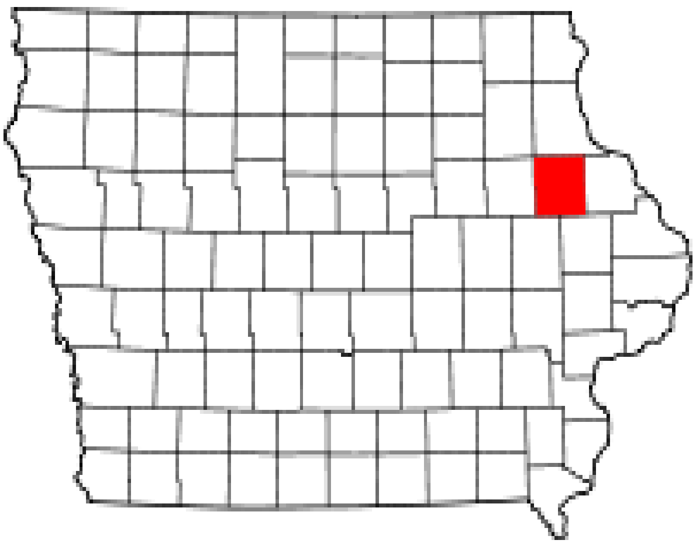
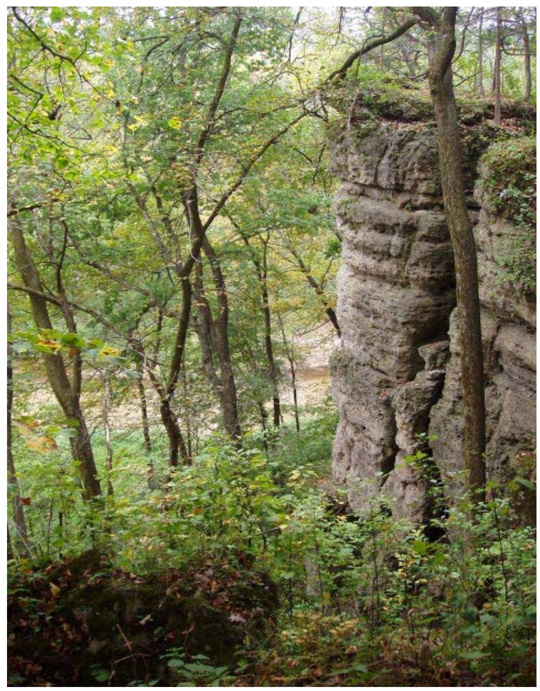
University of Northern Iowa

The Geology of Delaware County: An Inquiry Unit and Field Trip Guide to Backbone State Park





Nick Mills

Geology of Iowa

Dr. Heinzel

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Abstract: It is often times difficult for a teacher to have time to find the proper resources necessary to create a fun and engaging lesson unit in the field of earth science. This paper is meant to be a resource to help guide teachers through a lesson unit on the natural history of Iowa. This paper explores two aspects of geology in the state of Iowa. First, a brief description of each geologic time period will be explored as to help give an overview of the depositional environment of the bedrock. Following this overview of the overall geology of Iowa, a deeper exploration into the geology of Delaware county will be described by a focusing on a particular area within the county: Backbone State Park. An in depth analysis of the park through the plant fauna and distribution, bedrock exposures, and quaternary deposits will help give a large insight on the geology of Delaware county.

Introduction: The research and writing of this paper is meant to help guide one through a concise summary of the geologic history of Iowa and an in depth look into the natural history of Backbone state park. Backbone state park is located in far South West corner of Delaware county. To help supplement the exploration of Backbone State Park, a lesson unit and field trip guide is included with this research. The lesson plan unit is in an outline format as to help give teachers a framework to build off of when planning this lesson unit. Students will also be able to use the research and writing of this paper as a reference guide when exploring the chosen theme in which they chose to explore in depth during the field trip portion of the lesson unit.

Iowa's Geologic History

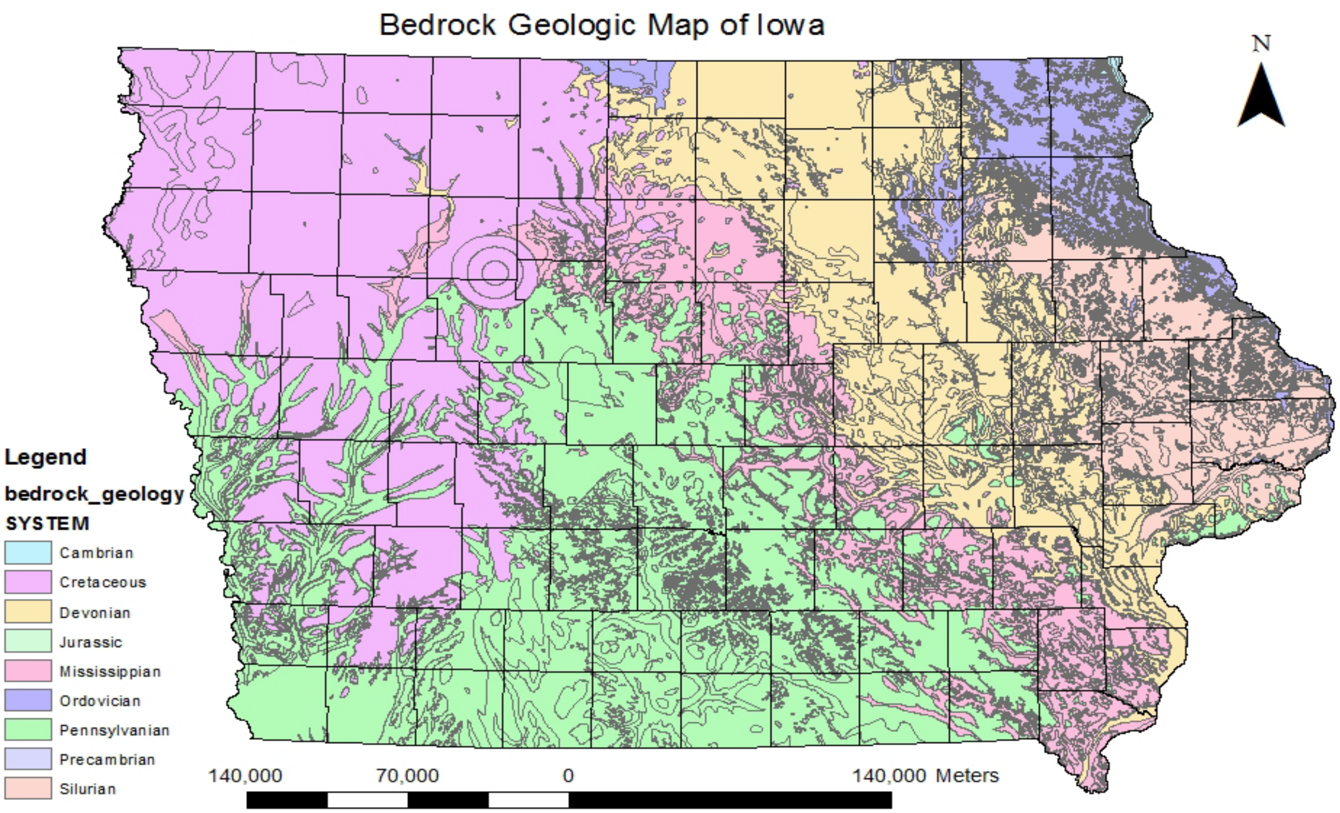


Figure 1 : Complete geologic map of the bedrock formations present in Iowa.

<u>Precambrian</u>

Iowa's Precambrian geologic history is characterized by extensive igneous and metamorphic bedrock formations. The precambrian bedrock of Iowa dates back to 3 million years ago. During this time, tectonic activity resulted in mountain building events that led to the deformation of the igneous bedrock features that will later be overlain by sediment deposition of major sea level fluctuations.

Iowa's oldest exposed bedrock features can be found in Sioux City Iowa. Located in the very NW corner of Iowa (Fig. 1), the Sioux Quartzite is a metamorphic rock that is formed by quartz rich sandstone being exposed to extreme heat and pressure. This causes the quartz grains to fuse together forming one, solid, unit of rock. Roughly 1.1 billion years ago, Iowa was nearly ripped apart by a structure known as the Midcontinent rift system. Due to this event, a series of uplifting occurred which created the Iowa Horst. At one time, this feature spanned heights of 30,000ft. Over the course of time, this once prominent feature has since eroded and is now recorded in the bedrock as gravity anomalies. (Anderson, 1998)

Cambrian

Though it is not extensive throughout much of Iowa, there is a very small portion of Cambrian aged bedrock located in the top North West corner of the state (fig 1). The Iowa Cambrian system is constituted by 6 formations. Mt. Simon, Eau Claire, Wonewoc, Lone Rock, St. Lawrence, and the Jordan formations. In early Cambrian (547 million years ago) Iowa's bedrock was not yet under water and continued to experience erosional processes. It wasn't until middle Cambrian time that much of Iowa's landscape was covered with marine waters. Marine shelf and shoreline deposits helped to form the well sorted quartz rich sandstones, muddy sandstones, siltstones, shales, and dolomites that make up the Cambrian rock record.

It is often noted that the cambrian time is known for the divergence of Trilobites. Other life forms including brachiopods, gastropods, mollusks, arthropods, and sticky algal mats were also present during the cambrian time period. Since a majority of Iowa's cambrian record consists of sandstones and other marine shore deposits that are poorly exposed, fossils from this time period are not well preserved or easily accessible and thus rarely present to study. Most of our knowledge on Iowa's Cambrian life forms come from studies conducted in Wisconsin and Minnesota. (Anderson, 1998)

Ordovician

During the Ordovician, warm shallow sea environments are the main depositional environments shown in the rock record. There are six formations that make up the Ordovician. Starting at the base of the formation (485 mya) Prairie du Chien, Glenwood, St. Peter, Platteville, Galena, and Maquoketa (443 mya). Overall, carbonates are the dominant rock type within this time period. The process of dolomitization and dolomite formations in the lower rock sequences help give insight of the shallow marine depositional setting that helped shape the landscape. Oolites and stromatolite fossils present also help determine that the lower sequences were shallow sea deposits.

Towards the end of the Prairie du Chien formation, the seas began to regress back across Iowa leaving much of the sediment to be weathered away. Following this major regressive cycle, the marine waters once again transgressed back onto the landscape and created marine shoreline and inner-shelf environments.

Much of the ordovician sea was home to a plethora of marine invertebrates. Graptolites, cephalopods, gastropods, scaphopods, brachiopods, trilobites, and bivalves all make up the extensive marine fauna. Most of Iowa’s Ordovician rock record contains fossils of these organisms. Stromatolites are commonly found in the Prairie du Chien and Galena groups while others can also be found in the Maquoketa formation. (Anderson, 1998)

Silurian

There are five major transgressive and regressive cycles that played a major role in shaping the Silurian rock formations of Iowa. Six dolomite sequences and two limestone sequences are what constitute the Silurian rock record of Iowa. Water level depths within the shallow sea floor environment ranged from 200 to 300 ft. deep.

