MATH 365

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Grass Blade Project

**Real World Problem**

In sports at all levels the benefits of artificial turf are seemingly becoming more and more known amongst sporting teams to where they are transforming their natural grass fields into fields with artificial turf. Artificial turf no longer requires any regular maintenance to it once it is installed. Since it is artificial it does not need water to maintain its condition (unless a team or lawn owner were to want to cool it) and since it cannot grow it does not need to be cut. This is a financial burden that is solved for anyone who has a lawn and who are possibly thinking about trading their natural fields for artificial turf. But at what cost does it come to the environment when this oxygen supplying plant is traded for a plastic artificial substitute? On the contrary, how much carbon emissions are being saved from not having to mow these artificial fields and is it enough to offset the carbon consumption that would be happening from the natural grass? If this is not the case, is there a max amount of times someone should mow their lawn per year?

**Problem Statement and Goal of Model**

The goal of this model is to determine if the carbon footprint from artificial turf is a better alternative for the environment when considering switching from natural grass. Answering the following questions is a more measureable means of answering which choice of grass is better for the environment. How much carbon emission is being saved from artificial turfs not having to be cut? How much carbon consumption is not being consumed by these artificial fields compared to their natural grass alternatives? With these two measureable problem statements we will be able to answer what type of grass is more environmentally friendly and beneficial.

**Assumptions to Be Made**

The biggest assumption to be made when answering this question with a mathematical model is that each square foot or square inch of grass in America has the same number of grass blades in it across the country. This grass across the country is also assumed to consume carbon at the same rate while the lawnmowers that mow this grass are assumed to be producing the same carbon footprint at the same rate. These lawnmowers are also considered to consume gas at the same rate as one another. With these main assumptions we can continue to solving, implementing, and refining a mathematical model that addresses the question from the problem statement.

Resources online were used to create values for the following variables. For one year a lawn that is 10,000 square feet in size consumes 300 pounds of carbon (Pennington). With this value for one year we can reduce it down to just the square foot for the grass. The following variable defines the relationship of pounds of carbon consumption to square footage,

per year (1)

stating that one square foot of grass consumes 0.03 pounds of carbon for one year’s time. The abbreviations on the variable in equation (1) stand for, “Grass Carbon Consumption” where the units are pounds of carbon consumed per square foot. This of course is for a period of one year. As for the number of grass blades per square foot for the conventional lawn in America, the Oklahoma Museum of Natural History says that there are 3,000 grass blades per square foot for a lawn (Flurge). This of course is identified in model terms with a variable of such,

(2)

saying that every square foot of grass has 3000 grass blades in it. The abbreviation for the variable pertaining to the number of grass blades in equation (2) are, “Grass Blade Count” with the units of grass blades per square foot. The next variables for this model pertain to the lawn mower that is used to cut the natural grass once the length is too long for the owner of the lawn. According to Sciencing.com the typical lawn mower will consume 0.1 gallons of gas in one hour’s time (Becker). Since typical lawns aren’t timed in the hours of which someone is mowing, the previous value is converted to gallons per minute yielding the next variable,

(3)

relating the consumption in gallons of the lawn mower per minute. The abbreviations on this variable found in equation (3) stand for, “Lawnmower Consumption Rate” with the units of the variable being gallons per minute. This variable is more useful in calculating the carbon footprint of a lawnmower because it will allow users to see how much of a carbon footprint is produced for one mowing, and then a year’s worth of mows for total consumption. The next variable that is defined is the variable that is involved with the actual carbon footprint of a lawnmower. Sciencing.com states that the typical lawnmower produces 17.7 pounds of carbon emissions for one gallon consumed in a lawnmower (Becker). With this information the following variable can be defined as follows,

