Catastrophic Water Mounding In the Nebraska Sand Hills

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Excessive rains in Nebraska's various Sand Hills are now crippling Ranches and Farms

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*Reasons For**, and** Intent Of **this publication:***

Author's Note:

The field of *soil science* is a relatively young field. It officially started here in the United States in 1899. Our first soil surveys in the nation were started in that year. We had to borrow a taxonomy system from the Russians during those early years. The taxonomy used in our Modern Soil Surveys was not completed and published here in the United States until 1965. It would take until sometime in the early-to mid-1970s before Soil Scientists were consistently *field-mapping* solely using only this new Taxonomy. *["It's hard to teach an old dog new tricks!"* However, it's harder to teach a new dog old tricks if the teachers with the knowledge of the old tricks have long since walked out the door of retirement!] This same lag-time can be seen in any system of classification such as the transition from *Range Sites* to *Ecological Sites*. It took years to get the Ecological Sites implemented into our Nebraska FFA Range Judging Handbook. And yet, there are some Range Sites that have been employed by the NRCS for decades now that have never yet made it into the Nebraska Range Judging Handbook.

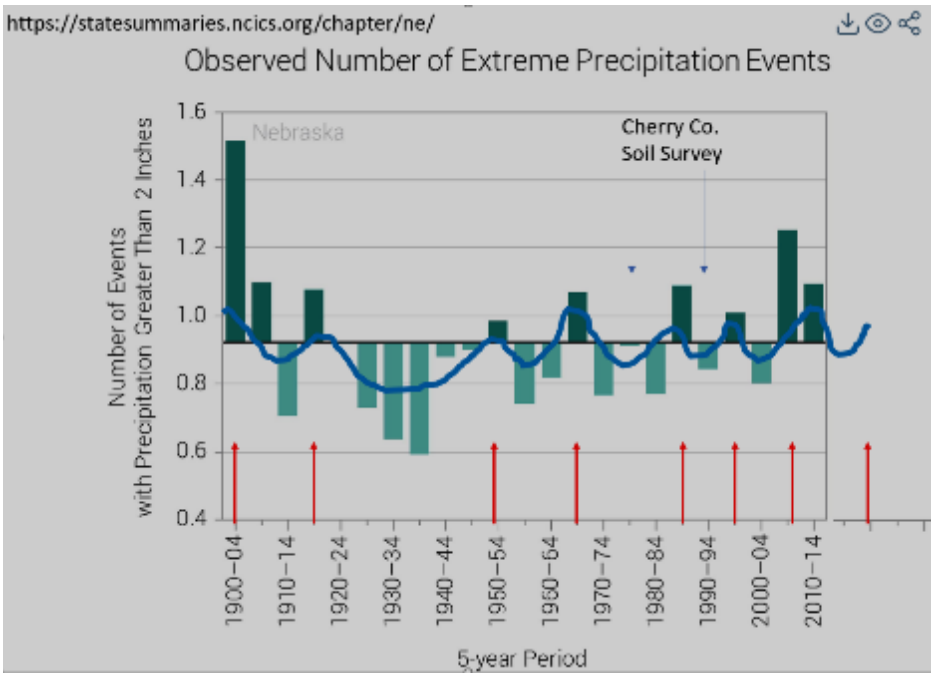
New employees and trainees sometimes start their jobs without much knowledge about these missing Ecological Sites. It is the job of the Resource Soil Scientist to help these new employees to understand these and all the breaks between Ecological Sites. Field mapping experience helped the soil scientist to understand and refine the soil, water, and chemistry of the Ecological Sites. However, no one is field mapping anymore. (True, there are MLRA updates to mapping units, but that is not field mapping!) A database is NOT – will not ever be a good teacher. Problem is, most of us with 100,000s to millions of acres of field mapping experience have already walked out the door taking our tacit-knowledge with us. My career has already spanned more than 40 years. That is exactly 1/3 of the time that soil science has been a science here in the U.S.

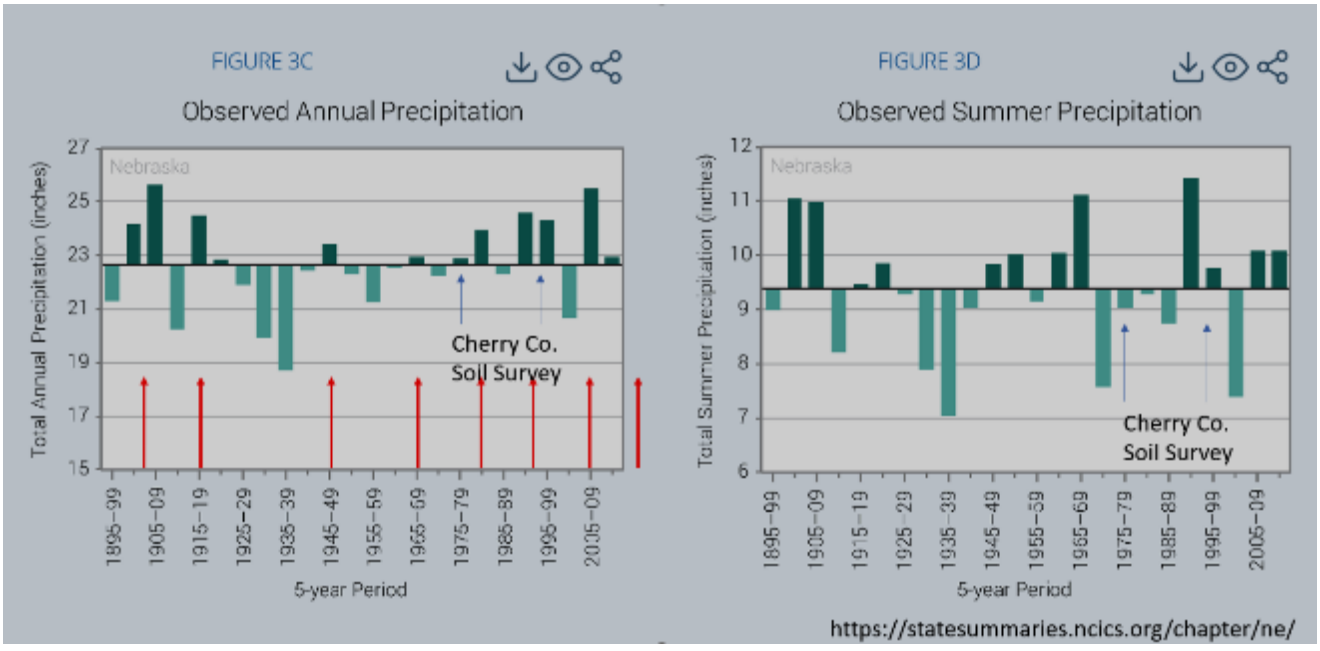
It peeves me that my career will soon come to an end, for I dearly love to learn about Nebraska soils, and plant responses to changes in soil characteristics and soil health. There is so much yet to learn about our soils and ecosystem and there is no one behind me with the years and years of regional soils knowledge that I have had to gain from field experience. How will others acquire that knowledge? I can teach one or two persons "one-on-one" for a summer and/or a year or two; and they can gain much of that experience as *head-knowledge*, but without field experience, will that knowledge remain in their heads with so much additional knowledge that they must also gain in their jobs? *My intent for this publication is to transfer **in writing** that tacit-knowledge I've acquired to the many younger employees coming behind me* so they will have a written record and way to remember it! What I am going to teach is not written down in text books! Sadly, in the future you'll either know it, or you likely may never again have opportunity to acquire it. There will likely never again be a chance to learn it from day-to-day, year-to-year field experience like I was privileged to have gained it.

