Insert a running head at the top left corner. The running head is a shorter version of your title. Do not exceed 50 characters. Only the first page should include the words: "Running head".

Page Numbers should be placed in the far right hand corner.

Surface Water Infiltration in Loess Soils of the Lower Mississippi River Valley: An Emphasis on Land Use

Matthew N. Thompson

University of Arkansas

The cover page should include the full title of the research paper, the author's name and institution. The entire page should be double spaced and centered. Place your information in the middle of the page.

Remember to insert the *name of your institution* underneath the author's name and title.

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The running head on all consecutive pages should include only the shortened title without the words "Running head".

The abstract provides a brief summary of the (1) purpose of the study, (2) data collection methods, (3) findings and (4) recommendations. Length of abstract will vary based on your discipline and the additional requirements of any journals or conferences to which you may be submitting your paper. A typical abstract will have a limit of 250 words. Check with your advisor.

Abstract

The primary source of groundwater being studied for the purposes of this research comes from the Alluvial Aquifer, which, according to the Arkansas Natural Resources Commission, is being depleted in excess of recharge at a rate of 17.6 million m^3 d^{-1}. Overall, this unsustainable withdrawal has led to a drop in the water table of around 30 cm per year for some areas within the Alluvial Aquifer. Since alluvial and loessial soils dominate the highly agriculturally productive Delta region of eastern Arkansas, and extensive irrigation has been a main culprit in the groundwater depletion issues the region faces, a better understanding of how ecological factors and/or agricultural best management practices could possibly increase infiltration, are needed in order to either slow down or reverse the declining aquifer levels through the Delta region of eastern Arkansas. Therefore, the objective of this study *[(1) The author successfully addresses the purpose of the study.]* was to evaluate the effects of landuse on surface water infiltration into alluvial and loessial soils in the Delta region of eastern Arkansas. Landuse combinations of interest included conventional and no-tillage agricultural practices, deciduous and coniferous forests, and native/natural grasslands. The analysis of infiltration rates across these different landuse designations, points towards which of the landuses, and/or agricultural management practices are able to facilitate greater surface water infiltration; infiltration being a precursor to increased groundwater recharge. Data was gathered across all landuse categories

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[(2) indicates data collection methods] by using a double-ring infiltrometer with a 15-cm inner-ring inside diameter. Additional values were gathered for site specific volumetric water content, and the physical characteristics at each site were recorded. The information gathered was quantitatively analyzed through a one-factor analysis of variance (ANOVA) using SAS (model 9.3, SAS Institute, Inc. Values produced by this analysis indicated that the deciduous forest systems facilitated the greatest amount of surface water infiltration, significantly ($p < 0.05$) surpassing the values calculated for all other landuse types. [*(3) The author specifically describes how the data was analyzed and the initial results/findings.]* Additional analyzation included that of the initial soil water content, the slope of the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time, and the intercept characterizing the relationship between ln infiltration rate and time. Initial soil water content showed significant differences ($p < 0.05$) between deciduous forests and grasslands, with respect to each other, and all other landuses. These results indicate that different landuses do indeed facilitate surface water infiltration rates at varying degrees and further research on the topic is encouraged. *[(4) the author describes the implications of the study and recommends further research.]*

Keywords: infiltration, infiltrometer, landuse, loess

Keywords allow the reader a guide to finding similar studies. Keywords also serve as markers for others to retrace your steps as a researcher.

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Typically, research papers separate the introduction and literature review. Consult with your advisor. You have plenty of space to move the literature review into its own section.

The introduction should set the stage for the study. Explain why there is a need for the study.

Introduction and Literature Review

Use et.al **only** if there are 3 or more authors on the second citation. Or use for articles with more than 6 authors.

Since the advent of industrialized agriculture following World War II, the human race has witnessed a threefold increase in agricultural output (Gennari et al., 2013). Through the utilization of practices such as mechanized tillage, application of manufactured fertilizers, pesticide use, and various methods of irrigation, outputs from agricultural lands have actually managed to exceed the caloric requirements of every human being on Earth (FAO, 2009). While this may seem like nothing but an advantageous development, this increased production has come with some significant cost to the environment.

Avoid using "like" in a formal research paper. The author could say "While this appears to be…"

One environmental cost is the amount of water that is supplied to areas of intensive agricultural production, in addition to natural rainfall. The Lower Mississippi River Valley, which encompasses the Delta region of eastern Arkansas, is an area of the United States that is well-known for its long history of extensive rice (*Oryza sativa* L.) and soybean (*Glycine max* L.) production. A tremendously large amount of water is needed to facilitate maximal productivity of both rice and soybean. For example, the University of Arkansas recommends that 5- to 10-cm of water remain upon every hectare of planted rice, up to a point roughly two weeks before harvest (Henry et al., 2016). That means that for the approximate six-month growing season, producers must keep each hectare of their land flooded with no less than

Use precise descriptive terms. "That means that" may confuse the reader.

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roughly 204-m^3 of water. With rice production across Arkansas estimated to be 607,000 hectares, the total water demand is almost 308.5 million m^3 per growing season in Arkansas (Hardke et al., 2014). This amount of water, however large as it may seem, still does not take into accou pla

Parenthesis should be used to indicate an in-text citation as per APA style.

Instead of using “i.e.” the author could say “such as transpiration” and begin a new sentence to expand their points.

infiltration, or drainage below the root zone.

Similar to rice, though not requiring flooded-soil conditions to grow, soybeans utilize an estimated 51- to 64-cm of soil moisture per growing season (Tacker et al., 2013). With an estimated 1.1 million hectares of irrigated soybean in Arkansas, approximately 204,500-m^3 of water per growing season is required for optimum soybean production. Although not nearly as startling as the water demand for rice, irrigated-soybean production is still a major contributor to groundwater depletion in Arkansas, especially considering that soybean occupies almost double the area as rice and shares the same groundwater aquifer in many cases (USDA, 2015).

