

Notes on developments in 2018 and 2019 – More to Worry About and Prepare for... For friends at the DARCA February 2019 Annual Meeting, from John Wiener, J.D., Ph.D., research associate at the University of Colorado but not representing CU or any other affiliation. john.wiener@colorado.edu // ibs.colorado.edu/wiener Questions welcome, though time is limited for responses. Apologies for how dense this is; my goal is make a lot of stuff better known at low cost. Ag on back.

THE BIG ASSESSMENTS: Clearly, the **Fourth National Climate Assessment** is big news. Released 23 November 2018. <https://www.globalchange.gov/nca4>. Ag is Chap 4. There was some media coverage, but not much detail. And, volume 2, the big assessment soft-pedaled, in my opinion, the most important part of volume 1, the **Climate Science Special Report**: <https://science2017.globalchange.gov/>: Chap. 15 on “tipping points”. Vol 2 has “key messages” and both volumes have summaries, so this note will focus on new information since the Fourth National Climate Assessment. A lot of new economics, e.g. Besley, Timothy and Avinash Dixit, 2018, **Environmental Catastrophes and Mitigation Policies in a Multiregion World**. Proceedings of the National Academy of Science. Published ahead of print, 25 Sep 18: www.pnas.org/cgi/doi/10.1073/pnas.1802864115; (about that money problem – we could do right!); Lemoine, D. et al, 2016, **The Economics of Tipping the Climate Dominoes**. Nature Climate Change 6: 514-519, DOI: 10.1038/NCLIMATE2902 . **Intergovernmental Panel on Climate Change: 2018: Special Report on Global Warming of 1.5°C** – what that will do and what going warmer will risk. <https://www.ipcc.ch/sr15/> . Important because going past 1.5°C is almost inevitable. The rest of the world and U.S. science use IPCC and contribute to it.

COLORADO’S COASTAL PROBLEM: Where will the money go? We’ll all be bitten by the losses and costs of Coastal flooding, and the astounding loss of real estate value: S Jevrejeva, et al., **Flood damage costs under the sea level rise with warming of 1.5 °C and 2 °C**. *Environmental Research Letters*, 2018; 13 (7): 074014 DOI: [10.1088/1748-9326/aacc76](https://doi.org/10.1088/1748-9326/aacc76); and Cleetus, R., Union of Concerned Scientists, **Underwater: Rising Seas, Chronic Flooding and the Implications for US Coastal Real Estate**, using Zillow real estate values. <https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-full-report.pdf> ; Garner, Andra J., Michael E. Mann, Kerry A. Emanuel, et al., **Impact of Climate Change on New York City’s Coastal Flood Hazard: Increasing Flood Heights from the Preindustrial to 2300 CE**. Proceedings of the National Academy of Sciences (2017) 114 (45): 11861-11866. www.pnas.org/cgi/doi/10.1073/pnas.1703568114 . **But it gets worse:** Altman, Jan, et al. 2015, **Poleward Migration of the Destructive Effects of Tropical Cyclones during the 20th Century**. Proceedings of the National Academy of Sciences, (2018) 115 (45): 11543-11548. www.pnas.org/cgi/doi/10.1073/pnas.1808979115 Rahmstorf, Stefan, 2017, **Rising Hazard of Storm Surge Flooding**. Proceedings of the National Academy of Sciences, (2017) 114 (45): 11806-11808. www.pnas.org/cgi/doi/10.1073/pnas.1715895114 ; Anderson, Tiffany R., et al., 2018, **Modeling Multiple Sea Level Rise Stresses Reveals up to Twice the Land at Risk Compared to Strictly Passive Flooding Methods**. Scientific Reports 8 article number 14484 DOI:10.1038/s41598-018-32658-x ; Regeuro, Borja G., et al., 2019, **A Recent Increase in Global Wave Power as a Consequence of Oceanic Warming**. Nature Communications 10, Article number 205; <https://doi.org/10.1038/s41467-018-08066-0> (Wave height is on top of storm surge which is on top of sea level; with more intense storms, surge is higher because it results from pressure differentials.) **But it gets worse...**