~ Chuck Markley, Resource Soil Scientist

Climatic Cycling versus "Catastrophic Water Mounding" in Sand Hill regions.

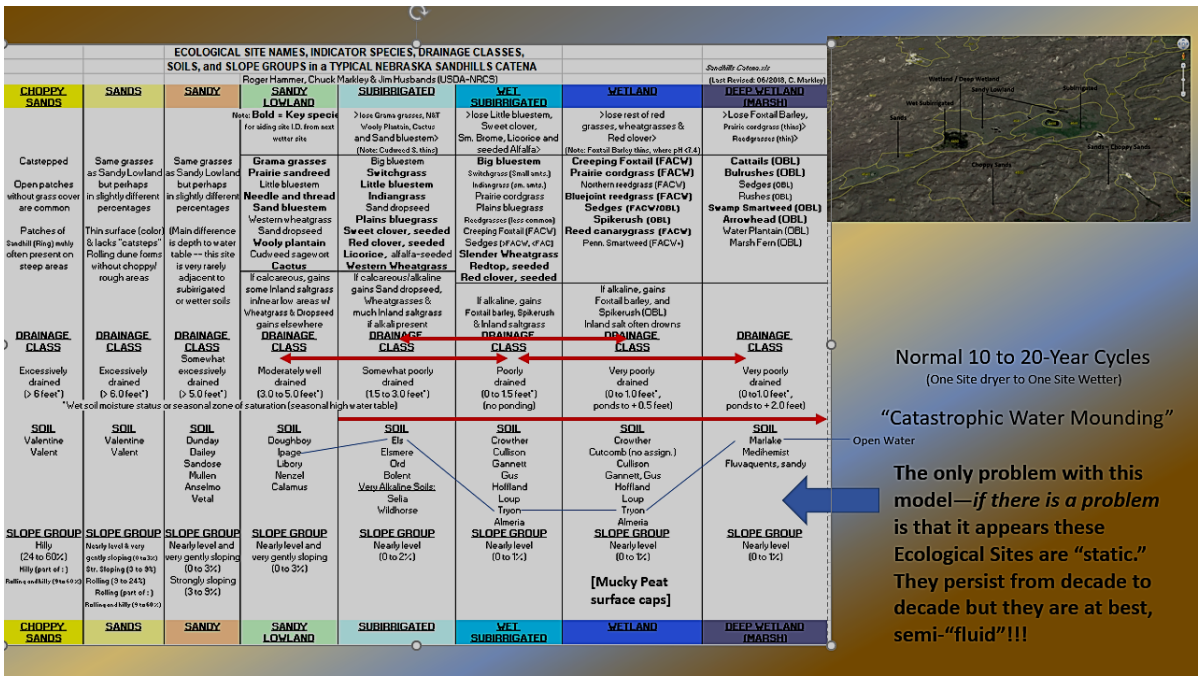
Most people are familiar with climatic cycles. Most of these cycles are related to ocean currents and to opposing climatic triggers known respectively as *El Nino* and *La Nina*. These triggers themselves may or may not be related to sunspots or some other galactic trigger. Climatic cycles, in the last century and a half or so, ebb and flow on more-or-less 10 to 20-year oscillations. Some oscillations have occurred on less than 10 or greater than 20-years . . . such as the extended oscillation coinciding with the severe drought of the 1930s.





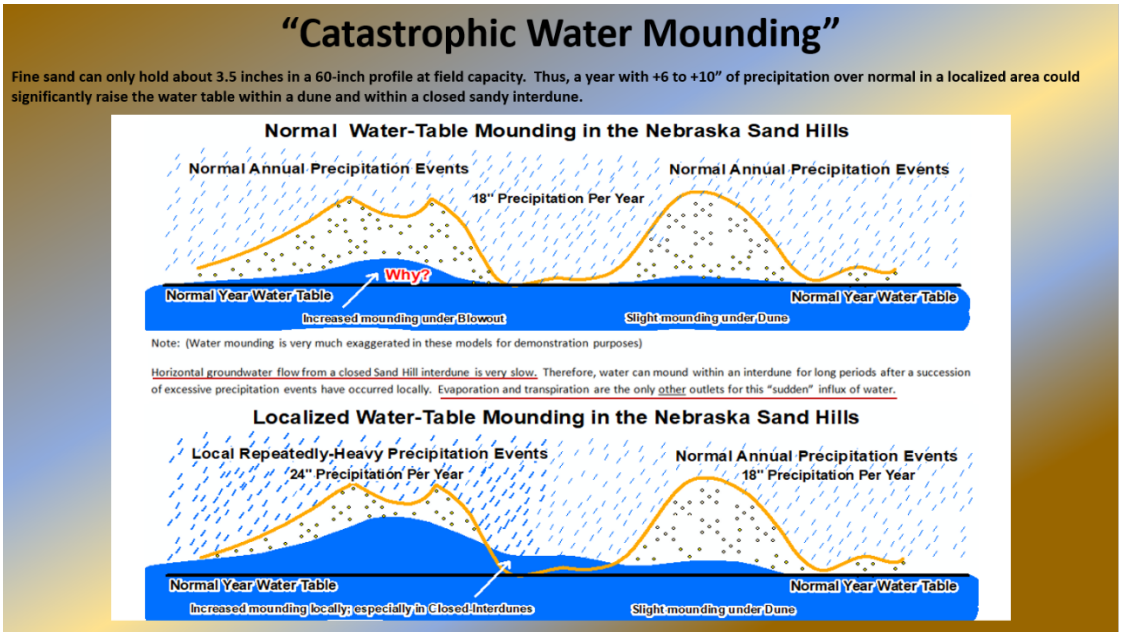
For most soils in the United States and [in Nebraska, more specifically] there is little change in soil characteristics that directly affect the plants growing on them . . . the Ecological Site is "static;" basically unchanging regardless of the oscillation to wetter or dryer cycling. However, we learned when mapping Cherry County over a period of more than 13 years that Sand Hill Ecological Sites—which change in relation to

the depth of the regional groundwater table are semi-fluid in that they often do change during one full oscillation from *one Site dryer* to *one Site wetter* than that which occurs during normal years of precipitation.

