Impacts of Desertification on Kansas Agriculture

Ryan Olsen
ES 368 Paleoclimates, Climate Variability and Climate Change
Emporia State University
December 15, 2022

Table of Contents

Introduction

Desertification *(n) - the gradual transformation of habitable land into desert; is usually caused by climate change or by destructive use of the land.*

- Princeton University WordNet

The process of desertification has the potential to negatively affect Kansas agriculture local economies dependent on it with the ultimate impact being felt nationally. Type and quantity of irrigation have the possibility to slow or reverse the process for as long as a readily available source of freshwater is present. The type of crop can slow the process, but natural prairie grasses do not typically make for a nutritious human food source and economically viable source of income. Climate change, the ever present boogeyman for pundits of a certain persuasion, is a fact; whether natural or anthropogenic the effects will be increasingly felt worldwide. Soil quality will change with an increase in desertification.

Unfortunately there is no one cause or fix to desertification, it is both a natural and anthropogenic process. With effort, planning, and coordination the process can be slowed, stopped, or even reversed depending on the location.

This paper attempts to ascertain the likely potential effect of desertification on Kansas agriculture, specifically in the southwestern region of the state. Additionally a hypothetical worst case scenario will be proposed if current rates and methods are maintained.

Discussion

Causes

The process of desertification does not have one specific cause as the process can happen in various environments and differing rates, two major causes can be broadly classified into natural processes and anthropogenic action (Katyal and Vlek, 2000). This paper will focus primarily on the effects of desertification rather than specific causes, and for this purpose anthropogenic action will be assumed to be a stronger cause of desertification in recent history to be in line with the impact on humans in the future.

Anthropogenicly caused desertification can occur as a result of deforestation, overgrazing, improper agricultural methods for the area, exceeding the carrying capacity of the land, and poverty (Katyal and Vlek, 2000).

Use of Irrigation

Irrigation has the potential to slow desertification at the cost of depleting freshwater sources at unsustainable rates. Usage of inefficient center-pivot spray irrigation is widely used in Kansas, some farmers have made the switch to more efficient low pressure or drip systems but more efficient irrigation does not solve the long-term problem of an aquifer depletion at a faster rate than it is replenished when irrigation is required to maintain crop yields. The effects of this are already being seen in the United States southwest Colorado River basin with water levels dropping at an alarming rate (Borunda, 2022).

While irrigation can slow or reverse desertification at a local level, widespread irrigation of more water sensitive crops not native to the environment depletes available reserves, further compounding the effects of desertification. The Ogallala Aquifer supplies 70-80% of Kansas with water daily (Buchanan, 2001). This USGS reports that in 2015 Kansas agriculture averaged 2,670 million gallons per day for irrigation with up to a 35% loss due to evaporation and wind (USGS, 2018). This combination of irrigation depleting aquifers faster than they are replenished and the inefficiency of common irrigation systems only compounds the long term viability of growing water intensive crops in areas vulnerable to desertification.

Models have been performed on the growing of maize (corn) in western Kansas, specifically Finney County (Araya et al., 2020). The results show that increased irrigation equated to increased yield. Rouhi et al. showed in 2020 that this also applies to other Kansas crops. Rouhi et al. has also shown that irrigation is a major cause of aquifer depletion.

Effects

The ultimate effect of desertification is degradation of the soil to the point that the existing ecosystem or agriculture can no longer be supported through conventional means.

The use of land in arid areas for agriculture is a recipe for eventual disaster. More irrigation increases crop yield however also depletes the available aquifer at a rate faster than it is replenished (Rouhi et al, 2022). As can be seen when comparing Figures 2 & 3, the areas of

Kansas that are more under threat of desertification also happen to be among the highest yield counties for corn, sorghum, and winter wheat. If this is compared to the aquifer water levels in Figure 4, it is obvious that those counties also show some of the highest drops in well measurements. If this is then compared with Figures 5, showing that aquifer withdrawals will eventually make growing crops in western Kansas unsustainable within 50 years for a large portion of southwestern Kansas with some areas already below threshold.

Economic Impact

With climate changing towards the warmer, the effects of desertification will be felt worldwide. Areas that are currently agriculturally productive and undergoing desertification will eventually become unproductive at current scale affecting local economies.

