Lee Corbett
GEOL 371
4/29/09

Review of: Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity
Authors: A.K. Holland and J.C. Jenkins

In this manuscript, the authors present a study that assesses the biomass productivity of turfgrass in the Baltimore area, Maryland. The study presents a new and more comprehensive method for quantifying turfgrass productivity, and assesses the relationship between productivity and other variables such as anthropogenic impacts and land use history. Overall, the manuscript is well written and thoroughly researched.

My main recommendation is that the manuscript would benefit greatly from having a broader focus. While the number of people who research turfgrass is relatively small, the number of people interested in carbon fluxes and land uses is much larger. I suggest using the results of your study to make some broader statements and speculations about carbon fluxes in urban ecosystems. I have several specific recommendations on this note:

1.) Your title ("Carbon stocks and fluxes…") makes it seem like your manuscript is going to discuss carbon. However, after a little bit of attention in your introduction, you rarely return to this topic directly. It would be helpful to convert all of the numbers in your results section from weight of biomass to weight of carbon, and therefore tie your numbers back into the big-picture idea of your title.

2.) Your manuscript could benefit greatly from a more synthetic discussion section. In this section, you could discuss the relationship of your work to larger ideas such as land use and carbon sequestration. Personally, I would be interested in hearing more about the following:

- How much carbon does turfgrass sequester in relation to other ground cover types typically used in urban areas? Can you make some sort of statement or recommendation about land use in urban ecosystems?
- How much carbon does turfgrass sequester in relation to forests? Can you make some sort of statement about the conversion of forested areas to developed areas and how that has affected the carbon cycle?
- Can you present some "back of the envelope" calculations regarding these ideas?
- What usually happens to turfgrass clippings after mowing? Has anyone done research regarding how these clippings can be used so that the carbon doesn't go directly back into the atmosphere? Is biomass burning a possibility?
- How does the carbon footprint of fertilizing and watering turfgrass compare to the amount of carbon actually sequestered by the turfgrass? Is there a net benefit?
- Can we regard turfgrass as a valid mechanism of carbon sequestration?

Good luck with edits and publication. Well done!

Lee
(abcorbet@uvm.edu)

Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity

Amanda K. Holland, Jennifer C. Jenkins

Review by Andrea Pearce
4/29/09

Summary: This manuscript describes a study on the productivity of residential lawns in Baltimore, MD as part of the Baltimore Ecosystem Study. The work estimates the stock and flux of C in turf. Two summers of field data collection determined pools of clippings, stubble, thatch and moss at each of the residential field sites. Estimates of above ground annual net primary productivity in Baltimore are in the general range of other urban studies of turf biomass production reported in the literature. The largest differences between data from 2006 and 2007 were in the percent of aboveground biomass as clippings and thatch.

This manuscript is well organized and written. I would recommend it be accepted with minor revisions. Specific recommendations are listed below:

Introduction – You mention adding a paragraph about broader implications. Seems like it would be a helpful addition. Some ideas: Consider describing how this data might be used. Is it a significant missing component of C-budgets. How do C-stores in turf grass fit into the bigger picture of the Baltimore ecosystem study. Sort of related to the first comment, is it a substantial missing piece of the picture?

Line 204 – Maybe change this subheading to 'Data Analysis' or 'Statistical Analysis'?

Results – I would benefit from seeing the results of your t-tests in a table. It could help the readers see what types of comparisons you did all at the same time. Even though you have carefully reported this in the text, tables are in some way easier for some people to digest.

Lines 321 – 325 – This might be interesting in the introduction. Though you do describe what you are calling thatch and stubble, some of these sorts of details helps paint the picture of the whole turf-grass situation.

Discussion (general) – In the hot Maryland summer, it seems like frequency, timing and duration of irrigation would play a huge role in how much biomass is produced. Just anecdotally, frequency of rain seems more important than sun intensity in determining how often we have to mow our grass. Is there a way to account for this variation between sites and does it even make a noticeable difference?

Table 5 – Is it reasonable to compare values from such climatically diverse regions (California, Maryland, Colorado)? It definitely demonstrates that the range of values you came up with is in the ballpark, which is great.

Figure 2 – Should the y-axis extend from 0-1 or 0-100? You describe it as a % in the axis label.

Figures 2 and 3 - Are you trying to show that 2006 was wetter than 2007 and that you would expect more clippings and likewise more thatch in the drier year. You could include a bar of cumulative seasonal precipitation on figure 2, or cumulative monthly precip if that is more demonstrative of your point. Just a thought.

