What is your hypothesis?	Why this is important?	What evidence (esp. citations) provide background for this hypothesis?	What data from STEPPS2 could confirm/falsify this hypothesis?
(H1) Decline in mesic species (e.g., beech, hemlock) and increase in fire friendly species (pine, oak) from 800 - 600 yr BP, consistent with Booth, Jackson et al's drought reconstruction. Fig 1 in Booth et al (2012) illustrates patterns interpolated in raw pollen percentages. If Bob et al are right, these areas should show significant spatiotemporally synchronous changes in mesic species anti-correlated with simultaneous shifts in drought/fire adapted species. (H1a) I will further propose (out of enthusiastic ignorance) that the signal of MCA drought extends into WI and that the range limits of beech and hemlock retreat at this time, due to drought.	Bob et al make a good point in their 2012 and related papers that mesic eastern forests are more susceptible to drought than we might have proposed. Documenting the extent and magnitude of this impact in a space-time statistical framework will allow us to learn more about the mechanism (e.g. through patterns of synchrony of changes across space, time, and species).	Booth et al (2012: Ecology 93: 219); Clifford and Booth (2015: DOI: 10.1177/0959683615580182); Margaret Davis vs Tom Webb arguments about species lags from the 1980's; PalEON Biomass paper (in prep).	(H1) Spatiotemporally synchronous declines in beech/hemlock across the region along with increases in pine/oak. Shift of range margin of beech/hemlock. Compare with time frame and maps in Booth publications.
1. The long-term change over 3000 years can be explained by the interacting effects of winter and summer temperatures and annual precipitation. When averaged over 500-1000 yr intervals, the multi-variate climate-species relationships (climate niches, environmental envelops) will remain conservative. 2. First-order patterns of spatiotemporal autocorrelation in the tree abundance reconstructions can be explained by spatiotemporal autocorrelation in climate, but second-order features likely exist as a function of edaphic factors, disturbance history, and neutral ecological processes. 3. Local communities in areas with low to intermediate rates of disturbance may show temporal changes consistent with climate even as range shifts and areas of frequent disturbance experienced significant filtering of climate signals via processes such as competition and dispersal. 4. The array of local-scale changes in tree abundance may show evidence of both lags that are slower than the background rates of climate change (e.g., due to delayed dispersal) and rapid, exponential changes that exceeded the rates of climate change (e.g., where fires or other disturbances enabled rapid turn-over; where temperature changes enabled exponential releases of certain taxa).	Climate-vegetation relationships represent a key area of concern regarding the future, and this dataset provides an exciting opportunity to examine how stable such relationships have been during a period of modest climate change. However, without independent, multi-variate paleoclimate reconstructions, it may be difficult to examine the direct associations in the past at scales finer than the long millennial trends. The climate model simulations do not sufficiently capture all of the ecologically-relevant variations in climate that took place. At a minimum, stochastic intrinsic variability manifest during the actual climate history will have differed from those produced even in an ensemble of simulations; more extreme, many models do not include processes such as stratospheric chemistry or external forcing that might might produce meaningful deviations from the long-term orbital trends (see e.g., Liu et al., 2015 PNAS) and thus are very likely missing important changes, such as during the Little Ice Age. However, patterns of spatiotemporal autocorrelation in the data may be informative even in the absence of specific climate datasets; are tree distributions spatially autocorrelated at a level consistent with that typically observed in the climate fields or do they have meaningful departures from such a pattern consistent with other ecological variables? Did disturbance, soils, etc significantly mediate the effects of even the long-term climate trends? (See e.g., Graumliche and Davis 1991). Also, paleoecologists love lags, but biological systems include many examples of exponential responses that may saturate before a climate trend has completed. Also, disturbances can push systems over thresholds more rapidly than climate changes (see e.g., recent papers on fire and drought by Booth et al.). Is there any evidence for such changes in this dataset?	Telford and Birks (2011) have some interesting ideas about examining spatiotemporal autocorrelation. They focus on the ability to reconstruct climate from variables, such as pollen, but the approach could potentially be inverted to examine patterns in the past as a test of the role of climate vrs other factors.	