The USDA reports that the 2021 value of Kansas field and miscellaneous crops to be USF 11.8 billion. Katyal and Vlek estimate the economic impact of desertification to be up to 15% of potential over an unspecified period of time. If this is 15% per year, this could mean up to a USD 1.77 billion loss to the Kansas economy per year. This would be in addition to the USD 3.8 billion that having the aquifer available increases the valuation of the land, decreasing land values at a rate of USD 34 million a year for western Kansas alone. (Hendricks and Sampson, 2022).

This will likely affect poor and smaller family farms first, these farms could potentially be bought out by larger farmers and commercial farming activities that can handle the increased overhead more easily for a time. This buyout could further aggravate the problem of soil degradation and desertification as result of attempts to increase crop yield and extract the most profit out of the land before agricultural activity becomes financially unviable for the landowner. The end result could be a scenario where the land is unable to support profitable crops.

A worst-case scenario may eventually be that the land becomes unable to support crops due to degradation of the soil with water needing to be brought in from outside of the region to maintain any at all. This could result in land with a higher value that can be extracted from that land or with so low a value that the owners face serious monetary liability as they are unable to sell their land. Letting the land return to a stable natural state may cost more time, money and effort wise than an individual farmer can bear. Ideally the land would be returned to a natural state through state or federal government programs. The land in its natural state could still eventually be used for economic agricultural activities such as livestock grazing through careful management to ensure that the carrying capacity of the land is not exceeded. This comes with its own economic liability, potential negative climate impact, and cannot be accomplished overnight (Aydinalp and Cresser, 2008).

Conclusion

Not enough research has been done on the topic of the effects of desertification specifically to Kansas agriculture, the majority of research is related to aquifer depletion. Time will tell if non-native water sensitive crops will remain economically viable in the future, especially in southwestern Kansas. One can expect the negative impact on Kansas agriculture from desertification, climate change, and reduced water availability will be felt in the southwestern corner of the state by poor and small family farms.

One thing can be considered an almost certainty, by the time a large-scale concerted effort is made it will be too late to stop. It is likely already too late.

Future Work

More research specific to the effects of desertification on Kansas agriculture must be completed. Bringing light to the possible economic end result may spur more action to slow or reverse the process as often does when people realize how a local event can impact them and their wallets.

Bibliography

Araya, A., P.V.V. Prasad, P.H. Gowda, V. Sharda, C.W. Rice, and I.A. Ciampitti. 2020. Evaluating optimal irrigation strategies for maize in Western Kansas. *Agricultural Water Management* 246:106677

Aydinalp, C. and M.S. Cresser, 2008. The effects of global climate change on agriculture. *American-Eurasian Journal of Agricultural & Environmental Sciences*, 3(5):672-676.

Borunda, A., 2022, Big changes are coming for the Colorado River soon—and they could get messy. National Geographic. Available at https://www.nationalgeographic.com/environment/article/big-changes-are-coming-for-the-colorado-river-soonand-they-could-get-messy (posted 16 Aug. 2022, verified 3 Nov. 2022)

Bestelmeyer, B. T., G. S. Okin, M. C. Duniway, S. R. Archer, N. F. Sayre, and J. E. Williamson. 2015. Desertification, land use, and the transformation of global drylands.

Brauer, D., D. Devlin, K. Wagner, M. Ballou, D. Hawkins, R. and Lascano. 2017. Ogallala Aquifer Program: A Catalyst for Research and Education to Sustain the Ogallala Aquifer on the Southern High Plains (2003–2017). *Journal of Contemporary Water Research & Education* 162(1):4-17

Buchanan, R. C., B. B. Wilson, R.R. Buddemeier, and J. J. Butler, Jr. 2001. The High Plains Aquifer. Kansas Geological Survey. (Revised Dec. 2009, Jan 2015) Public Information Circular 18

Cano, A., A, Núñez, V. Acosta-Martinez, M. Schipanski, R. Ghimire, C. Rice, and C. West. 2018. Current knowledge and future research directions to link soil health and water conservation in the Ogallala Aquifer region. *Geoderma* 328:109-118

Condos, D. 2022. How Kansas could lose billions in land values as its underground water runs dry. High Plains Public Radio. Available at https://www.kmuw.org/news/2022-04-01/how-kansas-could-lose-billions-in-land-values-as-its-underground-water-runs-dry (Posted 1 Apr, 2022, verified 3 Nov. 2022)

Ding, Y. and J. M. Peterson. 2012. Comparing the Cost-Effectiveness of Water Conservation Policies in a Depleting Aquifer: A Dynamic Analysis of the Kansas High Plains. *Journal of Agricultural and Applied Economics,* 44(2):223-234.