Review by: Carrie Pucko
Title: Carbon stocks and fluxes from residential lands: turfgrass biomass and productivity
Authors: Amanda Holland, Jennifer Jenkins

Summary:

This paper examines the carbon storage of lawns and turfgrass in urban and/or suburban ecosystems, a contributor to the carbon cycle largely undescribed. The authors use methods developed for the calculation of NPP and carbon storage in natural systems and adapt them for use in residential areas with some success, though some standard methods were shown to drastically underestimate carbon storage or NPP of turfgrass. The study looked at the effects that past landuse, maintenance routine (irrigation, fertilization) and course vegetation density had on turfgrass carbon storage. This study took place within one of the urban Long Term Ecosystem Research sites in/near Baltimore, Maryland. The findings were that current methods can not accurately capture the carbon dynamics within urban turfgrass systems and that confounding variables make prediction of carbon storage very difficult. Some such variables include human behavior and pet behavior, year to year environmental variables and unknown information regarding prior land usage.

Review:

While overall I think the ideas backing up the paper are very strong and the case for why this type of research is important is clear, there was a bit of a gap in results for me. Along these lines, I think that some of these results need to be incorporated into the abstract. It reads now more like a review paper or an evaluation of current methods. While both of those components are clearly important, the important findings, whether they be numeric or the fact that current methods can't give you accurate results, should probably be mentioned in the abstract.

In the introduction, I thought you gave a good overview of the current state of turfgrass research and the important factors that govern growth. You also gave some good contextual details regarding the prevalence of lawns in the US in that first paragraph. Could you also include some of those same statistics for Baltimore? I think this could be done either in that first paragraph as well, or a bit later in the intro. Something that would have helped me out a lot in the paper in general, although comment may be better suited for the study site section, would be pictures of the range of sites you looked at. Perhaps where you are describing each neighborhood, you could show a picture of a representative lawn that shows the range of locations you were dealing with. Are we talking downtown Burlington lawn size or Essex Junction lawn size? Is it urban or suburban? Does it even matter? Perhaps the average lawn size in each neighborhood would be helpful. Maybe even comparing average lawn size for each neighborhood to the average lawn size used in the study would make sense. In the last sentence of the first paragraph on line 67, I think you could be a bit more definitive in your statements perhaps getting rid of the phrase starting with "but is probably not critical.....evaporative demand" to a more simple statement such as ..."irrigation may be necessary for aesthetic purposes, especially in dry years, though lawns irrigated to avoid water stress are likely to

grow more quickly." In the placeholder where you said you needed to add a paragraph (line 83) I think what I wanted to see from that section would be that it is important to understand the climatic/carbon costs of urbanization/ suburbanization, not only in the US but in other rapidly growing countries like India or China.

In terms of the methods section, I thought it was very detailed, but I also acknowledge that a study like this, with so many variables, needs to be well outlined in order for results to be credible. In the site description, as before, I think pictures would help here along with the average lot sizes in the neighborhoods and in the study. One question on line 98, does "the study area was focused on three neighborhoods", does this refer to the LTER site as a whole or only the part you chose to study? On line 104, I don't think you need to report both the depth to bedrock and that the soils are "very deep", I'd just keep the bedrock info.

In the sampling design section, I though the overview of where much of the data came from was well outlined. The only information you may want to also include is where in the yard cores were taken from. Was it in the middle or on the edge? Did core/sample locations depend on use? Did you go for low or high use areas? I imagine all these things would drastically alter results. There was also one part of the discussion I felt might be better suited for the methods section. It was the paragraph or two beginning on line 286 through the calculation of TNPP.

In the discussion, I think I needed to get a better picture right off the bat of what your results found. What were the 2 or 3 major things I should take out of this paper? I think I got a little lost with the importance of the questionnaires that were given out. Did those yield any good information other than how many people use artificial nutrients or water to supplement their lawn? Admittedly though, I did not go through the discussion as well as I should have.

In terms of the tables and figures, for the big table, Table 2, could you summarize the data by cluster and just include how many lawns fell into each. How did you decide on 10 clusters? Scree plot? Are the clusters a result of a PCA? Or another multivariate technique? Could you show the plot with each point and the clusters drawn as well?

That's it. Nice job, this was clearly a lot of work and I can't believe you got to this point so fast!

Carrie

Carbon stocks and fluxes from residential lands : Turfgrass biomass and productivity
By Amanda K. Holland, Jennifer C. Jenkins

4/28/09
Review by Christina Syrrakou

The manuscript presented is a study aiming at characterizing the processes through which residential lands cycle carbon and the various parameters that affect them. For this reason, multiple residential sites were selected where aboveground net primary productivity (ANPP) was measured from collection of lawn clippings and cores fro stubble, thatch and moss during spring 2006 to fall 2007. In the end this research provides the ways that the variables affected (or not) the carbon cycle and a comparison to other studies presented so far, concluding that characterization of carbon sequestration in urban areas is a challenging task and presents great differences compared to natural forest and grassland systems.

