AHolland review of "Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont" by William Hackett

This paper explores the changing land use in the Winooski River Basin from 1937 to 2003. During this time period there have been alternating shifts between land clearing for agricultural practices and reforestation due to land abandonment with a slow increase in imperviousness in the later time steps.

Starting with the abstract and introduction there is a good layout of easing the reader into what is coming next. There are a few inconsistencies in tense with present and past mixed, for most of the abstract it is present but past tense is used on line 8 with "We found…". As much of the manuscript is past tense, you could consider using past throughout. One thing you should be careful of is the use of the word "landuse"; is it one word, hyphenated, or 2 words. These varied throughout the manuscript (Ex. hyphenated version on pg3 line15, written as one word on the following line16, and use as 2 words on pg5 line19). The correct spelling of this word has always perplexed me in land use classification; I would either use it as one word or 2 but not hyphenated. Also you should compare your choice with publications on this topic for reference as to what others are reporting.

The study area section provides a rich background of the VT history (found very interesting!) however some of the detail could be cut to still convey the important points regarding the changes that have taken places such as deforestation, rise in sheep herding, reforestation, etc. The following methods section provides excellent step-by-step detail on the methods used along the way on the imagery allowing for reproducibility. I think the section that follows "precision, accuracy, reproducibility" could be a subsection of the methods and designated as 4.1 (see pg 8 line14). This section is currently only discussing reproducibility of the results, I see the comment that this section is still growing but I would rename this to just the material it is currently discussing until more is added.

Due to the nature of the analysis, the results for this type of work are reporting the percent change of the land use classes between years. Therefore I suggest combining results and discussion section as some of the data trends mentioned in the results section then needed to be restated in the discussion to provide reasoning for change. Example of such is the 1st full paragraph on Pg 11 in the discussion on the differences between upland and lowland sites. Also, I would shorten discussion section by remove some of the extra historical data on VT development; information contained in the paragraph starting on page 12 line 20 and continuing onto page 13 contains some repeated background information and then information on urban development that is interesting but not necessarily relevant to the rest of the paper (with this aspect of the paragraph sounds more like an urban planning discussion than historical land use change). With keeping the discussion focus on trends in general and losing some of these interesting tidbits it will help to strengthen reasoning for the applicability of this method and keep the focus on the results of land use change over time.

I like the mention of fields to which this method of classification could be applicable, it was briefly mentioned in the introduction and later in paper the importance of understanding land use for hydrological concerns (discussion section on Pg14 paragraph starting on line 12). You provide some ancillary statements regarding how hydrology may

be affected by lowlands/uplands in general; I would consider broadening this topic to include other applications and being more general with your statements. As you do not have evidence on the ground from this study as to how these changes in land use influenced hydrology of the particular area included in the text.

- Figures: I really liked figure 1 of study region, I think you only need to use the state of VT boundary for context of watershed and would remove average elevation from legend, as it is redundant with information presented in Figure 2. For the figures showing the different land use classes, I would suggest changing the forest class pattern to something more distinct (even diagonal lines) as this will likely be printed by many in black and white. May also consider combining Fig 5 and 6 for an easier side by side comparison of the differences between upland and lowland distribution of the categories.
- In Table 3, I would suggest renaming methods to be more distinct or refer to these technique names in text. Example Pg9 line 13, "The resulting land use distribution shown by technique '300 point (2)', using…".

I think this paper should be accepted with revisions. This manuscript presents a method for performing change detection and provides good detail in describing this particular method but it is unclear as to whether this paper is being framed as a methodology paper and its applicability or as a historical account of the Winooski River Basin. To me the history of the river basin seems to be the focus of the paper and tied for second is the presentation of a novel method for land use classification and its applicability. For either focus, this paper is set-up as introducing a novel methodology for land use classification and I would suggest including the following:

- Include more information in the introduction on other heads-up digitizing and automated classification methods. Could provide information here as to the accessibility of the data and software needed to perform these methods – this would tie into the justification sentence you had in the discussion that heads-up digitizing was more accessible and lower cost as performing on aerial photograph (that were free to obtain) than performing on Landsat imagery. You could also mention the historical availability of the Landsat imagery; is there a complete dataset for the Winooski River Basin?
- In the discussion section you should be more direct in comparing and contrasting these methods to yours. In the discussion, you do touch upon automated classification by providing the percent land cover class of the 2001 Landsat classification but I think you should spend more time on discussing the comparison with this classification. The numbers were fairly similar between these classifications with the reasoning for discrepancies likely due to definitions in land use classes themselves – something that also differed when Analyst 2 manually classified using your method.
    - Could the discrepancies also be due to differences in pixel size?
    - What was the minimum mapping unit defined in your study (smallest area that would constitute it's own polygon) and how does this compare to the 30m-pixel size of Landsat imagery?

- Many would say these are close numbers when considering the area covered and automated analysis is a faster method, how would you describe the accuracy of these classifications with what is on the ground?
- Since archived images are lower cost than having aerial or satellite images flown, is the method of accessing free aerial photography and manually digitizing really less costly than purchasing archived imagery and automatically classifying? (Recognizing that both methods need a technician to manually perform parts of the analysis). I am not suggesting a cost comparison in the paper I am just throwing out some points that you should consider when writing justification for why this method is a contribution to land use classification literature.

The Journal of Environmental Management mentions in the description of the sections that a discussion or discussion and results section could be used. I think in this case a combined section would be good to reduce the amount of replicate information provided in these sections and tighten up this section. Also, there were some inconsistencies in way reporting citations in text, make sure to use (Author(s), Year).

Joe Bartlett

2/11/09

Critical review of Hackett and Bierman

The purpose of this paper is to describe an easy and cost-effective method for quantifying land use change for a large geographic area using point counting and manual classification of aerial imagery. This study was focused on the Winooski River watershed in Vermont. Aerial imagery taken over the past 70 years was georeferenced and sampling plots were randomly selected throughout the watershed and applied to each set of imagery. 300 sampling points were selected in each quadrat and were characterized for each time period. This analysis produced an accurate record of land use change over the 70 year period for the Winooski River watershed. Land use trends over this time period were similar to other studies in New England with a gradual reforestation as agricultural fields were abandoned and a more drastic increase in impervious surfaces as land was developed in recent years. The point counting and manual classification method was validated against several other commonly used methods for land use characterization and would be feasible for use in other areas.

The paper is well written and describes the methodology and the results clearly. In its current draft form, the paper is halfway between a methodology article and research article. The author stated that more work is pending to make the article more clearly a method paper. If this is the final goal, it should be clearer in the abstract and introduction that this is a method paper. The abstract and introduction are very good but could use more mention of the validation process. The study area section may contain too much information on the historical land use, and needs to add more information on land use trends after 1850. Consider condensing the land use description prior to 1937 to one or two paragraphs and then adding a paragraph that covers the study time period. The methods section is clear and provides an appropriate level of detail, however, I would like to see a mention of how long this process takes in comparison to other land use classification methods. The results section would benefit from summary tables and less written description of the results as they are straightforward. The corresponding figures are good but definitely need a better color/texture scheme. The discussion section contains a disproportionate amount of land use characterization versus methodology analysis. I would like to see further discussion on the problems presented by brush and other land cover types that produced errors in the classification. The conclusion is excellent.

