**To:** Manti-La Sal NF Forest Plan Revision Team

**Re:** Annotated bibliography of some new information relevant to assessment of MLSNF for the forest plan revision

**Submitted by**: Mary O’Brien, Grand Canyon Trust

**Date:** July 25, 2017

*Note*: Each of the following documents can be downloaded by clicking on the link.

**Climate Change Papers:**

**[Bestelmeyer, B. T., Okin, G. S., Duniway, M. C., Archer, S. R., Sayre, N. F., Williamson, J. C. and Herrick, J. E. (2015), Desertification, land use, and the transformation of global drylands. Frontiers in Ecology and the Environment, 13: 28–36. doi:10.1890/140162](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/Bestelmeyer_et-al-2015.pdf)**

**Topic:** Using state change-land-use change framework to consider desertification and dryland transformation

The review suggests a detailed model of vegetation and soil change (i.e. state change that comprise of equilibrium states, non-equilibrium states, and thresholds) combined with an understanding of land-use change as a broad, process-oriented way to manage the continued transformation of drylands.

**Implications for forest plan assessment:** State changes and land use changes that push dryland ecosystems over thresholds are emerging and effective ways to think about ecological change. This could be a good model with which to think about lower elevation woodlands.

[**Castle, S. L., B. F. Thomas, J. T. Reager, M. Rodell, S. C. Swenson, and J. S. Famiglietti (2014), Groundwater depletion during drought threatens future water security of the Colorado River Basin, Geophys. Res. Lett., 41, 5904–5911**](http://onlinelibrary.wiley.com/doi/10.1002/2014GL061055/abstract)

**Topic:** groundwater comprises a greater fraction of CO River basin water use than previously thought

This modeling study found that throughout the CO River basin, there was a net negative change in groundwater over the last decade, which the authors considered an indication that groundwater withdrawal was not balanced by recharge. The rapid rate of depletion of groundwater storage (5.6 ± 0.4 km3 yr1) far exceeded the rate of depletion of Lake Powell and Lake Mead. Results indicate that groundwater may comprise a far greater fraction of Basin water use than previously recognized, in particular during drought, and that its disappearance may threaten the long-term ability to meet future allocations to the seven Basin states. The opportunity for the groundwater to recharge will be infrequent under future climate change.

**Implications for forest plan assessment:** The assessment needs to consider all sources of groundwater withdrawal in the context of climate change. Future trends and assessments of these withdrawal sources need to be incorporated into the projected reductions in groundwater under future climate.

**[Clifford, Michael J.; Rocca, Monique E.; Delph, Robert; Ford, Paulette L.; Cobb, Neil S. 2008. Drought induced tree mortality and ensuing bark beetle outbreaks in southwestern pinyon-juniper woodlands. In: Gottfried, Gerald J.; Shaw, John D.; Ford, Paulette L., compilers. 2008. Ecology, management, and restoration of pinon-juniper and ponderosa pine ecosystems: combined proceedings of the 2005 St. George, Utah and 2006 Albuquerque, New Mexico workshops. Proceedings RMRS-P-51. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 39-51](https://www.fs.fed.us/rm/pubs/rmrs_p051/rmrs_p051_039_051.pdf)**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Topic:** climate induced mortality of Pinyon in the Southwest

**Research:** This field based research focusing on pinyon trees looked at the results of drought-induced mortality of pinyon trees in Arizona and New Mexico from 1998-2004. They found stand densities did not impact mortality levels for trees, but had some effects on fire structure; and that arthropods either increased or decreased with pinyon mortality depending on the arthropod species. Together these findings suggest the impacts of drought-induced tree mortality might not appear for years or decades after a major mortality event.

**Implications for forest plant assessment:** Pinyon mortality is occurring in the Manti-La Sal and expected to continue to occur in the future. The ecological implications of large scale tree mortality should be included in the assessment.

**[Copeland, S. M., J. B. Bradford, M. C. Duniway, and R. M. Schuster. 2017. Potential impacts of overlapping land-use and climate in a sensitive dryland: a case study of the Colorado Plateau, USA. Ecosphere 8(5):e01823. 10.1002/ecs2.1823](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/Copeland_et_al-2017-Ecosphere.pdf)**

**Topic**: Overlapping influence of land use and climate change on the Colorado Plateau

The combination of co-occurring climate change and increasing land-use is likely to affect future environmental and socioeconomic conditions in drylands. These hyper-arid to sub-humid landscapes are limited by water resources and prone to land degradation. The researchers characterized the potential for geographic overlap among land-use practices and between land-use and climate change on the Colorado Plateau. This analytical framework for assessing the potential impacts of overlapping land-use and climate change could be applied with other drivers of change or to other regions to create scenarios at various spatial scales in support of natural resource planning efforts.