The Silurian rock record in Iowa is notable for its economic importance and easily visible cliff forming features present in many of Iowa’s state parks. Backbone state park, Maquoketa Cave state park, Palisades state park and Picture Rock in Jones Co. Iowa are all exposures of the Hopkinton formation. These prominent features within our state are due to the weather resistant dolomite that makes up a majority of our Silurian period. Dolostones and dolomites also come into play as a major resource for building material, road aggregate, and ag. Lime. Most of the economically important bedrock is found in Anamosa and Stone City, IA.

Marine life during the Silurian time was extensive. Brachiopods, crinoids, gastropods, graptolites, nautiloids, stromatoporoids, trilobites are all found within the silurian formations. (Anderson, 1998)

Devonian

Throughout the course of the Devonian period, many T- R cycles are what have attributed to the depositional environment recorded in the rock record. Much of the mud sources found in the rock record are due to the surrounding mountain ranges nearby and other exposed surfaces. Occurring in long intervals, the T-R cycles generally lasted 1 to 3 million years at a time. During the regressive cycles, the seafloor and other environments are subjected to weathering processes and extreme drying conditions. Overall, the rock strata that makes up the Devonian period can be summarized into a variety of carbonate rocks and dolomites with an extensive fossil record in the upper devonian rock strata. A majority of the rock record during this period is made up of dolomites, limestones, dolostones, and fossiliferous limestones with an extensive array of biostromes.

Devonian period (416 mya - 359 mya) was teaming with life. Though there were many T-R cycles took place, there was still an abundance of marine life in the oceans and oceanic shelf facies in Iowa. Brachiopods, stromatoporoids, corals, and fish were all present during the Devonian and are prevalent in the rock record of Iowa as well. (Anderson, 1998)

Mississippian

Ten major T-R cycles make up the mississippian sequences of Iowa. Some of the deposits contain silicate bearing sediments that were deposited during some of these T-R cycles (mainly regressive stages). Each depositional cycle started with a thin, basal transgressive unit and end with a thicker regressive sequence.The bedrock of this period stretches in a long, continuous belt from the far SE corner (Lee county) upward to the middle of the state (Wright/Hamilton Co.) Much of the rock of the Miss. period serves as an economic resource in terms of road aggregate, and is a viable source of groundwater for the north central part of the state.

Much of the rock strata in the Miss. period are a combination of limestone, dolomite, shales, chert, and a vast array of fossiliferous limestones. Oolites are also a common occurrence in Miss. rocks. These spherical balls range in sizes of .02 - .04 inches in diameter and are comprised largely of calcium carbonate. At a closer look, these little structures can tell us several things about the environment in which they were deposited. 1. there was lots of agitation at the time. Water was constantly moving and thus helped these calcareous balls to accumulate more $CaCO_3$. 2. ooids are usually found in shallow, warm marine environments in lower latitudes.

Looking at the overall environment, we can now shift over into the marine life that was present during the Miss. As stated before, a vast majority of Miss aged rocks have a diverse fossil content. One of the most notable fossils present in the rock strata is the crinoid. Other marine life was supported during this time as well. Many echinoderms populated the ancient marine environments as well as crinoids, mollusks, corals, arthropods, fish, foraminifera, and conodont remains. There were also remains of terrestrial species of amphibians recovered in Iowa dating back to 340 myo. (Anderson, 1998),

Pennsylvanian

Throughout the Pennsylvanian rock record of Iowa, there is much evidence of cyclic patterns of marine and non marine based sediment deposition. This type of deposition is termed as cyclothems. Bedrock formations of this time period are extensive throughout Southern Iowa and stretch all the way to Webster Co. Sea level fluctuations during the Pennsylvanian were due in part by continental glaciation near the southern hemisphere.

During non marine deposition, Iowa was characterized by low lying coastal swamps and deltaic plains. Evidence of this can be found in cliff forming rock structures consisting of sandstones. Most of these outcrops can be found in Dolliver Memorial, Ledges, and Wildcat Den state parks here in Iowa. Coastal swamp areas were once filled with thick vegetation. Over time, this was eventually buried and now preserved as coal beds. Most of the coal located in Iowa was extensively mined from 1870 - 1920. Eventually, coal production slowed after 1920 and has since been obsolete.

Marine deposition throughout the Pennsylvanian is characterized by extensive limestone, shales, and fossiliferous limestones. A majority of the Pennsylvanian limestone resources throughout the state have been used in brick manufacturing and aggregate material in cement. This has played a major role in Iowa’s infrastructure and created a vast majority of work for locals near these established companies.

Since Iowa was not entirely under water during this period, Pennsylvanian life can be split into two groups; non-marine and marine life. Much of the non-marine life can be characterized by a variety of what is known today as horsetail ferns and club mosses. Plant life during this time period can be grouped into several major taxa; scale trees (lycopods), ferns, rushes (sphenopsids), and cordaitean trees. Moving towards the water, Pennsylvanian marine life can be easily found throughout much of the upper rock layers. Several fossils that are characteristic of Pennsylvanian rock strata are brachiopods, fusulinid foraminifera, and calcareous algae fossils. (Anderson, 1998)

Mesozoic Era of Iowa

For simplicity purposes, the following summaries of Iowa's geologic past will now be grouped into eras rather than time periods. Though the geologic history of Iowa does not stop 251 mya, there is no record of earth's history here in Iowa during the Permian and Triassic. This helps make clear the amount of erosion occurring during this period of time in Iowa's history. Even though there is no Permian or Triassic aged rock present in iowa, there is a small amount of Jurassic aged rock in the form of gypsum deposits (Fort Dodge Formation). Located in the Webster Co, these gypsum exposures have given way to an industry in Fort Dodge that has lead the area to be one of the nation's highest gypsum producers. Products that gypsum are used for ranges from plaster production, plaster board, portland cement, and other similar products (Anderson, 1998)

Also present in Iowa's Mesozoic record is an extensive amount of Cretaceous aged bedrock located in western and northwestern Iowa. A variety of sandstones, mudstones, shales, siltstones, conglomerates and lignite comprise this age of bedrock across Iowa. These deposits were caused by an influx of various depositional environments such as fluvial, nearshore marine and coastal conditions. During this time period roughly 73.8 mya, a meteorite crashed into what was at the time, a seaway. This impact created a nearly circular crater with a maximum diameter of 23 miles. Due to its location in Iowa, this structure is named the Manson Impact structure. Even though this structure extensively large, it is not visible by surficial observations due to it being filled in by with glacial drift from the following Pleistocene glacial episodes (Anderson, 1998)

Life of the Mesozoic is characterized by a diversification of reptiles and other dinosaurs along with the appearance of mammals, birds, and angiosperm plant species. Most of the fossil evidence for life during the Mesozoic is found in neighboring states. Fossils of the marine reptile ,plesiosaur, have been found in the Sioux City area in Iowa. Fossil remains of bony fish and sharks are also found in Iowa and other neighboring states. A diverse fauna of plant life can be found extensively throughout Iowa's Mesozoic rock strata. Some of these include species of bryophytes, lycopods, ferns, gymnosperms, and angiosperms. Tree species include pine forests, cypress-like trees, and Cycads. (Anderson, 1998)

Cenozoic Era of Iowa

Iowa's Cenozoic is divided into two time periods, the Tertiary and Quaternary. These two time periods account for the last 65 million years of earth's geologic past. Here in Iowa, there is an extensive amount Cenozoic aged deposits present across the state. Much of the Quaternary is characterized by long durations of erosion which is why much of the Tertiary deposits throughout Iowa are small in thickness.

The Quaternary period of Iowa is characterized by extensive deposits and features formed from the Pre-Illinoian, Illinoian, and Wisconsinan glacial episodes. Some of the glacial deposits formed during these episodes include glacial drifts, tills, loess, paleosols and fluvial sediments. These deposits are the most extensive and complete sections of continental glacial deposits found in North America. One of the most obvious and observable features of Iowa's geologic past is the surface characteristics of the landscape. Located throughout the state are a number of various surficial characteristics that help distinguish various geographical areas. These are known as landform regions (figure 2). To help wrap up the summary of Iowa's geologic history, main attributes of the seven landform regions of Iowa will be explored. (Anderson, 1998)

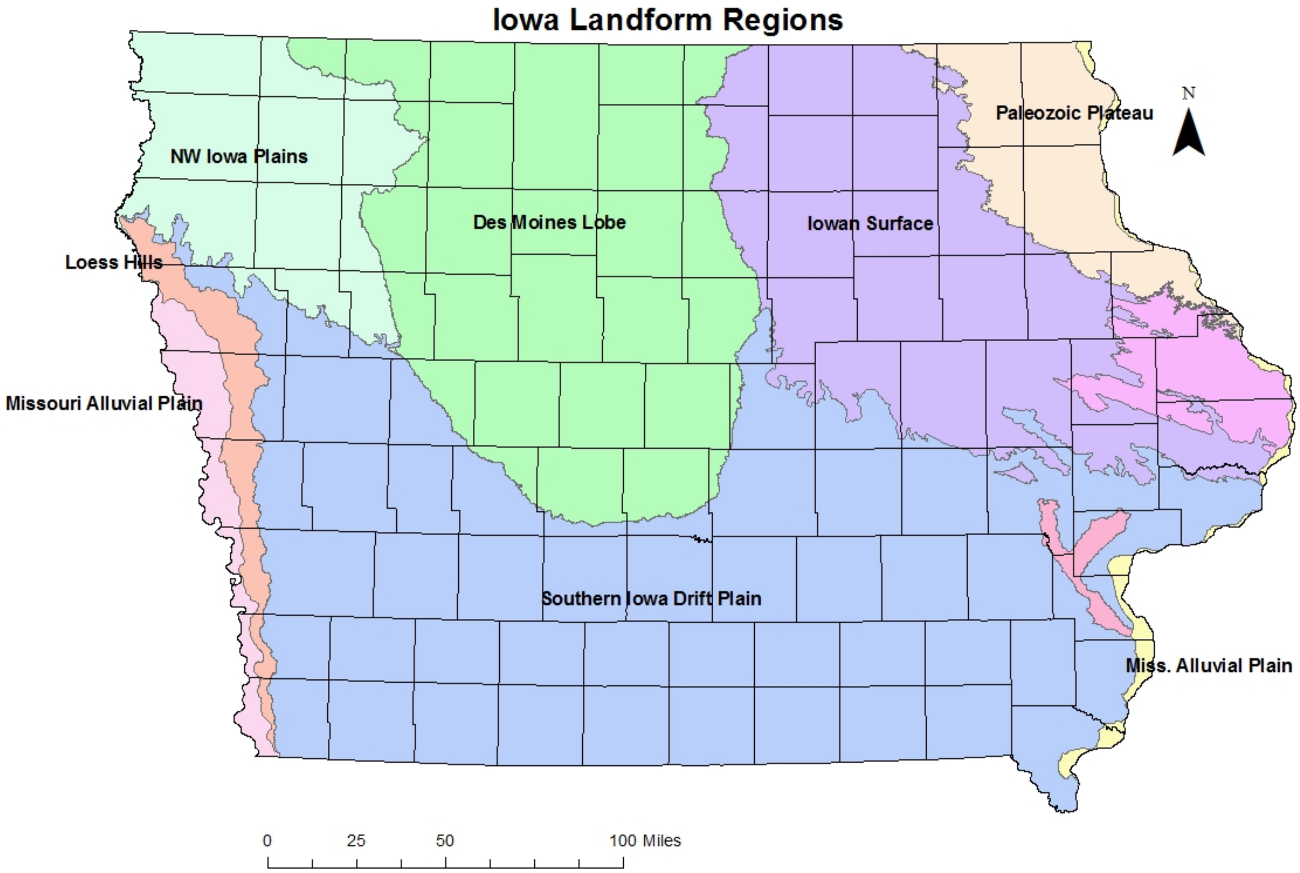


Figure 2. Landform Regions Map of Iowa

<u>Des Moines Lobe</u>

______Even though Iowa was completely glaciated, the Des Moines lobe is the only landform region that preserves a topography directly formed from glaciation. Starting 15,000 years ago, the last advancement of glaciers entered in a series of surges ending around 14,00 years ago. Evidence of these various advancements and dormant stages of the glacier is evident through series of laterally extensive glacial debris dumped in a series of terminal moraines. Terminal moraines are long, curved shaped features comprised of rocks, gravel, and various sized sediment deposited along the borders of stagnant glaciers. Another feature characteristic of this landform region are the extensive kames. Kames are produced when deposits of sand and gravel from meltwater accumulate in openings of the glacier. (Prior, 1991)

