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# Grain Cart Pathways and Compaction

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# Grain Cart Pathways and Compaction

## **Problem Statement**

A typical field is compacted by wheel tracks on 80-90% of its area (NRCS National Soil Survey Center, 2011). This results in reduced yields, reduced soil health, and reduced water infiltration. Creating a plan to limit compaction could provide numerous benefits to farmers everywhere. John Deere Intelligent Solutions Group (ISG) is located in Urbandale and is responsible for developing precision agriculture hardware and software for John Deere (Ciha et al., 2017). Farmers all over the world use these products. ISG would like to know more about the effect on yield and profit that compaction from grain carts is responsible for. There are some statistics pertaining to yield loss from previous compaction studies that will be used to make an inference based on the amount of compaction that is found through collecting in the field samples. ISG wants some insight into this problem because of the potential for completely changing the way grain carts are operated in fields. Minimizing compaction is important because of the harm that it can cause to yield. Compaction affects farmers across the globe because there is a need to drive equipment through fields in order to complete necessary work. The potential to educate farmers with a new philosophy that could arise from this project could help to increase overall production of grain. It is unknown if other companies are looking into this problem. However, there are many scientists in the academic world that have spent their entire careers trying to solve the problem of compaction. A solution to directing grain cart traffic could also have an effect on how other field operations are performed as well.

## **Disciplines**

Bioresource and Agricultural Engineering | Industrial Technology

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TSM 416 Technology Capstone Project

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## 1 PROBLEM STATEMENT

### Problem Statement

A typical field is compacted by wheel tracks on 80-90% of its area (NRCS National Soil Survey Center, 2011). This results in reduced yields, reduced soil health, and reduced water infiltration. Creating a plan to limit compaction could provide numerous benefits to farmers everywhere. John Deere Intelligent Solutions Group (ISG) is located in Urbandale and is responsible for developing precision agriculture hardware and software for John Deere (Ciha et al., 2017). Farmers all over the world use these products. ISG would like to know more about the effect on yield and profit that compaction from grain carts is responsible for. There are some statistics pertaining to yield loss from previous compaction studies that will be used to make an inference based on the amount of compaction that is found through collecting in the field samples. ISG wants some insight into this problem because of the potential for completely changing the way grain carts are operated in fields. Minimizing compaction is important because of the harm that it can cause to yield. Compaction affects farmers across the globe because there is a need to drive equipment through fields in order to complete necessary work. The potential to educate farmers with a new philosophy that could arise from this project could help to increase overall production of grain. It is unknown if other companies are looking into this problem. However, there are many scientists in the academic world that have spent their entire careers trying to solve the problem of compaction. A solution to directing grain cart traffic could also have an effect on how other field operations are performed as well.

### Business Case Statement

- What:** The soil is compacted when large farming equipment travels over it, which leads to reduced yield and profits for the grower. This also leads to a decrease in the yield potential for farm acres.
- How:** Compaction is present in nearly every farming operation because equipment has to travel through the field in order for work to get done.
- When and Where:** Compaction occurs wherever heavy equipment passes over the soil. The weight of this machinery causes soil particles to be squeezed together and reduces the size of pores in the soil. Healthy soil is comprised of approximately 30% air and compaction decreases this number (De-Jong-Hughes et al., 2001). Wet soils and silty loam soils are more prone to this problem.
- Why:** Addressing and finding a solution to this problem presents an opportunity for farmers to increase their yields and in turn their profits and productivity per acre.

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- E. **Who:** This problem affects farmers directly because it impacts their way of life including how land can be farmed as well as their overall income. Indirectly, everyone worldwide is affected due to the need to be able to produce more food with a limited amount of land for an ever-growing world population.

## 2 GOAL STATEMENT

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A. The goal is to find the impact of compaction, and along with that, the piece of equipment that causes the greatest amount of compaction in farm fields.

B. The improvement will be measured according to compaction levels across various parts of the field, compaction levels in the grain cart path, and on yield impact.