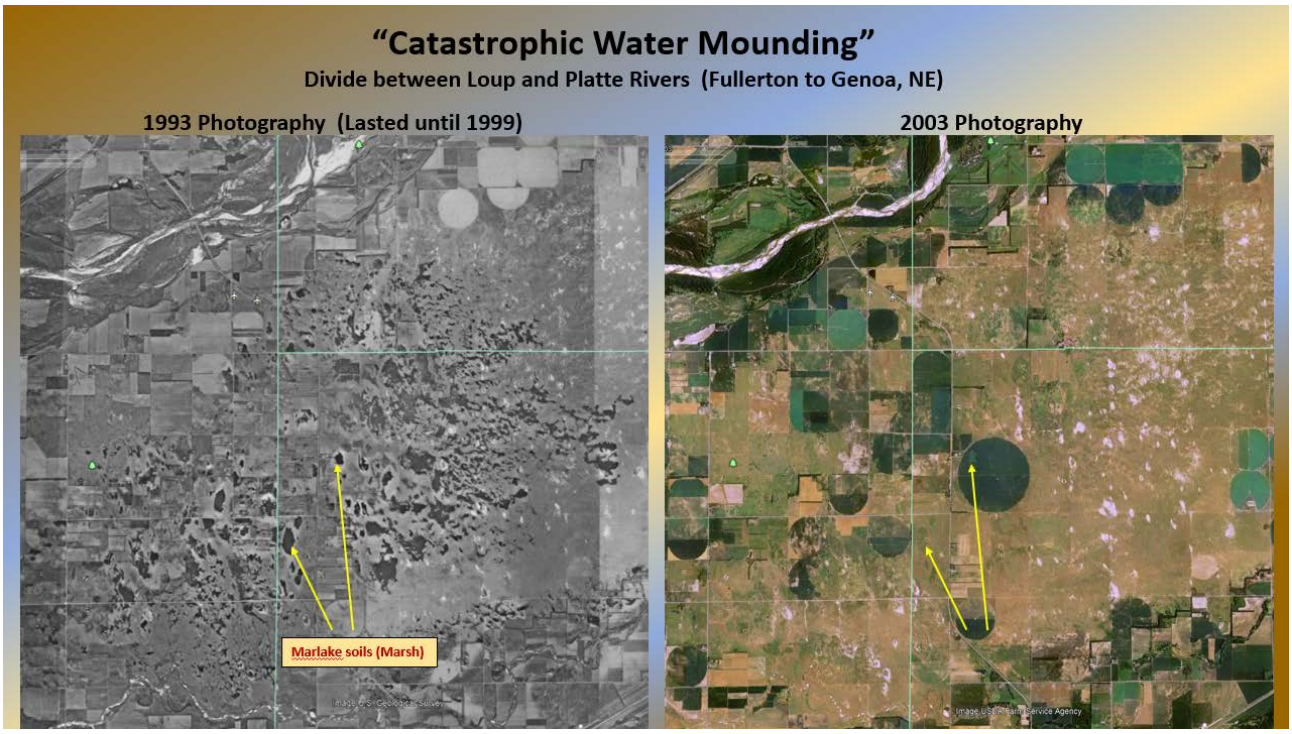


The seed bank is there—it's just waiting. If the water table rises or falls about 6 inches and remains there for more than one growing season, it will trigger confusion in the plant community as it starts transitioning toward the wetter or dryer Site. By the second or third year the transition is mostly complete. It will stay as the new ecological site until normal conditions return.

Catastrophic water mounding is a complicated phenomenon that is *usually* localized in a relatively small region where multiple excessive precipitation events have occurred in an area that includes one or more closed interdunes; or perhaps in numerous closed pockets in a rolling sand-sheet landscape.



I say “usually” as in the past—over the last hundred years it has only been reported as occurring on local ranches—not necessarily affecting most of their neighbors. The water table doesn’t just rise some 6-inches or a foot, but often rises 3 to 10-feet in the closed interdune and/or as much as 10 to 18-feet in closed pockets in some rolling sand sheet areas. There are exceptions to this “localized” rule. On the Platte River system, and in-between the Platte and Loup River systems in Buffalo, Hall, Merrick, Nance and Platte Counties where there are sand-sheets blown out over the moderately clayey river terrace soils—catastrophic water mounding



Yellow arrows point to spots mapped as marsh during normal years.

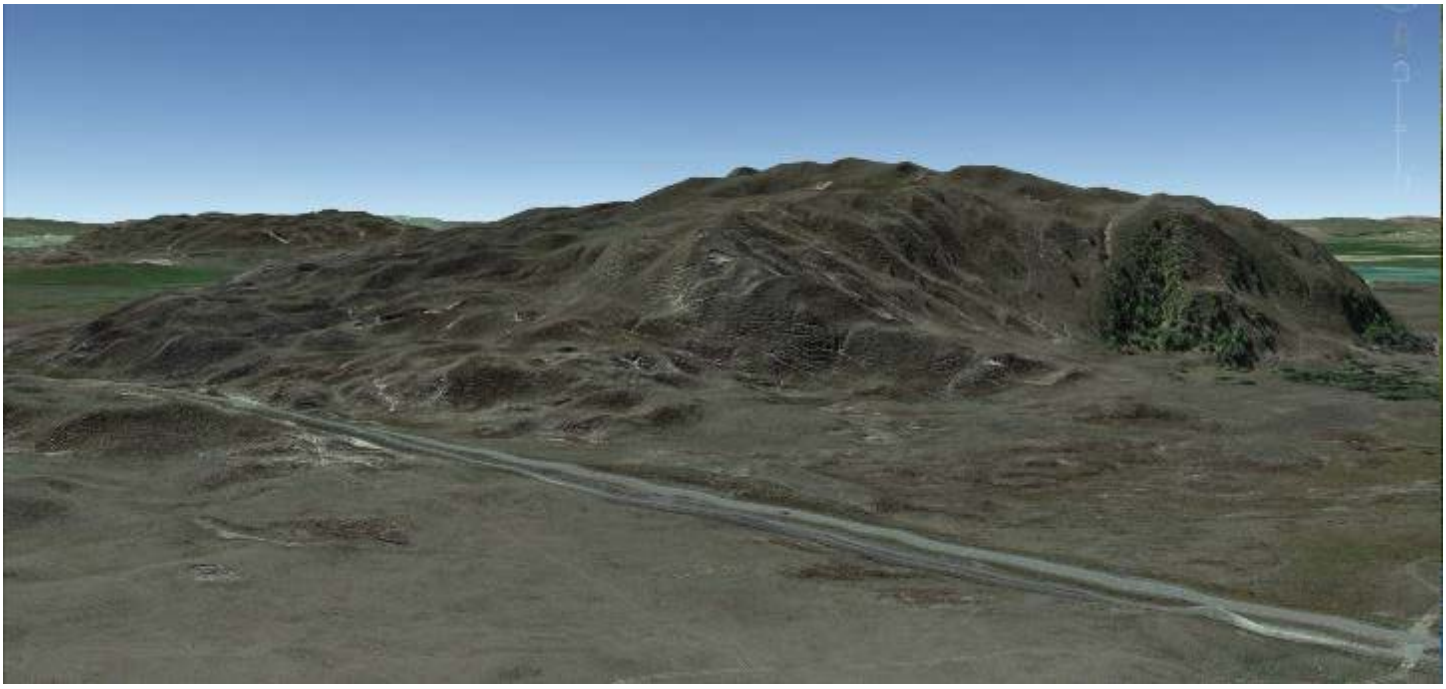
occurs moderately uniformly over a broad region. Subirrigated soils become marshes or even open water areas and these have—at least twice in recorded history—lasted for up to **seven consecutive years**!

Valentine soils which make up most Sand Hill dunes and sand sheets is generally comprised of 92% to 96% sand, with FS dominating. Fine sand can only hold about 3.5 inches of water within a 5-foot profile at field capacity. Any more than that amount of precipitation is going to leach downward as free-flowing gravitational water. However, in the Sand Hills, the groundwater table is often only a foot to 5-feet below the interdune surface. Gravitational water will travel downward to the water table, but since *water cannot be compressed*, the mound of water within each dune rises significantly [every 5 feet only holds 3.5” of water].