This paper should be accepted with major revisions to the Journal for Environmental Management. A few minor tense, voice, and weak wording instances need to be addressed in addition to a clearer purpose (research or methodology). There were also a few corrections needed to be compliant with the journal submission guidelines: spaces instead of commas for numbers over 1,000, continuous line numbering, and the overall arrangement of the article with a theory section instead of results. Other specific recommendations for improvement are as follows:

- P3L15 This paragraph needs to be worded more clearly as the purpose statement
- P4L12 This sentence is redundant and could be included in L9
- P4L13 Is all of this historic information necessary? Consider focusing on the time range of your orthophotos
- P5L15 Should the historical descriptions keep going past 1850? Consider using less detail but covering the land use history from settlement up to present
- P5L21 Citation and version number needed for ARC GIS,
- P5L21 What is normally distributed, the land use type?

- P6L2 What is the mean basin elevation?
- P6L6 Can you show this with a statistical test?
- P7L6 Awkward passive sentence, might be better in active voice
- P7L19 a table would present this data better – also since you have a figure you don't need to describe it with so much depth in the results section
- P8L3 awkward sentence
- P8L6 this non spatially homogenous statement might not merit an entire paragraph as it is almost an expected result.
- P8L19 The reproducibility and bias data could be in a table too
- P10L2 Watch redundancy with the results section
- P11L1 50% difference in cultivated land is not "slightly" different
- P12L6 A citation for the connection between roads and development would be nice
- P13L8 Should some of this recent history description go in the introduction?
- Is it possible to estimate the percent cover of brush, which could have been classified either as forested or cultivated and the major source of differences between the methods?
- Try to avoid weak language: about, since, near, probably, so
- Need to watch tense throughout, especially in methods
- Include a mention of how long it takes to classify 1 sample site

Paper Title: **Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont**
Paper Authors: W.R. Hackett and P.R. Bierman

Reviewer: **Lance E. Besaw**
Date: February 11, 2009

Summary
The authors present a method for quantifying landuse change over decadal timescales using aerial photography. They apply the method to the Winooski River Basin, located in Northern Vermont. The history of the basin is presented and correlations are drawn between the recorded history and results of the aerial photography application. They quantify general trends of the basin history and find that, in general, agricultural landuse has decreased, forests have rebounded and impervious surfaces have increased. By separating the basin into upland and lowland regions, the authors further quantify the interstate highway impact on landuse.

Evaluation
Overall the story reads somewhat dichotomously. The Discussion reads as a historic overview of the Winooski River Basin/Vermont/New England, while the remainder reads as the demonstration of a method of quantifying landuse change. There are times when the two stories blend seamlessly. However, I feel the paper does need some additional editing to merge the two "stories".

Some of the methods do not have justifications/citations associated with them. For example, the determination of uplands and lowlands seems to have been a subjective rather than objective; also, the georeferencing of images using hydrologic features. Are these methods commonly used in the literature? Are there references?

The data and results section is very concise and well written. It presents a good overview of what was found. However, a table may be beneficial to the reader to summarize some of these results. The figures provide a lot of information to the reader. I would like the authors to provide more explanation of the figures in the text.

The statistical foundation of some of the findings does appear to be unstable. Can more objective measures of precision, accuracy and reproducibility be used to solidify the statistics? For example, the same analyst might want to classify the points more than just two times to determine the reproducibility of the findings. The variability between analysts (1 and 2) does seem to be important (is it statistically significant?). How do these variances affect the result interpretations? Maybe the presentation of the "rules" for classifying the points should be included in the methods. Overall section 5.0 needs additional work (as noted by the authors).

The authors comment on common approaches of landuse classification using aerial photographs, as well as some of their drawbacks (e.g. time consuming). However, the authors do not compare the conduciveness of their method as compared with these

common methods. Automated classification of aerial photographs can be inaccurate (especially with panchromatic images), but the tradeoff is greater spatial coverage. How is the authors' presented method any better (as measured by time spent, ease, accuracy, etc.) as compared with these common methods?

Following the earlier statement (dichotomous "stories"), the conclusion and discussion seem to be disconnected. In my opinion, the Discussion wonders away from the rest of the paper and further presents the historical landuse change, while the Conclusion seems to tightly wrap up a paper that successfully applies a method of quantifying landuse change over 70 years. I feel like the last sentence of the paper needs to be highlighted earlier and more frequently in the document.

Recommendation

Overall, I think the manuscript is well written and it contribution is significant. I recommend the manuscript be accepted with major revisions. Those revisions stated in the Evaluation and Specific Comments sections of this review. The paper makes valuable contribution (as stated in the last sentence in the conclusion) but does need revision.

Specific Comments

I feel like Table 1 is not needed in the paper. I feel they could be greatly simplified to simply show the number of photographs available for each time period. Likewise, table 2 should be simplified or removed as well. Since specific information is not pulled from the tables and discussed in the text, their inclusion in the document does not seem necessary.

The abstract was very well written and provides a good overview of the papers contents.

Line 9 of page 3, I am not sure of the use of the word uncertain in this context. The image interpretation could be difficult, unreliable or may produce variable results. The results of the interpretation could be uncertain. I would ask the author to revisit the meaning of this sentence.

The Study Area section does not discuss the history of the basin past the 19th century (but the Discussion does). Could portions of the discussion be moved to the study area section? This would allow the discussion to discuss the results and how they are validated by the known history of the basin.

How were upland and lowland classifications determined? Are there references to this approach in the literature? Are the results sensitive to the determination of uplands and lowlands? Likewise, are the landuse classifications presented in the methods section typically, used in the literature? If so are there citations?

Overall, there are some tense changes within the paper sections. Many of these have been highlighted in the annotated manuscript. (e.g. methods are typically written in past tense).

February 11, 2009

UVM internal review of:

Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont

Authors: William R. Hackett and Paul R. Bierman

This paper is focused on determining the land uses changes in the Winooski River, VT basin since the late 1930s to 2008. Thirty sample plots of 3km X 3km located within the basin were selected randomly. The land cover was then evaluated for 300 points within each of the sample plots, for three separate time steps. The results from this analysis was then compared to other sampling methods including a 500 point evaluation scheme and the yet to be conducted polygon evaluation. The results of this study showed an increase of forest area and of impervious surface while experiencing a decrease in agricultural land across the Winooski River basin. These results were then compared to the land use history and geology of Vermont. The results were also compared to highway development and land use across larger areas of the Northeast and North America.

Organization of this paper is quite good the author demonstrates the importance of knowing land use change with respect to time before progressing with the long term land use history where there is little quantitative data but only historical records. The quantitative data that is given in this section is well supported by multiple references. In addition the author highlights that fully automated digitization may not be of good quality when using older imagery further supporting the need for a manually interoperated sampling approach for increased accuracy. The discussion, though a bit long, is quite comprehensive in explaining the grouping of areas of similar land use with respect to upland, lowland, and proximity to road infrastructure. The figures used in this report are clear and easily interoperated by the reader due to the well structured captions and clear labeling. Furthermore figures are placed in the text where they are most advantageous for the readers understanding. For the most part this paper is quite well written with the exception of several cumbersome sentences.