- Specific parameters that were measured are compaction levels and the grain cart path through the field.
- Yield impact will be the toughest to measure because there are multiple other variables that play a major part.
- **Main Objective(s) and Specific Objectives**
  - **The main objective is to:** Create a plan to help reduce compaction from grain carts.
  - **Specific objectives include:**
    - (1) Collect data from grain cart monitors in order to create a map of pathways.
      - Determine methods for gathering customer data according to John Deere and Iowa State University policies.
        - Comply with John Deere and Iowa State University privacy policies.
    - (2) Collect compaction data using a penetrometer.
      - Data will be collected within the wheel track.
      - Control data will also be collected in an area outside of the wheel track.
      - Data will also be collected within various soil conditions.
      - Create a correlation between grain cart paths and compaction data.
    - (3) Create pathway recommendations for growers to minimize compaction.
- **Rationale**

The client will have a better understanding of how grain cart traffic in fields affects compaction levels as well as how this problem can be managed. This will be measured by determining how much compaction grain carts cause. In addition, economic impacts will be analyzed to determine if it pays to change the way grain carts are operated.

## 3 PROJECT PLAN/OUTLINE

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A. **Methods/Approach**

- Collect soil compaction levels with a penetrometer
- Centralize field traffic data in SMS or MyJohnDeere Operation Center
- Correlate compaction levels with the amount of traffic and economic loss
  - **Reference Materials**
    - The client has provided some reference materials as well as some guidance on sources to reach out to for more information.
  - **Data collection**
    - The data that will be collected are the compaction levels within the grain cart path and outside path. In order to collect this data, we must also have the grain cart path data.
  - **Skills**
    - The skills that will be used are program skills with SMS Advanced, My John Deere, and various tracking system monitors such as a John Deere GS3.
    - The classes that are the most useful at this point have been TSM 433, TSM 324, TSM 415, TSM 416, TSM 214, Com St 214, and Eng 302.
    - The materials used from these classes are precision agriculture tools, soil properties knowledge, project planning skills, and business communication skills.
  - **Solutions**
    - The solution for this project will be evaluated on if the client was criteria were met. The main problem for this project left the solution to be very wide open. Therefore, no exact scale can be used to measure the success of the project.
    - The metric to evaluate solutions will be developed using the client's requested deliverables and considering their possible benefit to farmers.

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- The proposed solution was evaluated to be better by the fact more extensive research was found. The economic impact that would be seen was evaluated and allowed for more information for the client.
  - Through our research, we were able to find that soil compaction is a major issue that farmers should be concerned about. Therefore, we found that limiting traffic in a field will help to make the farmer profitable. However, we were only able to test in one certain set of variables. More extensive testing with different variables needs to be done to evaluate each individual case and how large of an impact it has.
  - Reducing compacted area of the field from grain carts will return approximately \$10.00/acre for every 10% reduction in field area traveled.
  - **Organization**
    - The team will meet every week through a virtual call and face to face with the client on a monthly basis.
    - The work has been split up as evenly as possible according to interest and expertise.
    - The major milestones for the project consist of identifying scope, data collection, and data analysis.
    - Fortunately, there have not been any changes at this point.
- B. Results/Deliverables**
- Develop an SOP for grain cart drivers. Set a plan to reduce the area in a field that is run over by equipment. ie. sizing equipment with the same wheelbase and track width.
  - If compaction data cannot be collected by the time that the ground freeze then the data will be collected in the spring.
  - The next steps in the project will be the implementation of the SOP in an operation to compare the benefits, continuing with data collection, and continuing with data analysis.
- C. Timeline**
- **Major Deliverable and Milestone Completion Dates**
    - Data Collection-week of 1-12-18
    - Data Analysis-week of 3-23-18
    - Modeling Data for Comparison to Other Published Studies-week of 3-23-18
    - Spring Oral Presentation-week of 4-27-18
    - Spring Final Report-week of 5-4-18