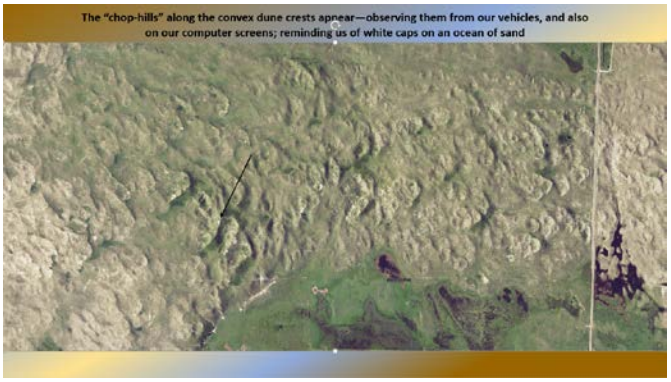
As the weight of the water mound building up in the dune exceeds some undetermined hydraulic pressure, it will eventually flow outward (anisotropic flow) from the dune towards areas of lower pressure. This is the reason that small pockets just outside the dunes and well above the lowest parts of the meadow often become marshes and or pocket-wetlands when the interdune—as a whole, is not yet as wet [*note wetter pockets near dune perimeters in picture below*].

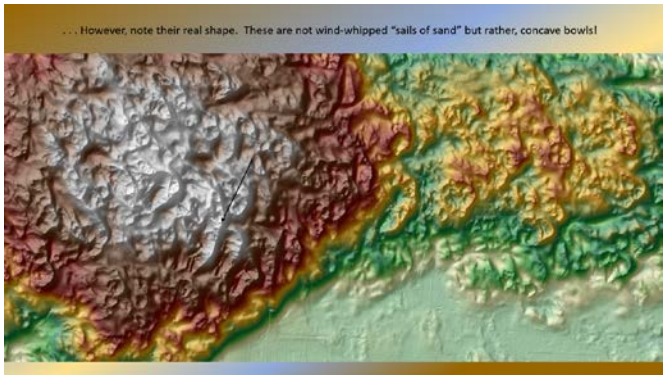
Closed interdune 1 valley south of Merritt Reservoir: Summer, 2019—this interdune filled up with a lake that was 4-feet deep over the Highway 97 roadway. Lake-level was approximately 3019 to 3020 feet when over the highway!

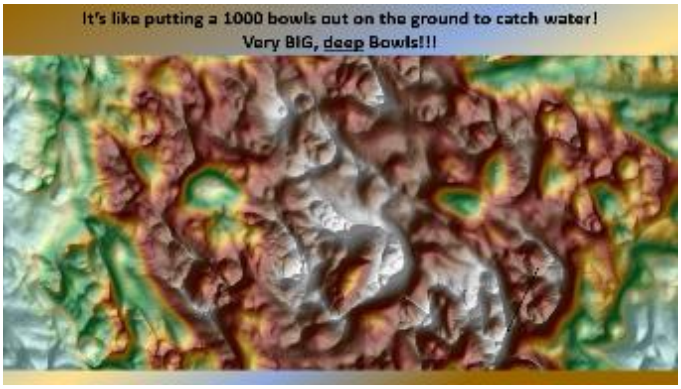
Why do the dunes collect so much precipitation? We all know that fine sand takes in water very quickly as compared to loamy soils. Yes. But when you think of a Sand Hill dune, do you think of it like a "depression?" Probably not!! [more like the dune pictured below]. But let's look at the top of the dunes next to where Highway 97 was recently under water. Pictured (next page) are the dunes just north of the Hwy 97

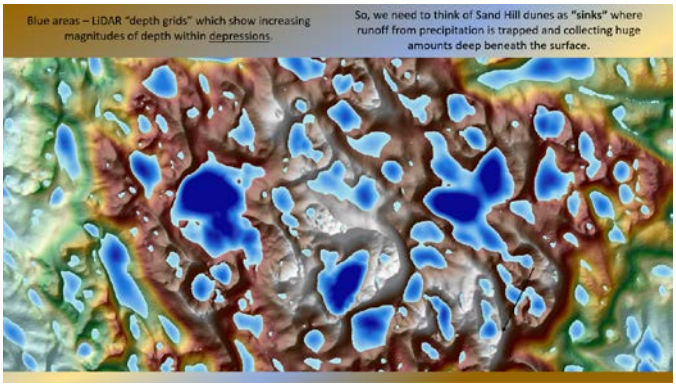


inundated interdune. Next to them is a LiDAR picture enhanced with engineering software that shows all closed depressions within an area. The darker the blue, the deeper the depression. These are called



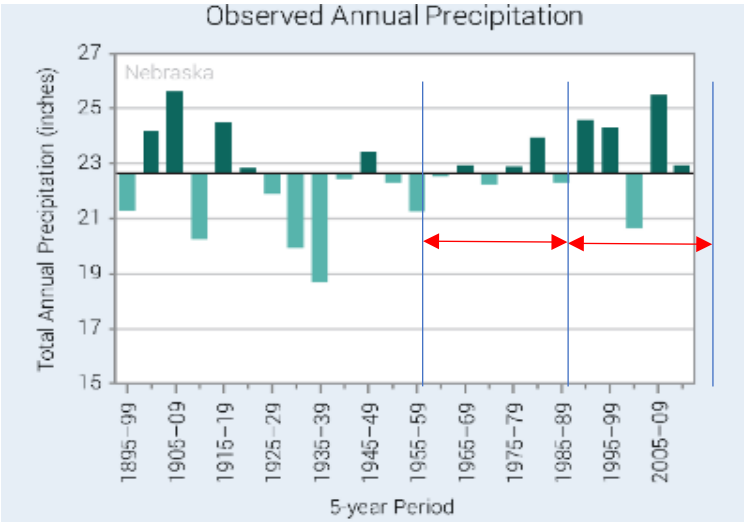






"depth grids." It is ***probably impossible*** to invent a more efficient "convex" surface to capture, trap and store more precipitation—than nature has created with these Sand Hill dunes!

Earlier I stated that Valentine fine sand can only hold about 3.5 inches of water within a 5-foot profile at field capacity. So, if a year of heavier-than-normal precipitation adds say, 7 inches (2X field capacity) over the 30-year normal for annual precipitation, effectively the water mound within a dune could rise almost 10-feet!! [See illustration below]. 2019 is now year 11 out of the past 12 years of higher-than-normal precipitation for central Nebraska—including the Nebraska Sand Hills. Just in the last three years [2016 through 2018] the Cherry County area has seen 19 to 28" over the 1961 – 1990 normals. And early 2019 was wetter yet. The average precipitation has been increasing over the past 60 years such that the 1991 – 2020 normals for Nebraska will likely not look anything like the 1961 – 1990 normals.