1) Mesic taxa increase during the LIA 2) The increase occurs regardless of changing fire regimes or declines in Native American populations.	First it would be show that forests changed in response to one of the largest climate 'signals' in the past millennium. It would also show that the model captures such changes. Then, the mechanism behind the forest change could be identified (climate or not-climate). This is Important because Abrams, Nowacki et al. argue that a decline in Native American populations caused a decrease in burning, which caused a shift towards more mesic taxa. If a change in climate (i.e., volcanically-forced temperature decline) can be shown to cause a shift in the taxa composition without any change in fire regime or populations, that would suggest that climate-veg interactions are the most parsimonious explanation for changes in forest composition in the NE during the LIA. Also the LIA is a good general test case for looking at sensitivity of veg response to a relatively large climate forcing.	LIA climate change --> Mann et al. 2009 Power et al. 2012 --> general argument is laid out Nowacki & Abrams --> NE case Same debate but in tropics: Dull et al.; Ferretti et al., 2005; Mischler et al., 2009; Wang et al., 2010; Frank et al., 2010; Ruddiman et al., 2011; Dull et al., 2010; Faust et al., 2006; Marlon et al., 2008; Pechony and Shindell, 2010	General increases in mesic taxa in response to climate (and not other) changes during the LIA.
The "Yao" hypothesis: When perturbed from "equilibrium", individual species, species pairs, and/or the whole multivariate assemblage tend to return to previous state.	Stabilizing mechanisms are hypothesized as fundamental to maintaining biodiversity (Chesson). Alternatively, equilizing mechanisms are hypothesized as fundamental to maintaining biodiversity (Hubble).	Clark and McLachlan (2003) Levine et al (2009) doi:10.1038/Nature08251 Chesson (2000) Annual Reviews of Ecology and Systematics 31: 343–366. Hubbel (2001) Yao is looking into this in the models. She thinks strong stabilizing feedbacks are important in nature, but missing from models.	(a) easy and dumb - see if they return to where they were before perturbations (b) harder and cooler - simple model of dynamic equilibrium
H1: Discrete shift at 1000bp from oak to pine along the ecotone suggested by Jacobson is only the local manifestation of a steady and ubiquitous shift in taxon composition across the region. H2: The pine/oak ecotone shift is unusually strong and discrete relative to elsewhere in time/space. H3: Lumping STEPPS2 taxa into decid vs conifer PFTs makes the changes look more discrete. Background: Jaconson and Grimm (1986) argue that the Billy's Lake pollen record shows continuous compositional change through the Holocene. Across the STEPPS2 time domain, a related spatial pattern (boundary of oak/pine ecotone is suggested in Jacobson (1979).	It's unclear if smooth consistent changes in vegetation resulted from smooth consistent climate changes in pre-industrial times, or whether discrete shifts happen at particular times (caused either my discrete env change or by threshold changes in veg response) or at particular places (e.g. ecotones are more sensitive to change). Related: The lumping of veg into few PFTs might (or might not) emphasize discrete shifts more than the multivariate community data.	Jacobson and Grimm (1986. Ecology 67:958-966). Jacobson (1979. J. Ecol 67: 697-726) Paleon site level MIP results.	1) Shift from oak to pine at "Billy's Lake" at 1000 BP 2) The spatial extent of this shift. 3) Temporally synchronous shifts at other grid cells on and away from ecotones. 4) Collapsing composition to PFTs (decid/conifer). How much of dynamics is captured? How much is missed? 5) For later, or companion paper with Yao/Christy: Comparing STEPPS2 patterns to Billy's Lake site patterns in models (I think ED2, actually gets this PFT transition right). This would let us assess mechanisms in various models in light of data on patterns.
H3: Patterns of community associations follow environmental gradients. H2: Anisotropy in community associations follows environmental gradients. There are also hypoths about associations of individual species based on their biology: hemlock always strongly negatively associates with oak (it shades it out). associations on sand plains persist while those on more mesic soils are fluid (Brubaker 1975). etc.	In some conceptions of Gleasonian community ecology (cf. cartoon version of Tom Webb), species respond individualistically to environmental gradients and spp interactions don't stabilize communities. What are the strongest (and weakest) species associations? Are there some spp associations that persist when other spp associations are fluidly changing? If we determine strength of spp associations with env covariates at PLS-time, do these provide insights into whether strong persistent associates are related to persistent env forcing?	http://www.ies.ucv.cl/fosorio/files/preprint/15_STAN_codismap.pdf Aaron Ellison and hannah Buckley have also worked on this (and are friends with Vallejos). spp loadings on EOFs over time is another mapping tool for whole community. Would be interesting to see cov of these patterns with env covariates.	Really, I'm just interested in strength and consistency of species associations. STEPPS provides a great opportunity to determine how spp associations change over time. Apart from strength/consistency of codispersion among spp, it would be cool to analyze codispersion of PLS-era composition with our best estimate of env covariates and see where this pattern is maintained and where it falls apart back in time.