## 4 BROADER OPPORTUNITY STATEMENT

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- A. Our project is based on a prior knowledge of general farm operation procedures. Therefore, some of the general public may not fully comprehend what we are addressing and just how large of an issue this is for farmers. However, through our explanation and graphical abstract anyone should be able to understand the general objective of our project and the steps that take place for this problem to occur.
- B. In the long run, this project will play a role in helping farmers feed the world's growing population. Farms are facing an issue of having to grow food for more people on less land due to urbanization. In order for farmers to combat this issue, we must find ways to help farmers reduce yield loss due to factors that can be prevented or reduced like compaction.
- C. Another industry that experiences issues with compaction would be the construction industry. The difference is the construction industry is typically looking to increase compaction by preparing the ground for them to build a road or structure on.
- D. The main industry that would benefit from our project would be the agriculture industry. However, the construction business may be able to use some of the information and reverse our findings to benefit them.
- E. At this point in time, there is no trend in farmers changing the way they operate to manage compaction differently than they have in the last few decades.
- F. There have been many studies conducted on soil compaction and its effect on the soil and future yields. However, from our knowledge, nobody has put a large amount of effort into coming up with a solution to the problem. Part of this has been nobody has been officially able to measure just how large of an effect soil compaction.
- G. At this current time the industry is still not sure exactly how much this issue is costing farmers and therefore, companies are not sure how much they should invest to solve the issue. Soil compaction is a hard issue to measure just how large of an impact it is having on yields. Many other factors could contribute to limiting yields and reducing the farmer's income. If we are able to figure out on average just how much this issue is costing farmers, we then will be able to address how much we should invest in solving this issue. For now, a farmer will invest as much as he thinks it is worth to him since each case will have different results.

## 5 PROJECT SCOPE

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The scope of the project is to analyze the effect of grain cart traffic on fields with an emphasis on yield and profit losses. The start of the project was collecting grain cart pathways through a field as well as the amount of compaction that was caused. The final deliverables will be recommendations for driving grain carts in fields and an economic analysis for the yield loss caused by grain cart compaction. The scope was

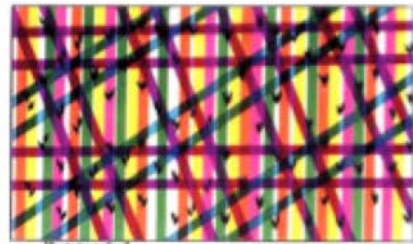
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changed throughout the beginning of the project as the end deliverables were narrowed down and were driven by both the client and group members.

## 6 GRAPHICAL ABSTRACT



Heavy loads compacting the soil during harvest



Typical passes through a field

Heavy loads compacting the soil during harvest



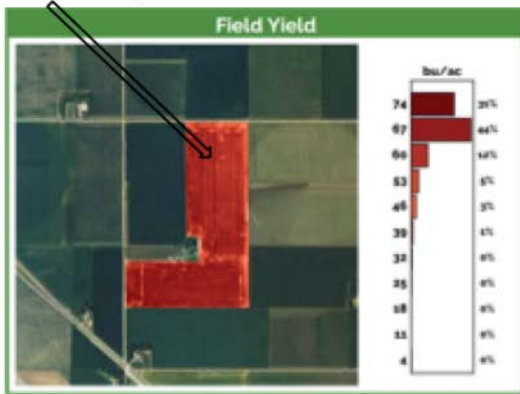
Test soil compaction levels and see how fields are compacted



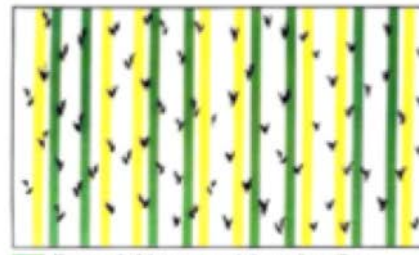
Take soil compaction data and field pass locations and layer them on top of each other



Streaks in field are where heavy compaction was done causing a reduced yield



Correlate compaction levels to yield and economic effect



Potential solution to limit area of field that gets traveled on

P

M

B

*Limit of 4-page maximum.*

## 7 REFERENCES

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- DeJong-Hughes, Jodi, John F. Moncrief, W. B. Voorhees, and J. B. Swan. "Soil Compaction: Causes, effects and control." University of Minnesota Extension, University of Minnesota. Accessed 3 Apr. 2018. <https://www.extension.umn.edu/agriculture/soils/tillage/soil-compaction/>
- NRCS National Soil Survey Center, ARS National Laboratory for Agriculture and the Environment, NCERA-59 Scientists, Department of Natural Resources and Environmental Sciences, and University of Illinois at Urbana-Champaign. Soil Quality for Environmental Health, NRCS East National Technology Support Center, 19 Sept. 2011. Accessed 3 Apr. 2018.
- Taylor Ciha, Adam Flinn, Johnny Hogan, Drew Loneman, Katelyn Vargas, Joseph R. Vanstrom and Jacek A. Koziel. Measuring Machine Productivity Using Modern Data Collection System. Final Report. TSM 416 Technology Capstone Project, April 28, 2017.



## 8 APPENDIX