Compare the 1961 – 1990 and 1991 – 2020 30-year normals

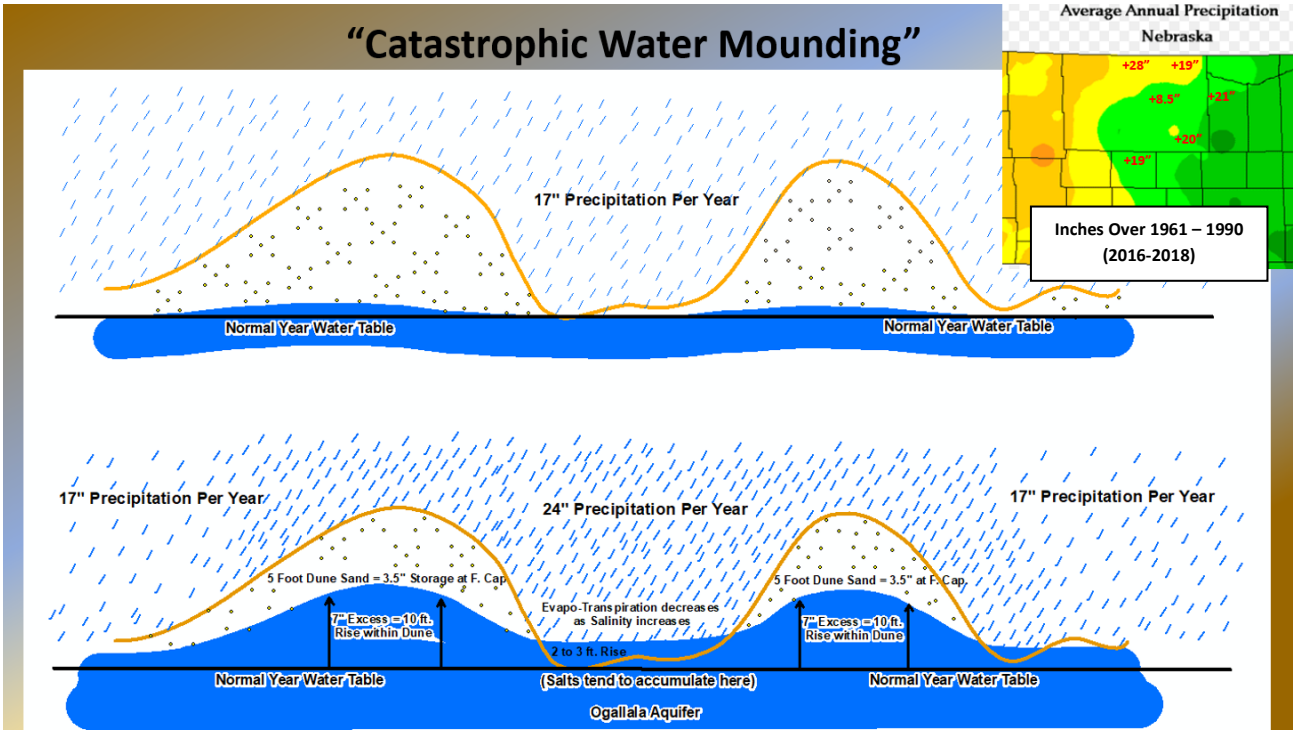
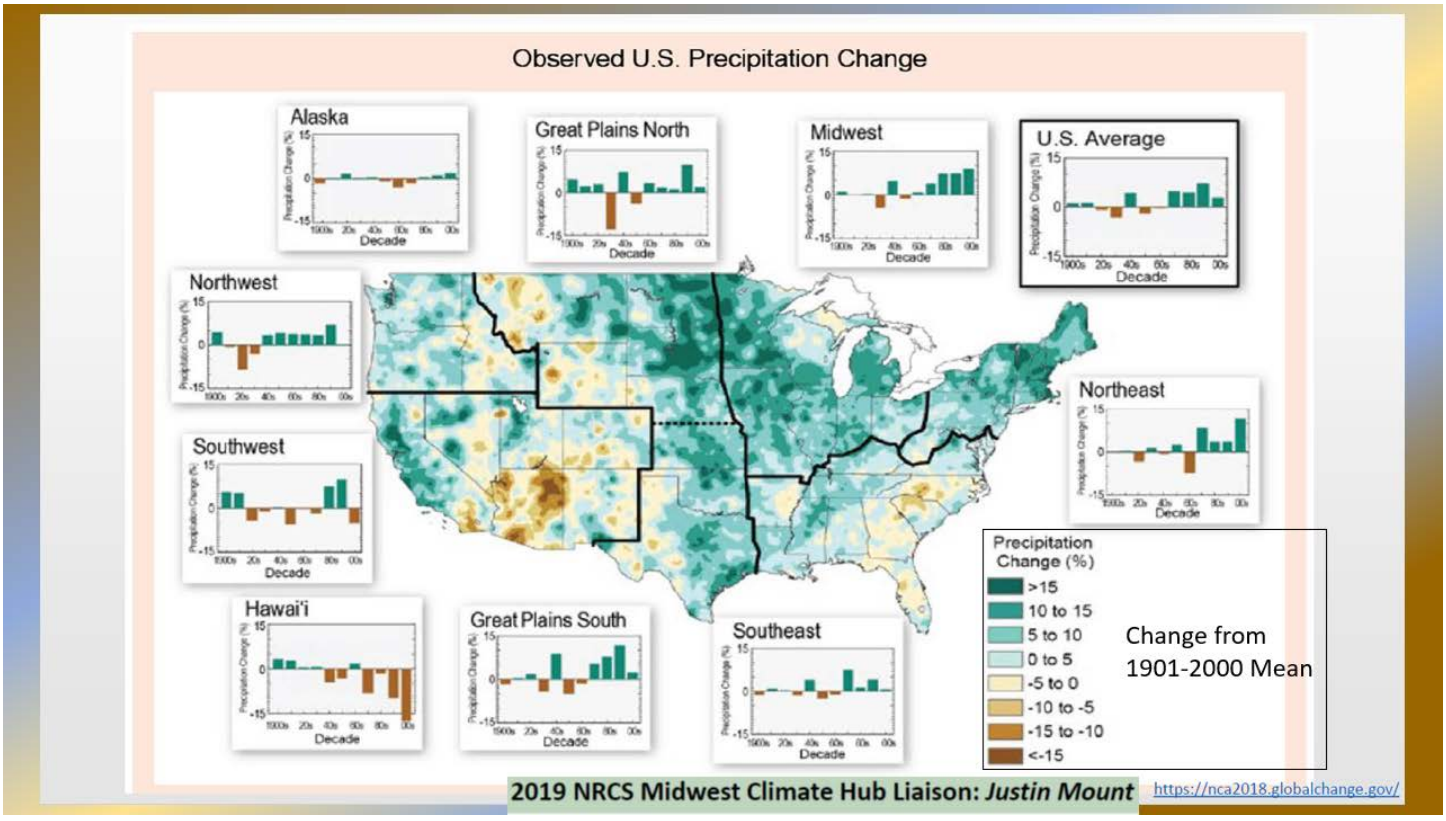
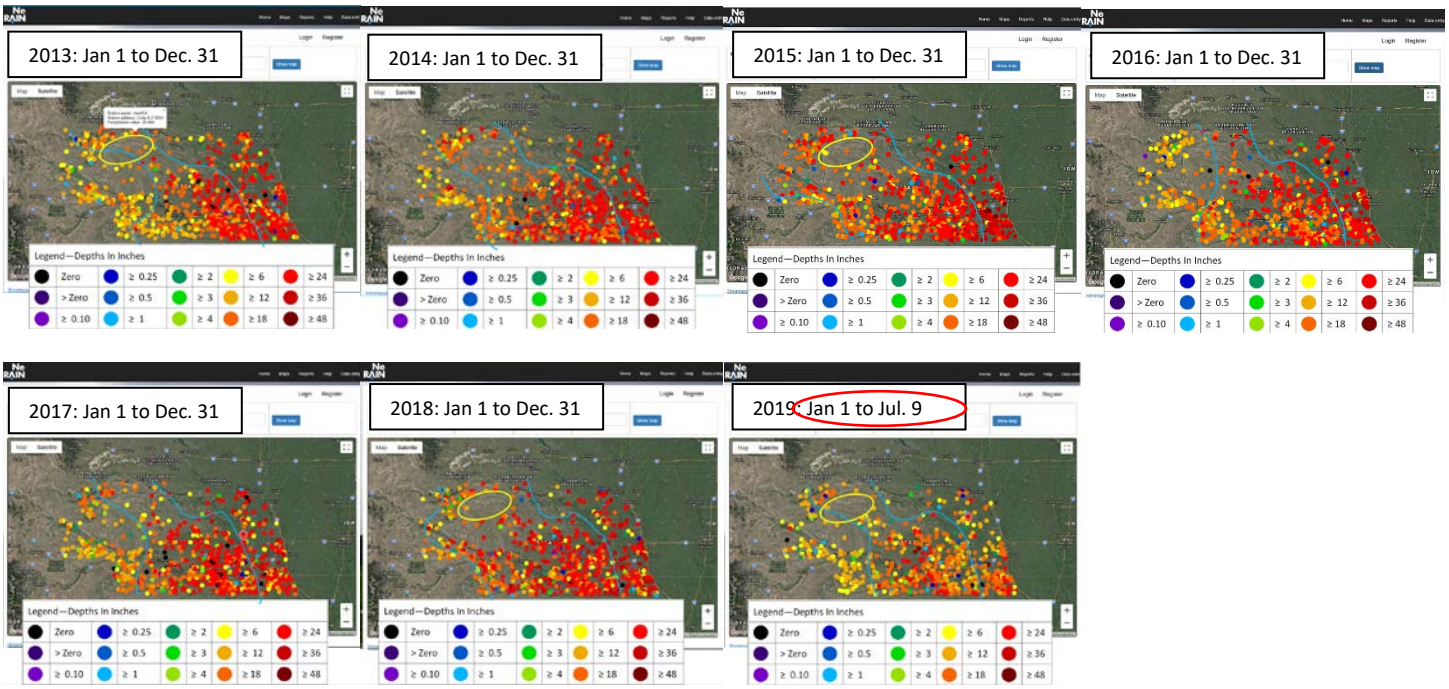