Generally, the text was well taken care of, written in a formal language appropriate for scientific papers and it is obvious that there is a lot of work done in the background concerning this research. I have to admit that at points, probably due to my lack of specific background, I found the text a bit tight-written, containing a lot of info. However, I think that through some revisions (and perhaps more time) it will improve significantly. So, I recommend that this paper is published with minor revisions, some of which include the following.

- Firstly, as far as I understood one of the main aspects of this paper is the focus on aboveground net primary productivity. For that reason I think it should probably be added in the title. For example, the title could be "Carbon stocks and fluxes from residential lands: turfgrass biomass and ANPP" (if that makes any sense).
- Another important aspect of this paper is the comparison to previous studies, a point which is not well mentioned in the abstract or introduction although it appears to be a major part in the manuscript. So, probably this should be emphasized more in the beginning of the text or perhaps at the goals of this study.
- In addition, although it is mentioned in the text (Abstract l17) that the study presented is a part of a larger NSF study I didn't quite capture what is contained in the NSF study and what is the part that this paper adds to the study. Also, at the abstract (l33) it is mentioned that this work provides an understanding on the impact of urban expansion on carbon dynamics which is something that in my opinion didn't come across well in the text.
- Furthermore, one thing that was not well depicted in the text is the way that land owners treated the lawn included in the microplots compared to the rest of the lawn. For example, did they perform the same tasks on the microplots (that is clipping, watering etc.) or were the microplots treated by research members that performed the sampling?
- Finally, it is noticeable that the specific study was not able to detect the impacts of all the variables that could have affected the carbon production as it was expected

from previous studies. However, because of the fact that this might leave a bad taste to the reader of this paper, I think that in the conclusions it would be good to mention more specifically the points that this study was successful. For example, the detection of prior land use, or annual respiration etc. to carbon production.

In conclusion, I believe that it was a good work. One of the things I liked most is the fact that it is emphasized that this research was performed in collaboration with the land owners, trying to interfere at the least degree with their regular activities (this is also seen by the fact that the owners were asked if there are any regions that cannot be included in the microplots). For more details please refer to the hardcopy of my review. I hope I helped in some way. Good luck with everything!

Eric Portenga
Writing Seminar
4/29/09

Holland et al. Review

This study aims to quantify the amount of carbon being produced in urban lawns and how it varies with time, type of vegetation, and soil, as well as looks into the effects of adding nutrients such as water and fertilizer. It is important to map the carbon flow in urban lawns since they are an important factor when it comes to ecosystems heavily influenced by human activity.

I think the ideas behind this type of research are very interesting and will have many implications in terms of human-environment interactions. There were a number of changes, however, I think would help make this paper stronger:

- It is clear that carbon is the main focus of the study as it is mentioned in the title and is the first keyword; however, the introduction neglects to mention carbon until halfway through the second paragraph. Since carbon is integral to this study, I would suggest moving things around a bit so we know right off the bat that the focus is on carbon and heavily focus on why carbon is an important player in (sub)urban lawn landscapes.
- A number of acronyms and ideas are mentioned before they are described, and even though I might know what you mean, other readers may not.
    - Line 62: N for Nitrogen – but is never previously mentioned
    - Line 114: Coarse vegetation – hasn't yet been said how it is different than plain-jane vegetation.
    - Line 406: soil OM – what is OM?

- In the Measuring Vegetative Components section, it might help to clarify whether you used the same vacuum bags each time or if each use of the vacuum included use of new bags so minimize C cross-contamination
- I may have missed it, but ANPP and aboveground NPP are used interchangeably and I think the paper would read better if the acronym was used consistently after it is defined.
- I generally like the figures and think they tie in well with the text. I would definitely add some items to Figure 1, however, to make it more familiar (e.g. county names, city names, scale bar, north arrow, waterway names, etc.)
- You set up the project really well, describing how things will be measured, what data you will collect, and why it is important. But then you go on to say that vegetation/building density data is dropped (Line 214), not enough information on fertilizer use could be gathered yet inferences to its importance are made (Lines 253 and 382), the growing season was inconsistent from the first year to the second year... I am concerned that too much variability in terms of data quality control is introduced between the 2006 and 2007 study years.