Alluvial Plains

Located along the southwestern and southeastern borders of Iowa are the landform regions formed by the Missouri and Mississippi rivers. These alluvial plains are characterized by sandy lowlands of river and flood deposits. Floodplains are usually submerged areas during times of higher than normal water levels within the rivers. Roughly 9,500 to 30,00 years ago, both of these river valleys were filled with an extensive amount of glacial water during periods of glacial advancement and recession. (Prior, 1991)

Loess Hills

The topography of the Loess Hills landform region helps to set it apart from all the other landforms in Iowa. Changes is relief throughout this small yet present area in iowa help to give it sharply ridged terrain features with lots of drainage features. Covering the entire length of the Missouri river valley, the Loess Hills cover a very narrow band roughly 2 to 10 miles wide across. Loess is defined as fine grained deposit of wind carried sediment. Typical size of the particles range from silt and clay sized to very fine grained sand. During glacial periods, rock and other debris picked up from the glaciers were deposited in the outwash and alluvial plains during glacial advancements and recessions. As these sediments dried, winds prevailing mostly from the west, would blow these sediments into sand dune, like features that are now known as the Loess Hills of Iowa. Today, much of these features have been extensively eroded due to the extensive water runoff and drainage caused by the relief of the landscape.(Prior, 1991)

Southern Iowa Drift Plain

Covering a vast majority of Iowa, the Southern Iowa Drift Plain is the largest of the landform regions. Formed by glaciers that extended into Missouri over 500,00 years ago, this region is dominated by glacial deposits. Most of the surface is overlying an extensive area of pre-Illinoian glacial drift with various thicknesses of Wisconsinan loess features. An extensive drainage network helps to set this region apart from the Des Moines lobe. Some of the deeper valleys within the area generally have exposed bedrock features.(Prior, 1991)

Iowan Surface

The Iowan Surface is very similar to the Southern Iowa Drift Plain region located just to the south. Unlike the extensive drainage system to the south, the Iowan surface is relatively flat and does not have distinctive hills and valleys. Located in the Northeastern part of Iowa, this region extends to the far eastern border along the Mississippi river. What helps to set this landform region apart from the others are the various Paha features that stretch across the lower portion of this landform region. Paha is the Dakota Sioux word for hill or ridge. These ridges were formed by wind blown sediments from Pre-Illinoian drift. These vertically thick depositional features are oriented in a NW to SW direction and are generally close in proximity to river valleys. Often covered in forests and woodlands, these are the only upland woods in the Iowan Surface location.(Prior, 1991)

Northwest Iowa Plains

Located in the far NW corner of Iowa lies the Northwest Iowa Plains. Surficially, this is most noticeable by the sparse wooded vegetation and a flourishing of prairie grass. Severe weathering and erosion due to the late Wisconsinan periglacial climate many of the depositional features present before it. This episode of erosion has helped give the landform region an extensive integrated drainage network with gently rolling terrain features. Despite the extensive amount of erosion that occurred, this portion of Iowa is uniformly the highest region of the state. Not only is it the highest region, but also the driest part of the state as it only averages 25 inches of rain per year.(Prior, 1991)

Paleozoic Plateau

Noted by its extensive bedrock exposures, the Paleozoic Plateau is the one landform region that is not strongly influenced by glacial deposits. Bedrock in this area plays a huge role in the overall shape of the landscape. Large rock outcrops and ledges with deep, narrow valleys with streams. Much of the wooded upland features sit on top of weather resistant dolomite layers. Though the bedrock of this area is well aged, the landform region itself is not. Much of what is present today formed during the Pleistocene and Holocene epochs (most recent in geologic history).(Prior, 1991)

Quaternary life

During the Wisconsinan glacial episode, Iowa was located in an area heavily dominated by spruce forests. As one moved closer to the southern portions of the U.S., the forest gradually shifted to a deciduous style woodland. It wasn’t until 10,000 and 9,000 years ago that Iowa began to develop a deciduous forests with oaks and other trees that prefer moderately moist conditions. Around 5,400 years ago, prairie began to replace the more mesic (moderately moist) conditions. Tree species that survived better in slightly drier conditions such as oak forests were also present around this time.

Animal species that roamed Iowa during this time are also extensive. There is much to say about some of the fossil finds of the mammals that once lived during these glacial periods and major vegetation changes. Some of the Ice Age species include wooly mammoths, giant ground sloths, deer, elk, caribou, reindeer, bison, wolf, fox, beaver, bison and a variety of smaller mammals as well. These are just a few of the animals found within Iowa's most recent geologic history. Currently located in the University of Iowa Museum is life sized replica of the giant ground sloth Megalonyx jeffersonii. The fossil remains of this species of giant ground sloth were found by Thomas Jefferson during an exhibition across Iowa.(Anderson, 1998)

Delaware County, Iowa

History of settlement, environment, economic resources at the time:

Delaware county was established in 1837 after the Black Hawk Purchase was finalized between Sac and Fox Tribes and officials that were part of Michigan at the time. After the purchase, settlements began across the mississippi on what is now the Eastern border of Iowa. At first, the entire eastern half of Iowa was divided up into two counties. It wasn't until 1837 that Dubuque county was divided into 11 different counties under Wisconsin jurisdiction. Delaware county was one of these. Eventually, Delaware was further divided into smaller townships for mapping and surveying purposes.

First settlement of Delaware county occurred in 1836 when William Bennett built a log cabin along Honey creek. The Maquoketa river extends in a diagonal line running from the top NW corner of the county to the mid SE corner. This was one of the major economic resources for many of the settlers who later inhabited this area since most were trappers and hunters. Three fourths of the land is described as beautiful, undisturbed prairie fields. Most of the deciduous forests occupy the river banks of the Maquoketa river. First extensive farming practices in Delaware county date back to 1838 near Milo township. Roughly 20 acres of prairie land was broken and cultivated for agricultural resources.

Delaware county's geology was of economic importance to the early settlers of Eastern Iowa. In earlier documentation, the bedrock of this county is described as magnesian limestone (dolomite) with an extensive record of marine fossils, corals, shells, and inarticulate brachiopods. Much of the exposed rock facies were repurposed for use in building materials. Locations near Delhi contain stone that was noted to be similar to that of what's found in Anamosa, Iowa. Records of people whom have had lithograph portraits of themselves are recorded in The History of Delaware County, Iowa. In Delhi, deposits of fine clay material was used in the manufacturing of bricks.

<u>Delaware County Stats Today:</u>

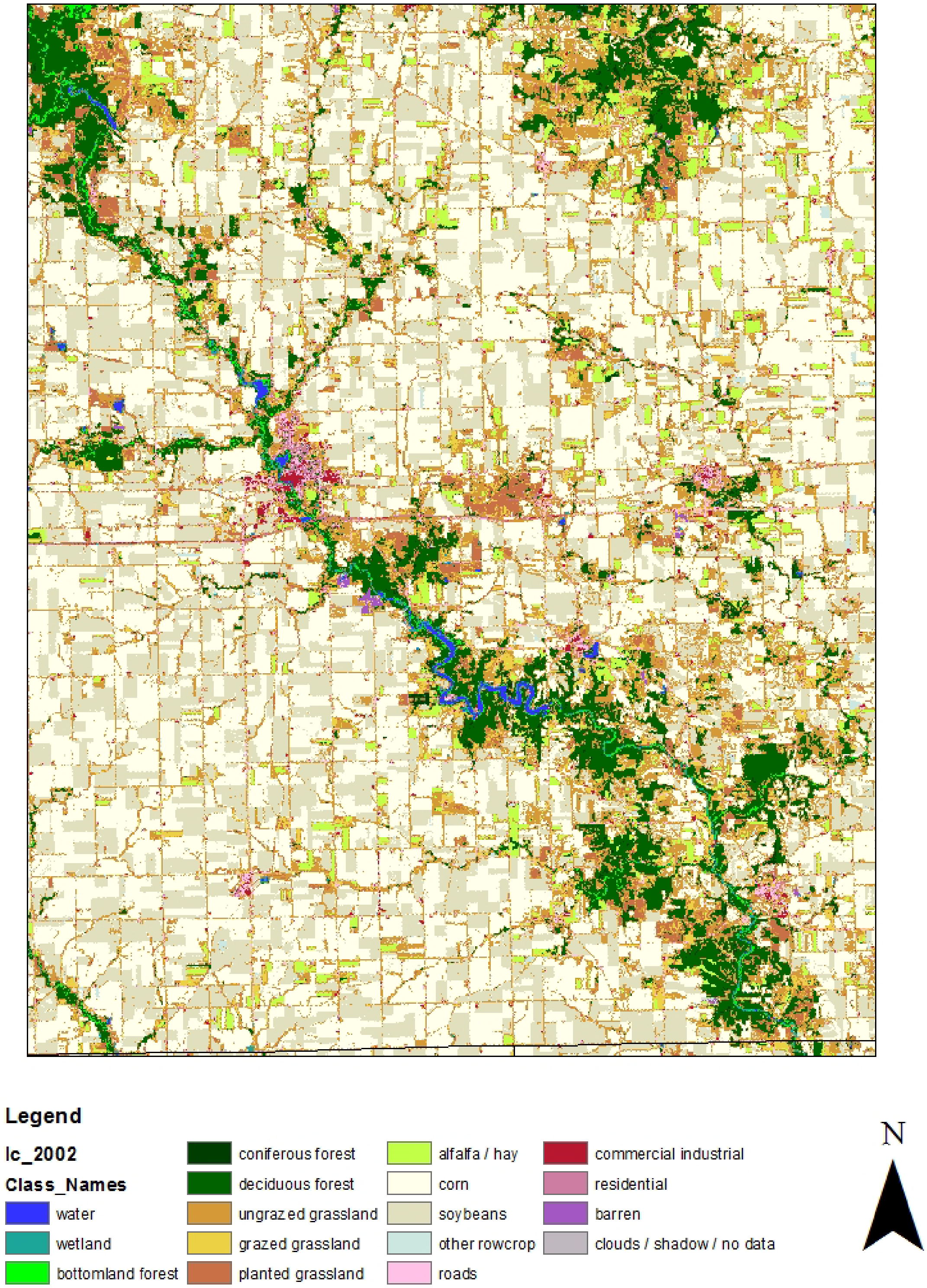
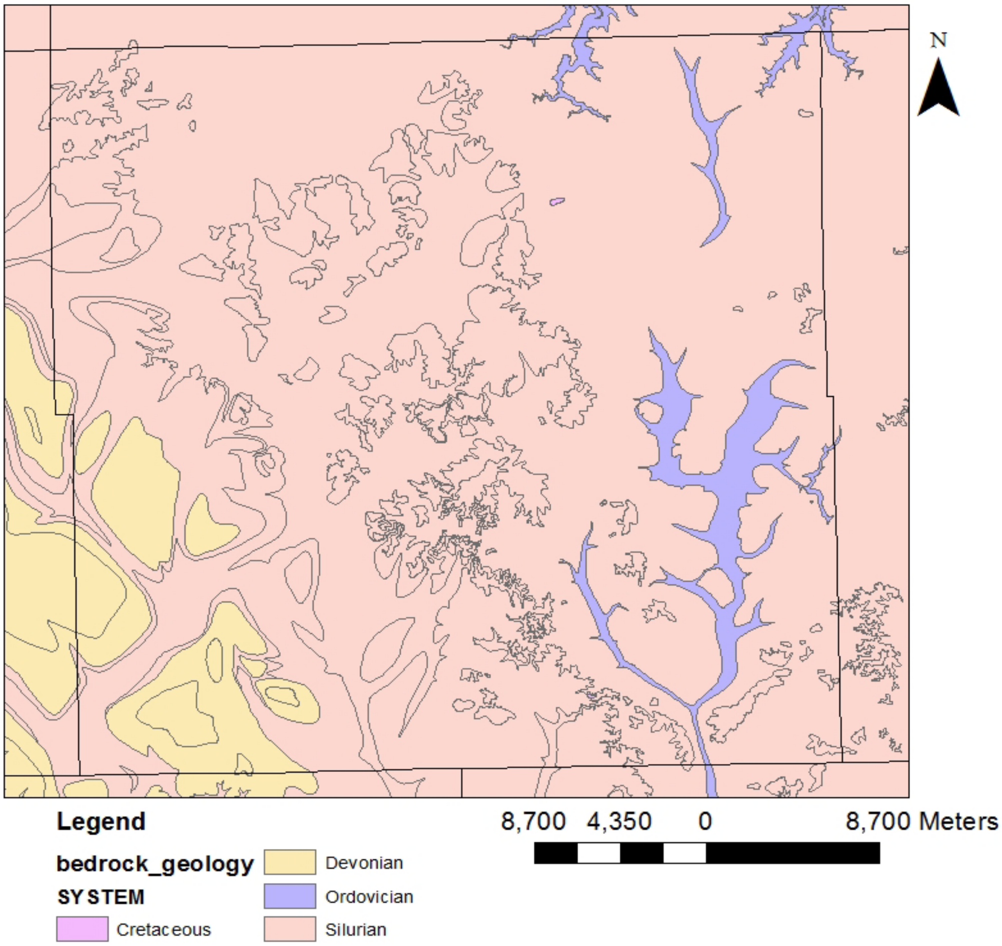


