*Reviewer: Amanda Holland*
*Carolyn Pucko manuscript "Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change"*

*Summary:*

This paper examines whether changes in vegetation composition over an elevation gradient are shifting as species communities or as individuals. They identified that the species of this montane environment are shifting as individuals and the species distribution changes can be explained by climate and anthropogenic changes (acid deposition) that are creating different temperature fluctuations, soil chemistry, and light availability.

*Evaluation:*

The abstract starts off the paper with a good briefing on the study itself and lays out the data to be examined. I would recommend restating the acid deposition tie; currently it is first mentioned in the abstract main conclusions and up until this point the broader topic was on discussing climate interactions. I would suggest a tie in earlier would be helpful even if it was not something that was considered for an initial driver of the system or to focus the first sentence of the conclusions on the climate interactions and then following with a statement on the non-climate environmental changes.

The material presented in the introduction sets-up the different aspects under consideration for the research starting with the two differing hypothesis in this field, describing the species community behavior to environmental conditions. From the introduction material, I did not get a good grip on what was meant by 'novel climate' in the third paragraph of the introduction, was this to convey that climate patterns have a complex nature? Perhaps it would help clarify this by describing what the components of climate are as mentioned on line 83 of text. The aims paragraph and following paragraphs on the montane environment and historic climate in region provide good justification for why this study will be able to add clarity to this subject. I would suggest removing the final paragraph of the introduction on the statistical methods, as it seems more appropriately placed in the methods section where you already give justification for the use of these statistics.

As mentioned above, the methods section gives a thorough discussion of the data used and methods taken for analysis. To further describe the chronosequence used for data analysis, I would include the years of analysis (1965, 1979, 1983, 1986, 2006) in this section. The first indication that multiple years were used in the analysis, other than the overall time period of 1965-2006, was on line 250 when stated "3 of the 5 years".

The results and discussion section is very smooth with the figure presentation and accompanying observations. The result of the 2006 species communities being more similar to the higher elevation of 1965 species was a pattern that was easily interpreted by use of the multipart figure and the text. The same can be said for figure 3 and its results. In the discussion of Figure 1 it would be a good to have a statistic that would accompany the interpretation of the low and high elevation climate records to say there is a significantly greater change in temperature at the lower elevations. Through visual interpretation the lower elevation seems to have a steeper slope but the variability around the lines seem similar for both elevations. For figures 4-6, I easily followed the results and discussion based on the optimal elevation or shift line but I had a harder time understanding this

relationship visually with the points displayed on these graphs. An added sentence in the figure captions that clarifies how to interpret these would be helpful.

In relation to Table 1, I could see the pattern that understory are moving at a different rate than the overstory by looking at the final time period for both variables. This relates back to what was described in the study site section, the overstory species are made up of certain communities and likely will change at a rate slower than the understory. However, the variability in the understory shifts in the table are not mentioned. The understory shift between 1965-1986 is almost 20m higher than the compared time periods before and after, is there an explanation for what was occurring at this time? I think it would have better presentation at the end of the discussion to give a statement on the variability of the data in Table 1 if you are going to be presenting all the intermediate time periods.

*Status of paper & recommendations:*

I recommend this paper be accepted by the journal 'Diversity and Distributions' as it describes the multiplicative nature of individual and community distribution and relevant site interactions (in this case both climate and anthropogenic) that were influencing factors.

- Would recommend a reorganization of the introduction paragraphs to start with the paragraph on the accepted hypotheses, followed by the climate and model paragraphs. This would shift the aims to come after this more introductory material followed by a paragraph that combines the montane environment and historic climate material. I think some of material in these last two paragraphs could be moved to the site description section as it is directly following and the information is site/region specific.
    - I think these changes would create a stronger focus in the beginning describing what the current literature says and then how your research compliments and adds to the field by ending with the study aims and justification of why the study site will provide clarification of these concepts.

*Edits for compliance with Journal:*

This paper conforms to the majority of the intended journal's format. I would check before submission of paper that the figures match the desired format with labeling multi part figures with a, b, c, etc and color specifications. Would also look into the preference for order of citations listed in text, should citations in the text be listed alphabetical or chronological as I think this order is interchanged in the manuscript (example lines 59-61 of introduction).

Joe Bartlett

2/3/09

**Pucko and Beckage critical review**

This study examined whether the montane understory plant communities present on Camel's Hump were responding to climate warming with a individualistic or a community shift. Historic data shows that temperatures have increased over the past 40 years and as a result, overstory and understory vegetation are moving upslope. This study found greater shifts at higher elevations where temperature increases were present, but less pronounced than at lower elevation. A varied response between different individual species was identified through the use of Bayesian modeling. They also determined that understory vegetation is moving upslope faster than overstory vegetation. These findings have important implications for predicting the composition of forests in a warming environment

This paper is well written and is successful in describing the study and conveying the results and conclusions. This is important since relatively complex statistical analyses and modeling methods were used. This paper is not quite at the final draft stage and as such there are some minor tense, grammar, sentence structure, and wording issues. There are also a few sentences with language better suited for a proposal than a report; we will do this…etc. The abstract is good considering the strange format required for submission. The introduction contains a very thorough literature review and provides a good background for the study. The purpose statement is a bit awkward and should possibly be moved to the end of the introduction instead of breaking up the literature review section. The paragraph on the historical dataset is also somewhat out of place and might be better incorporated into the study site section. The field methods section does a decent job describing a rather complex sampling design; a rough drawing of the sampling design may be very helpful. The NMDS and Bayesian modeling methods are well written and fairly clear given my lack of experience with these methods. The results and discussion section may benefit from an opening paragraph that gives an overview of the results before diving into major conclusions. Also, an appendix of summarized field data would be a good addition. The discussion on high elevation red spruce die-off may warrant a mention on how this may affect the NMDS analysis. The conclusion section is very good.