(4)

conveying that the typical lawnmower produces 17.7 pounds of carbon for one gallon used. The variable found in equation (4) has the abbreviation of, “Lawnmower Production Rate” with the units being pounds of carbon produced per gallon used. From this we can deduce that the average lawnmower is going to produce 17.7 pounds of carbon emission for one gallon used. This will be a variable that determines one of the advantages to having artificial turf due it not having to be mowed. The last variable to consider is the average time that it takes to mow one lawn, or in more precise terms how long it takes to mow one square foot of lawn. The Lawn Institute claims that it takes 30 minutes to mow an average lawn with the size of 10,000 square feet (Institute). This value isn’t too much help in modeling terms, so it is converted to different units yielding the following variable,

(5)

stating that it takes 0.003 minutes to mow one square foot of grass. The abbreviation for the variable found in equation (5) is, “Lawn Mow Time” with the units of minutes per square foot. This variable comes into great use to determine how long someone will take to mow a certain square footage of lawn and then with that information we can figure out how much carbon emissions are produced from mowing this lawn at its specific size. Knowing then how often someone might mow can determine the advantages from having artificial turf to the disadvantages of not having carbon consumption from the same size of lawn but natural grass instead of artificial.

**The Actual Model**

To recap, this model is trying to answer the general question of what is better for the environment, artificial turf or natural grass when it comes to a carbon emission and absorption standpoint. Artificial turfs have the benefit of not needing to be mowed where they have the disadvantage of not consuming carbon emissions like natural grass does. To answer the main question of what is better for the environment the only information needed from the person using this model is how many times per year the lawn is mowed. From this information we can calculate the carbon footprint of the natural lawn from the lawn and from the lawn mower as well. For this equation to be useable we need to define some new variables that come from the person of interest using this model. These variables are,

(6)

where this variable has units of square feet. The variable found in equation (6) is abbreviated for, “Square Footage of Lawn” in units of feet squared. According to the Lawn Institute, the average square footage of a lawn is 10,000 square feet (Institute). The next variable is a variable that relates the times a lawn is mowed per year. This variable is the only variable that can change in the model from the user who helps find the carbon footprint for a specific lawn from the lawn mower being used. The following variable defines this relationship,

(7)

with this variable putting a number to the times a lawn is mowed per year. The abbreviation of the variable found in equation (7) is, “Times Lawn Mowed” with units of number per year. The units of,   
“#” are dimensionless but nonetheless play a big role in the calculation. With these two new defined variables we can construct an equation that will calculate the carbon footprint of a lawn with only needing to know the square footage of a lawn and the times that lawn is mowed per year. The following equation incorporates most variables in this model and looks as follows,

(8)

conveying the total pounds of carbon consumption for a natural lawn in one year. The equation that is found from (8) has units of pounds of carbon emissions per year with the abbreviation of, “Total Carbon Consumption” quantifying the total carbon footprint of a natural lawn. From this, one can determine if the rate at which they mow their lawn and how big their lawn is what the total carbon footprint is. If the calculated value from equation (8) comes back positive, it means that the lawn consumes more carbon emissions than it takes for the lawnmower to maintain it. If equation (8) comes back negative (this can only happen if the variable is huge) it means that the natural lawn does not consume more carbon emissions than it takes to maintain it. To clean up equation (8), the following substitutions are made,

(9)

(10)

where both equations (9) and (10) have units of pounds of carbon emission per year. Equation (9) is abbreviated for, “Lawnmower Production” pertain to carbon emission production per year. Where equation (10) has the abbreviation for, “Natural Lawn Consumption” with units of pounds of carbon emission per year. These two new equations redefine equation (8) to be a simpler form of,

(11)

again, showing the total carbon consumption per year of natural grass. With the calculation that is yielded from equation (11) we can know the benefits of a natural grass field if someone doesn’t cut said lawn too frequently. The next equation aims to quantify the benefit or detriment to having an artificial turf lawn. The variables and units of this equation are the same and the following equation is as follows,

(12)

with the units being the same as equation (11). The variable found in equation (12) that quantifies the carbon consumption, or lack thereof, for artificial turf comes back negative in most calculations. This negative value tells the user of this model that this artificial turf is losing out on carbon consumption from the natural grass alternative and is acting as a detriment towards the environment. A positive value would indicate that the artificial turf would be a better alternative for the environment.