The overall data and interpretation that the author shows in this report justify its publication. However as there is limited data showing the inherent variability of the sampling scheme more work should be shown to demonstrate its robustness. With that in mind this paper should be accepted with additions that would highlight this part.

- As noted by the author the precision and accuracy section of the report needs further work. The data that is presented here shows that there may be some small variability between interpretations of the same sample areas by a single individual and that there may be major differences in land use interpretations when multiple observers look at the same sampling scheme. To address these issues it seems that a fair amount of work must be done.
    - Although using random sampling of the plots in theory should be quite robust it would be nice to have the same site analyzed many times by the same observer using the

random sampling scheme of 300 or 500 points and showing a histogram or stating the standard error associated with the classification. However as there is an interdependency between the percentage of each land use this would only be necessary for a single land use to convey the accuracy of the sample method.

  - To show how robust the sampling scheme is for multiple observers again it seems that only classification of one land use would be necessary, but all types would be especially nice to see. This would involve having another observer look at several of the sites that have already been counted using the same sampling scheme as the primary observer. In this it a full scale sampling would not be necessary and may shorten the time to get the same results. The data collected (i.e. count or percent land cover defined by the second observer) could then be compared using a paired t-test to show the variability between the two observers.

- The conclusions section does well at noting the changes observed in reforestation. It does not do justice to some of the more interesting parts of the study conducted. It would be nice if inferences in this section can be made about the sub sets. As for now it only mentions that there are differences but the actual magnitude and direction of the land use seen in lowland, upland, and Highway proximity plots should be noted.

After closely looking at the instructions to authors for this journal everything seems to comply with the accepted manuscript form. In all the flow of this paper made it quite easy and enjoyable to read with decisive conclusions. I feel that this paper will have a large amount of merit if the suggested analysis of the sampling procedure can be conducted and will surely have an impact on quantitative determination of land use history.

Jaron

Lee Corbett
GEOL 371
2/11/09

Review of: Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont
Authors: W.R. Hackett and P.R. Bierman

In this manuscript, the authors present techniques and data from an analysis of land use change using aerial photographs from the Winooski River Basin in Vermont. The authors present a simple, robust, and novel approach to quantifying land use patterns and compare their method to other widely used techniques. The results from this study show that farmed land has decreased, forest cover has increased dramatically, and urbanized areas have increased slightly since 1937. The authors connect these land use patterns with historical events and are able to put their work into the larger context of the changing Vermont landscape.

Overall, the manuscript is well written and effectively weaves together two separate ideas: the benefits of a new methodological approach and the story told by the aerial photographs. The strength in this manuscript lies in the authors' ability to quantifiably demonstrate a trend that has been qualitatively understood for a long time. The point-counting approach described in this study will be applicable to many types of research in a wide range of fields.

Please refer to the hard-copy edited version of the manuscript for small comments regarding structure and rhetoric. In addition, I have several broader comments for the authors:

1.) A significant portion of your manuscript is methodological. Can you incorporate this into your title? Maybe something like "Quantifying seventy years of land use change in the Winooski River Basin, northern Vermont, using point sampling of aerial photographs". Right now, your title only really applies to about half of the material in your manuscript.

2.) I like your Study Area section, and I think you do a good job recreating the history of Vermont's land use. I think it could be improved by the addition of two additional items:

- You never fully connect the ideas and describe *why* all of this history is relevant. Your discussion of historical events and trends, especially the older material, is far removed from the 1937-2003 time window. Why do deglaciation, Native Americans, etc, matter to what has happened recently?
- Your historical overview ends at about 1850. What about the more recent events? I was surprised that you didn't discuss the time period that your study concentrates on. It would be helpful to know what was going on then so that you can place your work in a larger context (and so that the reader has some background information before you begin making interpretations about the land use changes you observed).

3.) Your manuscript could be greatly improved by adding some basic statistics. For instance, is the increase in impervious surface significant? Is the difference between point-counting and polygon digitizing significant? A few simple p-values (t-tests should be fine) would strengthen your work and would help your readers understand the data more fully.

4.) I was really interested in your discussion of how your method compares to other established methods. I think you can (and plan to) do a lot more with this. I'd be interested to see how your 300-point method compares to 100 points, 500 points, points on a grid, assisted digitizing of polygons, and supervised classification. This would be a good way to bulk up your results and sell your method to others.

5.) Your manuscript might be a good example of a study where results and discussion could be mixed. Your results section, as you have it now, is quite short. Additionally, you introduce new data into the discussion. They might work well intertwined.

6.) Your current discussion (and especially if you combine your results and discussion!) is pretty long and contains a range of different types of information. Adding subheadings would help to break it up and would give the reader an idea of what to expect.

Good luck with edits and publication. Well done!

Lee

Paper Review 2/11/09
Carrie Pucko

Title: Quantifying seventy years of landuse change in the Winooski River Basin, northern VT

Authors: Will Hackett and Paul Bierman

Summary:

This paper looks at land-use change in the Winooski River Basin since the early 1900's by using a time-series of aerial photographs. The methods used to classify and extrapolate land-use types over the entire basin are logical and as far as image classification goes, fairly accurate. The outcome from the study supports other work that states that much of New England was deforested for pasture in the late 1800's but that by the mid-1900's fields were being abandoned and allowed to regrow into forest. This is one trajectory of land-use change discussed in this paper. Others deal with the conversion of farm land abandoned later in the century to develop into commercial or other "urban" land-uses. The construction of I-89 is another important factor in land-use history of the WRB and one that has increased the percentage of "impermeable" land, which affects hydrology and can lead to increased run-off or other problems associated with changes to the natural flow of nutrients in a system.

Review:

I thought that overall this was a very strong paper, with logical conclusions derived from a solid methodology. As a practitioner of this type of image analysis (although most of my experience is in automated classification), I am going to focus on the methods section for my review. One question I had during the introduction to the paper focuses on the use of the term "random point sampling". Until I was pretty deep into the methods section, I was unsure whether this referred to ground truthing at random points, or whether it was done within the image (which it was). That part makes sense. I liked the use of so many of the random points within each 3km2 site. I also think the use of 30 of those sites is probably adequate. This covers roughly 10% of the basin correct? I don't know though what the standard for this is though. I think a citation indicating the percentage of the site that should be covered for a good extrapolation might be helpful

here. Was there an effort to stratify the random sites identified in Arc by elevation? Is the proportion of high elevation sites proportional to the high elevation area? I guess if it truly is random, it should be. I did miss though what the cut off elevation was for a site to be considered a high elevation site.

The other piece of the methods I wanted to clear up is in reference to the orthorectification. The accuracy of your orthorectification down to 10 pixels is very impressive, particularly having seen these photos. I would have liked to know the pixel size though. Also, how did you determine your accuracy? Was there any ground truthing done? Also, since your photos are orthorectified and you have a set of pre-orthorectified photos in the 2003 set, are you able to discuss changes in land-use type by hectares or in m2? I've run into this where the percentage change can be deceiving but if you can report actual area changed over time, it tends to be more convincing. Again though, I think the procedures you used were thorough and well-planned and that your results are not only convincing, but logical. Good job, that's a lot of work.