Specific recommendations for changes are as follows:

L57 Consider splitting this into a paragraph for each hypothesis

L57 Consider adding a real world example of the 2 types of shifts from the literature.

L71 Too many "if" statements, try stating your hypothesis with stronger language

L71 Purpose statement is a bit awkward: The goal of this study is to test the differing hypotheses of species or community shifts in response to climate warming by examining the understory community…

L110 this paragraph needs to go with the study site section

Throughout, much of the language is written as if a proposal – we will do this

L141 Mention the avg temp/precip for mt Mansfield instead of just BTV

Throughout watch tense

L174 sampling design is confusing, consider adding a drawing of the sampling plot layout

L201 Do you need to comment on potential effects of historic destructive sampling?

L262 Start the R&D section with some results before going straight to major conclusions

L274 awkward but important paragraph, consider rewording

L280 can you infer “significance” from NMDS?

L285 Move the acid rain sentence up to here to make the paragraph flow better

L310 How much does this documented red spruce decline affect your NMDS? Could you consider dropping it from the analysis?

Would like to see more discussion on the problems encountered with such a long term dataset – more info on destructive sampling etc.

L657 Excellent figure captions

This article meets all of the guidelines for a biodiversity research and reviews article and should be accepted with moderate revisions to the Diversity and Distributions Journal.

Lee Corbett
GEOL 371
2/4/09

**Review of**: Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change
**Authors:** C. Pucko and B. Beckage

In this manuscript, the authors present the findings of a long-term vegetation study on Camels Hump in Vermont. The study focuses on understory vegetation plots along an altitudinal transect that were first created in 1965. The authors attempt to quantify the amount of vegetation shift (both in terms of communities and individual species) that has occurred over the past 40 years as a result of warming temperatures.

Overall, the manuscript is well written, clear, and organized in a logical fashion. Although the research is far out of my field, I had an easy time understanding most of the material because the authors' writing was very accessible. It seems as though this research is filling a much-needed void in the current literature and will help to clarify how understory vegetation communities change and migrate as a result of evolving climate. These results will be important in modeling and predicting future impacts of climate change.

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

1.) Your introduction is well-written and strong. Unfortunately, the last paragraph is more methods-related and you lose some of that momentum you worked so hard to build up. Is it possible to move some/all of this material to the methods section? Ending the introduction with your second to last paragraph would be more powerful.

2.) In your methods section, you do a good job describing the field methods used to collect species data. This might be an ignorant question, due to the fact that I know nothing about living things, but I was wondering whether you should address the accuracy of your data. Were the people doing the plant identification experts in the field? How easy is it to misidentify a species? Were there any quality checks or quality control measures taken? Was all of the identification conducted in a similar fashion?

3.) I liked the statistical modeling you conducted to study community shift and I think you described it well. However, I was a little put off by the last sentence in the community shift section. Couldn't there be numerous environmental variables that would contribute to a unified direction of community shift? I think your paper would be greatly strengthened if you could make a better linkage between the shift you observed and climate. Is there any additional data you could use to rule out other possibilities or to demonstrate that climate is the most likely cause? Or are there any other manuscripts you could cite that have similar findings? If not, it might not be appropriate to have "Climate Change" in your title if you're not reasonably certain that it is the key controlling factor for community and species migration.

4.) I was a little bit confused about how you attempted to differentiate between community shift and species shift. You mention using a model that finds the ideal elevation for each species and then comparing this ideal with the data you gathered throughout the study. How was the ideal elevation for each species determined? How do you know the accuracy of this method? The analysis you do here, and your conclusion that species are moving independently, is quite clever. It would be helpful to strengthen it with more information regarding how the ideal elevations were determined.

Good luck with edits and publication. Well done!

Lee Corbett
abcorbet@uvm.edu

**Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change**

**Review by Christina Syrrakou**
**02/04/09**

The manuscript presented studies the movement of species in a single understory community due to changes in their environment and aims at determining whether those species respond individualistically or similarly, as intact units. The area under study is located in Camels Hump in the Green Mountains of Vermont, USA. For the process of the data the writers used statistical methods and modeling and finally concluded that for the specific case, species seem to respond as individuals.

Generally, the text presented is very well written and in formal language, which gives a serious tone and shows that the writers have devoted a lot of time for both the text as well as the research part of this paper. Also, the manuscript contains a significant amount of technical terms, which indicates that it mostly addresses people with a background in ecology and not so much a broader audience. The paper contains a big amount of info and data and the results are carefully explained and in a logical way try to show to the reader the analysis of the thoughts of the writer. However, I have to admit, that taking into consideration my lack of background on this matter, it was a difficult and at some points tiring text to follow but as I mentioned earlier it seems a serious work and I believe that after some revisions it should be published.