One of the most prominent aquifers utilized for irrigation within the Lower Mississippi River Delta region of eastern Arkansas, is the Alluvial Aquifer. The Alluvial Aquifer, which spans a land surface area of around 8.3 million hectares, sprawls across the borders of six states (i.e., Arkansas, Louisiana, Mississippi, Tennessee, Missouri, and Iowa). The Alluvial Aquifer has an

Use e.g. when listing items as opposed to i.e., which suggests examples.

estimated thickness of 15- to 30.5-m, and in most places the vadose zone is composed of a combination of silt- and clay-sized sediments. The vadose zone varies between 3- and 15-m thick, and discharge from wells drilled into the aquifer average a rate of 3000 L min^{-1} (Czarnecki et al., 2013). According to the Arkansas Natural Resources Commission (ANRC), 30.4 million m^3 d^{-1} were pumped out of the Alluvial Aquifer in 2012 for irrigating crops. This is an important

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Remember to be specific with your language!

amount due to the fact that ~~this~~ the withdrawal rate stands in stark contrast with the estimated sustainable yield of 12.8 million m^3 d^{-1} for the Alluvial Aquifer (ANRC, 2015). This means that water is being withdrawn from the aquifer at an approximate rate of 17.6 million m^3 d^{-1} in excess of the sustainable rate of recharge (ANRC, 2015). Overall, the excessive pumping for irrigated crop production has led to a drop in the water table of around 30-cm per year for some areas within the Alluvial Aquifer (Freiwald, 2005).

Reword your ideas to enhance clarity for the reader.

~~Not only are these unsustainable, agriculturally related practices of water usage a problem for the Lower Mississippi River Valley and the Delta region of eastern Arkansas, but similar trends have been recorded across many areas of the globe.~~ Similar trends of unsustainable agricultural water usage practices have been recorded around the world. In Punjab, India, for example, a slow escalation of groundwater withdrawal for irrigated wheat (*Triticum aestivum*) production has led to an aquifer depletion rate of nearly 91-cm annually between 2000 and 2005 (Kaur et al., 2015). Central California, one of the most agriculturally productive regions of the world, has likewise experienced an increase in groundwater withdrawal, as water demands for increased crop yields grow. ~~According to Wang et al. (2016), who utilized satellite imagery to determine groundwater depletion, an estimated 28- to 34-km^3 of groundwater storage in Central California was lost due to unsustainable withdrawals between 2006 and 2012.~~ Wang, et.al (2016), utilized satellite imagery to determine groundwater completion. The study estimated 28 to 34 km^3 of groundwater storage in Central California was lost due to unsustainable withdrawals between 2006 and 2012. This means that, when combined with water loss due to a long-term, regional drought, the central valley of California experienced a loss of over 186-km^3 of groundwater storage in only six years (Wang et al., 2016). Numerous other examples of

Separate sentences when necessary to expand on thoughts separately.

Remember to be specific! "This means that" is vague language.

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unsustainable groundwater withdrawal, associated at least in part with agricultural practices, have also occurred in the Middle East, Mexico, China, and regions of the African continent (Gleeson et al., 2012). In fact, Gleeson et al. (2012) calculated that the demand for groundwater on a global level is around 3.5 times greater than the estimated yiel[illegible] combined (Gleeson et al., 2012).

This is an appropriate place to insert the "Literature Review" heading. Once the need for the study is established in the **introduction**, the author should specifically reference the findings of previous studies in the lit review.

Literature Review

[With the depletion of groundwater due to agricultural practices established as a pressing concern, the next logical step is to then create more efficient methods, or best management practices, so that unsustainable groundwater withdrawals can be curbed.] *Note: In the above sentence, the author* ***successfully*** *links the issues stated in the introduction with the need for the current study. One way to address unsustainable water usage in agriculture, is to establish a standardized set of best management practices.* In a study conducted by Verkler et al. (2008), a possible relationship was shown to exist between the maintenance of high surface residue and factors such as greater maximum soil water content, increased soil water residence time, and greater minimum soil water content (Verkler et al., 2008). Verkler et al. (2008) studied the effects of surface wheat residue level (i.e., high and low, achieved with differential nitrogen application rates), residue burning or non-burning, conventional tillage or no-tillage, irrigation and dryland soybean production, on near-surface soil properties. These factors were analyzed for effect on soybean production in a loessial soil in eastern Arkansas and in a wheat-soybean, double-crop production system. Water content reflectometers were installed at 7.5-cm into 16 the 48 field plots so that growing-season averages for soil moisture could be attained for each of

Remove i.e. and insert a sentence explaining the information in parenthesis. Use parenthesis for citations.

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When comparing two studies, rather than listing the previous authors each time, it is appropriate to say "Similarly, Harper (2008) found…"

16 possible treatment combinations. While the Verkler et al. (2008) study did not specifically focus on surface water infiltration rates, it is known that the velocity of surface water runoff is slowed significantly by the presence of surface residue (DeFauw et al., 2014). The decreased velocity of runoff would then, in turn, allow for a longer period of time by which the surface water could infiltrate into the soil, pointing towards infiltration as a possible cause for the reduced runoff and greater soil water content that was exhibited in high-residue and no-tillage field treatments (Verkler et al., 2008).

Similarly, ~~to Verkler et al. (2008)~~, Harper et al. (2008) ~~showed~~ *suggested* that conservation tillage practices had the potential to significantly reduce the amount of nutrient runoff from agricultural fields. Harper et al. (2008) conducted rainfall simulations at the native, undisturbed Roth Prairie near Stuttgart, Arkansas, as well as in adjacent conventional-tillage and ridge-tilled soybean agroecosystems, in order to quantify the effects of landuse on surface runoff. ~~Like Verkler et al. (2008),~~ Although, Harper et al. (2008) did not specifically identify increased surface water infiltration as a mechanism for reducing runoff, ~~but did show~~ the results indicated that the runoff coefficient associated with conservation-tillage ~~(i.e., ridge tillage)~~ practices was similar to that of a native prairie ecosystem. Much like the Verkler et al. (2008) study, Harper et al. (2008) concluded that the maintenance of the soil's natural structure, as well as the presence of surface residue, could significantly increase the water residence time on the surface of the soil. Logically, this would then point towards either evaporation or infiltration as the driving forces behind reduced runoff. ~~Evaporation, however, is the less likely of the two scenarios given the increased soil water content shown by Verkler et al. (2008)~~. However, Verkler, et.al., (2008) suggest that evaporation is the less likely scenario, given the increased soil water content.