**Implications for forest plan assessment:** All of the impacts of the multiple uses of the Manti-La Sal are going to be exacerbated under climate change. This paper does a good job showing how overlapping stressors can present novel management scenarios that need to be addressed in this assessment.

**[Fisichelli NA, Schuurman GW, Monahan WB, Ziesler PS (2015) Protected Area Tourism in a Changing Climate: Will Visitation at US National Parks Warm Up or Overheat? PLoS ONE 10(6): e0128226](file://C:\\WPDOCS\\A Utah Forest Plans\\A A MLSNF_Forest Plan - M-LS 2016-2019\\Draft Forest Assessment\\Trust versions\\climate\\Fisichelli NA, Schuurman GW, Monahan WB, Ziesler PS (2015) Protected Area Tourism in a Changing Climate: Will Visitation at US National Parks Warm Up or Overheat? PLoS ONE 10(6): e0128226. https:\\\\doi.org\\10.1371\\journal.pone.0128226)**

**Topic**: increasing year round temperatures will increase visitation to national parks

This modeling study found that visitation to National Parks increases with increasing monthly temperatures. Warming-mediated increases in potential visitation are projected for most months of the year in most parks, with 13-31 day expansion in visitation to most parks. The results suggest that protected areas and neighboring communities need to develop adaptation strategies for these change in visitation.

**Implications for forest plan assessment:** It is important that when assessing the trends of recreation impacts on the Manti-La Sal, the potential impacts of increased visitation and prolonged summer recreation under future climate be examined.

**[Hoover, D.L., Duniway, M.C. & Belnap, J. Pulse-drought atop press-drought: unexpected plant responses and implications for dryland ecosystems. Oecologia (2015) 179: 1211. doi:10.1007/s00442-015-3414-3](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/hoover_duniway_and_belnap_2015_oecologia.pdf)**

**Topic**: responses of plant communities to pulses of extreme drought on top of prolonged drought

When subjected to an extreme drought on top of a prolonged drought (which is a likely scenario in the northern Colorado Plateau under future climate change) plant community types responded differently. Cool season (C3) grasses (e., *Hesperostipa hypmenoides*) were most sensitive and prone to mortality. Warm season (C4) grasses (e.g., *Pleuraphis jamesii*) and shrubs (e.g., *Atriplex confertifolia*) had intermediate drought sensitivity. C3 shrubs (e.g., *Artemisia filifolia*) were the most resistant to mortality. These differential responses to overlapping drought events suggest that ecosystem components will respond differently to climate changes, and resilient ecosystems are needed in order to mitigate potential and unexpected mortality.

**Implications for forest plan assessment:** The implications of combined drought events will have differential impacts on vegetation community members. The EIS should indicate which native grasses and shrubs may be at particular risk from drought events.

**[Hoover, D. L., Duniway, M. C. and Belnap, J. (2017), Testing the apparent resistance of three dominant plants to chronic drought on the Colorado Plateau. J Ecol, 105: 152–162. doi:10.1111/1365-2745.12647](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/hoover_duniway_and_belnap_2016_journal_of_ecology.pdf)**

This field study in the area spanning Arches National Park and Canyonlands National Parks examines the responses of grasses and shrubs on the Colorado Plateau to chronic drought. It appears the shrubs are avoiding drought, possibly by utilizing moisture at deeper soil layers, while the grasses are limited to shallower layers and must endure drought conditions. Given this differential sensitivity to drought, a future with less precipitation and higher temperatures may increase the dominance of shrubs on the Colorado Plateau, as grasses succumb to chronic water stress.

**Implications for forest plan assessment:** Examining how climate change will influence MLNF vegetation community members is important information that should be included in each “stressor & driver” section of the assessment and in the EIS. The success of shrub removal for grass production, for instance, may be counterproductive.

**[Nordhaus, WD (2016). Revisiting the social costs of carbon. Proceedings of the National Acadamy of Sciences, 114 (7), 1518–1523.](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/PNAS-2017-Nordhaus-1518-23-1.pdf)**

**Topic**: economic cost to society caused by addition of CO2

This study estimates the social cost of carbon in terms of the economic cost caused by an additional ton of carbon dioxide emission. The study estimates that the social cost of carbon is $31 per ton of CO2 in 2010. The real social cost of carbon grows at 3% per year over the period to 2050.

**Implications for forest plan assessment:** This is relevant to the Manti-La Sal Forest Plan due to the carbon emissions associated with grazing, mining, and recreation. While the US Forest Service may be under pressure to ignore the social costs of carbon, the Trust and other conservation organizations submit this information as economic data that must be included in the EIS unless the Forest Service has data indicating there are no or other global economics associated with greenhouse gas emissions from the Forest.