- First of all, the first two paragraphs of the introduction are well written helping the reader get a general idea on the subject and the aim of the specific study. However, I think that the third paragraph (lines 81-90) would fit better at some point earlier, since it seems to be explaining more what was generally said at the beginning about climatic changes and their importance, and not so much after the aim of the study mentioned in the previous paragraph (lines 71-80).

- At the final part of the introduction, it seems that some general information about the site is mentioned, as for example temperature and also the various reasons that the specific site was selected. Perhaps, this info could fit better at the "Study Site" section.

- As a reader, I would like to see a map showing the location of Camels Hump as well as the various locations where data were collected. Also, although in lines 146-155 you define the kind of forest types that occupy the area I was a bit confused on what type of understory species existed at the specific locations that measurements were taken. Maybe a kind of map showing those locations could also help in this matter.

- The numbering of the different sections was not very clear. For example was the "Study Site" included in the introduction or was it a different part? Both have the letter A.

- The text contains a lot of jargon which makes it difficult to understand for a non-expert in this domain. For example what is the nested plot design (line 167), the vegetations survey plots (line 156), the dbh (line 178), the boreal/deciduous ecotone (line 284) etc. Could there be a small section or perhaps a table explaining basic terms?

- At page 10, lines 238-245, perhaps you could explain a bit more some terms except the parameter estimates.

- The conclusions seemed to be missing some points mentioned earlier in the discussion. For example, the importance of the overstory to the understory's shift as well as the anthropogenic disturbances that may have affected the movement of the species.

- In figure 2, I think that some use of arrows like the ones used in figure 3 could be very helpful. Also, although the figure captions are explained in another page some kind of legend on the plots could help visually the reader. For example you could add the years on figure 2 or what the axis mean in figure 4 and 5. Also, the letter notation is missing from figure 4.

Generally, as I mentioned previously it is obvious that there is a lot of work behind this paper and in my opinion some clarifications and adjustments could make this paper easier to read and would be very helpful for the readers.

Review of

**Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change**

This paper looks at how vegetation has changed on Camel's Hump since 1964. Two main hypotheses are laid out; one saying that as climate changes each plant type will react differently to the changes, the other saying that communities of plants will all move together during changes. These hypotheses were tested by laying out plots on the mountain and checking what types of plants were in each of the plots over time. After full analysis, it is obvious that there has been a large shift in the plant populations since 1964. In addition, it is clear that the plant types are moving up the mountain individually instead of communities moving together.

This was a very good paper and for the most part easy to read for someone who knows very little about the subject. The data seems to be very good; the only thing that bothers me is that the plots had to be moved after 1964 because of destructive sampling. Your interpretations make sense given what you observed and really are what I expected from the beginning when reading the paper. The writing for the most part is very clear but sometimes it was hard for me to follow simply because I do not have the necessary background in this field. The graphics seem to be fine but again are difficult for me to interpret given that I have little background in this field.

I believe the paper should be accepted with minor revisions. I think this paper presents very important information for the world at large so that we can better understand how vegetation will change as climate continues to change. The revisions below, except for #1 and 2, are based on my on ignorance and ideas for expanding the paper to a wider audience.

1. I believe you should fully explain why you could still use the data from 1964 given the destructive sampling. Some might think it would be best to start with the 1979 data.
2. I think you need to add a figure with a map showing where the sampling site is.
3. I would like to see a better explanation of what NMDS is.
4. I think a reduction for abbreviations could help the paper to be easier to read.
5. I think better explanations of the figures could help specifically completely describe what each axis is and what it means.

From what I can tell this paper follows the requirements, my only concern would be the style of the abstract not fitting what I normally see and having subsections.

**Charles Trodick**

Eric Portenga
Writing Seminar
February 4, 2009

# Pucko and Beckage Review

This study is a continuation of the long-range observations of ecological variations in plant diversity on Camels Hump in the Green Mountains. It focuses on two competing hypotheses of species migration as a result of warming climates and whether species shift geographic locations individually or as a community. Plant communities are observed to be dissolving as individual species shift in elevation, both up and down the mountain, resulting in new species communities hitherto unseen in this area.

I think the data presented in this paper and interpretations taken from physical and statistical observations provide strong support of the authors' conclusions. Though I am not familiar with the analyses used, I was able to understand the authors' intentions by means of the visuals provided in the figures with time.

This paper furthers the observations of the floral diversity of Camels Hump and challenges hypotheses of how these communities are changing through time with respect to changes in climate through time. Since the same site has been carefully studied for over 40 years, I would deem this paper publishable with some revisions:

- Introductory phrases such as "However," "In other words," "In as much as," and "If..." are overused and detract from the strength and forwardness of the ideas being presented.
- Some sentences include a lot of different ideas that might be easier to follow if split into simpler phrases.

I thought the synthesis of the Results and Discussion sections worked to the authors' benefit because so many observations were taken and analyzed, it was easier to follow with the interpretations accompanying the observations. I think there would be a lot of flipping back and forth between the two sections if they were split. The flow from observation to interpretation is smooth and the transitions between different observation-interpretation sets are well set-up.