Informal language. Use wording such as *indicate* or *suggest*.

As you proof-read, reword segments that don't "flow". Reading your work aloud may help.

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intentions of the study.

An additional study, conducted in Hebei Province, China, was initiated in an effort to better understand surface water infiltration into soil (Cao et al., 2012). The focus of ~~that~~ the study was to determine the role that organic residue plays in the infiltration process by treating different soil columns with various methods of straw applications. The various application methods ~~utilized~~ included straw mulching, ~~or layering straw directly on top of the soil surface;~~ straw mixing, ~~where the straw was physically mixed into the top 10-cm of the soil;~~ and straw inter-layering~~, placing straw in a layer 20-cm below the soil surface~~ (Cao et al., 2012). A constant water-head method, combined with HOBO U20-001-01 data recorders, was used to measure soil column infiltration rate. A control was also set up without straw amendment. Results indicated significant differences between all three straw amendment methods and the control. Increased infiltration rates were exhibited in both the straw mulching and straw mixing methods, with straw mulching demonstrating the second largest increase in infiltration, while straw inter-layering actually seemed to retard surface water infiltration; a result attributed to the compaction of the straw by the overlaying soil (Cao et al., 2012).

"Reinforces" has better flow.

The study conducted by Cao et al. (2012) ~~study~~ is valuable in that it ~~points towards~~ reinforces the concept of increased surface water infiltration as a result of increased surface residue and soil organic matter. While Cao et al. (2012) focused exclusively on straw amendments to soil columns in an effort to curb water use in agricultural fields, field studies designed to investigate the effect of actual in-field residue level on infiltration would be beneficial and would provide more insight into the potential effects of varied landuse on surface infiltration.

Instead of saying The Cao, et al. study, the author could say "The study conducted by Cao, et al (2012)"

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Remove parenthesis and replace with comma.

Wang et al. (2012) also studied surface water infiltration into agroforestry systems in the Loess Plateau of north-central China. Loess is wind-blown, silt-sized sediment~~s~~, and one of the most erodible soil parent materials. The Wang et al. (2012) study was designed to compare infiltration rates between systems that were planted as a walnut (*Juglans regia*) monoculture, a wheat monoculture, and an agricultural system that combined the two by planting wheat in the alleyways between the walnut trees. The study was conducted over an 11-year time period in order to observe the temporal effects of not only rainfall events, but also changes in infiltration rate over time as the inter-cropping technique became better established. The double-ring infiltrometer method was used to measure infiltration rates in each agricultural environment and how that information related to rainfall events. The results of the study indicated that the environments where wheat was planted with walnut trees had a significantly increased infiltration rate after 7 years compared to the walnut monoculture. Significant differences were achieved between the polyculture and monoculture wheat nine years into the study. In fact, the polyculture out-performed both the walnut and wheat monocultures with infiltration rates being greater by a factor of 2 and 1.8 respectively, after 7 years. Infiltration rates over the entire 11-yr study period were 2.13 and 1.28 times greater in the alley-cropped system than in the walnut and wheat monocultures, respectively (Wang et al., 2012).

See the above note

Fully spell out numbers less than 10 unless they are specific, such as "1.8"

Since alluvial and loessial soils dominate the highly agriculturally productive Delta region of eastern Arkansas, and extensive irrigation has been a main culprit in the groundwater depletion issues the region faces, a better understanding of how ecological factors and/or agricultural best management practices could possibly increase infiltration are needed in order to

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either slow down or reverse the declining aquifer levels through the Delta region of eastern Arkansas. Therefore, the objective of this study was to evaluate the effects of landuse on surface water infiltration into alluvial and loessial soils in the Delta region of eastern Arkansas. Landuse combinations of interest included conventional and no-tillage agricultural practices, deciduous and coniferous forests, and native/natural grasslands. The comparison of infiltration rates across these different landuse designations indicates which of the landuses, and/or agricultural management practices, are able to facilitate greater surface water infiltration; a precursor to increased groundwater recharge.

Reword the hypothesis to be clear and formal in tone.

The primary hypothesis associated with this study suggested that more naturally maintained soil systems would exhibit a greater rate of surface water infiltration. ~~was that the more more naturally maintained the soil system, the greater the rate of surface water infiltration.~~ More specifically, it was hypothesized that infiltration would differ among landuses, with conventionally tilled agriculture exhibiting the lowest rate of surface water infiltration, followed by no-tillage agriculture, grassland, and then the forested systems, coniferous and deciduous, respectively. Since the coniferous forest sites measured in this study were planted as a row crop, a formal comparison was also made for the between and in-row infiltration measurements, with in-row measurements expected to produce greatest infiltration rates. An additional formal comparison was conducted between two Conservation Reserve Program (CRP) sites and two native tallgrass prairie systems, which collectively constitute the grassland landuse for the purpose of the main objective of this study. The native prairie was expected to exhibit a greater infiltration rate than the CRP.

Materials and Methods

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Sub headings should: describe the next section for the reader, be left aligned, and be **bolded**.

Measurement Periods and Site Descriptions

Infiltration measurements were conducted in November 2015, and March and May 2016 using a double-ring infiltrometer with a 15-cm inner-ring inside diameter (ID). On 7 November 2015, measurements were conducted at the Lon Mann Cotton Branch Experiment Station (CBES) near Marinna, AR, in the Lower Mississippi River Valley (Figure 1). Measurements were conducted on 15 field plots of a long-term wheat-soybean, double-crop production system that was initiated in 2001 (Brye et al., 2006). One infiltration measurement was conducted per field plot, which had dimensions of 3-m wide by 6.1-m long. Plots represented the combination of several agricultural management practices associated with a wheat-soybean, double-crop production system: conventional tillage and no-tillage, residue burning and non-burning, high and low surface residue level achieved with differential nitrogen fertilizer application, and irrigated and dryland soybean production.

Figures should be embedded in text OR specifically reference the location in the appendix.

