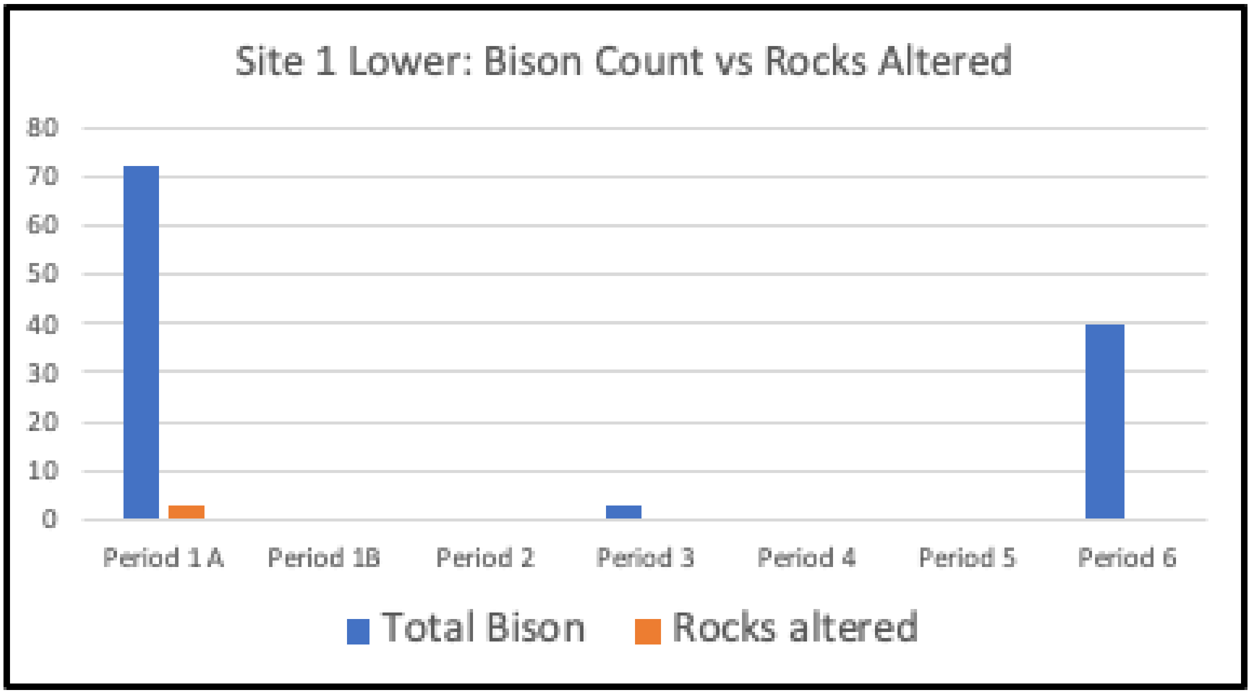


Figure 14: Bison activity relative to rock movement site 1 lower section.