Figure 3: Land distribution in Delaware County

______Today, Delaware county's landscape is used primarily for farming practices. According to the 2012 Census of Agriculture, 87.9% of all land in Delaware county was used for cropland. It is also recorded by the Census that the average farm size in Delaware county ranges from 180 to 499 acres. Of all the farms combined, 154,494 acres are used for corn production and 81, 634 acres are used for beans. Overall population of Delaware is recorded in 2014 as 17, 398 people total. This gives a total population density of 31 people per square mile. Total number of housing units across the county were noted at 8,026 units total. A map attached to this document will show distributions of structures within Delaware county. There will also be a soil map with a description attached to it to help the reader better understand the soil distribution patterns and farmland locations in the county as well.(U.S. Census Bureau, 2015)



Delaware County Geology:

Figure 4: Geologic Map of Delaware County

As depicted in figure 3, a vast majority of the bedrock in Delaware county is comprised of Silurian aged dolomite and limestone. Hopkinton, Blanding, Tetes des Mortes are the three formations that constitute a majority of the Silurian bedrock. Also largely present throughout the southern portions of the county and central Delaware is the Scotch Grove formation. Older stratigraphic units of Ordovician aged features containing the Maquoketa shale formation are located in the SE corner of the state with small amounts in the NE portion directly above.

Though some of the Ordovician bedrock is visible, there is a major unconformity between the Ordovician and Silurian systems across much of Iowa. (Calvin, 1898)

Nowhere more evident is Delaware county's bedrock than in Iowa's first official state park, Backbone. The Silurian bedrock is well exposed in the park and form major cliff faces ranging in 50 to almost 100 feet in height. Since most of the bedrock found in Delaware county is visible within this park, it makes sense to shift the focus towards the observable geology and other aspects of the park which helps to give us an idea of the geologic past of the area.

Applied Geology

Backbone Lesson unit, Park Field Trip Guide and Follow up Lab Activity

For the applied geology portion of this paper, a focus on Backbone state park's' plant fauna, topography, and geology will be explored in depth. This in depth look at the 3 aspects of the park will be used as supplemental material for a unit lesson on the natural history of the park along with detailed field trip guide, maps, and a schedule/lesson plan for an week long unit of a student based exploration of backbone state park.

Vegetation of Backbone

Woodland: While walking around backbone state park, one will easily take note of the drastic change in elevation from the lower areas to the tops of the cliffs. In areas of higher elevation, a diverse and extensive woodland is present throughout the park. A large majority of the wooded areas are comprised of large, mature trees. Only about 5% of the woodland in the

park is made up of smaller tree species.

Figure 5. Aerial map of Backbone State Park

Figure 4 shows an aerial photograph of the entire Backbone State Park area. Notice how heavily wooded the areas surrounding the Maquoketa river are. Though it is difficult to distinguish the elevation changes in this map, the heavily wooded areas are concentrated in areas of generally higher elevation in comparison to the bodies of water within the park. Some of the mature tree species throughout the park are white and red oak, black oak, white pine, sugar maple, and basswood. Though each may seem evenly dispersed, there is an overall sight of preference for some of the tree species. The white and red oak species occur in mixed patches throughout the park. On dry ridges and rocky upland areas, white oak tends to become the dominant species. Sugar maple and basswood trees tend to concentrate in the flat to slightly sloping areas of the highlands consisting of soils with high amounts of loam. Black oak trees occupy the areas with sandy soil south of the campgrounds.(Anderson, 1995)

Along the Maquoketa River in the lower areas of the park is a different variety of tree species all together. Walnut, hackberry, ash, box elder and cottonwood trees are a small but present portion of some of the wooded areas in the forest. On page 22, figure 6 shows a general distribution of plant life within the park area.

Glade: This habitat is an extremely small yet present natural phenomenon within the state park. A famous area in Backbone State Park is the hiking trail called The Backbone Trail or as most call it “The Devil’s Backbone”. Located on the northern end of the park, this trail is characterized by an extensive amount of bedrock exposure across the top, narrow ridge. Even with minimal soil cover, there is still a variety of plant species that thrives here.

Glade habitats are generally characterized by shallow, rocky soils with exposed bedrock. Wildflowers, and native grasses with few trees and shrubs are what usually make up the plant fauna of these types of areas (NRCS Missouri, 2008). Specific to the style of glade in Backbone, some of the plant fauna that make up this habitat include a wide variety of prairie species and cliff species of plants that have adapted to the microhabitats. These species are listed in a table below. Some of the tree species include chinquapin oak and eastern redcedar. (Anderson, 1995)

Prairie species	Cliff species
Zizea aurea	Campanula aparinoides
Euphorbia corallata	Pellaea glabella
Lespedeza capitata	Comondra richardsonii
Liatris aspera	Polygala senega
Gentiana alba	Aquilegia canadensis
Stipa spartea	Artemisia caudata
Andropogon gerardii	Cystopteris protrusa
Coreopsis palmata	Castilleja coccinea
Schizachyrium scoparium	