I think this study has a lot going for it, but more detail is necessary before being sent out for publication. One final comment I will make, which I think will help the overall structure, is that the Introduction seemed to be very broad and general, mentioning urban lawn studies from around the country, but then the rest of the paper is narrow and specific to the Baltimore area. You mentioned that you are going to put a paragraph in the introduction that speaks to the project's big-picture importance, which I think definitely needs to be there. But then I would also come back to the big-picture in your discussion and conclusions a bit more forwardly.

Joe Bartlett

4/29/09

Review of Holland et al.

The purpose of this study is to test the importance of several factors in urban lawns for carbon cycling. 33 lawns in Baltimore were selected to characterize the range of urban ecosystem structure. Aboveground net primary productivity was quantified every 2 weeks and cores were taken bi-monthly. Precipitation was identified as a major factor while comparing the results between a dry year and a wetter year.

This paper is very well written and needs very little editing aside from a few grammatical issues. The paper could benefit from some reorganization. The abstract is well written and provides a good summary, but could use more description of results/conclusions. The introduction contains a thorough literature review and has some great background information on the material. An additional paragraph to describe the role of lawns and carbon cycling in general could be helpful to appeal to a broader audience. Some mention of lawn management practices and lawn age would also be nice in the intro. The methods section is great. The discussion section has some great discussion, but way too much information that would be better suited for the introduction. Starting around L286 there are several paragraphs that contain more introduction information that discussion. Some of these sections, including the discussion on the role of moss are actually great justification for the project if they were in the introduction. The conclusions are good and concise, consider adding a sentence to better relate this to broader carbon concerns. The figures are good, I think it would help to have a general picture of the lawn carbon cycle, and possibly a picture of a grass core.

The article is well suited for Ecological Applications and should be accepted with moderate revisions. More description of the application of this method might be a better fit for the journal. You may need to define how this could be conducted in other areas or is it specific to Baltimore. Specific recommendations for editing are as follows:

- L21 confusing
- L57 consider a paragraph and more info on mowing
- L60 is this a common method? Citation?
- L70 Consider mentioning water consumption rates, especially in arid regions
- L110 This paragraph might be too thorough
- L245 awkward
- L273 awkward
- L286 this section might be better in the intro
- L312 this also might be better in the intro
- L441 awkward

- Could maybe use a paragraph in the intro to open this up to broader carbon cycling to appeal to a broader audience.

- Abstract is pretty good, ends very well
- Good job framing the study
- Consider adding a paragraph on the importance of lawn age on C cycling
- Add some intro info on lawn management options
- All of the background info is there to show the need for your project but a few more sentences could justify your research much better.
- A few missing punctuations
- The falk's equation section in the discussion would be better in the introduction.
- The thatch section in the discussion is also better suited for the intro
- Might have too much discussion on problems and future research needs.
- The discussion section in general is very thorough, but might have too much literature review.
- The constraints paragraph needs some more work
- Conclusions are good, could add a few more sentences to better summarize the paper
- A figure showing the lawn carbon cycle could be helpful

April 29, 2009

UVM internal review of:

Carbon Stocks ad fluxes from residential lands: Turfgrass biomass and productivity

Authors: Amanda K. Holland, Jennifer C. Jenkins

The primary purpose of this paper is observing the net primary productive in urban landscapes, focusing on the roll of residential lawns. Throughout the summers of 2006 and 2007 detailed measurements of primary production and the local environment were catalogued for 32 separate sites. Productivity was measured above ground (lawn clippings), at the ground air interface (thatch and moss production), and below ground (root systems) at regular intervals during the summer months. Analysis of percent carbon and nitrogen was also conducted for each of these sites. The data collected from these sample periods were then cross compared relating them to prior land use history, precipitation, and individual lawn management practices (irrigation and fertilization). Primary findings of this paper showed that typical relationships that have been observed in natural landscapes are quit dissimilar from those found in urbanized areas. This suggests that further analysis is necessary to discern the cause and effect relationship of natural or anthropocentric causes to the change in net primary production. After these are more established data such as those collected for this report may be used to determine the mass flux of carbon into urbanized landscapes.

This paper is quite organized and easy to reference across pages allowing for it to be easily read. The wealth of data in this paper is a strong point allowing the author to report many significant observations, deserving of publication. Overall the interpretations in this paper were made with sound logic while referencing other papers for support and noting why differences may be seen in the values obtained from other papers. Tables in this paper displayed the data in a logical manor that can be easily referenced by the reader to increase their understanding of the author's interpretations. While more formatting will be necessary to give the figures a significant impact on this paper. This paper can be difficult to understand for an outside reader, not familiar with carbon sequestration measurements as some of the variables that are used are not well described when they are initially introduced. Wording in this paper can also be reworked, along with removal of some erroneous information to make the paper more concise and punctual. Overall the content of this paper was able to bring the reader in due to the quality of the data that was provided. It is with fond hopes that after some more editing to bring in outside readers and improve the conciseness of this paper it will be accepted with little trouble.