Three replications of a conventionally tilled, non-burned, high-surface residue, and irrigated treatment combination were targeted for measurements. In addition, three replications of four no-tillage treatment combinations were selected, including no-burn/high-residue-level/irrigated, no-burn/low-residue-level/irrigated, no-burn/high-residue/non-irrigated, and no-burn/low-residue-level/non-irrigated treatment combinations. Three infiltration measurements were also conducted in an adjacent pecan (*Carya illinoinensis*) grove to represent an undisturbed, deciduous forest ecosystem.

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Between 22 and 23 March 2016, infiltration measurements were conducted at the Pine Tree Branch Station (PTBS) near Colt, AR (Figure 2) in two conventionally tilled agricultural fields. The agricultural fields were fallow at the time that measurements were conducted, had minimal surface residue, had not been burned, and were likely irrigated in a rice-soybean rotation in the past.

This date format is European, typically the American wording would be March 22-23, 2016. Pay close attention to this.

In addition to the conventionally tilled fields at PTBS, two deciduous forest systems adjacent to the agricultural fields were targeted for infiltration measurements (Figure 2). The major tree species present were oak (*Quercus* spp.), hickory (*Carya* spp.), gum (*Eucalypus* spp.), and dogwood (*Cornus* spp.). Although these forested sites had likely been cleared at some point in the past, based on the height of the trees present the forest stands were estimated at 30 years old and likely had not been disturbed during that period.

A CRP was also located in the vicinity of the agricultural fields and forested areas at PTBS, within which infiltration measurements were conducted (Figure 2). Species included within the CRP consisted of switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardi*), and Indiangrass (*Sorghastrum nutans*). The CRP grassland was converted from cultivated agriculture at least 15 years previous to measurements and had been only minimally disturbed by periodic mowing and removal of aboveground biomass.

On 23 March 2016, infiltration measurements were conducted at Kenneth Gray and Seidenstricker Prairies near Stuttgart, AR (Figure 3). Both sites are undisturbed, native tallgrass prairies. Both sites have been managed by periodic burning. The Gray Prairie had been burned within two weeks of the time of infiltration measurements. The Seidenstricker Prairie had been

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burned within the previous six months. Since the Gray Prairie had been recently burned and the Seidenstricker Prairie appeared to have been recently mowed, much of the native vegetation was unavailable for species classification at the time of infiltration measurements.

On 24 May 2016, infiltration measurements were conducted in another conventionally tilled agricultural site at CBES (Figure 1). The site had recently been tilled, bedded, and was awaiting seeding; likely soybean. No surface residue was present, the field was set up to be irrigated, and there were no obvious indications of surface residue burning. Measurements were conducted near the field edge. A deciduous forest site (Figure 1) was located directly adjacent to the conventionally tilled site, and infiltration measurements were also conducted within that location. Primary tree species were very similar to the two previous sites selected at PTBS, and consisted largely of oak (*Quercus* spp.) and gum (*Eucalypus* spp.). Also comparable to the previous forested systems at PTBS, the CBES forest site had at one time been cleared and allowed to naturally regenerate. However, this particular site was likely closer to 50+ years old based on average tree height.

On 25 May 2016, infiltration measurements were conducted at another CRP site at PTBS (Figure 2). Additionally, four coniferous forest plantation sites were targeted at PTBS (Figure 2). All four coniferous forest sites were at least 12 years old and had been under cultivated agriculture in the past. Infiltration measurements were conducted in and between the tree rows. Tree rows were roughly 3-m apart and trees within the rows were also an estimated 3-m apart. The plantation sites consisted of Loblolly pine (*Pinus taeda*) of varying heights between 5- and 10-m tall. Evidence of past burning and management of undergrowth (i.e., periodic mowing between rows) was also present at all four coniferous forest plantation sites.

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In total, four separate sites, representing five landuses (i.e., cultivated agriculture, no-tillage agriculture, deciduous forest, coniferous forest, and grassland) throughout the Delta region of eastern Arkansas were targeted for infiltration measurements. Table 1 summarizes additional specific information about each site where infiltration measurements were conducted and Figures 1 through 3 provide the locations for each measurement site.

Tables should follow the reference unless your discipline has alternate guidelines.

Infiltration Measurements

Random locations in each plot, or at a specific landuse site, were chosen. Surface residue, if present, was gently moved aside and the infiltrometer was installed manually to a depth of approximately 2.5-cm so that no water leakage would occur from the perimeter of the outer ring. Once the infiltrometer was installed, the soil water content in the 0- to 6-cm depth interval was measured in triplicate using an ML2x Theta Probe (Dynamax, Inc., Houston, TX) in the outer ring of the infiltrometer. The outer ring of the infiltrometer was then filled first, followed by the inner ring. All water used for infiltration was tap water transported to the site from the University of Arkansas – Fayetteville campus or obtained from a nearby experiment station building.

The height of the water column inside the inner ring was recorded immediately after filling the inner ring nearly to the top. After filling the inner ring to represent time zero, the height of the water column in the inner ring was subsequently recorded at 1, 2, 3, 4, 5, 8, 10, 12, 15, 18, and 20 minutes, thereafter. If all water in the inner ring infiltrated before the twenty minute measurement period ended, then the time into the infiltration measurement when all the

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water had infiltrated was recorded. Three separate infiltration measurements were conducted at each of the four separate sites representing each of the five different landuses.

The overall infiltration rate was calculated over the 20-min measurement period. If complete infiltration occurred before the 20-minute measurement period elapsed, then the overall infiltration rate was calculated based on the time it took for complete infiltration to occur. In addition, infiltration rates were calculated between each time interval, then natural-logarithm (LN) transformed and regressed against the mid-point of time (i.e., 0.5, 1.5, 2.5, 3.5, 4.5, 6.5, 9, 11, 13.5, 16.5, and 19 minutes) to characterize the LN of infiltration rate over time. The slope and intercept parameters from the resulting linear regression equations were recorded along with the coefficients of determination (i.e., R^2 values) for the relationships.

If referencing specific time frames, use e.g. rather than i.e.

Soil Sample Collection, Processing, and Analyses

Bold all subheadings.