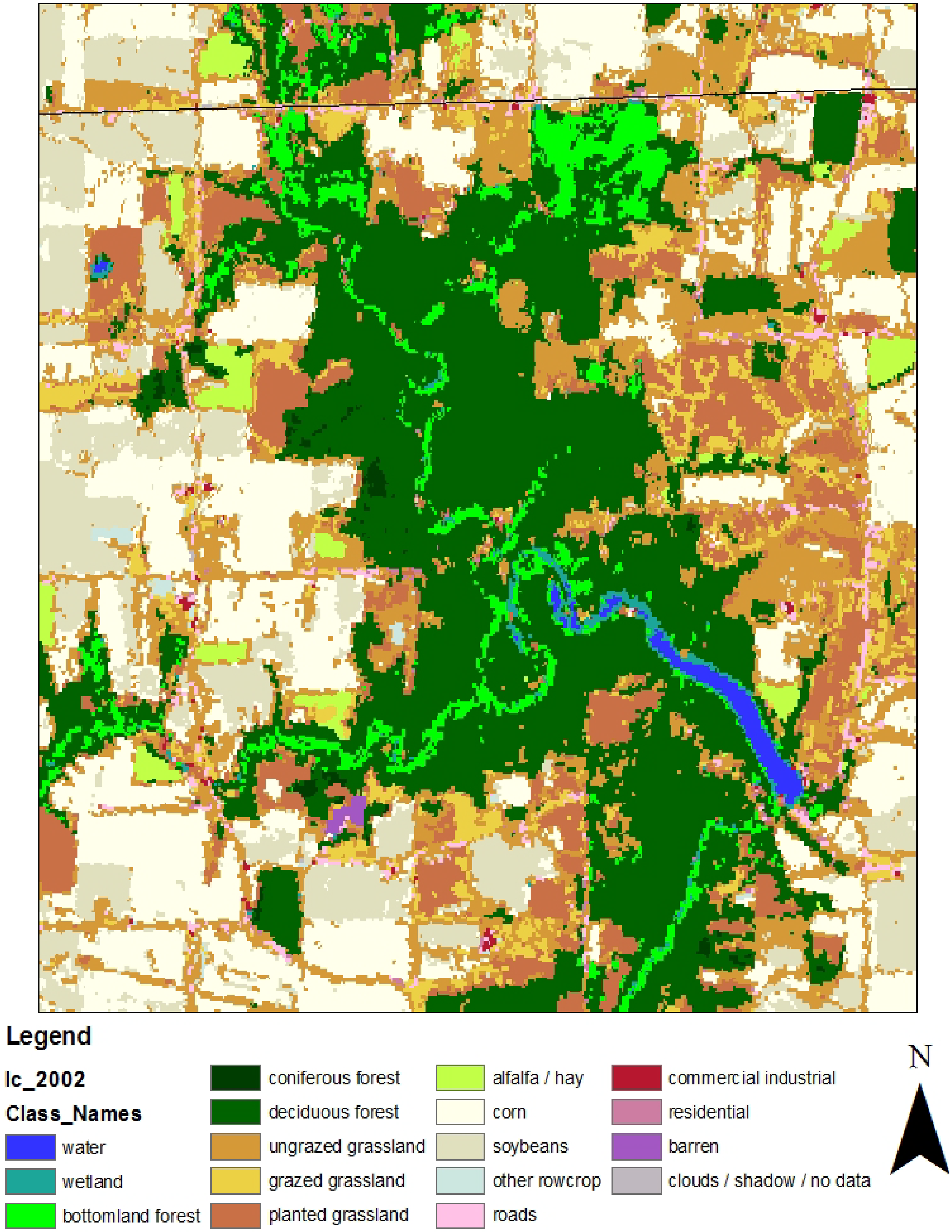
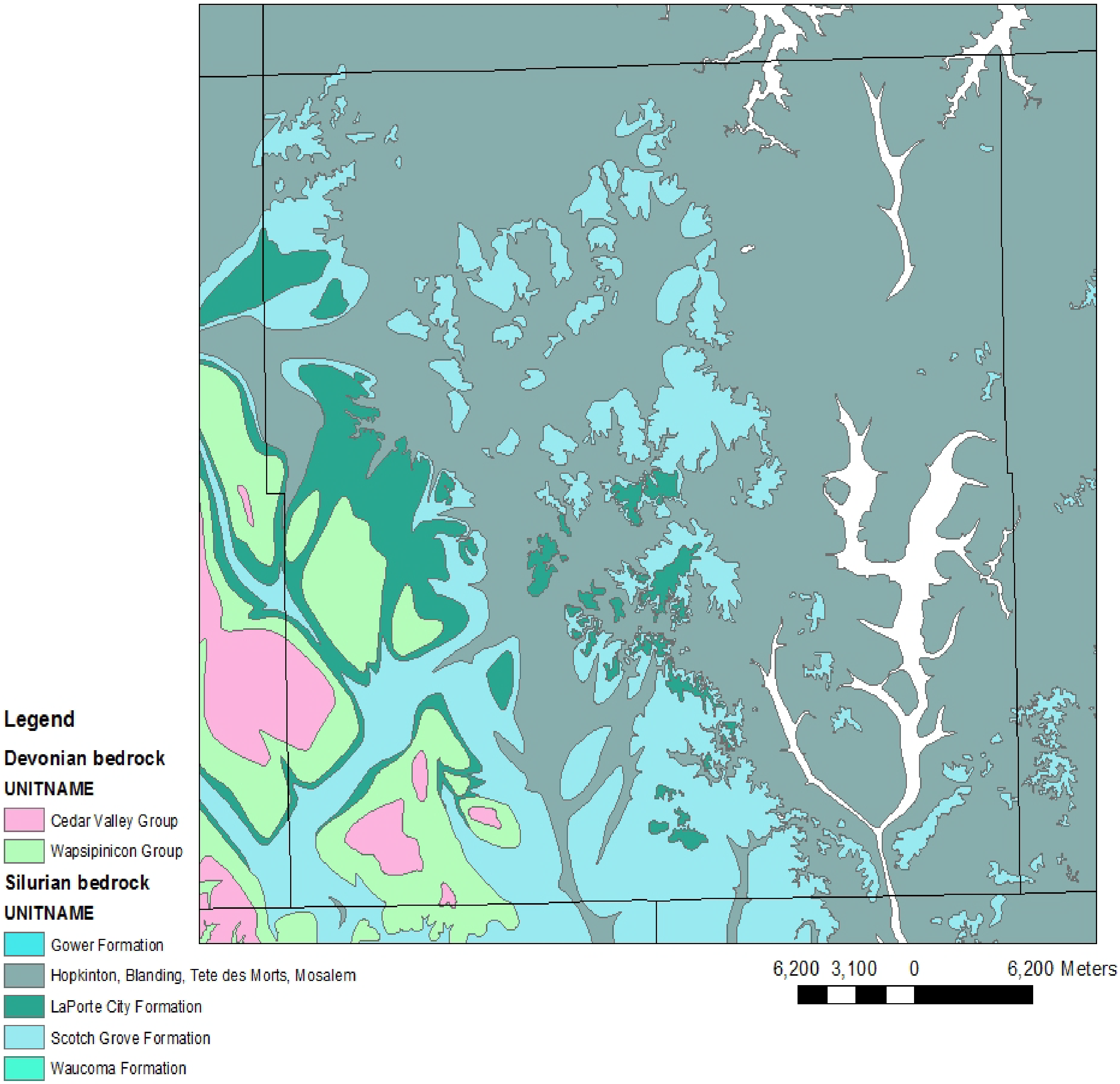


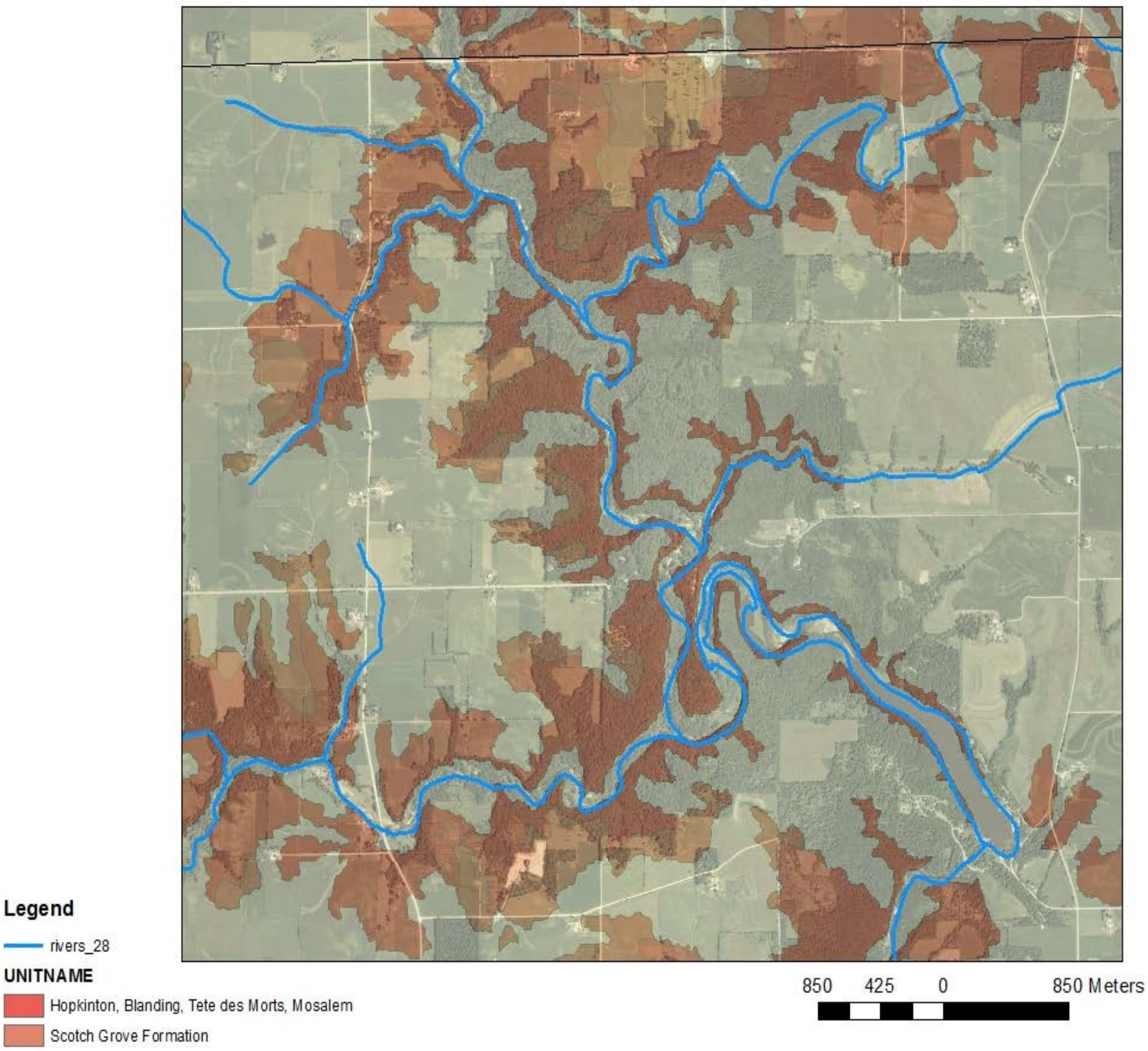
Figure 6: Plant life distribution within park



Geology of park

Figure 7: Bedrock Geology of Units Present in Delaware County

Backbone State Park is most notably recognized for one of the defining features of the park; the extensive cliff faces. These extensive cliffs reaching heights of 80 feet are not just breathtaking in display, but a key to helping understand the geologic history of Delaware county as a whole. Geologists have been able to map the various bedrock exposures throughout (figure 8 and 9) the park and thus use a plethora of data to help interpret what this area looked like during ancient times. This state park has been more than just a recreation area. It has been a tool for



geologists to better understand the geologic history of Delaware County and Iowa as a whole.

Figure 8: Transparent Aerial Map of Park with Bedrock Exposures. This map helps to show the most prominent exposures within the park. Most of the scenic cliff forming exposures (Red and orange) are located

along the river (blue) and drainage systems are present.

Figure 9: Bedrock exposures located throughout the park. With easy access to a majority of these facies, they have become a major attraction for local climbers and hikers alike. With easy accessibility, these exposures also played a major role in earlier studies of the geology of Delaware county

To help give an idea of the depositional environment, one should refer back to the Silurian summary (page 4) of Iowa's geologic history previously outlined in this paper. Overall, a shallow tropical sea dominated the landscape at this time (430 mya). Most of the life during this time were shelled species such as brachiopods, gastropods, and a variety of corals. Originally, sediments deposited during this time were calcium carbonate or better known as limestone. Through a series of chemical processes, these limestone beds have been transformed into what is known as dolomite.

One of the ways the process of dolomitization can take place is known as the mixing model. In this process, groundwater within the shoreline sedimentary rock mixes with salt water that saturates the pores within the rock under the sea water. If there is more freshwater being mixed than saltwater, then there will be saturated with respect to dolomite [$CaMg(CO_3)_2$] vs. calcite $CaCO_3$). Though dolomitization processes in Iowa are poorly understood, the mixing model proves to be the more likely model since there was a major sea level fluctuations that could lead to the dolomitization process covering large expanses of land.(Anderson, 1998)

Scattered throughout the faces of the cliffs, one may notice irregular shaped holes within the beds of dolomite. These hollow holes that range in sizes of a few inches or more are called vugs. During the process of dolomitization, there is a reduction of rock volume due to the rearrangement of crystal structure within the sediments. When the volume of the rock decreased, spaces were created and thus vugs are formed. In other cases, vugs and other porous areas in the rock were dissolved during more recent weathering processes. (Anderson, 1995)

One of the more weather resistant structures often times found within the beds of dolomite is a rock called chert. Chert is a micro crystalline, sedimentary rock composed solely of silicon dioxide (SiO_2). Silicon dioxide is the same chemical composition as the mineral quartz, In some cases, large continuous beds of this rock can be found between layers of dolomite. Other instances, they are found in small pockets called nodules. Since chert is more resistant to weathering, most of the chert located throughout the park can be found as gravel in the nearby Maquoketa river. Chert gravel can also be found along some of the ridges along hiking trails. One of the trails that displays a large amount of chert gravel is the Barred Owl trail located on the north end of the park. This gravel is often poorly rounded and is characterized by sharp edges. Since chert is one of the defining features in the beds of dolomite, it is important to look more closely into how it is formed.