- The introduction of this paper does a wonderful job of showing supporting literature. It also shows how other authors have gone about quantifying similar item, while showing how the work for this paper is distinctly different. Although this section of the paper gives strong

support as to why it is important when studying urban ecosystems it does not easily draw in the outside reader. This is particularly true for readers that do not live in more urbanized areas as it feels there it has limited applicability on a larger scale. A few brief sentence in the beginning of this section could be added that would really draw in the outside reader buy showing that what happens on lawns has effects on the whole of a watershed or larger.

- The conclusion section of this paper does a nice job of using the results to show the reader that more research in urban ecosystems is necessary. However I feel that if the section was made to include implication the paper could be much more powerful as the author can apply some of the data collected to show what levels of carbon sequestration are possible in this urbanized ecosystem.

Best of luck with your submission

Jaron

Jared Nunery
GEOL 371
April 29th, 2009

Review of:

Holland and Jenkins, **Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity**

For submission to:
Ecological Applications

This manuscript describes C stocks in residential lawns and the influences of management and climatic (biophysical) factors on these stocks. Furthermore, this paper presents a methodology for quantifying C stocks, as currently, inconsistencies within methodologies make comparisons difficult.

Overall I thought that this was a great paper, with an excellent description of the methodology used in this study, so that it could be easily replicated in other studies. This study has significant implications in enhancing our understanding of the terrestrial carbon sink, and in particular, the role of the urban landscapes that are often overshadowed during the calculation of forest pools in the terrestrial sink. However, I feel that this point was not stressed enough, especially in the introduction. By stressing this point, it strengthens the relevance of this study, as well as the importance of it. On line 54 and 55 the author highlights the relative strength of the residential lawn C sink to the forest C sink. Elaborating this point and brining it out the forefront of the paper will help solidify the necessity of publication of this paper.

The literature review of relevant studies presented in this paper was thorough, especially as this is a field that I imagine a limited number of studies have been completed. However, the presentation of these studied could be strengthened by highlighting the specific components of each study that are relevant to this study. For example, on line 47 through 49, the author says: "*Most assessments of turf production have focused on scoring aesthetic quality rather than quantifying yield and production, and the vast majority of published production measurements…"* Replacing terms like "most" and "vast majority" with numerical values, as well as describing terms like "aesthetics", will strengthen the technical rigor of the argument. For more areas where this could be added see the attached hard copy. Furthermore, incorporating studies from other continents would help broaden the scope of this study, as Eco Apps encourages broad, non-regionally focused studies. Also, the passive voice is used throughout the manuscript, switching to active voice will also help strengthen the tone of the manuscript.

For more specific comments, I have broken the paper up by section below. Once again, I would like to commend the author for an excellent paper, which I feel will make an excellent contribution to the field with several revisions to help emphasize the key points of this study.

Abstract:

In the abstract when you mention the study site on line 20, be sure to include United States, as the audience of Eco Apps is international, so the more specific you can be the better. Also on line 34 you use the term identities the need for standardized methods, is this really what you are doing with this study, or are you presenting a methodology. You allude to the need for a standardized methodology in your lit review, but your study does not actually address this, rather you present a new methodology for future studies to use.

Introduction:

I would move the sentence on 52 to 55 where you compare the relative strength of residential lawn C sink to forest C sink in the US, to the first sentence. This is a homerun sentence that really strengthens the importance of including residential lawns in terrestrial C sink quantifications. Also, use the more recent Birdsey 2006 numbers, as 1992 is out of date. Then follow this with numbers of total lawn coverage in North America, and other continents. As the journal you are submitting to is an international audience, try to get some citations from Europe or other continents as well. The challenge in this section will be to really set the foundation for why this study is important to an international audience, highlighting that yards are not restricted to just North America, or that they are (I'm not sure), either way, highlight the relative importance to other terrestrial C pools, as you did on line 52-55. Also, in general, try to omit prepositional linkages whenever possible, as in the third paragraph (see hard copy).

Methods:

You did a great job explaining clearly what you did in this section. The one part that I felt might have been glossed over a little is the discrepancy between n values in the different study years. This is quickly mentioned in the results, but a thorough description in this section would reduce confusion in following sections. Also, in this section, the passive voice is used quite heavily. Switching over to the active voice will help strengthen this section.