After each infiltration measurement, approximately eight soil samples were collected within the infiltration measurement area from the top 10-cm of soil using a 2-cm diameter push probe and mixed for one sample per infiltration measurement. Samples were dried in a forced-draft oven at 70^{o}C for 48 hours, crushed, and then sieved through a 2-mm mesh screen.

Soil particle-size analyses were conducted on dried and sieved soil sub-samples according to a modified 12-hr hydrometer method (Gee and Or, 2002). To accomplish this, 50- (± 0.1) gram subsamples of processed soil were combined with 50-mL of sodium hexametaphosphate to disperse soil particles. Soil suspensions were briefly mixed by manual swirling, quantitatively transferred into 1-L sedimentation cylinders, and then diluted to the 1-L mark with tap water. Cylinders were allowed to equilibrate to a uniform temperature overnight.

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Suspensions were then manually mixed with a plunger and suspension densities were recorded with a hydrometer after 40 seconds. The 40-sec hydrometer readings were conducted in triplicate.

After the third 40-sec hydrometer reading was recorded, the cylinders were left standing until a hydrometer reading was recorded again at the 6- and 11-hr marks after plunging. Blank (i.e., no soil, just 50 mL of sodium hexametaphosphate and water) cylinders were also prepared to judge the accuracy of the hydrometer. The temperature of the blank was measured at the start of each set of 40-sec, 6-, and 11-hr hydrometer readings. The percentage of sand, silt, and clay in each soil sample was calculated using standard equations (Gee and Or, 2002).

Statistical Analyses

Bold all subheadings.

A one-factor analysis of variance (ANOVA) using SAS (model 9.3, SAS Institute, Inc., Cary NC) was conducted to evaluate the effect of landuse (i.e., cultivated agriculture, no-tillage agriculture, deciduous forest, coniferous forest, and grassland) on the overall infiltration rate, the volumetric soil water content prior to infiltration measurements, and the slope and intercept parameters from the linear regression equation characterizing the relationship between the LN of infiltration rate and the mid-point of time. Separate ANOVAs were also conducted to evaluate the effect of time (i.e., native prairie and CRP) using the grassland sites, and to evaluate the effect of measurement position (i.e., in-row and between row) using the coniferous forest sites. When appropriate, means were separated by least significant difference (LSD) at the 0.05 level.

The **results** section should explain the outcome(s) of your data analysis. Inform the reader of the results in a direct manner, saving any commentary or discussion for the conclusions section.

Results

Bold all subheadings.

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Initial Soil Water Content

In an effort to maintain uniformity across all sites and landuses, volumetric soil water content (VWC) was measured prior to each infiltration reading. This was conducted in order to determine whether there may be a relationship between the rate of surface water infiltration and the antecedent water content present at each site. It is logical to hypothesize that larger volumetric soil water content readings would result in lower infiltration rates due to the fact that wetter soils would have less pore space into which surface water could infiltrate. It is also important to point out that a saturated soil possesses a greater propensity for directing water away from the soil surface due to an increased hydraulic conductivity.

The highlighted portion includes a strong claim. Such a sentence is called a "normative statement", which should be supported with a citation. Appropriate wording would be "The literature **suggests** that…larger VWC would result in…"

The initial volumetric soil water content in the top 6-cm differed among landuses (p<0.05; Table 2). Initial VWC prior to beginning infiltration measurements was greater in the grassland (0.41 m^3 m^{-3}) than in all other landuses. Furthermore, initial VWC was greater in the deciduous forest (0.32 m^3 m^{-3}) than in the coniferous forest and agricultural landuses, which did not differ and averaged 0.18 m^3 m^{-3} (Table 2). Assuming the hypothesis that wetter soils lead to lower infiltration rates is true, grasslands and deciduous forests should exhibit lower infiltration rates as they indicated much greater antecedent soil water contents. However, these results also indicate that the soil conditions prior to conducting the infiltration measurements were not as uniform as desired and the initial VWC differences may be somewhat responsible for potential landuse effects on infiltration.

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Overall Infiltration Rate

With the primary hypothesis of this study focused upon the effect of landuse on infiltration rates, it was expected that this was where the greatest number of differences would become evident. However, the overall infiltration rate was greater only in the deciduous forest (7.2 cm hr^{-1}) when compared to all other landuses, which did not differ and averaged 0.66 cm hr^{-1} ($p < 0.05$; Table 2). Interestingly enough, these results indicate that the forested systems facilitated the greatest rate of surface water infiltration, despite having the second wettest initial VWC behind grassland.

Slope Characterizing the Relationship between LN Infiltration Rate and Time

The slope of the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time was also determined and tested for landuse effects. In contrast to results for overall infiltration rate and VWC, the slope parameter was unaffected by landuse (Table 2), indicating the process of infiltration over the 20-minute measurement period was relatively uniform across all landuses. It is interesting that, despite large differences in initial VWC (Table 2), there were no differences in the slope of the relationship between the natural logarithm of the infiltration rate over time among landuses. This result indicates that the slope parameter may have been affected by factors other than the antecedent soil water content.

Intercept Characterizing the Relationship between LN Infiltration Rate and Time

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In addition to the slope, the intercept parameter characterizing the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time was analyzed. The intercept of this linear relationship relates to the soil's innate structure, porosity, and water-holding capacity. This would then collectively affect the soil's ability to transmit water at the soil surface. These innate soil properties are important possible sources of variation to explain potential differences in surface infiltration among landuses and how those differences may be related to specific management practices. For example, soil aggregation is highly effected by tillage practices and could influence the intercept parameter associated with a particular landuse. These hypothetical differences would then ~~point towards~~ suggest tillage as a possible cause for the differences between initial infiltration rates.

The highlighted portion should be supported by a citation as the writer is making a claim. Support all of your claims with citations or use cautious language.

In fact, the intercept parameter did differ somewhat among landuses ($p < 0.05$). The intercept parameter was greatest for the two forest ecosystems, which did not differ, and smallest for the grassland and two agroecosystems, which did not differ (Table 2). Differences in the intercept parameter characterizing the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time among landuses demonstrates that, despite no effect of landuse on the slope parameter, landuse clearly affects the process of surface infiltration. The minimally-disturbed, forested ecosystems appear to have inherent soil surface properties that are more conducive to promoting infiltration than are the inherent properties of present and former agroecosystems, which have experienced more surface disturbance over time.