So where does chert come from? As stated before, chert is solely comprised of silicon dioxide. There needs to be a sufficient amount of SiO_2 in order to form these laterally continuous beds and nodules. In ancient oceanic environments, microscopic organisms of plankton had shells that were comprised of silica unlike today's plankton which have shells composed of calcium carbonate. As the planktonic organisms died, their shells would sink to the ocean floor. In depths greater than 100 meters, the pressure causes these silica shells to be buried over time. Given enough time, the crystal structure of the silica rearranges itself to the point of lithification and thus, chert is formed. Gradually, this chemical precipitate could eventually turn into pure quartz if given enough time. Chert often times became a useful resource for many of the Native American people living in the area. Due to it's fracturing properties, chert was manufactured into sharp cutting tools that proved to be useful for the native inhabitants of the area. (Andersen, 1995)

All exposed bedrock features within the park are assigned to the Hopkinton Formation of the Silurian time period. Overlying the thinner beds of the Blanding-Mosalem formations, the total thickness of this bedrock is 160 feet. In the park, the exposed bedrock reach heights of 80 feet or just above. Sweeney, Marcus, Farmers Creek, and Picture Rock members are what compose the bedrock of the Hopkinton Formation. Located in the lower Valley walls of the exposures is the Sweeney Member.

The Sweeney Member is best characterized by bold-faced cliffs with vuggy, thick-bedded dolomites. Fossilized coral is often present in the form of molds or partial to complete silica replacement. Finely crystalline dolomite is another characteristic of the Sweeney Member.

Overlying the Sweeney Member are vuggy dolomite beds with overhanging cliff features which help characterize the Marcus Member.

Most of the Marcus beds are more defined and easily noticeable unlike the beds of the Sweeney member. The Marcus strata also stand out by displaying large amounts of brachiopod shell molds, bands of nodular chert, and finely crystalline dolomite structures. A majority of the chert beds are scattered throughout the middle of the Marcus bedrock. Due to major weathering processes, younger bedrock strata of the Hopkinton Formation are not present throughout the park. Though it is not present, other areas of Iowa do contain younger successions of the Farmer Creek Member overlying the Marcus beds. Though there is a plethora of information gained from measuring and interpreting the various bedrock layers throughout the park, the depositional environment can further be explored and understood through the study of the fossil succession of the park.

Fossils

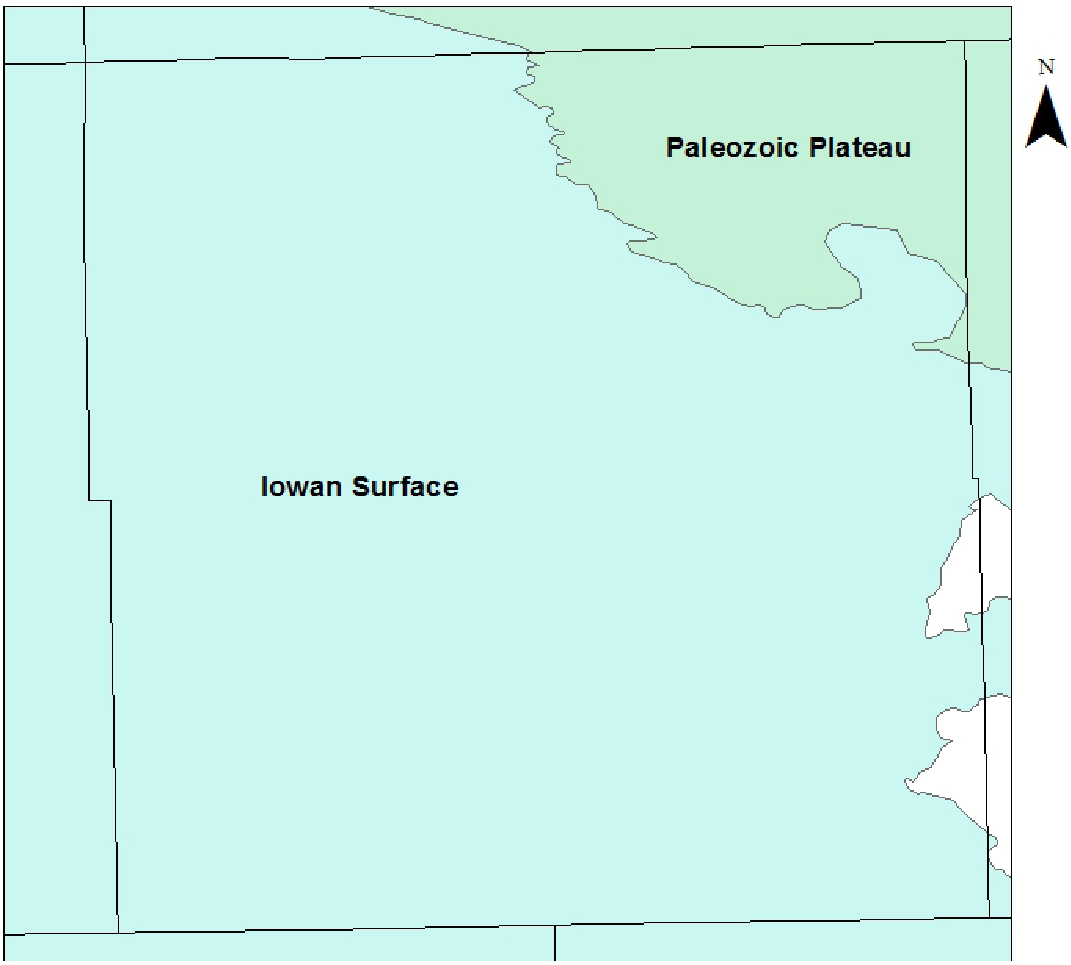
Fossils can help geologists and paleontologists reach back into the distant past and hypothesise what the ancient ecosystem of the area was like. In the Hopkinton formation, there are various species of fossilized corals, brachiopods, sponges, snails, nautiloids, trilobites, and conodonts that all point to an ancient sea environment. To help interpret the fossil succession of the park, a deeper look into the location within the strata of each fossil will be outlined .

Coral fossils are located throughout a majority of the Sweeney Member. Though there are coral fossils within the Marcus bedrock, they are generally less recognizable and not as well preserved. Some of the fossils are preserved in an upright position while others are overturned which is usually characteristic of active water environments. Tabulate corals fossils are among the most common in the park. *Halysites* are one of the more abundant. These are characterized by their elaborate chain shaped structure which in turn give them the common name "chain coral". Another common tabulate coral species are the *Favosites*. This coral is best characterized by the honeycomb shape of the corallites. Other, less common tabulate corals are Syringopora which are noted for their loose arrangement of small tube-like structures.

Other extinct coral groups that are less abundant are the rugosans. Rugose corals are commonly stationary species that are often termed "cup-corals" or "horn-corals". Each of these species show a radiative pattern of corallites when viewing from the top of the fossil. Stromatoporoids, ancient sponge species of fossils, are preserved as silicified skeletons and molds. These can be found commonly throughout the Sweeney bedrock in the park.

In the upper Marcus Member of Backbone, brachiopod molds are easy to come across due to their large abundance. Most of the brachiopod fossils located in the park are known as *Pentamerus oblongus*. This species of brachiopod reached peak abundance during the Silurian time period of geologic history. Often times, these fossil molds can be mistaken as deer hoof prints. Bands of fossilized Pentamerus are characteristic of environments with lots of wave action. During episodes of high energy (ie. a storm event), theses shells were uprooted from the shallow sea floor and deposited in an mixed pattern across the surrounding area. In some cases, there are bends of these shells in life position with the opening of the shell pointed downwards into the seafloor sediment.

Though they are not as prominent as the previous fossil species discussed, the abundance of crinoid fossils are a noteworthy fossil throughout the park. Crinoid debris is not easily distinguishable and can often times be mistaken as sand fragments in the crystalline dolomite structures in the beds. Due to the delicate structure of crinoids, any wave action within the environment of deposition often times causes the small calcite shaped discs that make up the stalk to disaggregate and spread across a wide area. (Anderson, 1995)



<u>Most Recent Geology of the Park</u>

Figure 10. Landform Regions of Delaware County

The Quaternary period of Iowa's geologic history is what has helped shape the landscape into what we see today. For the past 1.7 million years, Iowa's landform regions have been shaped to what we now see on the surface today. According to the Iowa Data Center website, the total amount of land used for farming in Iowa adds up to 30,622,731 acres. Delaware county sits along the southern boundary of the Paleozoic Plateau and Iowan surface. Though a majority of the landscape is dominantly Iowan Surface, the very top, NE section of the county is part of the Paleozoic Plateau region.

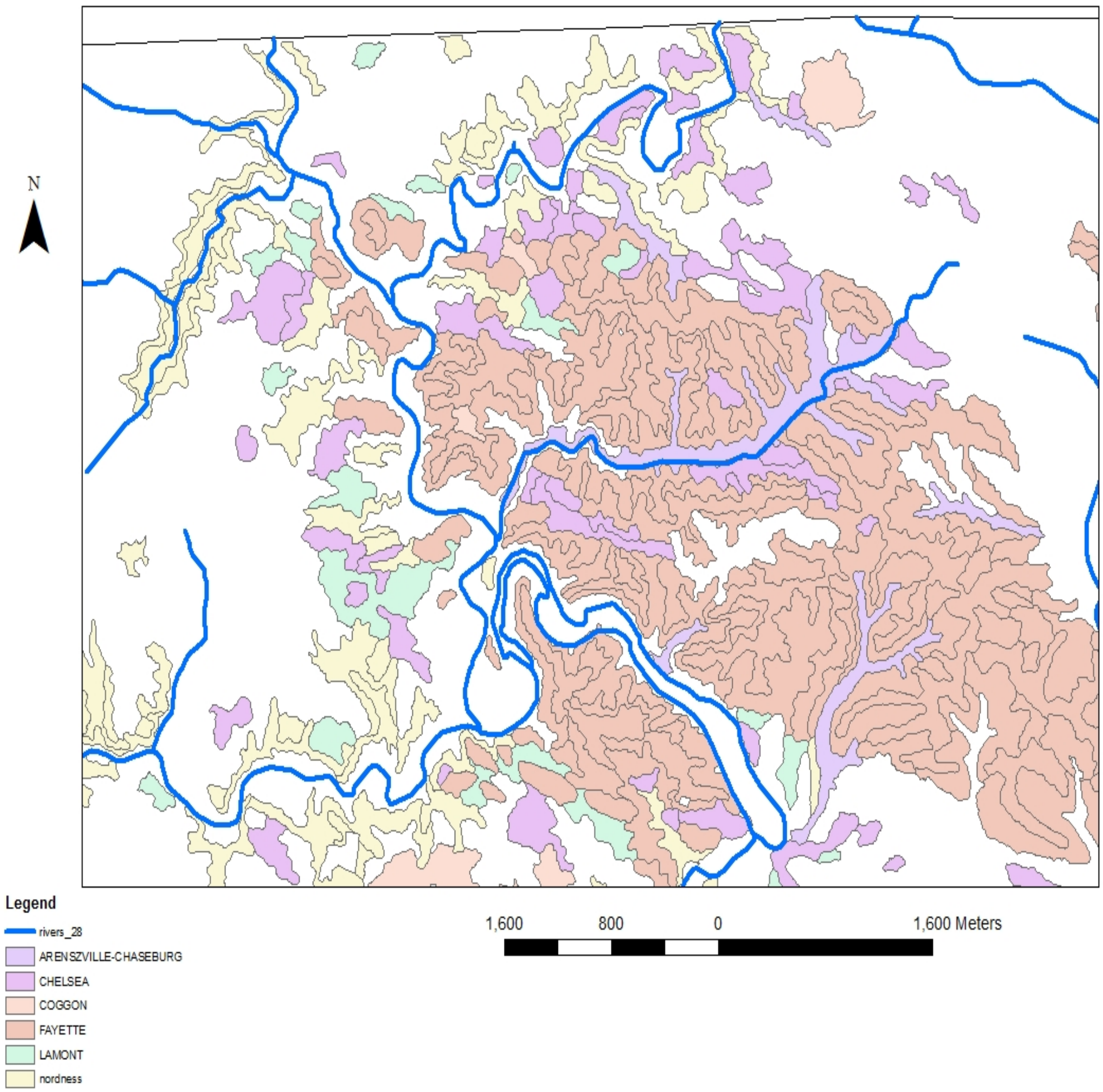
Since the park has a complex drainage system, a majority of the quaternary sediments groups are hard to distinguish. These deposits are characterized by location in the landscape and content. Rocky colluvium and talus deposits are among the oldest Quaternary deposits of the park. Modern stream deposits are characterized by sandy, gravelly and loamy alluvium sediments often found in the lowland areas of the park. (Anderson, 1995)