Dregne, H., M. Kassas, and B. Rozanov. 1991. A new assessment of the world status of desertification. *Desertification control bulletin*, 20(1):7-18.

Helldén, U. 1991. Desertification: time for an assessment?. *Ambio*, 372-383.

Hendricks, Nathan P., Sampson, Gabriel S. 2022. The Value of Groundwater in the High Plains Aquifer of Western Kansas. *Kansas State University Department Of Agricultural Economics Extension Publication.* Available at https://agmanager.info/ag-policy/water-policy/value-groundwater-high-plains-aquifer-western-kansas (Published 3 Feb 2022, verified 26 Dec. 2022)

Hu, Y., Z. Wang, Z. Zhang, N. Song, H. Zhou, Y. Li, Y. Wang, C. Li, L. Hale. 2021. Alteration of desert soil microbial community structure in response to agricultural reclamation and abandonment. *Catena* 207:105678

Kansas Geological Survey, Water Resources. Water-level Measurements. Available at https://www.kgs.ku.edu/Hydro/Levels/index.html (Updated 20 Jul. 2022, verified 3 Nov. 2022)

Kansas Geological Survey, 2022. Interpolated Change in Feet, Cooperative Water Level Network, 2021 to 2022. 2022. Retrieved from https://news.ku.edu/sites/news.ku.edu/files/images/general/2022_news/march/provisional_results_2021_2022%20copy%202.jpg on 3 Nov. 2022

Katyal, Jagdish C. and P. L. G. Vlek. 2000. Desertification: Concept, causes and amelioration. *ZEF Discussion Papers on Development Policy, No. 33, University of Bonn, Center for Development Research (ZEF), Bonn,* October 2000, pp. 65

Johnson, Pierre-Marc, K. Mayrand, M. Paquin and Canadian International Development Agency, Unisféra International Centre. 2006. Governing Global Desertification: Linking Environmental Degradation, Poverty and Participation. *Ashgate Publishing, Ltd.*

Leestma, D. 2017. Why These 8 States Could Soon Form the ‘Great American Desert’ [Online] Available at https://www.ecowatch.com/ogallala-aquifer-depletion-2511600266.html (posted 22 Nov. 2017; verified 3 Nov. 2022)

Mouat, D., J. Lancaster, T. Wade, J. Wickham, C. Fox, W. Kepner, and T. Ball. 1997. Desertification evaluated using an integrated environmental assessment model. *Environmental Monitoring and Assessment*, 48(2):139-156.

Princeton University. 2010. About WordNet. Princeton University.

Rouhi Rad, M., Araya A., Zambreski, Z., 2020. Downside risk of Aquifer depletion. Irrigation Science. 2020. 38:577–591.

Sheridan, D. 1981. *Desertification of the United States*. Council on Environmental Quality.

Sîli, N., E. Şuleru, F. Faur, and A. N. Izabela-Maria. 2021. The use of central pivot irrigation systems in the productive recovery works of the lands affected by desertification. an opportunity analysis for Dolj County. *Research Journal of Agricultural Science*, 53(4):208-217.

Skujins, J. 1991. Semiarid lands and deserts: Soil resource and reclamation. *Marcel Dekker, Inc.*

Steiner, J. L., D. L. Devlin, S. Perkins, J. P. Aguilar, B. Golden, E. A. Santos, and M. Unruh. 2021. Policy, Technology, and Management Options for Water Conservation in the Ogallala Aquifer in Kansas, USA. *Water*, 13:3406. https://doi.org/10.3390/w13233406

Rivera-Marin, D., J. Dash, and B. Ogutu. 2022. The use of remote sensing for desertification studies: A review. *Journal of Arid Environments*, 206:104829.

USDA, 1998. Desertification Vulnerability. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/worldsoils/?cid=nrcs142p2_054003 on 6 Oct 2022.