My hypothesis is that temperature and precipitation changes, including seasonality changes, over the past 3 millennia have been big drivers of vegetation changes in this region. In particular, high resolution Lake Mina pollen shows increasing effective moisture and declining temperature from the MCA through the LIA.	It would be good to estimate the sensitivity of forest type to climate giving that our climate is currently changing so rapidly due to global warming. We need long realizations to do this, so we have to use paleo data. STEPPS2 provides the forest data. Other independent proxy methods can provide the paleoclimate.	The PAGES2k NAM group is busy on a number of highly relevant manuscripts that will have alot of synergy with PalEON. There's a treering based temperature reconstruction (contact Greg Pederson USGS for info). A bunch of us (Bryan Shuman is leading) are also pulling together a broad range of proxy data to infer low-frequency effective moisture/hydroclimate for NAM. Working with PAGES2K would hopefully allow independent construction of midwest paleclimate records that could be used by STEPPS2. The timing is excellent. See St. Jacques, J.M., B.F. Cumming and J.P. Smol. (2008) A 900-year pollen-inferred temperature and effective moisture record from varved Lake Mina, in west-central Minnesota, USA. Quaternary Science Reviews, 27: 781-796, doi:10.1016/j.quascirev.2008.01.005 for the 4-year resolution effective moisture reconstruction from Lake Mina Minnesota from pollen.	Do we see a general shift towards more mesic and more northern taxa across the upper Midwest throughout the last millennium?
1) Tree migration: We should be able to see detectable evidence of hemlock expansion into the UP and Wisconsin. Possibly also yellow birch expansion (B. lenta) but this may be confounded by presence of other birch species. 2) Beech crash. We should be able to detect the crash of Fagus americana around 1000 years ago. 3) Spruce expansion. We might be able to see a re-expansion of Picea over the last few thousand years. This is a subtler signal and may or may not be noticeable. (Note: 1-3 are in a sense confirming what we think we already ‘know’ from prior papers reporting trends in pollen data. 4) Within-site variability in tree population abundances increased/decreased over the last 3000 years. I have no idea whether compositional variability increased or decreased, but it'd be cool to look at. CARBON CONSEQUENCES 5) Shifts in forest composition during the Medieval Climate Anomaly and Little Ice Age caused a net release of carbon from terrestrial ecosystems during the MCA and net drawdown of carbon from terrestrial ecosystems during the LIA. Loss and recovery of beech is an important factor. **** THIS IS MY FAVORITE HYPOTHESIS **** 6) The late-Holocene expansion of hemlock was the single biggest influence on regional aboveground carbon budgets between 3000 years ago and EuroAmerican settlement. **** SECOND FAVORITE HYPOTHESIS **** CAUSATION 7) Beech crash at 1ka was primarily triggered by hydrological variability and regional drought. 8) We can link late-Holocene shifts in the variability of forest composition directly to shifts in the frequency/intensity of external forcings to the climate system such as solar variability & volcanic eruptions. 9) We can link late-Holocene shifts in the variability of forest composition directly to teleconnections in the climate system such as shifts in the frequency/intensity of ENSO or AMO.	Because long-dead trees are cool. The carbon-based hypotheses are cool because they really let us use the power of data-model assimilation to tackle questions about whether northern US forests were in steady state or had legacy effects of last-millennium climate change, prior to EuroAmerican settlement.	(numbers match to hypotheses above) 1. Davis, M. B., et al. (1991). "Detecting a species limit from pollen in sediments." Journal of Biogeography 18: 653-668. Booth/Jackson papers looking at tree species migration into UP; can't recall the exact paper. Jackson, S. T., et al. (2014). "Inferring local to regional changes in forest composition from Holocene macrofossils and pollen of a small lake in central Upper Michigan." Quaternary Science Reviews 98(0): 60-73. 2, 7. Booth, R. K., et al. (2012). "Multi-decadal drought and amplified moisture variability drove rapid forest community change in a humid region." Ecology 93: 219-226. Wang, Y., et al. (2015). "Pronounced variations in Fagus grandifolia abundances in the Great Lakes region during the Holocene." The Holocene. 3. Gajewski, K. (1988). "Late Holocene climate changes in eastern North-America estimated from pollen data." Quaternary Research 29(3): 255-262. 8. Steinhilber, F., et al. (2012). "9,400 years of cosmic radiation and solar activity from ice cores and tree rings." Proceedings of the National Academy of Sciences 109(16): 5967-5971.	Detection questions can probably be addressed by STEPPS2. Other hypotheses will require assimilation with ecosystem models.