Grassland History Effects on Infiltration

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In addition to evaluating the general effect of landuse on infiltration, a specific analysis was also conducted to evaluate potential differences in infiltration between undisturbed native prairie and CRP landuses, which were combined as grassland in the general analysis. In contrast to the results of the main objective of this study, there were no differences in initial VWC, overall infiltration rate, or slope and intercept parameters characterizing the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time, between native prairie and CRP sites (Table 3). These results seem to indicate that the CRP program is actually very effective in returning cultivated land to its natural equilibrium, as judged by the similarities in infiltration characteristics between CRP and native prairie. It is important to point out, however, that the sample size of this analysis was extremely limited and no substantive conclusions can be inferred from these results. Consequently, further research on this topic would be warranted.

Measurement Position Effects on Infiltration in the Coniferous Forest

Similar to the specific evaluation of infiltration into CRP and native prairie landuses, an additional specific analysis was conducted to evaluate infiltration among in-row and between-row measurement positions in the coniferous forest landuse. This analysis was conducted to determine whether infiltration rates measured in the coniferous forest plantations may have been influenced by the fact that the trees had been planted in rows and also that the inter-row area had been partially disturbed by periodic management.

Similar to the results for the native prairie and CRP comparison, there were no differences in initial VWC, overall infiltration rate, or slope or intercept parameters characterizing the linear relationship between the natural logarithm of the infiltration rate and the

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mid-point of time, among in-row and between-row measurement positions (Table 4). However, the overall infiltration rate was more than three times numerically greater in the row (0.34 cm hr^{-1}) than between the rows (0.11 cm hr^{-1}; Table 4). If these numeric differences in overall infiltration were an indication of actual effects, had more data been able to be gathered, these results might be attributed to the root density, which may have been greater in the row than between rows. It is also possible that there was greater soil compaction between rows than within rows due to periodic mowing that occurred within the pine plantations. [Once again, it is important to point out that the sample size associated with this analysis was extremely limited and no substantive conclusions can be inferred from these results. Consequently, further research on this topic would be warranted.] *Note: In the above passage, the author successfully acknowledges the limitation of a small sample size. Acknowledging and discussing the limitations of your study informs the audience that potential changes could be introduced to strengthen the study if replicated.*

The **discussion** section should compare findings between your study and the previous literature. Discuss the implications of your findings and conclude with recommendations for future research.

Discussion

To further understand the meaning behind the results quantified in the statistical analysis of this study it is helpful to compare them to the results found in similar studies of a similar nature. For instance, in the study published by Cao et al. (2012), which investigated the effects of straw amendments on existing landuses, results showed significant differences in infiltration rates to be present across the different methods of amendment. However, organic matter and surface residue, as close a comparison as could be drawn to straw amendments for the purposes

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of this study, did not appear to be significant mechanisms within the sites that were analyzed for surface water infiltration for this study. In fact, the only significant difference in infiltration that was shown to exist among the landuses analyzed for this study, existed between the deciduous forest systems and all other landuses. Given that organic matter and surface residue varied widely across all sites, it would stand to reason that if it were a significant driver for surface water infiltration, then greater statistical differences would be present upon analyzation of data.

Avoid casual phrases such as the highlighted portion.

Not only does this stand in contrast to the Cao et al. (2012) study, but it also, at least at first glance, seems to contradict the published results presented in Verkler et al. (2008) and Harper et al. (2008) .

Add the year in parenthesis following each in-text citation.

Verkler et al., for instance, gathered data from two landuse types: conventionally tilled and no-tillage agricultural fields. While the results from ~~that~~ the study did include several variations to those landuse categories (burn or no-burn, irrigated or non-irrigated, and high and low surface residue), it was ultimately comparing soil water content which showed greater values where surface residue was maintained. ~~The Verkler~~ Verkler, et al, (year), however, did not have to contend with the wide variation in landuse characteristics present between, for instance, an established forested system versus a regularly tilled agricultural field. It is possible, therefore, that the range of values calculated in the Verkler et al. study was smaller, thereby influencing the statistical results. Furthermore, since the Verkler et al. (2008) study was interested with soil water content and water residence time, rather than specifically focusing on the causal factors surrounding surface water infiltration, the mechanisms which lead to the observed increase in soil water content can most likely not be attributed to infiltration alone.

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Likewise, Harper et al. (2008) ~~was~~ were focused primarily on comparing results between ridge tilled agricultural fields and native prairie ecosystems. ~~That~~ The study analyzed volumetric differences in runoff between those two types of landuses, and ultimately found similar coefficients associated with both. While it was hypothesized earlier in this paper that the similar coefficients found to exist between ridge tilled agriculture and native prairies may be linked to an increased water residence time, due to surface residue and the ridged structures present in the agricultural plots, it seems again that surface water infiltration may not be the primary driver associated with the observed reduction in runoff. Due to the fact that the present study found no significant differences in infiltration rate between grasslands and any other landuse besides the deciduous forests, it is possible that evaporation~~, for example,~~ may have played a larger role than first expected. It could also be hypothesized that the surface residue itself, when allowed the time, may absorb a portion of the potential runoff volume.

An additional observation can be made when comparing the results for surface water infiltration across the deciduous and coniferous forest systems. Similar to the findings of Wang, et al., (2012), A significant difference was shown to exist between deciduous and coniferous forest landuse categories, which ~~, and much like the Wang et al. (2012) study,~~ could possibly be attributed to the manner by which these systems are maintained. ~~In the~~ The sample site in the study conducted by Wang et al. (2012) ~~study~~, were agricultural fields planted as a monoculture exhibited a higher rate of surface water infiltration than did the walnut monocultures. It was explained in ~~that paper~~ the study that annual tillage was implemented between the rows of the walnut monoculture and could possibly have been a cause for the reduced infiltration. Likewise, in the present study, the coniferous forest systems that were selected had been planted in rows

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and were subjected to regular maintenance in the form of mowing. The deciduous forests, on the other hand, appeared to have been largely undisturbed by a magnitude of decades. This could have led to factors such as reduced soil compaction, increased root growth, increased surface residue and soil organic matter, as well as increased macro and micro-invertebrate activity; all of which would have an effect on surface water infiltration rates. One further interpretation that could be made is that the species of the trees themselves could have an effect, primarily with regards to the degree of root growth. Larger expanses of root development would have the ability to create a more prolific network of micro- and macropores, thus increasing the rate by which water is able to infiltrate the soil.