Paper Title: **Using long-term ecological data to identify altitudinal shifts of species and communities in response to recent climate change**
Paper Authors: C. Pucko and B. Beckage

Reviewer: **Lance E. Besaw**
Date: 2/4/09

**Summary**
The authors investigate the temporal and spatial changes in understory communities as a response to climate change and acid deposition. They use vegetation survey data gathered from 1964-2006 from Camels Hump, VT to look at overstory and understory community changes (both direction and magnitude). They found climate change and acid deposition impacts to be major drivers of species composition change at their study site. They found that species are shifting independently in elevation direction and magnitude which suggests they are not moving as units.

**Evaluation**
The data collection seems very sound. The presence of permanent plots is very important in this study as it reduces the possibility of data non-stationarity. Also important is the utilization of non-destructive sampling techniques.

As someone unfamiliar with the field of study, I found the Methods sections to be difficult to follow conceptually. Many of the paragraphs do not clearly state their purpose, especially sections "Species data" and "NMDS". The authors' interpretation and explanations of their findings seem defensible. I have no background or experience that allows me to contend with any of their arguments. Overall, the figures do a good job relaying the authors' findings and interpretations to the reader. Captions are informative and provide adequate description of the displayed concepts.

**Recommendation**
Overall, I think the manuscript's contribution is significant. I recommend the manuscript be accepted with minor revisions; those being corrections to increase the read- and understandability of the paper. The manuscript provides great insight to the ecological migration of over- and understory species.

**Specific Comments**
The introduction does a good job of reviewing the literature and framing the importance of the paper's contribution.

Several run-on sentences exist in the document and should be separated to increase read- and understandability.

Many paragraphs do not start with "topic sentences" which make the paper difficult to read. I would suggest restructure many of the paragraphs and starting them with topic sentences to highlight the important information contained within them.

Luke Reusser
GEOL 371
Feb 4th, 2009

Review of:
Pucko, C., and Beckage, B., **Using long-term ecological data to identify altitudinal shifts of species and communities in response to recent climate change.**

Planned submission to:
Diversity and Distributions.

In this manuscript, the authors report their findings from a long-term ecological study of plant and tree community and species shifts from 1965 to 2006 in the montane environment within Camels Hump State Park. The over-arching aims of the study are to determine 1) how plant species and communities shift in elevation in response to anthropogenic climate change, and 2) whether individual species within communities respond similarly, or individualistically to changing climate over the period of study. With the aid of non-metric multidimensional scaling (NMDS) and Bayesian models, the researches determined that 1) between 1965 and 2006, understory communities have become more homogenous and low elevation communities have shifted to higher elevations, 2) while some species have shifted upslope, others have remained relatively stationary, and several have actually shifted downslope, and, 3) the average elevational shift of understory species is almost double that of canopy species indicating that understory species shifts can not be attributed solely to soil chemistry and light availability determined by canopy conditions. Their findings suggest that plant communities are currently undergoing a reshuffling of species in response to warming climate that may have implications for competitive interactions and ecosystem function. Further, their study demonstrates the importance of incorporating individual species analysis into models of large-scale community dynamics in order to maintain biological accuracy.

Overall, this manuscript is well written and clearly organized. Understanding how plant communities have and will continue to respond to climate change is imperative in today's world, and this study offers intriguing findings for northern mountainous regions. This manuscript should definitely be published with revisions, and perhaps some reorganization.

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

Abstract:
Will the abstract be restructured into paragraph form, or will it remain in outline form as it stands right now. I looked through the guides to authors thinking that this form was required by the journal, but couldn't find any abstract specific instructions.

Introductions:

1. The intro lays out well the importance of this study and your specific hypotheses. However, at present it seems somewhat long. I would suggest

narrowing in on the big ideas you are going after and stripping out some of the other stuff. Refer to the manuscript for detailed comments.

2. An interesting notion you bring up in your conclusions is that large-scale models today take a community approach, and in doing so, they may not be completely biologically accurate. This is a really important finding, and I think it is worth stating it more directly in the intro. Maybe somewhere in the later part of the first paragraph.
3. This probably isn't really important, but it kept popping up for me. When you discuss the two dominant ways researchers think about community vs. species shifts, you refer to them as "hypotheses." I read them more as theories, but maybe this is semantics.
4. The first sentence of the last paragraph on page three is really long. I had to read it several times to pull out what you were getting at. May be better to split it up, or lead with the ending clause "It is increasingly important…" so folks know right up from what you are trying to get across.
5. The second paragraph on pg 4 (starts at ln 103) doesn't seem to logically follow the preceding ones. Maybe consider folding this paragraph and the next into the study site section.

Study Site:

Reads pretty well as is. Provides all the pertinent details. As a geologist, the first thing I want to see in a paper about a specific place is a location map. And perhaps even a picture showing typical flora in a montane environment.

Methods:

1. (Field) Again, being a visual person, I wanted to see some sort of schematic figure depicting the plot layout you describe in this section. Maybe have plot boxes overlying a topo map of camels hump.
2. (Species) Just want to make sure I understand this. For each of the quadrants with six understory sub-plot, you did a separate survey in each sub-plot, and then averaged the result to get one percent cover for the whole quadrant right? Also, how variable were these estimates? Did you propagate these errors through further analysis?
3. (Statistical) For the NMDS, on page 9 you state that the technique shifts point the cluster more similar points. Does this artificially increase the difference between things? Just seems a little fishy to me, but I really don't have much multivariate statistical background. Did you try doing a PCA? Why did you choose the NMDS over PCA?
4. (Statistical) Exactly what information was included in the NMDS analysis?
5. (Statistical) On line 229 on pg 9, you state that estimates were based on average basal area per plot. Is this based on you dbh measurements?
6. (Statistical) Line 254 page 10….what is a "mast" year?