Carrie Pucko

Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont

02/11/09
Review by Christina Syrrakou

The aim of this paper is to quantify landuse areas located in the Winooski River Basin, using a random sampling and manual, point-based classification method which is based on aerial photographs of the broader region. After presenting the methodology used and the results, the authors concluded that there is a decrease in cultivated land and an increase in forested and impervious land. Another important issue presented is that this landuse change is affected on whether the area under study is located in the uplands or lowlands of the basin.

This paper is well written and has a good flow, which makes is quite easy to follow even for someone with no specific background on the subject. I found that the writers explain every point made and justify all their decisions through this process. The good quality of the manuscript is also helped by the plots which are simple in form (bar plots) but provide the reader with a good visual description.

I specifically liked the reference in the historical background of the area under study, which gives useful information relevant to this study. I think that the topic is covered in every direction and shows that the writers had in mind all the possible areas that the results could be questioned and therefore provided the readers with justifications. This can be also seen by reference in precision, accuracy, and reproducibility of the method used as long as with comparison to other techniques and the applications and limitations of this method mentioned in the discussion.

I think that this paper should be published with minor revisions. Some points that in my opinion should be revised are the following:

- First of all I feel that the very first sentence of the abstract is a bit too straight-forward. I think that just for a better introduction to this manuscript you could use an introductory phrase such as: ”In this study…” or something similar.
- At the introduction, (page 3 line 9), you mention that the use of unrectified, predominately monochromatic images of varying quality is uncertain. Does this comment refer to a method used so far that is not very good in the writers’ opinion?
- Also, when the method used is first introduced in the manuscript (page 3 line 16) I didn’t quite understand if this is a new method that just started being used or if it is an older method not used so far.
- Additionally at the last sentence of the same paragraph (page 3 lines 18-21) seems to be more like results. Should it be at the introduction?
- At the methods it wasn’t very clear to me how these 30 locations where chosen. In page 5 lines 19-20 it is mentioned that thirty sample locations

where generated using the “random point generation” tool in Arc GIS. Does this mean that those locations were randomly chosen or that the 300 points inside those locations where randomly chosen? Also, later in the text (page 7 line 17) it says “analysis of 30 randomly distributed sites”. However, in page 6 line 4, it is stated that “the thirty quadrats are representative of the basin as a whole in terms of elevation” which leads me to believe that the thirty locations were not randomly selected but according to elevations. I think that some further clarification could help.

- In the paragraph at page 7 lines 6-15 the rules according to which the categorization of the landuse areas was made are mentioned. However I don’t see any literature references included which leads me to believe that that there is no specific rule and that the classification is according to the sampler’s judgement. Do you think you can specify whether those rules were determined by the writers?
- At the conclusions I think you could add the limitations of this method.

Generally, it is a very good job and presents an interesting topic. I hope I helped.
Good luck.

Review of

Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont

This paper analyzes aerial photographs from the Winooski River Basin, from 1937 to the present. The analysis of the photographs is an attempt to see how landuse over time has changed in the Winooski River Basin. 30 locations were chosen for analysis based on a random sampling method, and at each of these locations 300 points were chosen at random. At each of these point landuse was determined. After full analysis it is apparent that around 1937 the river basin contained many farms, then from 1937 to the present the farm lands have gone away with rapid increase in forested area and a slight increase in development.

I think overall this is a very good paper and it is nice to finally get a better understanding of how landuse has changed in Vermont. The data is very good and the writer does a good job of showing that it is reproducible, but I can see many researchers having problems with the data collecting method, even though it is well thought out and well done. The interpretations by the author made sense and were what I thought they would be for the Vermont area before reading this paper. I thought the paper as a whole was well written and easy to read and understand, after all of the grammatical errors are fixed anyone should be able to read this paper and understand it. The figures are very good for the most part, the only change I would make is the shade of gray for forests can be hard to see.

I believe the paper should be accepted with minor revisions. This is an important paper for the scientific community but even more importantly I think the public at large, especially in Vermont would find this information interesting. Once the paper is has all of the error resolved it will be a very solid paper that could lead to new landuse analysis across the nation. A few suggested changes are outlined below.

1. Abstract starts off abruptly. I think you could are a better introductory sentence to the beginning of the abstract.
2. Put historical section by itself. I think the study area section could be split into two sections, geologic history and human history. The geologic history could be expanded on.
3. In the methods or reproducibility section you may want to have more justification for why the method works and why it is important that only one person does the analysis and even if another person does the analysis and gets different numbers the landuse change will be roughly the same.
4. More historical references.

Appears to follow the paper guidelines.

Charles Trodick

February 4, 2009
J. Nunery response to Hackett and Bierman

Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont

This paper demonstrates simple, cost-effective measures for quantifying landuse change, employing proven techniques to accurately measure changes in the Winooski River Basin over the last 70 years. Landuse changes in the study area since 1930 have resulted in decreased agricultural lands, and increased forested and impervious cover.

This paper offers an excellent overview of historic landuse change throughout both New England, and specific to Vermont. The authors show how the use of a simple technique, that is easily replicated, can accurately quantify landuse changes. One of the challenges that I see in making this a stronger paper is bringing forward the methodology. My understanding of this paper is that it is a methods paper, meant to convey a technique for quantifying landuse change. This message gets slightly lost in the lengthy descriptions of historic landuse change in Vermont and more broadly New England. Simplifying the discussion on historic landuse change would bring forward the methods, and provide a more straight forward description of the importance of this research and how it will contribute to the field.

In the introduction, the author does an excellent job of framing the importance of their proven methodology in providing another way to quantify landuse change. The challenge is to build upon this foundation in the discussion section, and show how this methodology either compliments or fills another niche where similar landuse methodologies fail. In the discussion section, a broader comparison of this methodology to other methodologies (USGS = NLCD 2001, USFS = FIA, etc…) would be helpful in conveying the relative importance and utility of this methodology. Some of the discussion on historic landuse in Vermont could be minimized/replaced with comparison to other methodologies of quantifying landuse change.

A more specific point to address throughout the paper is to maintain consistent use of terminology. Specifically, use either: land use, landuse, or land-use (I'm actually unsure which is the correct term, I would suggest looking at articles from the journal and see how published articles spelled it). This is a problem I have had as well in my writing, which is why I think I keyed into it rather quickly in this paper.

More specific points:

L5P2: Is more recent data available than 2004 (or was it 2003 that you used- the abstract and methodologies contradict). As a large amount of sub-development in "marginal" agricultural

land has occurred in the greater Burlington area in the last 5 years, incorporation of more recent data might alter difference in impervious cover.