> "This" is vague. Be specific! What in particular could have led to the factors mentioned? Avoid terms such as "this" or "that" when writing your thesis.

Further factors to be discussed when considering the results of this study include the presence of burn management, as well as the soils volumetric water content. Burn management has been shown to significantly reduce the rate of surface water infiltration, as presented in both the Mallik et al. (1984) and Verkler et al. (2008) studies, and relates across many of the landuses selected for this study. Mallik et al. (1984) demonstrated that burning Heather (*Calluna vulgaris*) reduced surface water infiltration by as much as 29 to 90% (Mallik et al., 1984). In relation to that, the coniferous forest sites selected for the present study all showed evidence of burning at some point in the past, as did the Gray Prairie system, which had been burned as recently as two weeks prior to taking measurements. This is an especially important point to make given that the grassland category included in this study, showed no significant difference in infiltration rate when compared to even the conventionally tilled sites. In short, this could be a

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source for the lower-than-expected infiltration rate, or at least is a factor that should be more extensively analyzed when comparing infiltration rates across burned and non-burned sites.

It is also essential to point out, when discussing the grassland category especially, that the CRP and native prairie sites had a significantly higher mean volumetric water content than any other landuse measured. This factor alone may likely be the cause for the reduced infiltration rates exhibited by the grassland landuse category. Additional studies should attempt to maintain a uniform VWC across all landuse combinations, or at least analyze those values to see whether there is a quantitative relationship between VWC and overall infiltration rates.

As for the lack of difference shown to exist between the conventional and non-tilled agricultural sites, this is most likely a symptom of a small sample size. As with all of the other landuse categories, only four sites were selected for each, resulting in an analysis of 12 samples per landuse. While the overall sample size between all categories (60) is a respectable start, when comparing across only two categories, 24 data points are admittedly insufficient to draw a conclusion with any degree of confidence. It may well be that no significant difference exists between the infiltration rates of conventional and non-tilled agricultural fields, but further analysis with a greater sample size is suggested before a solid conclusion can be reached.

Use parenthetical citations in the **conclusions and recommendations section** to compare your findings to the

Conclusions and Implications

The primary hypothesis in place during this study was that the more naturally maintained the soil system, the greater the rate of surface water infiltration. It was also specifically hypothesized that conventionally tilled agriculture would exhibit the lowest rate of surface water infiltration, followed by no-tillage agriculture, grassland, and then the forested systems,

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coniferous and deciduous, respectively. Although the results of this study do not specifically reinforce the primary hypothesis, beyond the rates exhibited by the deciduous forest sites, after further examination of the numerical values calculated, it becomes evident that while no significant differences exist for many of the characteristics analyzed, there does exist a large quantitative range between many of the values. It is therefore ~~hypothesized~~ recommended that more sites and samples should be collected in order to expand upon this study. It is the opinion of this study that increasing the number of sites may increase the range of values calculated between each landuse, and thereby allow for a more accurate representation of the landuses as a whole.

The design of this study could easily be utilized as a template for further investigations involving surface water infiltration rates. The methods utilized ~~are definitely valid in and of themselves,~~ were validated, and the hypothesis that infiltration rates vary across landuse categories, is an important question to answer. Given the incredible rate at which groundwater is being consumed, it is vital that steps are taken to better manage that valuable resource. A better understanding of how surface water infiltrates into the soil is a piece of that puzzle and could help streamline the efficiency of irrigation techniques across the globe.

Informal/casual language. Avoid these types of phrases. Simply say that "a better understanding of how 'x affects 'y', can lead to…"

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Each of these references should follow the example below. APA style references typically do not capitalize the name of the article. Check APA online formatting through OWL Purdue's website.

Example:

Brye, K. R., Cordell, M. L., Longer, D. E., & Gbur, E. E. (2006). Residue management practice effects on soil surface properties in a young wheat-soybean double-crop system. *Journal of Sustainable Agriculture 29*, 121-150.

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Table 1. Summary of landuses and site information included in this infiltration study.

Landuse	Specific Site	Location	Soil Parent Material	Mapped Soil Series (Taxonomic Description)
Grassland	CRP[a] 1	PTBS[b]	Loess	Henry (Coarse-silty, mixed, active, thermic typic fragiaqualfs)
	CRP 2	PTBS	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	Gray Prairie	Monroe County	Alluvium	Stuttgart (Fine, smectitic, thermic albaquultic hapludalfs)
	Seidenstricker Prairie	Prairie County	Alluvium	Dewitt (Fine, smectitic, thermic typic albaqualfs)
Deciduous Forest	Pecan Grove	CBES[c]	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	Forest 1	PTBS	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	Forest 2	PTBS	Loess	Calhoun (Fine-silty, mixed, active, thermic typic glossaqualfs)
	Forest 3	CBES	Loess	Memphis (Fine-silty, mixed, active, thermic typic hapludalfs)
Coniferous Forest	Forest 1	PTBS	Loess	Loring (fine-silty, mixed, active, thermic oxyaquic fragiudalfs)
	Forest 2	PTBS	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	Forest 3	PTBS	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	Forest 4	PTBS	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
Cultivated Agriculture	CT[d] 1	CBES	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	CT 2	PTBS	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	CT 3	PTBS	Loess	Calhoun (Fine-silty, mixed, active, thermic typic glossaqualfs)
	CT 4	CBES	Loess	Memphis (Fine-silty, mixed, active, thermic typic hapludalfs)
No-tillage Agriculture	NT[e] 1	CBES	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	NT 2	CBES	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	NT 3	CBES	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)
	NT 4	CBES	Loess	Calloway (Fine-silty, mixed, active, thermic aquic fraglossudalfs)

[a] CRP, Conservation Reserve Program
[b] PTBS, Pine Tree Branch Station, near Colt, AR
[c] CBES, Cotton Branch Experiment Station, near Marianna, AR
[d] CT, conventional tillage (CT 1: No-Burn, High Residue, Irrigated; CT 2: Burned, Low Residue, Irrigated; CT 3: No-Burn, Low Residue, Irrigated; CT 4: No-Burn, Low Residue, Irrigated)
[e] NT, no-tillage (NT 1: No-Burn, High Residue, Irrigated; NT 2: No-Burn, Low Residue, Irrigated; NT 3: No-Burn, High Residue, Non-Irrigated; NT 4: No-Burn, Low Residue, Non-Irrigated)

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Table 2. Summary of effects of landuse on soil volumetric water content (VWC) in the top 6 cm, overall infiltration rate, and the slope and intercept parameters characterizing the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time.