**Implementing the Model**

This section of the paper is for implementing the model that was derived to show lawn owners the amount of carbon consumption they were losing out on with artificial turf compared to the actual carbon consumption of natural lawns. For the first implementation we will look at equation (11) which finds the total carbon consumption by a natural lawn per year. Since the only variable in that equation that is not constant is, which is the times the lawn is mowed per year, we can figure out what the max number of times the average lawn can be mowed per year before the lawn mower offsets the carbon consumption of the grass. First, we set equation (11) equal to zero,

(13)

rearranging (13) we get,

(14)

substituting in for both sides of (14),

(15)

a square footage parameter ( can be eliminated and (15) reduces to,

(16)

and now solving for max times mowed per year we get,

(17)

from (17) we plug in the parameters for this model,

(18)

with (18) having a result that is dimensionless. This result is the max times per year (Since this is the period we are looking at in this model) that the average lawn size should be mowed. The max times the average lawn should be mowed per year is,

(19)

which can be rounded to,

(20)

with (20)’s result stating the max number of times the average lawn can be mowed per year before the carbon production of mowing a lawn offsets the consumption from the lawn. Now the attention will shift to how the artificial turf model, which is equation (12), is implemented for the person using it. Equation (12) aims to show the user how much carbon consumption is being missed out on from a natural lawn as well as how much it could possibly save from being produced. Since this equation uses the same parameters as (11) the only time the carbon consumption can be offset is if someone mows their lawn 339 times per year. So, equation (12) should be used to show how much carbon consumption is lost from an artificial turf. Using equation (12), let’s say someone mows their lawn two times per month for every month giving a total 24 times per year. So, let’s say is equal to 24 times per year. Plugging this variable into equation (12) we get,

(21)

with (21) yielding a value of,

(22)

giving us a value showing that artificial turf is missing out on 300 lb.’s of carbon consumption per year if it were natural grass. The only variable that changes with the user is the times mowed per year for the lawn. With this knowledge and the known parameters anyone can figure out whether switching to artificial turf is better for the environment contingent upon how frequently someone mows their lawn.

**Verifying the Model**

Real data was collected for this experiment and here we are testing the model with real world data. With collecting data the grass blade count of 24,000 grass blades per square foot made us have to make modifications to equation (1). This equation now has a new value of,

(23)

now changing equation (18) to these new values we can find out the max number of times someone can mow a 10,000 square foot lawn with this new grass blade count. Equation (18) then turns into,

(24)

with (24) yielding a value of,

(25)

which can be rounded to,

(26)

showing that with real world experimental data we can mow a 10,000 square foot lawn 2,712 times before the carbon production of the lawnmower offsets the lawns consumption of carbon per year. Even though the amount of times per year that a lawn can be cut is different from what the model stated, we can make relations to why this is. Looking back at equations (18) and (24) we compare that as the density of the grass increases per square foot so does the times someone can mow per year. Therefore we can say that the times someone can mow and average sized lawn at an average rate is proportional to the density of the grass. With this new relationship we can create this proportionality equation of,

(27)

with being the scaled factor of the density of the grass. Equation (27) was found by comparing the results of (26) and (20) showing that when the density (from 0.03 to 0.24) increased by a factor of 8, the max amount of times a lawn can be mowed increased by a factor of 8 (from 339 to 2712) as well. This result shows that the max amount of times mowed per year (found in equation (27)) is proportional to the Grass Carbon Consumption of the lawn. The value in the bottom of (27) is a constant that is found from the user of the model.

**Maintain the Model**

For this model to be applicable and easy to the user, some simplifications can be made to the equations. Simplifying equation (8) we have,

(28)

and equation (12) can be rewritten as,

(29)

where the value in both (28) and (29) is the scaling factor for how much denser a lawn is compared to the average density. The third simplified equation is that of equation (27) which was previously defined. To address the original goal of the model this model, if the amount of times mowed per year is less than the value that (27) produces then artificial turf is not found to be advantageous for the environment concerning carbon consumption. If the number of times mowed is greater than what (27) produces, then artificial turf is better for the environment concerning carbon consumption.

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