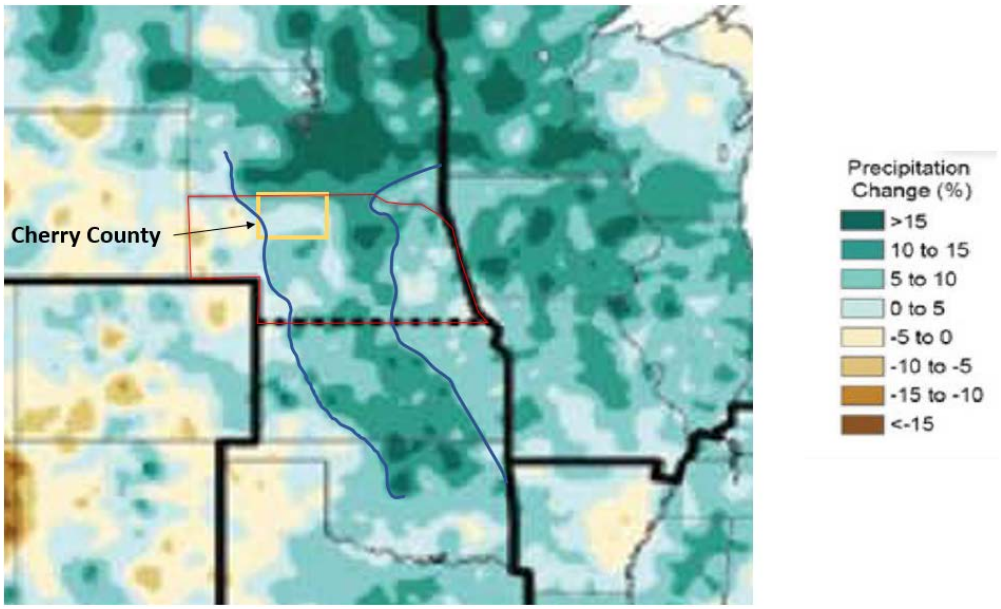
Illustration of 7-inch surplus of precipitation and hydrology effect within dunes

This more-or-less 12-year wet-cycle we're currently in is just adding to a 120-year trend that has been happening throughout the Great Plains and the Northeastern United States.





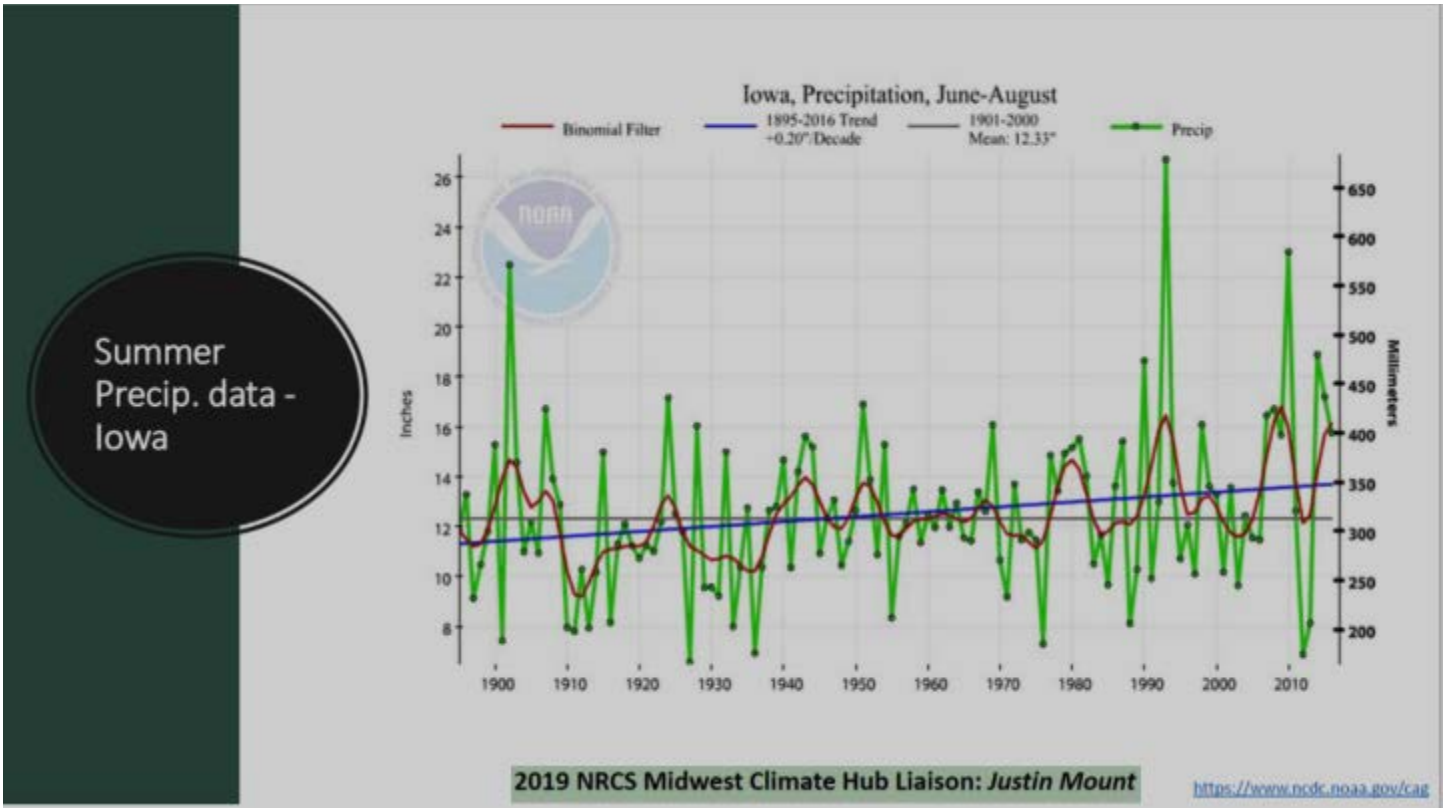
NE-Rain Maps showing excessive rainfall (between blue lines) in central Nebraska. Yellow circle—seriously lacking data???