USDA, 2022. County Estimates. Available at https://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/County_Estimates/index.php (update 8 Sep. 2022, verified 4 Dec. 2022)

USGS, 2018. Irrigation: Spray or Sprinkler Irrigation. Available at https://www.usgs.gov/special-topics/water-science-school/science/irrigation-spray-or-sprinkler-irrigation (posted 11 Jun. 2018, verified 4 Dec. 2022)

Warren, A., and C. Agnew. 1988. An Assessment Of Desertification And Land Degradation In Arid And Semi-Arid Areas. Available at http://www.ciesin.org/docs/002-315/002-315.html (verified 3 Nov/ 2022)

Wilson, Brownie. 2022. Groundwater levels fall across western and central Kansas. [Online] University of Kansas. Available at https://news.ku.edu/2022/03/23/groundwater-levels-fall-across-western-and-central-kansas (posted 23 Mar. 2022, verified 3 Nov 2022.)

List of Figures & Tables

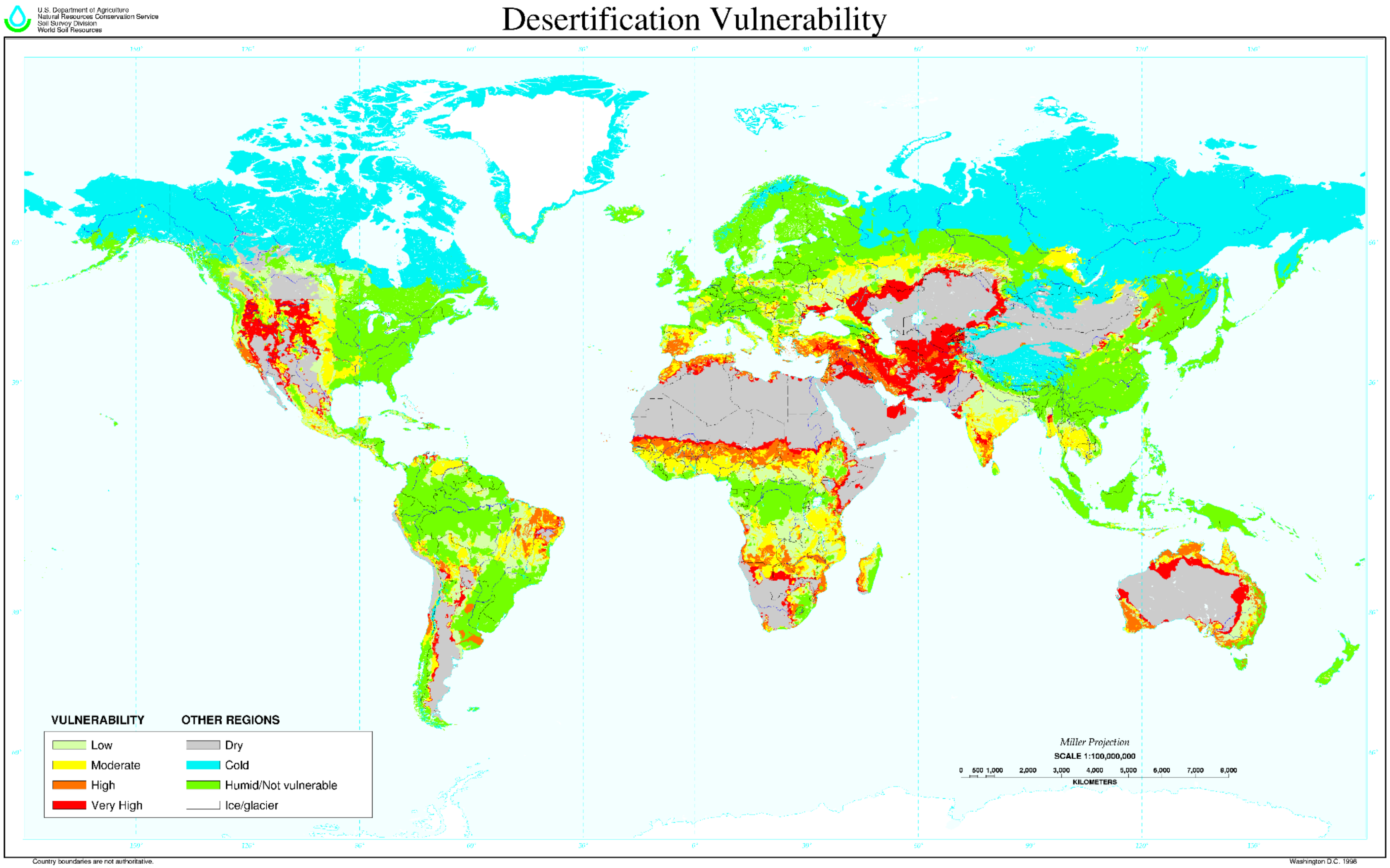

Figure 1. Desertification Vulnerability, *USDA. 1998.*

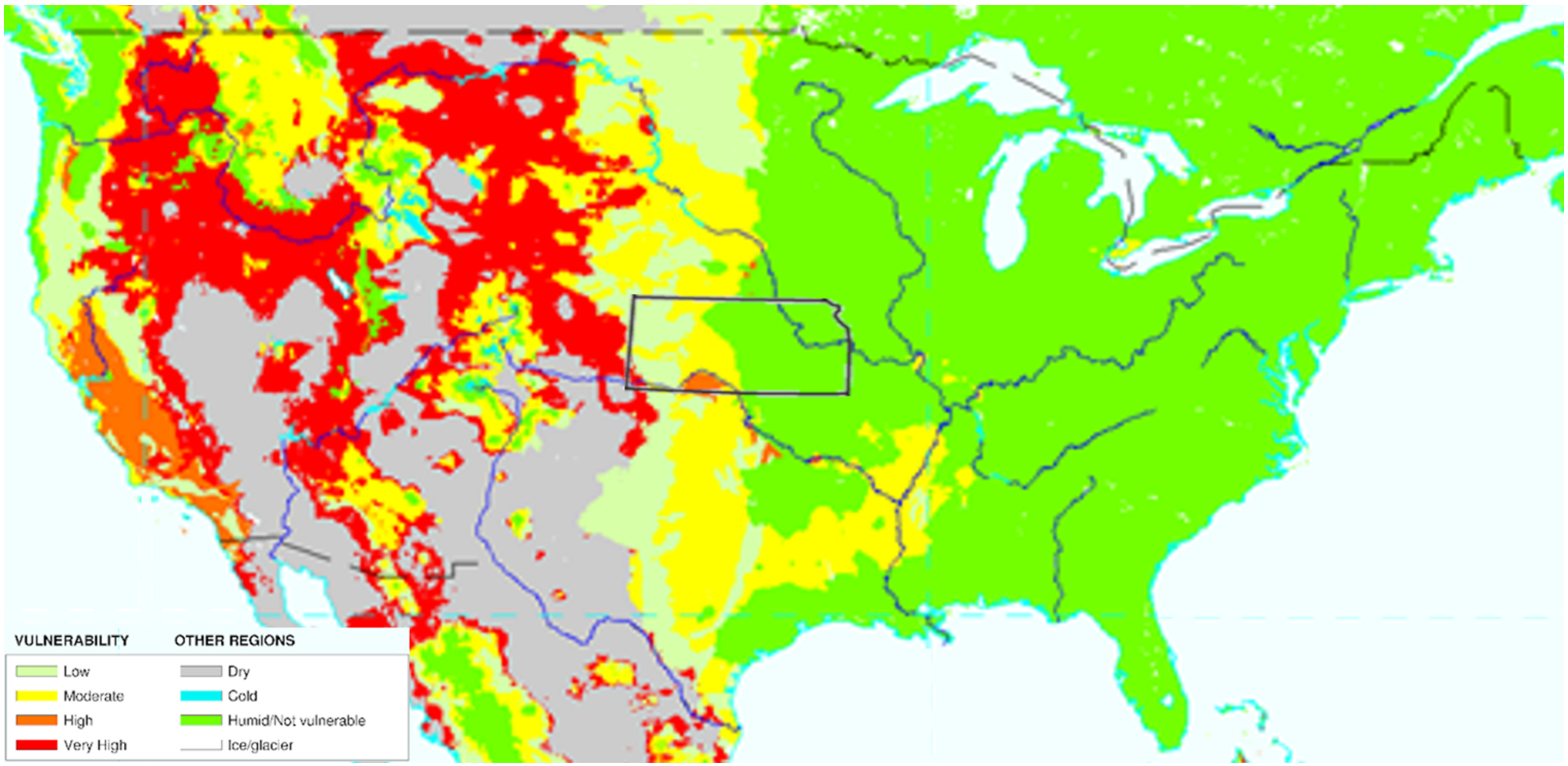

Figure 2. Approximate location of Kansas, not to scale. R Olsen, adapted from Desertification Vulnerability, USDA. 1998.