In this section on line 162, you present the formula used for ANPP, writing out this formula and separating it from the text will make it easier to read. I believe the Eco Apps guidelines for authors have instructions for formatting formulas.

On line 196 you cite Raciti (unpublished data) as a source for further explanation, if it is unpublished, you will have to explain it here as there is no way for someone to obtain that data. Also, it would be helpful to elaborate more on the survey techniques used, as this is an important component of your findings

Results:

Good job presenting the results in this section, the only thing I might suggest is also highlighting the "no results" components of your study, as this is as important as the significant results.

Discussion and conclusion:

I thought this section was very well written. Again I thought you did an excellent job with the framing this study into the extant literature, as well as providing multiple excellent inferences into the findings of this study. The literature review might be expanded beyond North America to appease the international audience. Furthermore, when citing studies, including the specific component of that study, as mentioned above, will help strengthen the technical rigor of the paper (see hard copy for specific citations to focus on).

Also I really like the constraints section, and almost feel that this could be further elaborated. This seemed to be a major difficulty with your study, discussing these challenges here would help future studies.

Great job Amanda, good luck with the submission and feel free to contact me if you have any specific questions.

Jared Nunery
jnunery@uvm.edu

Paper Title: **Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity**
Paper Authors: A. K. Holland and J. C. Jenkins

Reviewer: **Lance E. Besaw**
Date: April 29, 2009

Summary
The authors study turfgrass production and the cycling of carbon in an urban setting. Data was collected in Baltimore, Maryland and the findings provide insight on the impact of urban expansion on regional ecosystem carbon dynamics. In addition they clearly define the need for a more standardized methodology for measuring lawn aboveground net primary productivity that is applicable in different regions of the country.

Evaluation
The authors' contribution is noteworthy in that they clearly reveal the need for a standardized methodology for measuring lawn aboveground net primary productivity. However, the introduction of the paper needs to be refocused with the large impact of this paper in mind. I feel many of the paper's contributions are undersold to the reader.

Regarding the data quality. The data collection and analysis methods appear to be very thorough. I am not an expert in this field and cannot provide further critique of the data collection methods.

For the timescale of focus in this paper, how might impacts of climate change affect the outcomes and interpretations?

Overall the figures present god material to the reader. I think Figure 1 could be improved. If the authors were to have the 3 regions of interest as call outs from the city (which is called out from the east coast), they might be able to zoom into the regions. I think zooming in will give the readers a better perspective to the spatial locations on the study sites.

Recommendation
Overall, I think the manuscript is well written and it contribution is significant. I recommend the manuscript be accepted but after its focus and contributions are more clearly described.

Specific Comments
I feel like the introduction does not set the stage for the importance of this study. The authors present some good material and facts but provide little guidance to the reader as to why this is an important subject. I think they need to take a broader perspective on the importance of their work (as noted in the manuscript). Authors did a good job clearly defining the goals and objectives of the study.

The authors do a good job describing the study site and sampling design in the Methods section. They give important information but don't inundate the reader with too much of the gory details. This section is very well written.

Term "grass production" seems strange to me. Is this a common term used in the literature? Growth seems more intuitive, while production has more of a process feel. However, this is just my subjective perseptive.

Results section is well written and does a good job presenting the data figures and tables in the study.

Table 2 is very large. Is all of this information necessary for the reader to comprehend what the paper is about? Can this be removed or can this be added as supplementary material?

Discussion section is very thorough and provides a great deal of comparison with the published literature.

Mark Isselhardt

Critical Writing (Geology 371)

4/29/09

Holland, A, et al., 2009. Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity **For submission to Ecological Applications**

This paper describes investigations into the driving forces responsible for Carbon sequestration and flux in a managed, residential turfgrass environment. The study area runs along a gradient of residential landuse from urban to suburban around Baltimore, Maryland. Several components of grass biomass production were measured within measured sample plots. The biophysical environment was also carefully described and quantified. The results indicate that annual precipitation and irrigation might have stronger influences on productivity then other biophysical relationships (% course vegetation, age of development, etc.)

This study looked at the productivity of urban/suburban turfgrass and its associated role in the storage and cycling of carbon. It is a complicated topic that gets more complicated when you try to establish plots on residential property. Human behavior will have potentially great and conflicting impacts on the results of this research. This paper is well written. There are some grammatical mistakes (please see the marked up hard copy for small ideas that need attention). The flow of the paper could be improved by eliminating some of the lengthy discussion. That being said, this paper deserves to be published with revisions. Below is a section by section review.