RIVERINE/FLUVIAL FLOODING PLUS COASTAL FLOODING: Moftakhari, Hamed R. et al., 2017, **Compounding Effects of Sea Level Rise and Fluvial Flooding**. Proceedings of the National Academy of Sciences (2017) 114: (37): 9785-9790. DOI: 10.1038/NCLIMATE2923 ; Piecuch, Christopher G., et al., 2018, **River-discharge Effects on United States Atlantic and Gulf Coast Sea-level Changes**. Proceedings of the National Academy of Sciences, (2018) 115 (30): 7729-7734. www.pnas.org/cgi/doi/10.1073/pnas.1805428115 . **And it gets worse...for inland flooding... Is your ditch ready?**

FLOODS: SNOW ON RAIN: SNOWPACK AND MELT: Musselman, Keith N., and 7 others, 2018, **Projected Increases and Shifts in Rain-on-snow Flood Risk over Western North America**. Nature Climate Change 8: 808-812. <https://doi.org/10.1038/s41558-018-0236-4> ; Huning, Laurie S, and Amir Agha Kouchak, 2018, **Mountain Snowpack Response to Different Levels of Warming**. Proceedings of the National Academy of Sciences. (2018) 115 (43): 10932-10937. www.pnas.org/cgi/doi/10.1073/pnas.1805953115 ; Harpold, Adrian A., and Paul D. Brooks, 2018, **Humidity Determines Snowpack Ablation Under a Warming Climate**. Proceedings of the National Academy of Sciences, 115 (6): 1215-1220. www.pnas.org/cgi/doi/10.1073/pnas.1716789115; **Intense Precipitation:** an item for your management: Witze, Alexandra, 2018, **Why Extreme Rains are Gaining Strength as the Climate Warms**. Nature (News feature, 20 Nov 18) 563: 458-460. doi: 10.1038/d41586-018-07447-1 Dottori, Francesco, and 10 others, 2018, **Increased Human and Economic Losses from River Flooding with Anthropogenic Warming**. Nature Climate Change <https://doi.org/10.1038/s41558-018-0257-z> Giuntoli, Ignazio, et al., 2018, **Uncertainties in Projected Runoff over the Conterminous United States**. Climatic Change. <https://doi.org/10.1007/s10584-018-2280-5> Diffenbaugh, Noah S. and 10 others, 2017, **Quantifying the Influence of Global Warming on Unprecedented Extreme Climate Events**. Proceedings of the National Academy of Science. www.pnas.org/cgi/doi/10.1073/pnas.1618082114 PNAS | May 9, 2017 | vol. 114 | no. 19 | 4881–4886; Neelin, J. David and 3 others, 2018, **Global Warming Precipitation Accumulation Increases Above the Current-Climate Cutoff Scale**. Proceedings of the National Academy of Science. 1258–1263 | PNAS | February 7, 2017 | vol. 114 | no. 6

www.pnas.org/cgi/doi/10.1073/pnas.1615333114; Tullos, Desiree, 2018, **Opinion: how to Achieve Better Flood-risk Governance in the United States**, Proceedings of the National Academy of Science. www.pnas.org/cgi/doi/10.1073/pnas.1722412115 PNAS | April 10, 2018 | vol. 115 | no. 15 | 3731–3734. **WHY SHOULD YOU CARE? All floods may be threats to ditches!**

FOOD SECURITY AND AG:– An interesting report on research priorities from the **InterAcademy Partnership** (130 academies of science etc., world-wide): <http://www.interacademies.org/48898/Opportunities-for-future-research-and-innovation-on-food-and-nutrition-security-and-agriculture-The-InterAcademy-Partnerships-global-perspective>; the press release: <http://www.interacademies.org/48945/Global-food-systems-are-failing-humanity-and-speeding-up-climate-change> . Who cares? See **World Resources Institute**: <https://www.wri.org/publication/creating-sustainable-food-future> ; **United Nations Food and Agriculture Organization** 28 Jan: “**Conflict-driven hunger worsens**” – new report to Security Council, <http://www.fao.org/news/story/en/item/1178080/icode/> and see “**The State of Food Security and Nutrition in the World 2018**” <http://www.fao.org/publications/card/en/c/19553EN> . **Relevance to Colorado:** We are subject to world commodity markets, but also trade wars and the dominance of US production by very few (as in, 3 or 4) firms in almost every sector except the high-risk parts of cattle raising. USDA Economic Research Service website has been radically debilitated, so harder to find information. Most recent I know of: James M. MacDonald, et al., 2018, **Three Decades of Consolidation in U.S. Agriculture**, EIB-189, U.S. Department of Agriculture, ERS, March 2018 <https://www.ers.usda.gov/webdocs/publications/88057/eib-189.pdf>? – rather understated. **Big trouble coming... And meanwhile, the US and Colorado are killing ag productivity and the flexible and innovative small farms very quickly... See Farms Under Threat, American Farmland Trust - best-yet land quality classification and precise measure of loss of ag land – very dismaying!** <https://www.farmland.org/>.