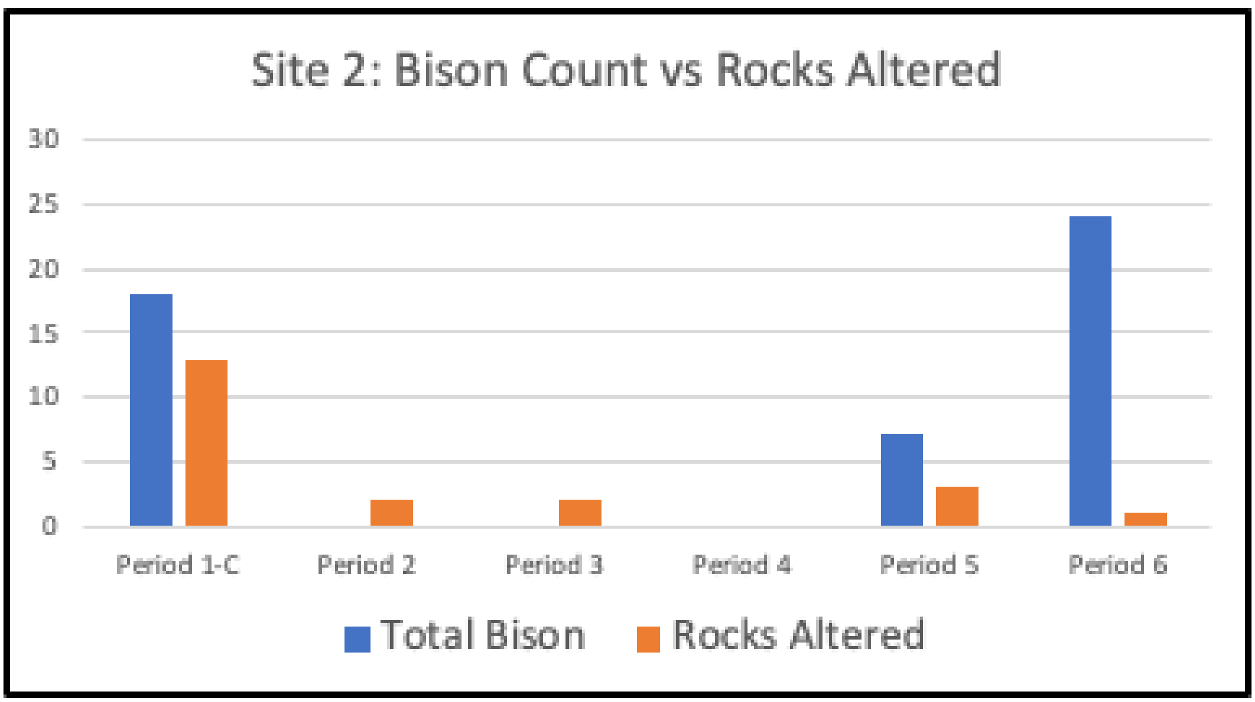


Figure 15: Bison activity close to rock movement site 2.

Discussion

When starting the project we started with a base knowledge of the previous findings when this study was conducted in the spring of 2022. These findings were something that we spent significant time going through and analyzing before we went into the field as well as after. We found ourselves referencing their information quite often. The main reason for this was not due to the similarity, but more the differences. When we finished analyzing our data we found that site 1 had 15% of its rocks altered and site 2 had 16% of its rocks altered. This was quite shocking to us because the previous study had found that 54% of the rocks on site 1 had moved. This was something very intriguing to us considering that we measured the same site again as well as a new one. We had expected similar numbers. Some of the reasons we discussed for possibly having much lower numbers could be things such as the land not being freshly burned, the time of year, or even simply our sampling strategies.

As we went about setting up a second site we started by making sure that we had a space that had the same goal in mind while also having some differences present. We automatically had the difference provided for us that the pasture had not been recently burned due to all of the pastures containing bison having all been burnt that spring. This was something we had found might have more effect than we expected. The reason behind that is the grasses surrounding the rocks had helped solidify the locations of the rocks helping hold them in the place they are located. This was also very helpful when in the field because we were able to tell when the rock had altered the grass. This might not seem super important but it was an excellent way to help confirm the rock movement. We also chose to put the new site on a different facing hill slope that had a game trail located nearby. Also, we noticed a fresh spring that could provide fresh water making the activity potentially higher. Additionally, compared to the previous study, we were very particular when observing which rocks had moved rather than recording movements due to negligible shifts in the baseline measurement. This explains the large difference in our final rock movement rate and the rock movement rate of the previous study.

When deciphering through the data we became aware of rocks showing noticeable movement even while bison were not observed. One way that the rocks could have moved are from weather related activity like heavy winds and rain. Another way the rocks could have moved is from the vegetation, the second site had areas of high and low amounts of vegetation which are a factor in how rocks are impacted on hillslopes. The first week of site 2 looked very promising and there was a lot of rock movement that is correlated with the number of bison present insights. However in week 2 rocks are being altered with no bison present. Then, in week 6, there are more bison present but there is very little rock movement recorded. In the graph showing the correlation between bison activity and rock movement there is very little data showing that bison activity is directly inline with the amount of rock movement. Perhaps bison are more sure-footed than we think and are consciencious of how they maneuver through the rocky sidehills of the Konza Prairie.