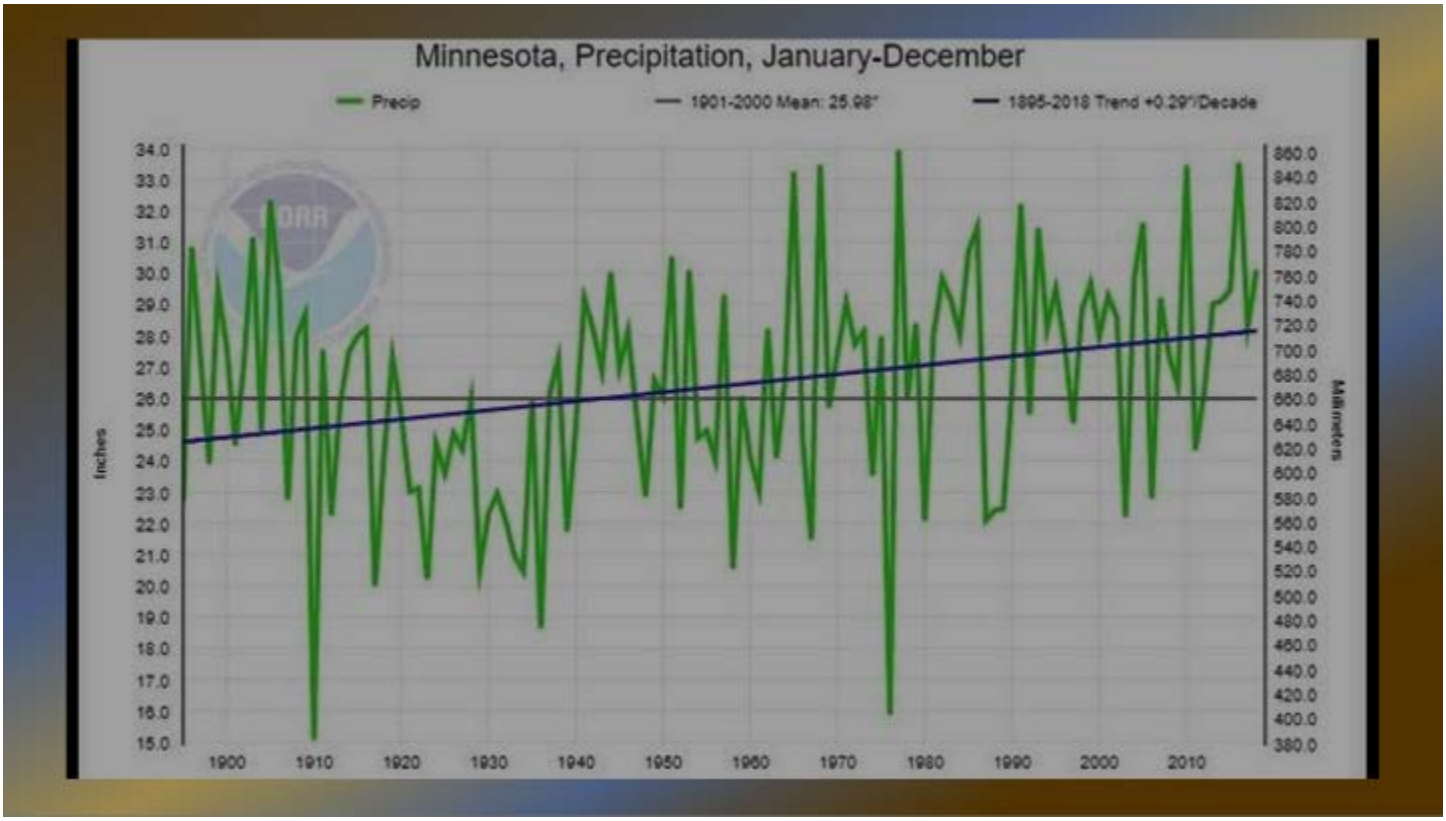


Close-up of National Map showing belt of excessive [10 to >15% over 100-year mean]

So, I've stated that we're apparently in a long-term wetting-cycle. It's now longer than any other wet-cycle for central Nebraska that we've recorded since 1895. (Similar to one in the start of the 1900s). Shorter wet cycles have triggered localized catastrophic water mounding events. This cycle is already triggering more severe water mounding events than known about in recorded history for the Nebraska Sand Hills. How long will it last? That is the Thousands to Millions $$$ question *yet to be answered*. No-one knows! But there is information available from the past which helps us see the present picture more clearly. The NRCS Midwest Climate Hub has published data for Iowa and Minnesota—states that are also in this same pattern.

[see next two illustrations]



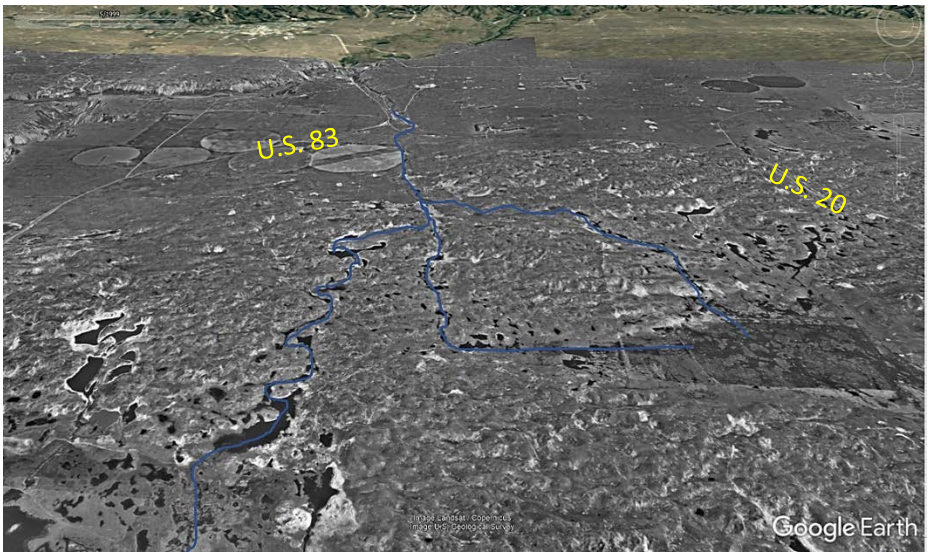


These both show in slightly different ways that precipitation patterns have been on a relatively steady increase since 1895. There is no indication that the increase has peaked or is declining in any way, yet.