Abstract: Good summary of the work, including its key findings and needs for future work.

Introduction: The second paragraph is a better lead in to this paper. It immediately gets the reader thinking about the actual production of grass and offers some numbers from similar studies. Isn't there some estimate of % lawn cover for these sites? How about a simple GIS calculation? The goals and objectives are clearly stated and help the reader connect with what is coming.

Methods: Good description of the area, the precipitation data is very helpful. Could this be fleshed out a bit more? Are there more climate metrics that can be included to illustrate the environment? How densely populated are the three neighborhoods? The sampling design section makes sense. The location of plots seemed to have a potential flaw; if the homeowners have the ability to "identify potential areas to avoid", won't that bias the sample? Are homeowners more likely to avoid the lush healthy section in favor of the dark, mossy areas? That's not to say that there was an alternative. What was the range in lawn size? The vegetation and soil sampling seems to make sense. I wonder how you clipped the grass. Was it

with scissors, lawnmower? Was there a reason to choose an alpha of 0.05 for the Mann-Whitney and 0.10 for the ANOVA?

Results: This section jumps right into the data. The results are laid out in figures and tables as well as the text. It would have been helpful to include the data as monthly production of clippings, thatch, stubble and moss along with monthly precipitation data. This would give the data a bit more resolution.

Discussion: This section started off strong with the results of the grass productivity over the two year study. The results are clearly in agreement with other similar studies. After the powerful initial paragraph the discussion seems to lose focus. There seems to be bits of introductory material mixed in. There are a lot of citations that take away from this study's findings. The section that talks about the precipitation could be given more prominence. It seems like this data could explain a lot. Was 2007 considered a drought year? How about 2006? The constraints section should probably go in the introduction.

Conclusion: This section could use a bit more. What are the implications of having NPP be so variable? What is the big picture? Ecological Applications seems to want ideas as to how this research can be used to help solve environmental problems. The papers length might also be seen as exceeding the journals limit for pages.

Figures: How about a figure that shows a simplified C cycle for residential turfgrass that includes the data generated from this research. Table 1 is hard to figure out. What is a reader to learn from this? Table 2, is there a way to organize the data along the urban-rural gradient? Figure 2: how about including the monthly data for the production along with the monthly precipitation data? Figure 3 could go. It would be great to see the regression of precipitation and clipping biomass for 2006&2007.

Nice work Amanda. Good luck with editing and submission.

Review of: Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity

By A Holland and J Jenkins

This paper investigates varying residential turf grass plots and the annual primary productivity of the plots with respect to Carbon cycling. The Gwynns Falls watershed of Baltimore, Maryland is sampled at ~33 residential locations and is categorized according to different land-use and land-cover proxies. The plots on the lawns were sampled biweekly for clippings, and cores were taken bimonthly for stubble, thatch and moss. These four biomass components were considered as the primary producers involved in C cycling during the collection period of 2006 and 2007. Other factors such as CO_2 respiration and precipitation measurements were used in analysis. It was found that precipitation significantly affected ANPP, and it was also found that that there was a positive correlation between clipping biomass and respiration. It was noted that not many studies to date have investigated turf grass for ANPP and the goal of this study was to help determine a standard practice for measuring C dynamics in residential ecosystems.

This study is important, especially in a time where quantifying C budgets is such a hot topic. I think this paper should be accepted to Ecological Applications after some reorganizing. This paper has important application, but I think you could help your paper by stressing some of the application further. The introduction paragraph should probably be more direct to your study, and how quantifying C cycling in residential areas is important. Do you know a percentage of residential land-use in the US? The current first paragraph could probably be the second paragraph. Those statistics are useful; I think they could just use some more context. Similar to the intro, your abstract and conclusion should have a sentence or two on application.

The results section is concise and I think you could help clarify some of the data further by placing some of it into a figure. Some of the data in Table 2 could be displayed as box and whisker plots to display the shape of the distribution. In the discussion section you define equations used by Falk, and I was not completely clear if you had used those equations or if you were contrasting those equations with what you used. I think it may be helpful if that section was placed in the methods by the other equations that you define. This way all equations can be consolidated and all aspects of the equations can be clearly defined at once. A figure and or schematic may be another way of illustrating the C dynamics in the system you consider. A figure would show the four primary components of the lawn, and a schematic

would help to illustrate where biomass and C are moving. Another broad comment is that in your conclusion you could briefly mention a couple of the significant findings of your research.

I have place some inline comments on the annotated copy of your paper, and following are a few bulleted points related to the content of your paper:

- Paragraph at line 160 introduces an equation for ANPP and I think it would be helpful if you explained the units related to each element of the equation. Also be aware of mentioning units throughout the text.