Result and Discussion:

I like how you have written these as one section separated by major findings instead of results vs. discussion. I think it works well given the information you are trying to convey.

1. (Community) The wording in the first paragraph of this section is a little difficult to follow. Particularly lines 266 and 267. What I get from the looking at figure 2 is that 1) communities are much more homogenous today than in the past, and 2) communities at higher elevations today look more similar to those at lower elevations, i.e. communities are shifting upslope. I think it is just an issue of sentence structure, unless I am totally misunderstanding something.
2. (Community) I know in PCA, each Principal Component is a combination of several variables that are usually listed. Is it the same for NMDS? Can you list the variable that each axis is composed of?
3. (Community) I found myself wondering a lot about error while looking at figure 2. How is error handled in NMDS? Also, how did you account for whatever errors were associated with the averaged quadrant sub-plot data?
4. (Community) On page 13, lines 301 and 302…you have an empty reference. I definitely think some citations would strengthen this claim.
5. (Species) I had another question about error here. Figure 4 is missing axes labels, so I'm note exactly sure what I am looking at, but my wonderment is whether or not these shifts are significant. Is there anyway to denote the amount of error in this analysis?
6. (Species) I found the finding that understory shifts were twice as fast as overstory to be really interesting. I think you could even go into a little more detail about this in the discussion. One question I had pertains to the table…it seems like there was a reverse in the overall amount of shift between 1965 and 2006, yet there is no mention of this in the text. It got me wondering what your thoughts are on this.

Conclusions:

1. Can you provide any specific examples of competitive interactions with regard to the species you encountered on camels hump? Are there species that occupy similar ecological niches that are now shifting into places where they will compete?
2. I think the last sentence of your conclusions is very powerful, and as I stated earlier, I think you should draw attention to this in the introduction. Your findings suggest that it probably isn't that kosher to ignore individual species dynamics when modeling large-scale vegetation communities.
3. How applicable do you think your findings are to other montane environments?

Figures and Tables:

I think including a location map would be very beneficial considering that this paper is site specific.

In addition, again because I am a visual sort of guy, a simple picture of typical green mountain forest and understory could help in setting the context. Could be a sub-panel in a location map figure.

Figure 1: You could perhaps include the regression models in these figures, and maybe overlay the temp increase for both Burlington and Mansfield.

Figure 2: I like this figure a lot. Clean, easy to understand. The only thing I would suggest would be to include the component variables of each axis in the caption.

Figure 3: Another nice figure. Can you remove the text overlying most of the plots? If it is important, define it in the caption.

Figure 4: This one is a little confusion. Above all, you should include axes labels. I assume Y is frequency percent, but I can't tell what X is. At first I thought it was elevations, but seeing as camels hump summit is 1244 m, this can't be so. Is it elevation in feet? If so, need to make it meters and label. Also, there is the issue of error here. Which of these shifts are actually statistically significant and which are noise?

Figure 5 and 6: These also need x-axis labels. You state meters in the captions, but good to include on the plots themselves too.

Table 1: For the understories, why does the trend reverse between 1986 and 2006? Also, do you have data for more overstory time steps?

Nice paper! Good luck with edits and getting it out the door.

Luke

Meredith Clayton
4 February, 2009

Review #4: Using Long-Term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change

This article presents the results of over 40 years of ecological data collection on Camels Hump, located in the Green Mountains of Vermont. More specifically, the purpose of the study presented in the article was to determine whether montane understory plant communities have shifted as intact units, or whether species are responding individually to documented changes in climate over the study period (1964-2006). Data was collected through repeated vegetation surveys completed during this period and were analyzed through non-metric multidimensional scaling (NMDS) and simple Bayesian models. The results of the study illustrate an overall increase in homogenization of species composition with varying amounts of change in composition across elevations. The greatest amount of change is occurring in the highest elevations and lower elevations are exhibiting the least amount of change. Bayesian models indicate shifts in the optimal elevations of individual species in terms of magnitude and direction through a wide range of migration patterns. While some species appear to be moving upslope, others are shifting their optimal elevation downslope. The average increase in the elevational optimum of understory species was nearly twice that of overstory species during the same time period, suggesting that shifts in understory vegetation are independent of overstory elevational shift. Overall, examination of spatial and temporal trends in understory communities indicate that climate change and acid deposition are major drivers of change in species composition in the Green Mountains since 1964; however, study results for individual species suggest that past communities are not moving as intact units, but are responding to climate change individually.