It is important to realize that though the landscape has been drastically altered during the Quaternary period of Iowa’s geologic past, there are still a plethora of processes occurring today that help to shape Iowa’s landscape: soil development. Throughout the park, there are is a very extensive variety of soil types. To get a better idea of which types of soils are most prominent throughout the park, refer to figure 10.

As defined by Wayne Anderson, soil refers to the unconsolidated surface material of the earth that supports plant growth. As described earlier, most of the wooded areas within the park are at higher elevations. Though the soil series varies greatly in small spatial scales within the park, they are nonetheless very productive soils that harbor growth within the park's ecosystem. Key factors that influence the formation of soil include parent material, climate, soil biota, topography, and time. The principal parent material in the park is derived from the major landform region which the park sits in. In the case of the park and Delaware as a whole, the main parent material happens to be pre-Illinoian drift underlain by thick loess deposits.

Though the landscape is very characteristic of the Paleozoic Plateau region, Backbone Park is located within the very northern boundary of the Iowan Surface. Delaware county’s glacial deposits include Pre-Illinoian and late Wisconsinan eolian deposits. Outcrops of these deposits are not present within the park but can be found in the well developed drainage system

Figure 11: Prominent soils series present within the park. This map is part of a larger database constructed by the Iowa Cooperative Soil Survey.



throughout. Other research done on Quaternary stratigraphic units in the area have concluded that this area was last glaciated around 500,000 years ago. Intricate drainage systems of the park were developed during the last glacial period (Wisconsinan). Upland areas of the park are covered in a thick expanse of Wisconsinan Peoria Loess and eolian sand from the same source. This loess formation range in thickness from 3 to 20 feet in thickness in all upland areas. Both deposits were the result of floodplains of rivers that coursed through the area during the time. (Anderson, 1995)

Paha is the native Dakota Sioux word for “hill”. In the Iowan Surface, Paha’s are oriented in a diagonal NW to SE direction. These features are very similar to a sand dune feature one could find in dry, sandy environments of southeastern U.S. Since glaciers produce a lot of weathered material, much of it is deposited at the base of the glacier. During dry periods, the finer grained sediment is blown by prevailing winds from the NW and deposited in areas of high vegetation. Given enough time, these wind blown sediments will accumulate and reach thicknesses of 50 to 100 feet. (Anderson, 1995)

In Backbone park, the upstream end of the gorge is aligned with prevailing winds which helped to funnel the NW prevailing winds. Two paha features are present within the park. On the northern most section of the park, paha sediment deposits can be found along the upland areas above the fish hatchery. Along the main road system is a trail that is marked “The Barred Owl Trail”. This path happens to span the entire width of this paha from one side to the other. If one wishes to better understand the dynamics of paha structures and drainage systems, this trail is a perfect resource for direct observation of this landform. (Anderson, 1995)

An Inquiry to Backbone State Park: Unit Schedule, Outline, and Field trip Lesson Plan

Overview: This last section of this paper is comprised of three parts. The first is an outlined schedule of the classroom the week leading up to the field trip day. Depending on the size of the class, the students will be placed into lab groups in which they will work with for the duration of this unit. During the week leading up to the trip, students will be introduced to a variety of topics/ disciplines pertaining to the park. Groups will then be able to choose which subject area interests them the most and would like to further explore. In the schedule, a teacher will have a general idea of what topics/material to cover on specific days, student tasks, formative assessments, and so forth. Overall, this portion is to help prepare students for the field trip day and data analysis following.

The second portion is a lesson plan for the day of the field trip. During the day of the field trip at Backbone, students will be collecting samples, data, and observations pertaining to the group's area of study they chose the previous week. With this lesson plan, a detailed outline of meeting locations, times, and instructions for the individual groups, and an appendix of various maps will be provided for the students. Also addressed in this portion of the lesson unit is a list of things to consider throughout the day. Since each school and class has a very different set of rules and dynamic, this portion of the unit is subject to change if the teacher feels it is necessary. It is important to keep in mind that this is just a helpful guide and nothing here is set in stone. The map appendix portion will have full page, colored prints of figures present within the paper and extra maps that may also be useful when students are deciding where to collect data points. A map of the state park with specific meeting points and directions will also be provided here.

In the third and final section of the lesson unit, students will be conducting a lab and create presentation with data collected in the park on their area of focus. During the week leading up to the day of the field trip, students will be required to plan a lab experiment/ data analysis day for when they return to the classroom. Once they have synthesized their data and figures, the groups will present their data to the whole class using a poster, powerpoint presentation, or another form that is approved by the teacher.

Part One: Group Planning and Scheduling

Class: 11-12th grade Earth Science/Environmental Science

Objectives: During this week, students will 1: choose a topic they would like to further research 2: collaborate with group members on what data they are going to collect while in the park 3: formulate a lab experiment/method of data analysis upon returning from the park

Day 1: (Monday)

- Introduce Backbone State Park. Some things you may want to include in the lesson that day are pictures of the park, maps, history of the park, etc. Essentially, you are trying to grab the students interests as much as possible. Also telling them that there you will be going on a field trip there will be something that helps motivate them as well.

- Introduce the project and expectations.
- Split the class up into lab groups. Again, this is a very flexible part of this lesson unit and depends entirely on the dynamic of your class and number of students.
    - **HINT!** It is not impossible to work on this project as a whole class. Since the park is so big, students can be split into groups and collect a large amount of data on one subject area if the teacher so wishes to take this route. Students can conduct lab experiments with the same data collected and collaborate as a whole class on what the data means.
- Possible Topics of student exploration: again, these are just a few ideas.
    - Water quality
    - Stream sediment analysis
    - Bedrock exposure mapping (stratigraphic mapping)
    - Plant fauna survey
    - Soil sampling and analysis/ distribution within park
    - Plant distribution along trail systems (More specific, Backbone trail)
    - Weathered rock sample analysis along trails
    - Fossil collection and identification (mainly along streams)
    - Stream characteristics
    - Specific water habitats (algae, insect, and fish./amphibian species present within micro ecosystem)
- Have them begin to do preliminary research on their subject area.

Day 2: (Tuesday)
- To help ensure that everyone in the group is putting forth effort, have the group turn in a document at the end of the class period stating who did what that day.
- Have groups continue preliminary research on their topics.
- Possible resources that the students can use include this paper, the map appendix, or various other sources that are provided below.
    - http://www.exploreiowageology.org/
    - http://www.iowadnr.gov/Places-to-Go/State-Forests
    - https://s-iihr34.iihr.uiowa.edu/publications/uploads/GSI-061.pdf
    - Books available : Iowa's Geologic Past, Iowa's Landforms, tree identification book,
- By the end of the class students should have these three key points prepared (will be turned in with project description)
    - Main question they are wishing to answer
    - Formulate a hypothesis
    - Come up with a testable prediction
    - What data will need to be collected
    - What materials will be needed to collect data

- Other questions that students should be thinking about during their research (use these as possible guiding questions for the groups thesis statement)
    - What environmental impacts can this have?
    - How does what I'm looking at effect the surrounding ecosystem?
    - Why does it occur?
    - How does it impact us?
- **The above questions should be copied and pasted into a document for the students to update as they continue their research.**
- Go from table to table and see how each group is doing throughout the class period. Make this the formative assessment of the day.
- Have groups confirm what their projects will be and by turning in a document stating what they wish to explore and the methods behind it. Evaluate each one and be prepared to give feedback on them the next day.

<u>Day 3:</u> (Wed)

- To help ensure that everyone in the group is putting forth effort, have the group turn in a document at the end of the class period stating who did what that day.
- Have the feedback on the papers for each group and meet with each group to clear up any misconceptions.
- While you are meeting with individual groups, have the other groups continue gathering research and information on their topic area.
- By the end of the class period, students should have these questions answered and turned into you
    - Where will you be collecting data points? (need to have specific points on maps. Depending on what the group is doing, some need to have more than others.)
    - Estimated time it will take at each data point.
    - What is the best technique to gather your data? (need to research this)
    - What technology/other materials will you be using to collect data?

<u>Day 4:</u> (Thurs)

- To help ensure that everyone in the group is putting forth effort, have the group turn in a document at the end of the class period stating who did what that day.
- This class period should be dedicated to walking students through how to properly take field observation notes when in the field. This is extremely important especially for when they return to the classroom and begin sample analysis.
- Students need to understand that all observations are valuable.
    - Time
    - Date
    - Location points
    - Weather conditions for the day
    - What is in their immediate surroundings

- Have them continue to work in groups and begin to gather materials in the classroom that they will use to collect data. These materials need to be set aside somewhere so that it is easy to identify loading the bus/van and when they get there.
- End of the class period, students need to turn in a document with the following
    - Materials gathered
    - Data collection plans for when they get to the park
    - Methods of collecting data
    - Task management (who will be in charge of what once at the park
    - Rough estimate on the amount of time it will take to collect data

Day 5: (Friday)
- This class period should be entirely dedicated to the following
    - **SAFETY**
    - **Expectation of behavior**
    - **Itinerary**
    - **Meeting locations (students that day will be given a map in which they will mark out the meeting locations themselves while during the lesson)**
    - **Emergency contacts (parents/other teachers whom will be on the trip as well)**
    - **Amount of time they have to collect data**
    - **Anything else the teacher feels he/she needs to share with the class**
- Have students turn in at the end of the class period a document with the above the expectations and safety rules they need to follow on the trip.

Backbone State Park Field Trip

Grade: 11-12th earth science
Lesson Goals: Throughout this lesson unit and field trip, students will be practicing data collection and analysis, field observations and literary skills. Students will also expand their communication skills while working with groups and presenting their findings to the rest of the class.
Lesson Objectives: Students will be practicing a variety of science skills during their time at Backbone State Park. Each group of students will be practicing data collection techniques while in the field as well as making important field observations relevant to the data. Understanding the surrounding environment of where they are collecting data will help the students better understand cause and effect relationships while conducting data analysis back in the classroom setting. Students will also be asked a series of questions while doing data collection (provided by the teacher). These questions will require students to use a higher order of cognitive skills and help lead them to use skills/prior learned information which will guide them through the inquiry process.