L5P3: In the citation, are these usually listed in a chronological order in this journal?
L1P4: Looking at the journal overview, the subject headings they propose are slightly different, study area might be a subheading under one of the journal's proposed headings.
Second paragraph P4 and first paragraph P5: I am not familiar with this journal, but this might be slightly pared down to maintain focus on methodology, or it might fit better in the intro.
L16P4: Be careful not to generalize; not all forests in this area were kept open. Forest management activities pre-European settlement was concentrated in lowlands, and not necessarily widespread throughout all forests of Vermont.
L18-21P4: These two sentences contradict one another.
L21P5: What version of ARC GIS did you use?
L2P6: What were your elevation thresholds?
L8P6: Is this supposed to be referring to figure 3?
L12 and L14P6: Careful of changing tense.
L17-19P6: These two sentences could be combined to avoid redundancy.
L3P7: Spell out RMS.
L4P7: How did you georeference forest sites, this is important and should be explained.
L7P7: Is this referring to figure 4?
L12P7: Are dirt roads included in roads? Are compacted soils considered impervious? A clear definition of how you defined impervious might be helpful here.
L20P7: Is water included as a land cover type?
L21P7: These percentages have different significant figures than previous percentages.
L7P8: Before you were spelling out 30 and numbers less than 10 (i.e. five instead of 5), maintain consistency throughout the paper.
L12P8: How much more land is in active ag in lowlands?
L18-20P8: This section was confusing; perhaps separating into different sentences would clarify this a little more.
First paragraphP9: This is an important point that you are making about analyst bias, one that might have broader implications on other methodologies as well. Is there anything on the literature about this? Could you do at least one more test with another analyst to get an N=3 and a standard deviation as well as a slightly stronger sample size to justify your conclusions?
L3P10: Careful to use "significant" without any statistical tests.
L19-20P10: Significant figures?
L1-2P11: A table might be helpful in presenting these results.
L21P11: How much of the increased impervious coverage in the Winooski River Basin is a result of the construction of I89? Is this worth noting?

Second paragrphP12: There is a substantial wealth of literature on suburban development and landuse change (Austin Troy might be a good person to contact). You might be able to find several studies that are supporting your inferences.
L2P15: Harmon et al. 1990 and Keeton et al. 2007 et al. (note the et al. as I am assuming you are referencing the 2007 Eco Apps paper) both describe how older forests continue to store large amounts of biomass and carbon. However, the way you phrase this sentence implies that you are referring to C uptake rates (through the use of the word "rapid"). These two citations are actually arguing somewhat against this point. I would suggest re-phrasing to describe the significance of the terrestrial carbon sink and cite (Birdsey et al. 2006). I would also check out the following papers if you are interested in getting into the relationship between landuse change, forests, and carbon (see below for full citations): (Houghton 1993, 1995, 1996, 1999, Houghton et al. 1999, Houghton 2001, Birdsey et al. 2007)
L2P15: One other point that you could make here is the effect of landuse change on wildlife in the regions, see: (Foster and O'Keefe 2000, Foster et al. 2002, Foster and Aber 2004)
L13P15: You probably don't need to spell out GIS as you didn't earlier.
L17-18P15: Is the bias truly overcome, or can you just not measure it with only one observer?
L12P16: Introducing a new term (landscape history) is a little confusing at this point in the paper, perhaps stick with landuse history.

Birdsey, R., K. Pregitzer, and A. Lucier. 2006. Forest carbon management in the United States: 1600-2100. Journal of Environmental Quality 35:1461-1469.

Birdsey, R. A., J. C. Jenkins, M. Johnston, E. Huber-Sannwald, B. Amero, B. d. Jong, J. D. E. Barra, N. French, F. Garcia-Oliva, M. Harmon, L. S. Heath, V. J. Jaramillo, K. Johnsen, B. E. Law, E. Marín-Spiotta, O. Masera, R. Neilson, Y. Pan, and K. S. Pregitzer. 2007. North American Forests. In: The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research Asheville, NC, USA.

Foster, D. R. and J. D. Aber. 2004. Forests in time : the environmental consequences of 1,000 years of change in New England. Yale University Press, New Haven.

Foster, D. R., G. Motzkin, D. Bernardos, and J. Cardoza. 2002. Wildlife dynamics in the changing New England landscape. Journal of Biogeography 29:1337-1357.

Foster, D. R. and J. F. O'Keefe. 2000. New England forests through time : insights from the Harvard Forest Dioramas. Harvard Forest Harvard University, Petersham, Mass.

Houghton, R. A. 1993. Is Carbon Accumulating in the Northern Temperate Zone. Global Biogeochemical Cycles 7:611-617.

Houghton, R. A. 1995. Land-Use Change and the Carbon-Cycle. Global Change Biology 1:275-287.

Houghton, R. A. 1996. Terrestrial sources and sinks of carbon inferred from terrestrial data. Tellus Series B-Chemical and Physical Meteorology 48:420-432.

Houghton, R. A. 1999. The annual net flux of carbon to the atmosphere from changes in land use 1850-1990. Tellus Series B-Chemical and Physical Meteorology 51:298-313.

Houghton, R. A. 2001. Counting terrestrial sources and sinks of carbon. Climatic Change 48:525-534.

Houghton, R. A., J. L. Hackler, and K. T. Lawrence. 1999. The US carbon budget: Contributions from land-use change. Science 285:574-578.

Luke Reusser
GEOL 371
February 11, 2009

Review of:
Hackett, W., and Bierman, P., **Quantifying seventy years of landuse change in the Winooski River Basin, northern Vermont.**

For Submission to:
Journal of Environmental Management.

In this manuscript, the authors detail a new method for quantifying trends in landuse change within the Winooski Basin, Vermont, over the past 70 years using repeat aerial photographs and the classification of randomly generated points into landuse categories. They assessed the accuracy and precision of this method through comparison to other commonly used means of landuse classification, and the use of counters others than the authors themselves. The prominent findings of the study include widespread reforestation, predominantly in the upland regions of the Winooski over the study period with corresponding decreases in agricultural landuse. Increases in impervious cover largely confined to the lowlands and greatest near access points to interstate 89. The authors raise the issue of scale in determining the greatest utility of this type of analysis; while their findings demonstrate trends in landuse change over the entire basin, this method may not be best suited for detailed consideration of smaller developing areas.

While several sections of the manuscript are still in construction, overall, it is in good shape. Most of the text is clearly written, well structured and easy to follow. Once edits are incorporated, sections finished, refs fleshed out, and some clean up to figures is done, this manuscript should be accepted.

Below, I have listed key suggestions by section. Refer to the actual manuscript for smaller more detailed corrections and suggestions.

<u>Overall Suggestions:</u>

1. You push in the intro the utility of this type of analysis to landuse planners and developers. However, you also state that while this analysis is excellent for assessing landuse changes over large areas, it isn't the best for more detailed consideration of smaller developing areas. I would consider finding another way of talking about its utility in the intro.
2. Sort of along similar lines, in talking about how findings such as these will be helpful to planners and developers at whatever scale, I think it is important to acknowledge and discuss that this "helpfulness" will be much greater when the landuse changes are coupled with other types of information. Things like records of runoff vs. infiltration, flood levels, nutrient loading and the like. Lets you get at causality (sort of), at least demonstrate that development increases runoff or nutrient levels etc. I think it would be simply modifying sentences to include this notion.

3. Really minor one. In title and throughout the paper, sometimes you write "landuse" and sometimes "land use." I'm not sure exactly which it is, but you should figure it out and run with it.

Title:
I would consider adding "A new method for…." to the beginning of the title, as this is a major component of your paper.

Abstract:
Nice. Minor edits in the manuscript.

Intro:
Again, overall, nice. The last sentence however is much more of a results sentence. Not sure you want it in the intro.