Overall, I believe that this is a well written paper that presents important ecological data in a relatively clear manor. I would recommend that this paper is accepted by the journal following the consideration of a few minor revisions. As a whole, the clarity of the writing is good; however, revision of a few run-on sentences noted in the text is recommended. The introduction is rather lengthy but provides a detailed description of the study site, justification for such a study, and background information surrounding the development of hypotheses for this study. This section contains valuable information for a reader, particularly one who might be unfamiliar with the Green Mountains, but I recommend re-organizing it slightly to remain effective but more concise. The only other issue pertaining to writing clarity that I noted was with the results and discussion section under the community shift heading. This section states that there has been a downward shift of communities but then states a few sentences later that there is an upward migratory pattern. I may be interpreting this section incorrectly, but as it is worded currently it appears to be unclear. In addition, I would suggest consideration for how much reference is made to the impacts of acid deposition on these shifts. The abstract mentions acid deposition as a major factor; however, there is very little supporting evidence provided in the article. It may be relevant to note this factor but without supporting data in the article I believe you should consider eliminating it from the abstract.

The data appears to be of good quality and the logic of the interpretations is clear. It is difficult for me to assess the quality of NMDS data in detail, as I have almost no experience with it. My initial reaction to the data exclusions described in the article was concern; however, justification for the exclusions seems reasonable. On the other hand, there was no explanation for the use of average basal area in overstory plots rather than the use of species frequency as seen in the understory plots. I can assume that this was used in an attempt to highlight the presence of new/younger trees but clarification of this choice in the text is recommended. Illustrations provided with this manuscript appear to clearly demonstrate the results described in the article. The caption to Figure 2 is lacking a reference to chart b and this should be added prior to submission. In general, this is a good paper and it is close to being ready for submission. There has obviously been a lot of effort and hard work put into this piece and it shows.

- Revise introduction to make more concise
- Improve clarity of explanations of community shifts in results and discussion section
- Revise run-on sentences noted in the PDF
- Provide explanation for exclusion of frequency test for trees and substitution of average basal area
- Revise caption for Figure 2 to include reference to chart b
- Consider reference to acid rain in abstract. You touch on this very little in the article. Your focus here seems to be climate related shifts

Review of: Using long-term ecological data to identify altitudinal shifts of species and communities in response to recent climate change

Main author: Carolyn Pucko

This paper approaches a complex phenomena, the shift of species and communities, and uses a long-term case study to provide conclusions. Data on species composition, collected from plots at different elevations on Camel's Hump in VT, were analyzed temporally to determine any noticeable shifts in species. This case study is used to answer part of a more global question: are shifts in species occurring individualistically or are they occurring as species communities? Furthermore, are these shifts creating novel communities due to anthropogenic climate affects? Statistical tests were performed on the data to detect changes that occurred to both overstory and understory plant communities from 1964 to 2006. The analysis showed that overall, species were migrating to higher elevations, but the rate of shift was greater at the higher elevations. Another important aspect of the analysis was that individual species were considered to be moving differently from their normal communities. The idea that novel communities are forming raises concern for conservationists, and this idea confirms that individual species should be used for modeling future vegetation.

This paper seems like it will be a great asset towards this area of research, and with some minor revisions this paper should be accepted. Describing the changes in multiple parameters over time is not a simple task, and the analysis in this paper deciphers important shifts in species over time. I am not an expert in plant biology but I can see the value of this research because the introduction and conclusion draw evidence that these possibly detrimental changes are due to climate change.

The paper was laid out logically, and the literature review in the introduction provides a good perspective on this field of research. The study location is described well; it is established in the intro and then described in detail in the Study Site section. A visual representation of the study site could be a good addition. The NMDS figures in the manuscript are informative, but the most important aspects of these plots might be able to be displayed more simply (is there anyway to put some of this in a table). Maybe you could display one or two representative plots from figures 2 and 3. The general trend from one plot can be described as being similar to the trend in the other plots. Make sure that legends in the figures are separated and brought to the end of the manuscript, per author instructions. Following are some more suggestions I came up with:

- 'we' is used many time on page 3. You could probably get rid of the 'we's altogether, because I do not think there are many other 'we's in the paper. If you use 'we' at least make sure it is used consistently (eg. Either your group, or the scientific community).
- Page 5 you have a paragraph on statistical methods in the introduction: this last paragraph could be condensed to a sentence because most of the content in that paragraph is mentioned in the Statistical Analysis section.
- In the Field Methods section (page 7) you describe the experimental setup well in words, but a diagram showing what a sampling plot looks like (and maybe where the plots are laid out on Mt.

Mansfield) could be beneficial. Having a contour map could help with displaying the elevations you are describing.

- The equations on page 10 could be simplified, because currently there are a lot of components (constants and variables) that are not described in the text. Could you maybe reference a statistical text with this analysis described?

Good luck with the editing,

Martin

Paper: 'Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change' by Carolyn Pucko

Reviewer: Nikos Fytilis – 02/03/09

This paper's goal is to determine the magnitude and direction of change in understory plant communities located in Camels Hump in the Green Mountains of Vermont due to the documented changes in climate over the past 40 years. The authors try to find patterns in order to define whether species are responding individualistically or as intact units. The statistical methods and models used in the paper presented (NMDS, Bayesian model) include both overstory and understory plant communities. The results indicate spatial and temporal trends of change in species compositions closely related to climate and acid deposition but at the same time the magnitude and direction of elevational change indicate that species are moving as individuals.

The abstract is well organized. It gives a great overview of the whole paper. Although you mentioned during the previous class that this is not the final format of your paper – especially the results/conclusion section, I think that you need to check the numbering of the sections. Also, I found the introduction too big and I believe is a good idea to split it in half (introduction, assumptions, related to study site??). One other point I would like to mention is that in page 4 where you give the temperature raise since 1963(last paragraph), if I understood Figure, the range of the values should be higher. I particularly loved the way you present the data collected and the related references in this section especially if we consider the amount of the information. The audience of the journal will follow the logical way you presented your thoughts and assumptions.