WATERS OF THE US: The repeal of the “substantial nexus” of a source of pollution and a water flow as basis for jurisdiction was said to provide certainty for abused farmers, but it severely limits control of pollution not flowing on the surface; e.g. toxic coal ash, and mining wastes. Colorado Geological Survey reports “*an estimated 23,000 abandoned mine sites on both public and private land.*” <http://coloradogeologicalsurvey.org/geologic-hazards/abandoned-mine-lands/> [Heap leaching: mercury or cyanide to leach ore. Sites not all known. These were sometimes small and may have been concealed by 100 or more years of sediments and overgrowth.] There is also industrial waste, sometimes under impervious cover and relatively immobilized by what was formerly adequate storm drainage. It is not apparently known how increased intensity of precipitation, longer frost-free time and earlier snow melt, increased acidity of precipitation, and increased frequency and intensity of fires and subsequent floods will affect water quality and mobilize mining and leaching wastes. Effects on water quality treatment needs and irrigation uses are not apparently known, but food safety rules and certifications may affect requirements for irrigation water.

FIRE AND WATER QUALITY: Charles Rhoades, of the U.S. Forest Service in Fort Collins has been conducting the first long-term observations of water quality after a major fire, and has published his 10 year findings; his 15 year findings are in progress. Rhoades, C.C. et al., 2012, Water Quality Effects Following a Severe Fire. Fire Management Today 72(2): 35-59. (Published by U.S.F.S.: www.fs.fed.us/fire/fmt .) Some toxics are still elevated years after the initial sediment etc. pulse.

What would help? (1) Resilience through **diversification**. (2) **Erosion and soil quality** improvement through cover crops – experiment with what mix works best for you and grazing. (3) **Watershed defense** to avoid being flooded. (4) Control expenses by (grit your teeth and do it) creating a **benefit co-op for big expense** (“benefit” specifies that your purposes can’t be hijacked by outsiders) for equipment that should be economically maintained as a fleet, and suitable for rotations across farms planned to make that feasible. (4) Start designing **better farming** without the limits and expenses of working in squares in which you struggle to make uniformity – work with what is there – a long-term goal. (5) **Urban areas should manage 3 flows** (a) sewage; (b) urban storm water, and (c), using floodways, relatively clean water passed through to downstream irrigation and small storage for ag use and for aquifer recharge, and augmentation credits once inspected after an event. (People love the off-road paths these create; real estate values and the tax base go up from this huge amenity.) See a good introduction to Green Infrastructure and make your cities and counties aware: Trust for Public Land: https://www.tpl.org/sites/default/files/cloud.tpl.org/pubs/water_building_green_infrastructure.PDF. More and more cities are defending their water supplies, increasingly using water rates as well as bonding. (See Trust for Public Land: Watershed Protection: Making the Case <https://www.tpl.org/how-we-work/research/watershed-protection-making-case#sm.0016t3cpt1du7f2gvzs2c5um3f25t> and Land and Water Publications <https://www.tpl.org/how-we-work/research/land-water-publications#sm.0016t3cpt1du7f2gvzs2c5um3f25t>. And Earth Economics: <http://www.earthconomics.org/urbangi>. Remember: Riverine flood Hazard Mitigation for cities pays back 7 to 1; be sure your local governments know! See Multi-Hazard Mitigation Council: https://cdn.ymaws.com/www.nibs.org/resource/resmgr/docs/NIBS_MitigationSaves_Interim.pdf.