Study Site:
I like this. Cool to hear all the landuse history of our area. My one issue is that you don't run it through the present day. Stops in the 1800's. Would be great to hear more about development, I-89 etc. Much of this is laid out later in the paper, but would be appropriate to have it up front so readers know it going in.

Methods:
1. For the 3x3 quadrants, did the random points fall in the center? On a corner? Was whatever criteria you used the same for all quadrants?
2. Why did you pick 3km by 3 km?
3. Page 6, second paragraph. How do the mean and median elevation compare across the Winooski?
4. Page 7, line 3: What is the pixel size? Would be more appropriate to list your error in meters or something instead of pixels.
5. When you generated the random 300 points for a quadrant, did you use the same 300 point for each time step, or did you generate different points for each?
6. Did you ever try replicating a count with several different iterations of random points? I think this is really critical in regards to whether or not the 300 points accurately reflect the landuse distribution.

Data and Results:
1. Pg 7. Last paragraph. Maybe list the percentages for the categories in the same order in both sentences so it is easier for the reader to compare.
2. Pg8. First paragraph. In the last sentence, you list percentages that add up to 100, but you do not include water.

Precision and Accuracy:
1. First paragrph, similar to a question above. When you say that you reproduce point count, did you use the exact same points? If not, I think this test is important to. I.E., do different batches of 300 points give you the same percentages?

2. Second paragraph. Well, looks like I messed this one up. It's got me wondering. When we talked after I had completed it, I think our difference were mostly because I didn't fully understand the classifications. May be worth me redoing it after a little time now that I really understand the separation better.
3. I would be interested in reading this section once you get it all laid out.

Discussion:

There is lots of really interesting information in the discussion. However, I think it would benefit the reader if you thought some more about how to structure it. Maybe the use of subsections would be beneficial as well. Don't know if you want to organized by time, by subject…

1. On page 13, line 15, you start to talk about increasing population, but don't go as far as you could. This is interesting, and I wanted to see some numbers.
2. On page 14, line 12, you start a paragraph about implications of your study. I think this should actually be a separate section. Maybe limit your discussion to considering the validity of your method and what it tells us about Vermont's changing landscape, and then talk about utility for others in the implications section. Again subsections may be useful. These are the important topics to cover as I see them:
    a. Changes in forest and impervious: As suggested at the beginning, I think it would be beneficial to state the utility of this type of analysis in conjunction with other information…runoff records, nutrient loading and the like.
    b. Effects of Scale: Like you have lain out, different approaches are better suited for different things. Your analysis is good at seeing large trends, but not so good for considering changes around the town of say Winooski over the last 70 years. However, as I understand it, you could easily adapt you method to address increasing impervious surface in this localized area.
    c. Limitations: Very good to address all these head on as you have. I would even consider expanding this a bit.

Conclusions:

Reads nicely. I hate to keep harping on this, but I think it would be good to state here that looking at trends in changing landuse in conjunction with other data is where the moneys at.

Figures:

I made chicken scratches on the manuscript. Check em out.

For figure 2, I would overlay to two distributions so we can see just how similar they are. Also include elevation axis (meters or whatever) to make sure the line up. Wouldn't be a bad idea to put dashed mean lines over each.

Table 1 is a little confusing. Look to manuscript.

Will, Cool paper and great job pulling it together so fast. Good luck with all the edits.
Luke

Meredith Clayton
10 February, 2009

Quantifying Seventy Years of Landuse Change in the Winooski River Basin

This paper presents a method for assessing land use change over the past seventy years in Vermont's Winooski River Basin, through the use of random sampling and manual, point-based classification of aerial imagery. Thirty sets of aerial photographs taken at varying intervals between 1937 and 2004 were evaluated and demonstrate a 23% decrease in cultivated land, a 22% increase in forested land, and a 2 % increase in impervious surfaces. These findings are consistent with landuse history of New England, which shows widespread reforestation as marginal agricultural land has been abandoned over the past century. Results of the study reveal that forested sites occur more frequently in upland portions of the basin, while sites with a greater amount of impervious surface area are more common in lowland areas and areas within close proximity to the interstate highways. A variety of tests were performed in order to validate this technique for determining landuse change over time and to demonstrate the feasibility of these methods for analysis of aerial imagery elsewhere. Overall, study results suggest that the method presented in this paper is easily adaptable, inexpensive, and utilizes minimal technology while providing a quantitative view of landscape change that a variety of interest groups can benefit from.

This paper starts off with a well written introduction that uses elevated diction and sentence structure, combined with clarity of thought. Although this piece is well written as a whole, the clarity decreases as the paper progresses. The clarity decreases particularly in the discussion section, and subsections. This portion of the paper reads as if there is uncertainty surrounding whether this paper should present the research or focus on the methodology. While I believe that you could write a paper on both, I am not sure that this paper should attempt to discuss both. The paper is grammatically sound; however, stylistically the beginning is stronger. From a data standpoint, the data presented appears to form a sufficient basis for the conclusions. Initially, I was uncertain of the use of hydrologic features as control points given their dynamic nature. After all, this is evaluating landuse change over a period of 70 years and hydrologic features vary greatly in some cases in a single season, particularly following significant weather events that may impact the smaller watersheds contained in the basin. Despite my skeptism, I have limited experience with the use of aerial photography and GIS and you have indicated in the discussion that the use of these features is a less accurate approach. As a reader and novice GIS user, I would have preferred to have been provided with a more detailed justification for this use, however; upon reflecting on the alternatives and the justification, I am convinced that this was a suitable selection for a control in forested areas (at least with my limited knowledge). On the other hand, I have noted in the text specific sections where your justification for the use of hydrologic features seems shaky and I have recommended that it be strengthened. The figures provided with the text appear to be well constructed overall. According to the instructions to authors from the journal, figures are to be placed on separate pages and it appears that a few of these might be combined on a single page. Overall, I would recommend that this paper be accepted by the journal following some minor clarifications in the discussion section and

consideration for additional information to justify the selection of control points. The information contained in the discussion section appears to be relevant but a little work can make it “mesh” a little better and clarify the main point of this study. Are you trying to emphasize the research findings on landuse change or the methods used to assess landuse change and the benefits of the approach you selected and tested?

- Clarify justification for use of control points, particularly the use of hydrologic features in forested areas given their dynamic nature
- Improve sentence structure in noted places in latter half of the paper, especially in the discussion section
- Attempt to place more emphasis on overall focus of this study and paper, either the presentation of landuse change data or methods used. If both, add supporting data and information.
- Take comfort in knowing you have come very close to having a publication worthy paper!

Review of: Quantifying seventy years of landuse change in the Winooski River Basin, Northern Vermont

First Author: William Hacket

This paper introduces a novel method for quantifying landuse change at a basin scale, and compares the results to other studies. The literature review tells a nice story of what human activity has occurred in the studied area over the last few centuries, and this human activity is directly linked to landuse change that is both expected and observed. The introduction of the paper discusses hydrological implications of landuse change, and states that random point sampling and manual classification are used to quantify landuse change. The study site is defined in terms of geology, topography, soil, and human landuse. The GIS analysis technique of sampling thirty 9 km^2 sites in the 2,704 km^2 basin (10% of the basin), and randomly selecting 9,000 points on the sites for manual classification is described: aerial photographs from 1937-1962 were analyzed to detect landuse change. The data and results section supply the percent of landuse cover that is present in 1937, 1962, and 2003. In 2003 the landuse was: 9% agricultural, 9% impervious, and 82% forested. The next section discusses the robustness of this method, and this section is still being developed. The Discussion section steps through the results of the landuse change analysis and interpretations are drawn, such as proximity to the interstate is probably related to change in landuse. Human cultural change is brought up, largely as anecdotal reasoning for landuse change. The landuse calculated for this study in 2003 is discussed as being similar to the state and New England average, but different from the national average. Implications of landuse change are brought up again, and carbon sequestration is an example differing from hydrology. The pros and cons of the study are stated at the end of the discussion, and a brief conclusion section sums up the important findings of the landuse change study.