Landuse	**VWC (m^3 m^{-3})**	**Overall Infiltration Rate (cm hr^{-1})**	**Slope**	**Intercept**
Grassland	0.41 A[a]	0.48 B	-0.05 A	0.08 C
Deciduous Forest	0.32 B	7.2 A	-0.15 A	1.65 A
Coniferous Forest	0.17 C	1.4 B	-0.04 A	0.94 AB
Cultivated Agriculture	0.18 C	0.36 B	-0.13 A	0.20 CB
No-tillage Agriculture	0.20 C	0.42 B	-0.14 A	0.50 CB

[a] Means in a column with the same letter are not significantly different (P > 0.05).

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Table 3. Summary of effects of landuse subcategories on soil volumetric water content (VWC) in the top 6 cm, overall infiltration rate, and the slope and intercept parameters characterizing the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time.

Landuse	**VWC (m^3 m^{-3})**	**Overall Infiltration Rate (cm hr^{-1})**	**Slope**	**Intercept**
CRP	0.39 A	0.06 A	-0.06 A	0.01 A
Native Prairie	0.42 A	0.10 A	-0.03 A	0.15 A

[a] Means in a column with the same letter are not significantly different (P > 0.05).

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Table 4. Summary of effects of landuse subcategories on soil volumetric water content (VWC) in the top 6 cm, overall infiltration rate, and the slope and intercept parameters characterizing the linear relationship between the natural logarithm of the infiltration rate and the mid-point of time.

Landuse	**VWC (m^3 m^{-3})**	**Overall Infiltration Rate (cm hr^{-1})**	**Slope**	**Intercept**
Coniferous In-Row	0.17 A	0.34 A	-0.04 A	1.06 A
Coniferous Between Row	0.17 A	0.11 A	-0.04 A	0.82 A

[a] Means in a column with the same letter are not significantly different (P > 0.05).

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Figure 1. Infiltration measurements were conducted at four locations at the Lon Mann Cotton Branch Experiment Station (CBES) near Marianna, AR representing three different landuses (i.e., cultivated agriculture, no-tillage agriculture, and deciduous forest).

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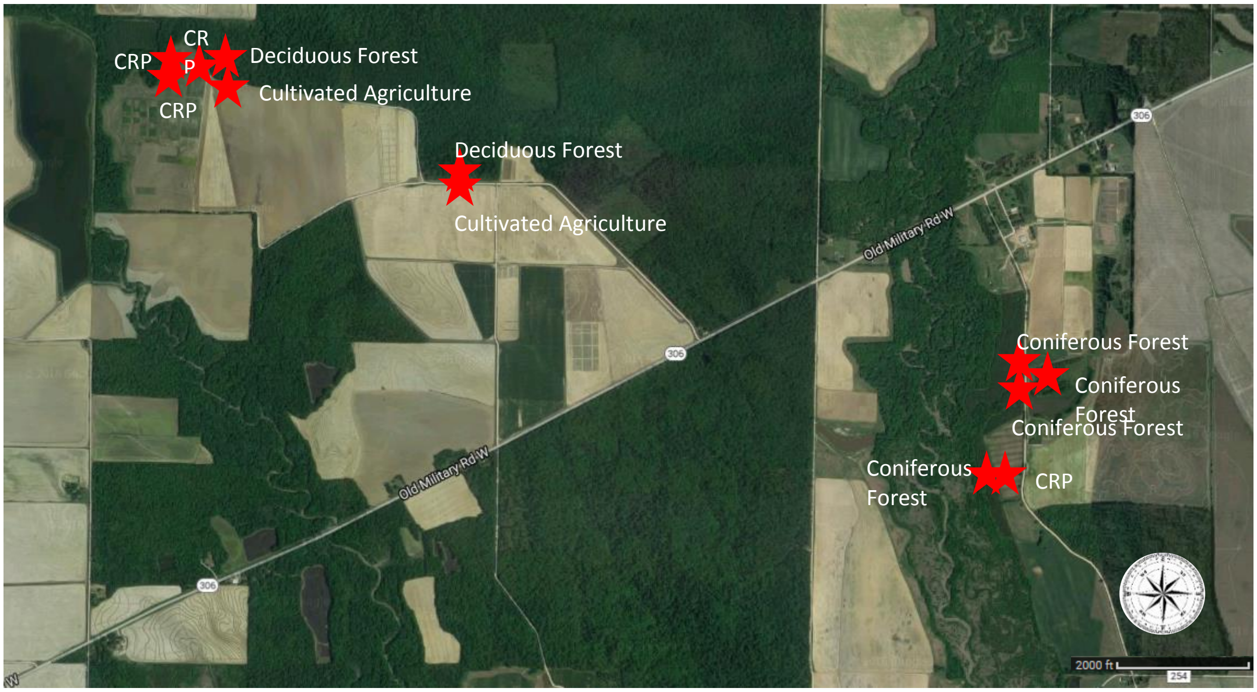

Figure 2. Infiltration measurements were conducted at 12 locations at the Pine Tree Branch Station (PTBS) near Colt, AR representing four different landuses (i.e., cultivated agriculture, Conservation Reserve Program (CRP) grassland, coniferous forest, and deciduous forest).

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Figure 3. Infiltration measurements were conducted at the two different native prairies located near Stuttgart, AR.

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