Figure 3. Kansas county level crop yields for 2021. USDA, 2021.

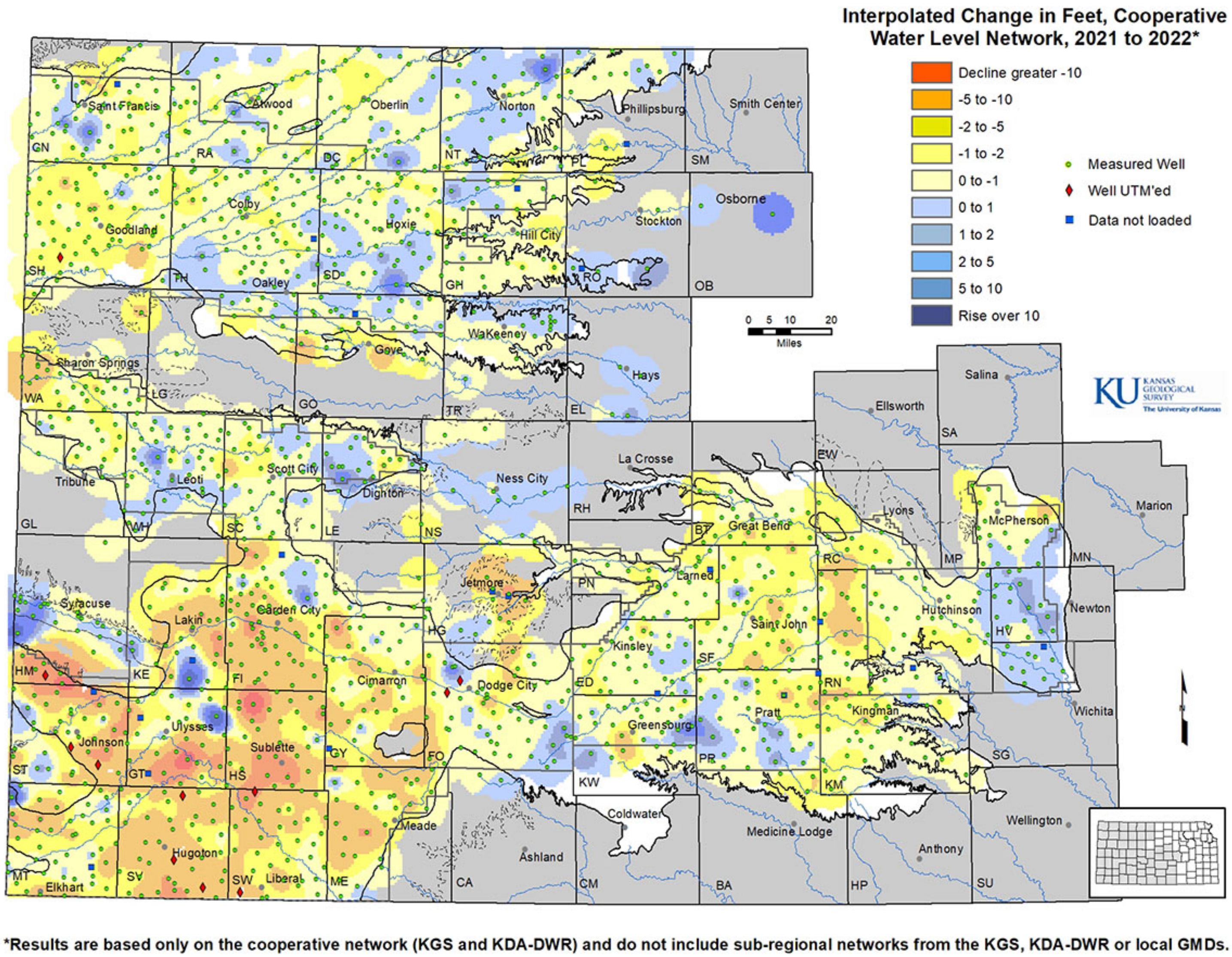

Figure 4. Interpolated Change in Feet, Cooperative Water Level Network, 2021 to 2022. *Kansas Geological Survey, 2022*.