I think this paper has an interesting subject matter, and both the results and the method of analysis are worthy of being published. By organizing the flow of some parts in the paper, I think the overall goal of the paper will be even clearer. So, first I think the goal should be stated a littler clearer because there are times in the paper when I am not sure if the results of the analysis or the method of analysis are the most important. I am pretty sure you are trying to do justice to both aspects, and I think the analysis of the data is clearly stressed throughout the paper. But, the robustness of the landuse analysis, focus of the paper, may be made clearer if it is brought up in the intro and discussion. I understand that the results are not complete for this section (5.0) yet, and that may be part of the reason for a limited discussion.

Overall, I think the figures are telling of how this analysis works. Figure 2 could use some numbering to represent what is being displayed in the histogram. All of the bar plots have a tough to distinguish transition between forest and cultivated landuses. Are tables 1 and 2 necessary (could they be supplementary data, not part of the paper)? Have you tried doing a simple scatter plot of any interesting changes that have occurred over the 80 years?

This paper should be accepted once all sections are complete and some minor changes have been made. Following are some specific suggestions:

- In the abstract I think the last sentence could be more specific about what other tests are compared.
- The introduction discusses hydrology implications, should other implications be introduced?
- The intro could use a sentence or two on your section 5.0, where you discuss the robustness of the analysis
- Have you looked into any simple categorical statistical techniques (eg. Chi-squared) that will help find significance that you discuss at the beginning of Discussion (page 10)?
- Again, at the end of your discussion (page 15) you could bring up the robustness of your analysis compared to other techniques.

I hope this review was helpful. Good luck.

Martin

Paper: 'Qualifying seventy years of land use change in the Winooski River Basin, northern Vermont' by William R. Hackett and Paul R. Bierman

Reviewer: Nikos Fytilis – 02/11/09

This paper's aim is to quantify land use change between 1937 and 2004 using random sampling and manual, point-based classification of aerial imagery. The results compared with other results form different methods and the conclusions for same areas were similar. The forested areas and the impervious lands in the Winooski River Basin over the past seventy years increased and the cultivated lands decreased. The distinction between uplands and lowlands part of the basin helped to support the differences in the land use. Finally, this technique has so many applications and it can be easily used for analysis of aerial imagery elsewhere.

In general, the paper is well-organized and it is written according the instructions of the journal. This is actually the first paper that I am totally familiar with the subject. The authors presented their project excellent so all the readers could understand the steps of the methods and the results. The whole structure of the paper helps the readers to follow the methodology exactly and reproduce it if it is necessary. The entire essential concepts explained very detailed and the figures helped to visualize more easily the results. The discussion part where historical references used is the best part of the paper. The additional historical information presented in this part is relevant to the subject and makes more valid your results. Although the discussion part is too lengthy, at the end I believe that the readers have all the necessary justifications to support your results.

The abstract is short but contains all the information needed and it can stand alone. I feel that the first sentence in the abstract is too straightforward. I believe that you can find an alternative way to start your abstract. In the introduction, I liked the last two paragraphs where you explain how you are using the older monochromatic images of variable quality to prove that the technique you are using is practical and accurate at the same time. I would like to point out that in the last paragraph of the introduction you use too many 'we' and I believe that you can use other similar phrases.

The next section was well written and has a good flow especially with the historical information presented in this part. As for the methods, I totally understand the procedure you followed to generate the sample locations but did you use another random point generation tool just to compare your results. Maybe you could add a figure showing the uplands and lowlands parts of the basin more clearly? Also, on page 7 at the top you mention that you used a second order transformation to achieve an average RMS error of ten pixels or less? Could you explain more how this second order transformation helped you (add a reference)? The results are well presented but the time periods used were too big and maybe some information about land use changes was lost.

The precision, accuracy, reproducibility and comparison to other techniques is an excellent way to show the limitations and the alterations of your method and which techniques can produce the same results as yours and why. The discussion sums up all the critical points of your research and provides details about your considerations about the results. Maybe it is not part of your project but you could include more classification categories.

The paper should be published with minor revisions and in my opinion you did a good job and I hope you have good luck with this paper.

Quantifying seventy years of land use change in the Winooski River Basin, northern Vermont

William Hackett & Paul Bierman

Review by Andrea Pearce, 11 February 2009

Land use is classified in 30 random sampling areas of the Winooski River Basin based on aerial imagery from 4 dates between 1937 and 2003. Within each of the 30 areas, 300 points are identified as one of four land use classes. This sampling is thought to be representative of the basin as a whole. Area of forested land and impervious land has increased over this time period as agricultural land area has decreased. Impervious increases are concentrated in growing, low-lying, urban and sub-urban areas and can have a significant impact on water quality. At the same time, reforesting cultivated land should improve some aspects of water quality.

The method proposed could be a valuable method for making use of historical images to document land-use change. The historical background and narrative about implication of the quantified changing land use patterns in Vermont reflect common sentiment about change in the region. And, I can imagine using this type of analysis to investigate need for stormwater infrastructure, etc. in urban areas and other uses in more rural areas. There seem to be two main goals of the paper, developing the method and describing the results of the application of the method to describe changes over time in Vermont. While these goals are related, I'm not sure weather or they belong in the same manuscript. They may, but require refining the structure to include adequate introduction (perhaps in different sub-sections) to both and reflecting both in the conclusions as well.

I recommend this manuscript be accepted with major revisions. Revisions should create more focus on the main point of the paper, and possibly further develop the QA/QC section intended to test the method. Specific comments follow:

- Introduction/Title – The title and introduction leave me with very different ideas about what to expect in this paper. The title suggests it is specifically about land use change in Vermont while the intro is very much focused on developing a method of detecting land use change from older aerial photos.
- Related to last comment – There are sections in the discussion (specifically Page 10, lines 17-20 and Page 14 bits from lines 1-11 and some from the end of pg. 13) where you introduce results of previous work in this area around New England. It's my opinion that the reader may benefit from a little of this background as well (depending on where the focus of the paper is – see comment above).
- Page 3, lines 15-21 – Clearly emphasizing the two major goals of the research – might be useful to reflect these both in the title.
- Page 5 lines 2-3 – This doesn't seem correct, or is unclear. A quick search on the web found many Vermont Towns incorporated in the 1800's.