This study was something that we all found ourselves very invested in. We would meet up to 3 times a week to go over and discuss findings in the field and analyze data. The more we spent time in the field, the more we began to observe that at the start we never would have noticed. Some of these things being something such as noticing the small holes dug in the ground and recognizing that it could be from a skunk trying to dig up grubs. Something else we had observed was you could sometimes tell the direction that the bison had moved through the area due to the flipped over manure and the direction it was facing. When we all first went to the Konza for the first time together we all were very excited to see and observe the bison, but as things went along we all became more aware of things the bison had altered and spent more time observing the land so we could better understand what was happening within our study area.

One super interesting thing we observed while going through our study was that our game cameras caught a wide variety of animals. We had expected it to catch maybe a deer or two but we ended up seeing everything from elk to skunks to birds fighting. This was something that was not super relevant to the bison's effects on the rocks, but it was very cool to be able to observe these other animals and see them in a natural space.

Interestingly enough, elk appeared on our trail cams a good number of times. This even peaked the interest of the current director of the Konza Prairie Biological Station. Elk have an inconsistent history in the state of Kansas. Numerous settlers of Kansas reported that the elk had already disappeared by the time they arrived around the time of 1865 to 1870 (Choate, 1987). However, there was a point where an early naturalist and hunter, J.R. Mead, reported seeing herds of over 1,000 crossing the Saline River around the year of 1866. Then, by 1985, declines in elk populations had begun in Kansas and then by 1905 it was reported that elk had be extirpated from the state (Conrad et al., 2006). So, it was very interesting to see elk on our trail cameras so often. This led us to believe that maybe elk populations are higher in Kansas than previously thought. Also, there is a herd located in Fort Riley that these elk possibly belong to.

When going through our research looking back we have a couple of things we have talked about trying to change in the future if we tested our question again. One of the big things is we would find a way to mark the exact location of our rocks so that we can be more confident in the small movements that we might have not caught with our hand measurements. We also discussed taking the slope of our hill and utilizing that information and testing different hill slopes. This was something we had discussed but never ended up having the time to get the hill slopes measured to add it to our data. Lastly, we would want to put more emphasis on the weather. We did some simple checking in on the weather, but when going back and putting some of the rainfall information into our data we struggled to make it flow smoothly. So in the future we would be sure to start the experiment with weather more present in our research.

When going through and analyzing some of our pictures we noticed that the cameras did not all take the highest quality images as well. This was something that did not change the outcome of our research but something we could most definitely improve on. Having high quality equipment in the field such as cameras we might be able to access remotely would be very beneficial to our research we were conducting. instead of having to pull the sd card ever time we went to get measurements in the field we could get high quality images directly to our devices every time we had movement. The last change that we discussed changing regarding cameras was trying to find a way to better view the rocks we are measuring. our cameras did a great job at helping us analyze when and where the bison and other animals were located when we had them on our sites, but it was not always super easy to tell where the rocks are located. In the future we would be sure to make sure we have the camera able to see the lines on as many rocks as we can at all times.

Conclusion

Although there is definitive evidence that bison act as geomorphic agents and interact with rocks on the Konza Prairie, the question remains of how much rock movement are they actually responsible for. To answer this, an already existing study site at Konza Prairie Biological Station was further observed for an extended period of time and a second study site was set up in which there were numerous differences from the first. Each site was located on a hillslope and composed of six transects in which rocks of varying sizes and shapes were selected, measured, marked, and then placed in a straight line. Each week these rocks were measured in an attempt to find a difference in rotation and both horizontal and vertical movement from their initial location of placement, as well as whether the rock had flipped. Trail cameras were also set up to observe the amount of bison activity within the two sites. Within the duration of the period of observation, bison presence on both sites was mostly concentrated during the first and last week. However, a correlation of bison presence and rock movement was only observed during the first week. Among the 60 chosen rocks from the original site, 9 of them exhibited a movement of some kind, giving us a 15% rate of rock movement. As for the second site, among the 120 chosen rocks 19 of them exhibited movement of some kind, giving us an 16.7% rate of rock movement.

Despite the similar amount of bison activity throughout the duration of this study, there was a lower rate of rock movement when compared to the previous study. This indicates that despite there being evidence that bison do in fact move rocks, the significance of their impact on rock movement at Konza Prairie is not as substantial as previously believed.

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