Iowa Core Standards:

Earth and Space Science Standards that apply

HS–ESS2–1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS–ESS2–2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems

HS–ESS2–5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS–ESS2–7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

HS–ESS3–4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

HS–ESS3–6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Life Science Standards that Apply

HS–LS2–2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS–LS2–5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

HS–LS2–6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS–LS2–7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Materials List: This will vary greatly from group to group. Overall, students will have access to the following items in order to help them conduct data collection in the field

- Technology (logger pro software/ handheld computers)
    - Current speed detector
    - pH sensor
    - Temp gauge
    - Turbidity sensor
- Meter stick
- Rock hammers and safety glasses
- Collecting bags (sandwich baggies)
- Permanent markers
- Collection vials/ bottles for water samples
- Cameras or allow students to use phones. These generally have better quality images anyways
- Maps, itinerary, walkie talkie for communication purposes (mainly a safety necessity)

Prior knowledge
1. Water cycle/ecosystems: erosional processes, effects of water being slightly acidic, types of streams and depositional features, pond/river/lake species of plants, animals, and cyanobacteria.
2. Geology: sedimentary rocks, basic understanding of Iowa's geologic past, landform regions of Iowa.
3. Plants: effects of nutrient availability on plants, soil preferences, forest patterns in Iowa (mainly deciduous type forests), how plant species correlates to geographic location within the U.S.
4. Common farming practices: effects on the landscape and surrounding ecosystems
5. Human impact: Ways humans have drastically altered the environment
6. Backbone: basic understanding of geographic location in Iowa and U.S. as a whole, main industry located in the area (farming/agriculture)

Safety

1. All students must stay within their lab groups while collecting data. During the planned activity session after data collection, students are allowed to just have one other person with them.

2. All students must stick to the main trail system. If they must go off the trail system to collect data, the road or trail they are venturing from must be in sight at all times.

3. Each student is required to have a map with them.

4. No climbing up escarpments. Any hiking that is done must be along the trail. If students need to collect rock samples, they must be from the base of the facies or supervised directly by either the teacher or adult volunteer.

5. Adults will be located at main picnic shelter locations throughout the park. These will be marked on the map and will be made apparent to each group of students.

6. Long pants and close toed shoes must be worn at all times. For students who may need to take data collections within the streams, there must be sandals worn only when getting into the water.

7. No swimming. Students who are taking water samples will not be allowed in water more than knee deep.

8. If students are running late, they must contact you (the teacher) either via cellphone or walkie talkie giving you estimated time of arrival to main picnic shelter and their current location.

Tentative Schedule:

9:00 - 9:30 am: **Arrival and class meeting at main meeting location (North Flats Shelter)**

- This is where the bus/vehicles will be parked throughout the day so students will be able to easily identify the main location.
- Run through expectations, safety, and have them start making a journal entry for the day to get them started and thinking about what they need to be doing
- Prior to students taking off, have them meet in groups and turn in a sheet of paper of estimated time they will be at the data collection points indicated by the group during Wednesday of planning week.

9:45 - 12:30 pm: **Data collection!**

- This is where the groups take off and begin collecting their data planned during the previous week.
- It may be useful for some groups to be driven to their first data collection points and work their way back to the main meeting shelter to help save time. This will also help them to follow the main road back and not get lost
- Have a parent/volunteer posted at several main shelter locations along the road so students are never too far from adult supervision
- Bring a bike/your vehicle so you are able to move from group to group quickly while this is happening. Though these kids are older, they will still need some helpful advice while collecting the datum.

12:30 - 1:00 pm: **Regroup/lunch**

- Students should start walking back to the main shelter around 12:30 to ensure they have enough time to get back to the main meeting location. Again, this should be on a written instruction sheet for each group to have while they are hiking to data points

1- 1:45 pm: **Lunch/discussion**

- During lunch, meet with each group to discuss how data collection is going. See what questions they may have and what progress they have been making. Evaluate how many more data points they need to collect and help them schedule out the time
- Go over the rest of the itinerary and let students know how much time they have to collect data. Again, they are allowed to use the entire time they are in the park to collect whatever data necessary.
- If there are some groups that are done early, have an activity planned for them to complete for the duration of the field trip day.

1:45 - 3:00 pm: **Data collection/group activities**

- Have students continue collecting data at their marked points.
- For the groups that are complete, give them an option of either a pre planned activity or an exploration of the area around the main meeting location (the backbone trail and six pines trail are within this area of the park. Make it known that these are their only two options and the must go in pairs.

3:00 - 3:45 pm: **Meeting at Main Shelter**

- Have the groups begin to gather at the main shelter area. All groups need to be back at 3:45 as to get a roster count.
- Briefly meet with each group to see how the rest of the data collection went.

3:45 - 4:00 pm: **Load the Vehicles/bus**

- Make sure all data collection materials are back and accounted for…..along with students
- Have a separate container/ tote for students to be able to put their samples in on the bus.
- Make sure all adult volunteers and vehicles are back.
- Once everything is accounted for and all students are present, the ride home begins.
- On the ride home, it may be useful to guide students to begin collaborating with their group members and finalizing any field notes taken. If they didn't complete the questions while at the park, have the groups answer them on the way home.

- Take time to go from group to group while on the bus and visit with them during the drive to see how everything went for them. Get an idea of what the students feel and ask them some questions pertaining to the data collection and general observations of the day.

Data analysis and Presentations

Objective: For the next three days, groups will be analysing the data they collected while at Backbone State Park. Once they are done analysing the data, they will then create a presentation that they will share to the whole class. Attached is a rubric that lets the groups know what you the teacher are looking for in their final lab report. Since this is a collaborative effort, students will need to turn in a sheet. The fourth day will be group presentations. Overall, the presentations should take no more than 6-8 min per group.

Questions to ask each group: It is important to have some guiding questions for groups while they are looking at their data. Listed below are some questions tailored to individual groups and a possible topic they chose to investigate further.

Water

- In what ways do you think the surrounding environment affects what you were testing in the water?
- What is land outside the park used for?
- How well vegetated was the area around each data point?
- In what ways would the surrounding agricultural practices affect the water quality in the stream?
- How can these negative effects be reduced? Give a list of detailed plans that one could carry out.
- Was the stream you were testing a part of a larger drainage system? What ways does this affect what you were testing?
- List some ways that you think your data collection could have been improved. (methods, techniques, places you collected data, number of total data points, etc)

Plants

- In what ways do you think the surrounding environment affects the plant fauna within the park?
- How does the topography affect the distribution of plant species within the park?
- What is land outside the park used for?
- In what ways would the surrounding agricultural practices affect the plant species within Backbone?
- What inferences can you make about the correlation between the data collected and the surrounding environment?
- If your data was collected near a water source, how do you think this affected the plant fauna within its immediate vicinity?

Geology

- What can you infer about the effects the geology of the park has on the ecosystems within the park?
- What erosional features were present? Give a detailed list on what they are and the processes behind each.
- What is land outside the park used for?
- In what ways would the surrounding agricultural practices affect the geology of the park?
- Give an example of another location within the U.S. that would have similar geologic features as Backbone. Be specific and give your reasons why.
- Given your current observations and understanding how the geology of the park is the way it is, predict what you think the future landscape will look like thousands or even millions of years from now. Give your reasoning.

MAP APPENDIX

References Cited:

Anderson, Raymond. R., The Natural History of Backbone State Park: Delaware County, Iowa, Geological Society of Iowa, 44 p.

Delaware County Iowa Agriculture Stats, 2012, Census of Agriculture: http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Iowa/cp19055.pdf (accessed March, 2016)

Library of Congress, 1878, The History of Delaware county, Iowa: Chicago, Western Historical Company, p. 19-561

Mappery, 2009, Map of Backbone State Park: http://www.mappery.com/Backbone-State-Park-Map (accessed April, 2016)

NRCS Missouri, 2008, Glade Information Sheet: REstoring and Managing a Glade: http://www.forestandwoodland.org/uploads/1/2/8/8/12885556/glade_information.pdf (accessed March, 2016)

Plummer, C. C and McGeary, D., 1991, Physical Geology, Fifth Edition: California, Wm. C. Brown Publishers, 543p.

Prior, Jean. C, 1991, Landforms of Iowa: Iowa City, Iowa, BurOak, 153p.

Samuel Calvin, 1898, Geology of Delaware County: Iowa City, Iowa, University of Iowa, 70p. http://ir.uiowa.edu/cgi/viewcontent.cgi?article=1345&context=igsar (accessed March, 2016)

The University of Auckland, New Zealand, 2005, Geology: Rocks and minerals: https://flexiblelearning.auckland.ac.nz/rocks_minerals/rocks/quartzite.html (accessed April 2016)

United States Census Bureau, 2015, Delaware County, Iowa QuickFacts: http://www.census.gov/quickfacts/table/EDU635214/19055 (accessed March 2016)

USGS, 2015, Geologic Units in Delaware County, Iowa: http://mrdata.usgs.gov/geology/state/fips-unit.php?code=f19055 (accessed February, 2016)

Category	Minimal 1 Point	Basic 2 Points	Proficient 3 Points	Advanced 4 Points
Title	Present but not focused			Describes focus of the lab
Purpose	Problem unclear	Clear but many details missing	Clear but some details missing	Clear with details listed.
Background	Needs to be relevant to the lab	Only partially relevant	Relevant with some detail	Relevant using proper vocabulary and details
Hypothesis	Needs to be stated as a hypothesis	Needs to relate to problem more directly	Directly related to problem, needs back-ground information	Directly related to problem, and has back-Ground information
Materials List	Listed but not appropriate for the lab	Listed, but needs to be more complete	Listed and complete, but need quantity	Listed, complete and quantity included
Independent and Dependent variables	Both need to be identified	One identified or, both identified but mixed up		Properly identified
Controls	Needs to be identified	One properly identified	Two properly identified	Three or more properly identified
Procedure	Needs a logical sequence	Logical sequence, needs to prove or disprove and need to be step by step	Logical sequence, Able to prove or disprove, not step by step	Logical sequence, Able to prove or disprove Need to be step by step
Data/Observatio	Includes a data			Includes a

ns	chart or graph that doesn't follow the rubric			data chart or graph that follows the rubric
Analysis		Needs to explain trends and oddities in the data.	Explains the trends and oddities in the data. Need to explain error source	Explain the trends and oddities in the data. Explain sources of error.
Conclusion	Conclusion does not restate the hypothesis	Conclusion restates the hypothesis, but needs to accept or reject the hypothesis.	Conclusion restates and accepts or rejects the hypothesis.	Conclusion restates and accepts or rejects the hypothesis and is supported by data.
Real Life Application		Explains what was learned, but needs to relate to your life		Explains how what was learned relates to your life
Mechanics/Grammar	Word-processed with many grammatical errors.	Word-processed with a few grammatical errors.	Word-processed with no grammatical errors.	Word-processed, with no grammatical errors. Includes graphics.
Classroom Performance	Demonstrated unproductive or unsafe behavior.			Demonstrated productive, safe, cooperative and orderly behavior.