In the section where you describe the study cite, I don't know if it will be helpful to add more data from other environmental parameters such as moisture, hours of sunshine per day and others. In the second paragraph where you describe the occupancy of the area, a map of the area and the major forest types would provide a better overview of the area. The same thing could be applied in the field methods section. A map made by using appropriate software could show the nested plots. The use of many acronyms was a problem for me but the readers of this journal will be experts so it is up to you if you want to add a glossary at the beginning of the paper. Also, in page 7 you can specify where the remaining 113 species belong to and what method you used to count the stem. At the next section you could explain more the parameters and variables used in each model (understory and overstory). Additionally, I would like to ask you how you come up with the 48 species you mention in the top of page 11. It was very good the part where you point out the reasons you select NMDS and especially the comparison with the PCA.

Again, as you said in the class you need to re-organize the last section with the results, the future steps and the discussion. In this part of your paper you use two acronyms which I couldn't understand what acronym BDF stands for. Maybe, you can create another table with the species you are referring to in lines 325-327. As for the figures, could you show bigger the arrows in Figure 3a, b, c? In Figure 4 I think that you have to put the letters in each Figure since you mention them in the conclusion even though you explain them perfectly at the end of your paper. Finally, in Figure 5 and 6 I couldn't found what y axis stand for.

General, I believe the paper is perfect and the whole project is very interesting. With some revisions, the paper should be accepted and published. Good luck and congratulations for your excellent work.

February 4, 2009
J. Nunery response to Pucko and Beckage

**Using long-term ecological data to identify altitudinal shifts of species and communities in response to recent climate change**

Climate change may be affecting plant communities in the Green Mountains of Vermont. Trends in elevational migration were noted in species throughout the study area. However, despite the over-arching unidirectional trends, a closer look at individual species migration showed that plant communities are not migrating as intact units. This study showed the importance of individual species modeling in more accurately projecting species and community response to climate change.

Results from this paper are a valuable contribution to our understanding of plant response to climate change at both the individual species and plant community level. This paper will inform future work attempting to model species range shift, and plant community response to a changing climate. However, the paper would benefit from several stylistic changes that may help the overall message be more clearly stated. In general, shorter and more concise sentence structure would help with the flow of the paper (see comments on pdf). Also, use of the active voice will help strengthen the paper, and aid the author in clearly stating their point.

The introduction provides a thorough overview of the issue at hand, study site, and basic methodologies. However, it begins to lose focus towards the end. Around the last paragraph on page 4, information that is more relevant to the methods section is given in this section. By separating details of site history and statistical analysis from the introduction section you might be able to maintain a more clear and concise introduction that frames the issue at hand.

More broadly speaking, the addressing several other factors that may affect understory species composition would strengthen this paper. In addition to possible explanations of species compositional changes over the last 40 years given in the paper (acid deposition), a review of successional and stand developmental dynamics would be helpful. Species composition and community assemblages change throughout stand development. This should be recognized, and it should be justified that the results seen in this study are not a result of successional or stand developmental dynamics.

*Specific comments*

L51: This citation makes it look like IPCC states that mechanisms of species shift is a fundamental objective of ecology, in addition to anthropogenic climate change, is this accurate?

L83-84: I am not clear as to exactly what you are talking about here. What components specifically are you addressing?
L87: geographic or elevational? Are you measuring elevational gradients and using this to make inferences on geographic range shifts (can you assume that the two are equivalent)?
L110: This phrasing implies that there is a gap of surveys between 1965 and 2006, be specific as to the exact years your data covers. Are they annual surveys, decadal, etc.?
L114: What is the temporal range associated with this temperature increase, is it 1965-2008?
L154: Is Mountain paper birch *Betula cordifolia* or *Betula papyrifera* var. *cordifolia*
L162: How much is "some". Readers who are familiar with the northeast history of the selective logging of red spruce will question the use of "some". The more specific you can be the better.
L164: How close to the outside of the research area did logging occur. Edge effects may influence understory vegetation, especially if invasive species are an issue, which they probably are not in this area.
L171: Instead of using "up" what about "on an elevational gradient along"
L178: Spell out greater
L181: What was the size of the PVC frame?
L183: Did you separate shrubs and seedlings? This might be very important, and should be specifically stated.
L195: Specify that data was aggregated by genus.
First paragraph page 9: Try to use the active voice at least intermittently to avoid excessive use of the passive voice.
L230: Are these two different things or are you defining optimum elevation? The use of "or" implies that they are different.
L273: Is the homogenization occurring as a result of the temporal scope of your project. Perhaps you are seeing the beginning of species movement, and overtime the lower elevation species composition may alter as latitudinal range expansion catches up with elevational range expansion.
L277: Do you expect or did you hypothesize; expecting implies a sense of subjectivity in your research, while hypothesize maintains objectivity.
L282: Can you make inferences about disproportional rates of species migration between latitudinal and elevational migratory rates.
L310: Was this loss entirely from acid deposition or also from selective logging at mid elevations?
L337: This would be a good place to link in succession and stand development - as these are two important factors in understory community changes that should be addressed.