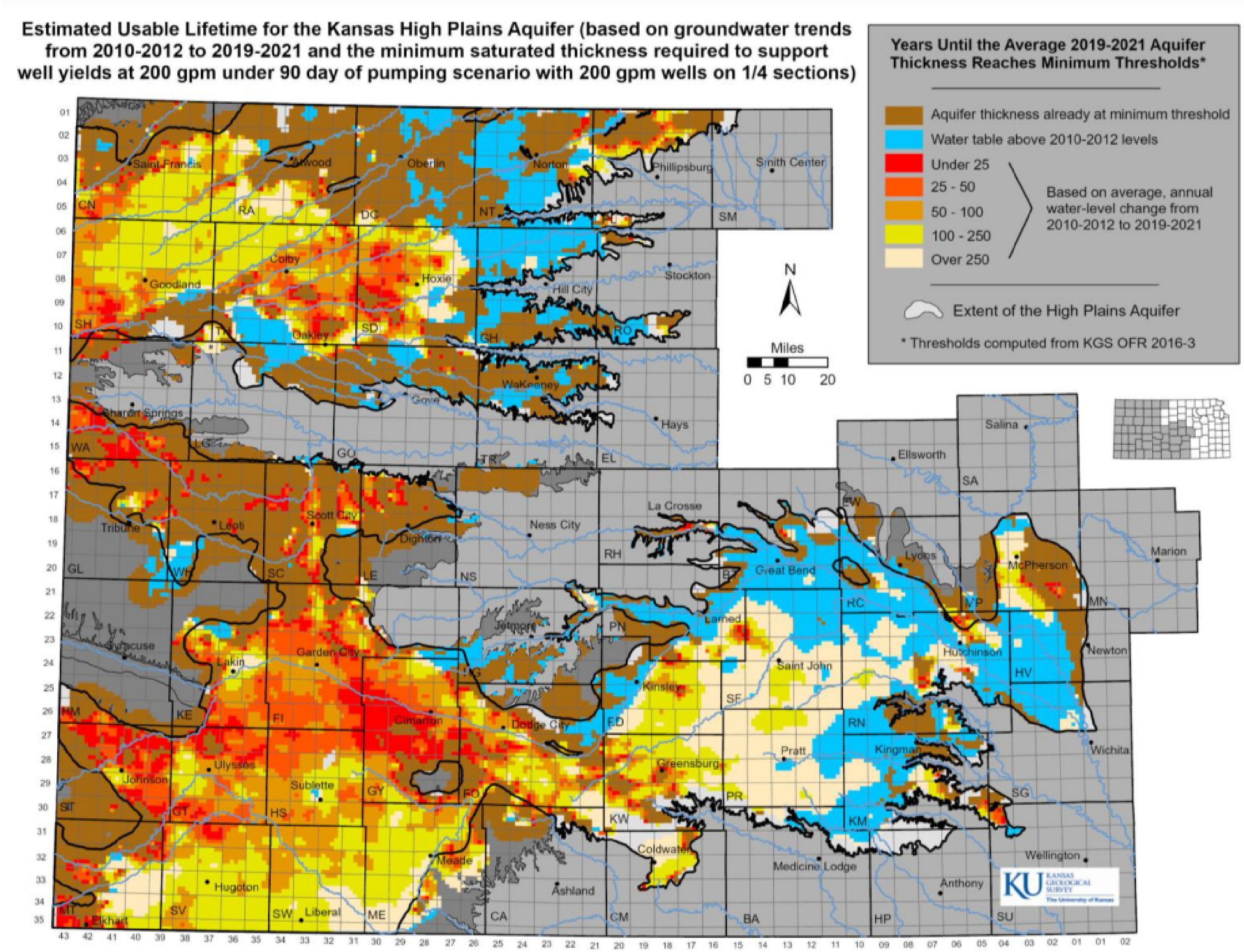

Figure 5. Estimated usable lifetime (average 201–2012 to 2019–2021 trend) for the High Plains aquifer in Kansas. *Kansas Geological Survey, date unknown.*