**[Painter, T. H., A. P. Barrett, C. C. Landry, J. C. Neff, M. P. Cassidy, C. R. Lawrence, K. E. McBride, and G. L. Farmer (2007), Impact of disturbed desert soils on duration of mountain snow cover, Geophys. Res. Lett., 34, L12502](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/Painter_et_al-2007-Geophysical_Research_Letters.pdf)**

**Topic:** Impact of dust on duration of mountain snow

Snow cover duration in the San Juan Mountains was found to be shortenedd by 18 to 35 days due to the changes in albedo and warmer surface temperatures associated with desert dust landing on snow. This has large consequences for the water budget of the CO River Basin. Additionally, the projected increases in drought intensity and frequency and associated increases in dust emission from the desert southwest may further reduce snow cover duration.

**Implications for forest plan assessment:** The assessment and EIS should address this added stressor to winter snowpack and subsequent streamflows when examining trends.

[**Yang S, Mountrakis G (2017) Forest dynamics in the U.S. indicate disproportionate attrition in western forests, rural areas and public lands. PLoS ONE 12(2): e0171383.**](https://doi.org/10.1371/journal.pone.0171383)

**Topic**: extent of complete removal of forest patches in the continental US

This modeling study calculates a total forest loss of around 90,400 km squared in the 1990s in the continental US. The study found very high levels of attrition in the western US, in rural areas and on public lands, along with the loss of key forests in adjacent ecoregions that serve as the closest forested resource for wildlife. In order to sequester more carbon, this study suggests understanding patterns of attrition, and mitigating the carbon cost by replanting trees may be necessary.

**Oil and Gas Papers:**

**[Nauman, TW. Duniway MC. Villarreal, ML. Poitras TB. 2017. Disturbance automated reference toolset (DART): Assessing patterns in ecological recovery from energy development on the Colorado Plateau. Science of Total Environment. 476-488. doi: 10.1016/j.scitotenv.2017.01.034](https://www.researchgate.net/publication/313371973_Disturbance_automated_reference_toolset_DART_Assessing_patterns_in_ecological_recovery_from_energy_development_on_the_Colorado_Plateau)**

**Topic**: multiple use - ecology recovery after well pad reclamation differs with climate and land ownership

This study used remote sensing to measure how effectively well pad reclamation efforts worked on the Colorado Plateau from 1997 to 2005. It found that well-pads in grassland, blackbrush shrublands, arid canyon complexes, warmer areas with more summer-dominated precipitation, and state administered areas had low recovery rates.

**Implications for forest plan assessment:** The Assessment needs to indicate in which plant communities well pad recovery efforts have been undertaken and the results of well pad recovery within the MLNF. This should affect EIS stipulations for well-pad treatment.

**Diversity of plant and animal communities:**

**[Arbetman et al. 2017. Global decline of bumblebees is phylogenetically structured and inversely related to species range size and pathogen incidence. Proc. R. Soc. B 2017 284 20170204; DOI: 10.1098/rspb.2017.0204](http://rspb.royalsocietypublishing.org/content/284/1859/20170204)**

**Topic:** [Research: global decline of bumblebees is phylogenetically structured](http://rspb.royalsocietypublishing.org/content/284/1859/20170204)

Research examining an assembled database representing approximately 43% of the circa 260 globally known species, which included species extinction risk assessments following the International Union fo Conservation of Nature Red List categories and criteria, and information on species traits presumably associated with bumblebee decline. We quantified the strength of phylogenetic signal in decline, range size, tongue length and parasite presence. Overall, about one-third of the assessed bumblebees are declining and declining species are not randomly distributed across the Bombus phylogeny. Susceptible species were over-represented in the subgenus Thoracobombus (approx. 64%) and under-represented in the subgenus Pyrobombus (approx. 6%). Phylogenetic logistic regressions revealed that species with small geographical ranges and those in which none of three internal parasites were reported (i.e. Crithidia bombi, Nosema spp. or Locustacarus buchneri) were particularly vulnerable.

**Implications for forest plan assessment:** The assessment and EIS needs to assess the decline of bumblebees in the MLNF.

**Multiple use: Grazing, forage production:**

**[Reisner, MD, JE Grace2, DA. Pyke3 and PS Doescher. 2013. Conditions favouring Bromus tectorum dominance of endangered sagebrush steppe ecosystems. Journal of Applied Ecology 50(4):” 1039-1049](http://www.greatoldbroads.org/wp-content/uploads/formidable/44/Reisner-et-al.-2013_Cheatgrass_Grazing_highlighted.pdf)**

**Topic:** Bunchgrass and biocrusts limit cheatgrass

Authors studied factors favoring or limiting cheatgrass at 75 sagebrush sites and document that bunchgrass communities and biological soil crust help limit dominance of cheatgrass. The authors note that limiting cumulative livestock grazing can favor high bunchgrass cover and diversity, and biological soil crust

**Implications for forest plan assessment:** The assessment and EIS needs to assess how grazing might be increasing non-native plant invasion, and the role of biological soil crust in reducing the invasion of non-native plants.