Table 1: What happened between 1983 and 1986 to affect the means so drastically? Why these year breaks? You should justify why you chose these breaks in the table description.

Mark Isselhardt

Critical Writing (Geology 371)

2/4/09

Pucko, C and Beckage, B. 2009 Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change **for submission to the Journal of Conservation Biogeography.**

The authors examine the impacts of recent climate change on montane forest understory communities and individual species. One particular focus is distinguishing if and how communities have shifted in the 40 years since data was first collected. Another focus is the way in which species are responding; individualistically or as established groups. The results are of broad relevance to predictions of future climate impacts. This paper uses sophisticated data analysis in an attempt to answer these questions. The result of the analysis indicates that the understory communities have changed not as complete units but more individualistically.

This paper is written clearly, presents original and compelling results and deserves publication. That being said, the paper could benefit from a few minor changes in grammar (see annotated version for mostly stylistic suggestions) and a few additions to the methods and discussion. The ample introduction supplies background information to support the study's hypothesis. The introduction also brought up the issue of individual species life history traits. It is suggested that certain species may be more reactive then others to a changing climate. It would be helpful to include some information about the sites understory species diversity. Reporting some measure of diversity would help the reader get a handle on the community's composition along the elevation gradient being discussed. The interpretation of the results is combined with the discussion in an effective way. Figure 1 is used to illustrate the change in air temperature at two elevations over the last 40 years. I think this data might be more clearly presented as a table with distinct mean temperatures for each site as well as a calculated change in mean temp. The results of NMDS and simple Bayesian models demand careful interpretation. I assume the readership of **JCB** is familiar with these tools but to unfamiliar eyes, understanding these techniques and the subsequent data is challenging. The methods section could include a generalized illustration that shows common rules to interpreting a NMDS graph and/or the plots of Bayesian models. Figure 4 seems to show a lot of variation in how specific species react to the changing climate. Could there be some discussion of how and why this might be? Could it be connected to species life history traits being more advantageous? The observation of lower elevation plots shifting inversely to the rate of warming was interesting. The potential impacts of acid deposition certainly deserve the attention given in the results section. Is there room for speculation as to how the loss of 50% of the red spruce basal area in the overstory could have still impacted the results? What if there loss hadn't occurred?

- Figures 2-6 could use more detailed axis labels. What are the units? Could the X axis on Fig 5, 6 have a narrower scale?
- The results presented in Table 1 are not discussed in much detail during the body of the paper. Were these values the result of the Bayesian model? There is a high level of precision with these values. Is there any way to estimate the accuracy? Did the understory have shift less from '65-'06 then from '65-'86? How?
- How about a picture showing an understory plot being measured?
- How about a simplified contour map of the study area with the plot locations overlaid?

The paper seems to conform to the formatting guidelines presented by **the Journal of Conservation Biogeography.**

**Using Long-term Ecological Data to Identify Altitudinal Shifts of Species and Communities in Response to Recent Climate Change**

Carolyn Pucko & Brian Beckage

**Review** by Andrea Pearce, 4 Feburary 2009

Vegetation research plots have been maintained on Camel's Hump, Vermont for approximately 40 years. This research aims to track the migration of understory plant communities over time as a response to global climate change citing a 1-2 degree C warming in the vicinity of Camel's hump. The author tests the hypotheses that the understory communities either shift up elevation as intact communities or that individual species shift up and down elevation independently and whether these shifts are linked to changes in the overstory. Non-metric multidimensional scaling and Bayesian modeling are two statistical tools used in the analysis. Communities at higher elevation showed more shifting than communities at lower elevations, despite that the lower elevations experienced greater warming. Species migration patterns vary in magnitude and direction indicating that communities are not remaining intact as they shift in response to global climate change.

The authors make good use of a rich long-term ecological monitoring dataset. Through the introduction they convincingly argue that distinguishing between the types of species shifting will be important to future ecological modeling. The authors keep the discussion and conclusions firmly focused on the data at hand. The only significant area of improvement from my (humble) perspective would be providing the reader with more of a basis for the computational analysis. Since the discussion and conclusions focus so heavily on the results of these analyses, it is worth more time and space in the introduction and methods sections more explicitly describing the analyses. You do describe how to interpret the NMDS which is very helpful, but more introductory references for the reader would help them reproduce this type of analysis on another dataset.

I recommend this manuscript be accepted with minor revisions. The subject of this research is appropriate to the journal and timely. Minor editorial comments are included in the attached annotated text. Additional comments are listed below. The first comment below is the most important in my opinion.

- The introduction is well written and thoroughly covers the issues related to the vegetation including a good review of relevant literature. The reader may benefit from a slightly expanded introduction to the NMDS and Bayesian methods including citing research using these methods in similar ways.
- You provide a very nice description of the research site, including geology, and overstory vegetation. Would it be useful (possible?) to also introduce the understory communities since they are the focus of the research?

- Field Methods section – While you describe creating an inventory of woody species, you never explicitly mention doing the same for herbaceous species? Are you? (This may be understood, but this isn't my field. I may be misinterpreting.)
- Figure 3 – The text on these NMDS plots is confusing and it does not appear in each sub-plot.
- Figure 4 – Is there any significance to the weight of the red and green lines? Some appear thicker than others.

Good job and good luck!