- Page5 lines 21-page 6 line 1 – This sentence could be clearer. Which specific elements of land use data are normally distributed and what is the connection to 30 sampling locations?
- Page 8 lines 1-4. You discuss the pace of land use change. It might be illustrative if you report average rates of change between the dates of the specific photos if this is important.
- Pages 10, 11 and 12(lines 1-6) – The tone of these paragraphs reads as a presentation of results possibly more appropriate to a section specifically for results of for results and discussion. A combined results & discussion could be followed up by a section on 'interpretations from the landscape' or something like that for more of your inferential comments.
- Conclusions Page 16, line 5-15 again back to the first and second comment in this list, your conclusions seem mostly focused on the method you use, yet much of the discussion was focused on implications of Vermont specific land use changes.
- Tables – Should table 1 and 2 be 'supplemental data'? Is this much detail needed to make your point?

Eric Portenga
Writing Seminar
2/11/09

Hackett and Bierman Review

I thought this paper provided a very interesting look into the land-use history of the state of Vermont and produces easy-to-use methods for studying land-use in other locations as well. The methods use combine aerial photography spanning an age range of 80 years and manual classification of randomly selected points within the study area to track trends in land-use change over the years.

I really enjoyed the use of aerial photography in the manuscript and maybe would have liked to have seen more in terms of progression through time for a single site, rather than the overall before and after (1930-2003) images. I think this would go well with some discussion of a single site through each of the time steps.

The methods used to determine where the 30 random study sites would be seemed like the best way to go about picking sites; however I have concerns that the sites are not fully representative of total land-use trends in the basin. My main concern stems from the fact that in Figure 1, some of the site areas are very close together (e.g. the north-central part of the basin) whereas there are some wide areas where no data was taken which might affect the outcome since the empty areas are in the lowlands where most increases in development were seen. If some sites were in those lowland areas, it may even provide a higher similarity between your observations and what the percent changes were in reality. I know, however, that this is a caveat of a random sampling method. I think I would just be a little bit more interested if a larger portion of the drainage basin were covered by the study sites. This could be done by enlarging

the study site, say, to 4km x 4km. Even if the same number of points in the quadrats were observed (n=300), to me, the fact that they would cover a larger area might be more representative of actual changes in the drainage.

I think that with a little bit more defense of why the site-selection process was chosen this manuscript would be ready for publication with some minor edits regarding sentence structures, grammar/spelling inconsistencies, and touch-ups of some figures:

- The four categories of land-use are important, and I think they should be capitalized throughout the paper to be further emphasized. They should also be named consistently throughout the text and into the figures, as well. Some categories are referred to differently throughout the paper such as "Impervious" and "Impermeable" land and "Actively Cultivated/Vegetation Repressed" and "Agricultural/Repressed" land. I know these two cases mean the same thing, but they should be consistent
- Sets of years are given sometimes with apostrophes and sometimes without: 1800s and 1800's.
- Other consistency-issues have been mentioned in the edits on the manuscript.
- In terms of defending the site-selection process and overall outcome, I think use of statistics beyond changes in percentages of land-use would be useful; however, I know next to nothing about statistics, so I'm not quite sure what this would be.

Mark Isselhardt

Critical Writing (Geology 371)

2/11/09

Hackett, W. R. and Bierman, P. R. 2009 Quantifying seventy years of land use change in the Winooski River Basin, northern Vermont **for submission to the Journal of Environmental Management.**

The authors applied random point sampling and visual land use classification to aerial imagery of the Winooski River watershed. Three hundred points were randomly placed within each of thirty 9 km2 quadrats. The quadrats were randomly placed across the 2,704 km2 basin. The use of corrected historical images and a consistent application of point locations through time allowed the authors to quantify the extent and type of land use change in a selected northern Vermont watershed. The results of the technique appear to agree with stated historical estimates of and potential causes for changes in land use from the time period in question (~1937-2004 cultivated land decreased, forested land and impervious surfaces filled in as a result of field abandonment and development). The authors grouped the sample quadrats by elevation (lowland and upland) and found differences in land use change between elevations. The technique presented utilizes simple classification methods that could be adapted in other areas. The method also allows for the use of imagery that predates more modern satellite based imagery.

This paper presents an interesting approach to quantifying the pace and extent of land use changes over time. It is written clearly and with minimal grammatical mistakes. The key premise appears to be that historic aerial photos represent a record of times before satellite based imagery was available and therefore has the potential add depth to the understanding of landscape change. This paper should be published in JEM. There are some areas in the paper that could be amended to improve the overall strength of the work. First of all; how was the watershed decided on as the unit of interest (is it considered ideal)? Secondly, is a completely randomized sample the best way to measure a watershed? Would a stratified sample allow for a more intense sample of areas that likely have seen more change? If landuse and landuse change is not “spatially homogenious” then aren’t you potentially oversampling some areas that have low variability and undersampling areas of high variability? What was the reasoning of having three landuse classes (is this too course)? These issues could be clarified in the methods section. The introduction and study site sections together make a pretty weighty chunk of the manuscript. Consider trimming down the history text a bit by adding a timeline in with the other figures. Add a bit more on other accepted landuse quantification techniques and how this method is an improvement.

On the subject of figures; Figure 1 should include the Winooski river channel, major roads, a rough set of contour lines (500’ interval or so) as well as town and city centers. Figure 2 what are the units and values for these axis? The two historgrams considered equivalent? Figure 3, how about a few arrows and text showing how selected points were classified? Figure 4, what is the n value here? Is it the 30 quadrats? There should be some mention of the 1942 data in there. Figure 5, could you use one bar graph and two paired bars (one for upland and one for lowland) at each time step? Table 1; what is

the reader being asked to do with this information? Where are the photo ID's for 1942? Table 2; Some of these %'s don't add up to 100. Is it that the water classified points are excluded? Table 3; this would be a great place to include historical data (NASS, Vermont Ag Dept, Forest service) and see how they compare.

Here are some specific questions from the paper that would not fit in the margins. The line number might correspond to the actual line or the entire paragraph.

- P5L9 This extensive history section could be pared down with the addition of a time line.
- P7L5 Does sacrificing accuracy in the forested settings impact the other areas depicted in the photos?
- P7L8 Could there be a bit of justification here for choosing three landuse categories? Are they considered equal in weight?
- P7L18 Are urbanization and impermeable being treated as interchangeable?
- P8L6 What are the major underlying human or geomorphologic reasons for this? What influence does proximity to Lake Champlain play?
- P9L6 The difference in impermeable surface values within one analyst went from was 1% (from 7-6%). Isn't that a 15% error? With the test of different analysts it was 2% (4-6%). Isn't that 34% error?
- P10L8 What test was used for significance?
- P11L18 This is more of an observation rather than the results of a specific experiment to test land use change as it relates to Highway proximity. Could you also be seeing an influence of proximity to the Winooski River?
- P12L13 Using a term like trajectories makes a reader want to see a line graph or scatter plot for illustration.
- P13L9 This section does a nice job of tying the results to historical accounts of landuse change but it does not use any hard (or soft numbers) to back it up. Could this be a place for inserting rough numbers of acres in cultivation, number of active farms or miles of maintained roads from town and state records?
- P13L18 Most of the discussion has been on the watershed scale. What is gained by mentioning the regional and continental scale here? Would the sampling technique have to be changed dramatically to work at the other spatial scales?
- P15L17 Careful with the use of significant here. Make sure you are either stating the results of a defined test or observing a dramatic result.