- You mention some known influences on productivity in lawns (e.g. precipitation, prior land-use, and N (line 255)), is phosphorus important for growth because I notice its presence in some fertilizers. If it is not maybe it would be worth saying that most lawns have sufficient P or are not limited with P.

- C production in forests is introduced at one point, and I am not sure if you mentioned C production in typical agricultural settings (Agriculture is a Land Use History in Table 1).

I hope you find my comments helpful. Good luck with the editing process.

Martin

Paper: 'Carbon stocks and fluxes from residential lands: Turfgrass biomass and productivity' by Amanda K. Holland, Jennifer C. Jenkins

Reviewer: Nikos Fytilis – 04/29/09

The purpose of this paper is to present the results from thirty-three residential sites within a larger NSF-funded study area on urban grassland biomass and productivity. The data include collection of lawn clippings and sequential cores for stubble, thatch, and moss collected for two periods. Sites were randomly selected based on four parameters: housing age, prior land use, level of coarse vegetation density and level of built structure density. More information obtained from surveys addressed to homeowners participating in the study. Besides the calculated turfgrass aboveground net primary productivity (ANNP), many more statistical tools used to account for all the important factors that affect this project. The results were able to quantify key carbon stocks and fluxes in the residential urban grasslands within the Gwynns Falls in Baltimore. Also it incorporates different natural and anthropogenic variables as drivers of production in these systems. The constraints and assumptions used in this study showed that there is need to differentiate better the biophysical versus human mediated signals and efforts should be made to characterize better the C budgets so the approach used in this manuscript could be applied to other region.

First of all, I would like to ask you how turfgrass is usually written. I remember that we have same problems with other words during the semester. Overall, your paper is good and I think it should be accepted with some revisions. In your abstract you summarize well your methods and results but I think it would be better to add some of your conclusion and discussion parts (especially the part where you compare your research with published papers). Your introduction is well organized and solid. My focus for this section of your paper is more on the writing and less on science. In line 44 I couldn't find what NM stands for. Also, your introduction doesn't include some important sections (methods) of your paper and I think you should mention something. A good job was done in providing background information on similar ecologist/carbon researcher interests (add that in your abstract). One general point that might help the flow is to maintain one constant tense throughout this section. At the beginning of your methods you could add more information about the specific study cites you are using. You could include if you have the rate of level of built structure density change for the last decade. All the comments I have for your methods section are related to my lack of knowledge. Just out of curiosity, what was your initial number of candidate households? I believe it should be great if you mention how many households you have in each neighborhood. In addition, in line 150 you mention that a subsample of the clippings per site per year was ground but you don't say what portion of your original sample is your subsample. Also, it would be easier for the readers to see each of the equations in separate lines (lines 160-164). The discussion about the moss production affect confused me a lot and I want you to ask you what usually happens in other cases where moss occur in more than one of the four sampling periods.

Because I am not familiar with the subject, could you explain more the technique used to measure the moisture (Trace System)? I believe the readers of this journal will definitely know this technique. The subsection where you mention the statistical methods you used I found it too short and with lack of important information about the key parameters of the methods used. As for the results

section I am not if you can compare the total ANNP range of values since your total number of sampling cites changed between the periods. Furthermore, looking at Table 4 I see that moss has also significant interannual difference but in the next few sentences you write that the moss values don't differ. The paragraph included between lines 258-262 points out some very interesting results which you can show them in a plot or in a table.

I found that in this paper, combining the results and the discussion would be very effective. Even though the discussion is large, I believe that it is the meat of your paper and it well written. I think your manuscript successfully argues that your method has potential to be further developed and used at other sites. Maybe it will help if you add a paragraph or two where you clearly mention about the feasibility and further modifications of this type of work. Your paper has very few implications and that is an issue where you have to write more. At the end of your discussion part I was totally lost. I wasn't able to recollect all of the important points inside this section and that is why I strongly believe to include all of them in your conclusion part. Finally, in some parts of your discussion you just document opinions from other papers but I couldn't understand if that is also your opinion. As for your tables and figures, my only suggestions are for Table 2, Figures 1 and 3. It is not a good idea to remove the first two columns of your Table 2 because you will loose vital information. In Figure 1, you could add the boundaries of the city and the watershed in which your study cites are included. As for Figure 2, the best thing you can do to depict precipitation/clipping relationship is to split the figure into two plots and show with vertical lines the relationship. Please refer to my hard-copy edited version of the manuscript for small comments regarding structure and rhetoric.

Good luck with edits and publication.