Catastrophic water mounding is more complex than just excess rainfall and sand dune sponges. If the "sponge" fills up and begins bleeding out water to an open valley, there will be no water mounding. The creek

or other surface drainage will carry the water to a river and out. It happens only in closed interdunes and/or closed-pockets within rolling sand sheets. However, there are other forces possibly at work to concentrate this water in these specific locations.

Before the Sand Hills *saltated* [marched] into place, there existed a former landscape. It was a loamy and silty hardlands region. Hardlands form *dendritic* [branching] drainage patterns. Water starts as sheet flow, then begins to concentrate into rills; which then grow into drains and gullies, which finally concentrate to form streams. Catastrophic water mounding seems in some cases to occur in places that coincide with these ancient surface drainages.



Then there are aquitards such as layers of sandstone, caliche, or heavy clay soils which may stop or greatly slow down the gravitational downward movement of collected water more than other surrounding areas. A little-understood phenomenon also accompanies some re-occurring closed interdune water mounds. They sometimes tend to collect strongly alkaline salts within the interdune after each inundation. This process of collecting salts on the surface may retard the infiltration of precipitation, making the catastrophic condition even more likely next time.

Impact to Farms and Ranches:

Highway 97 was closed for many months due to deep water over the road. Highways US 83 and Nebraska 61 both had broad areas where water was (2019) over the paved surface and traffic was down to one lane. Many Cherry County and Brown County secondary roads were either closed or otherwise impassable to and from market for the ranchers and producers needing to use them. Some of the roads that were “fixed” (raised in low places) are now approaching inundation again (late 2019 and 2020???). Numerous ranches have lost their driveways into the ranch. They are driving to and from up in the dunes. Houses and other ranch building have received water damage from inundation and wet basements/foundations.

But that is only the beginning. The loss of revenue from hay meadows that are now inundated, is catastrophic. According to one producer, with agreement from another dozen still in the room at a County Commissioner Mtg (summer, 2019), reduction in meadow hay production was 70% in 2018 and is looking to

be 80 to 87% for the 2019 hay production year. Even half those numbers for the last two to three years would be a severe impact. There remains hayable areas within the meadows, but no way to get to them—even with 4-wheel drive tractors. Winter grazing is made impossible by the ice covering the hay meadows, and cattlemen are facing the real possibility of having to reduce herd-size due to too much rainfall, continued ponded conditions, and/or flooded runoff.

Some center pivots are no longer in production. Conditions are too wet for alfalfa hay. If this wet cycle continues into 2020 or beyond, and the water mounding worsens, small farms and ranches may face severe financial trouble—not to mention the Covid-19 virus troubles that are already crippling ranch operations.

Talking Points to Ponder: Impacts to NRCS Planners:

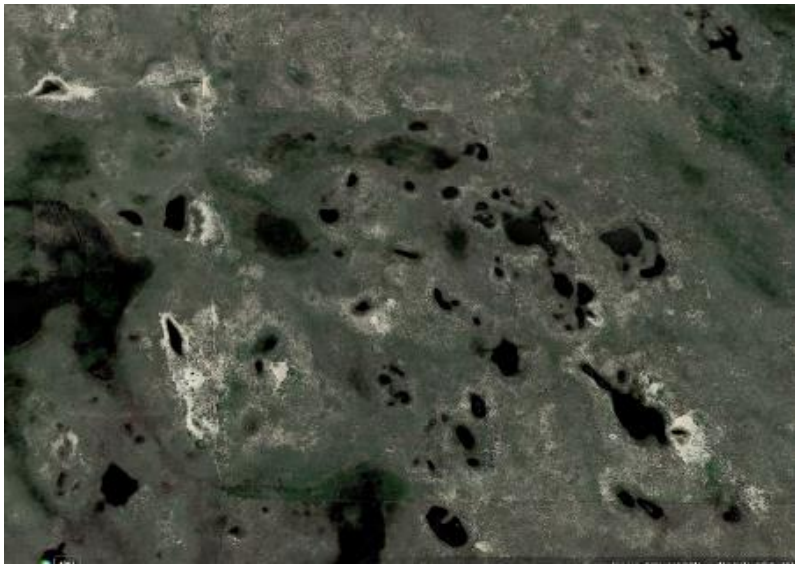
Someone may wonder why I compared the current precipitation totals to the 1961-1990 statewide normals. I did so for two reasons. I'm not sure that we have access to older 30-year normal precipitation data. Secondly, a vast majority of the ranch managers today were alive and can relate better to 1961 – 1990 data than perhaps older data as they have lived through at least some part of the listed period. It is obvious that the mean annual precipitation lines (MAP-lines) moved westward in the 1971-2000 normals, and once again in the 1981-2010 statewide normals. But what is now starting to happen regionwide on many ranches has never been seen or experienced *to the degree that it is happening today*. Relating it back to the older 30-year normal data is like stepping back and looking at the bigger picture. Everyone must understand that the dunes have a "tipping point" where they can no longer hold more water, and this deep-water seeping into the meadows will continue to be played out (in 2020 and beyond) in the closed interdunes if this wet cycle continues on into the future. It may also *take several years* for the waters to recede from inundated meadows . . . and they *may fill back up again after only moderate rainfall* in subsequent years as the dunes quickly fill up again to beyond capacity.

I think it may be a hard pill to swallow for all of us to think that planners may someday soon not be able to take the production numbers from our database at face value. The low/high and representative values of production numbers for each interdune mapping unit were designed for the standard 10 to 20-year oscillations of the climate. These numbers take care of individual lean and fat years of precipitation. But we do not have an adequate value for lengthy wet periods resulting in wide-spread *catastrophic water mounding* which could turn an Els soil or even an Ipage into a Marlake (marsh) or even *open water*. [see Chart, p. 4]

Some might think that extended wet years will just line the pockets of Sand Hill ranchers with more money. I think that idea may be very mistaken. Just like an extended drought such as we had in the 1930s was devastating to many ranchers, I believe an extended wet period (12 years into it already . . .) is just now becoming similarly devastating to those ranches that are experiencing year-round inundated. We cannot use the high values traditionally used for "wet"-year hay production and stocking rates. Nor can we use the dry year values to represent this loss of production. The losses can far-exceed the low-values listed in our data-base. Each parcel must be re-evaluated on an individual basis by a planner *who understands what and how much change has occurred to the listed Ecological Sites* within that parcel since mapping and publication.

Another major impact is that other databases (such as land valuation and taxation) use our expected production numbers in their databases. This will only compound the already crippling pain for the ranch owners, operators, and managers.

Planners need to understand that where marshes pop up in a mapping unit [say, 5-10% of the delineation) that was mapped as straight sands [such as a Valentine FS, 3 to 9 percent slopes], the marshes contribute virtually no grazing (or haying) value and now become loitering points in a larger range unit during the heat of the summer. Worse yet, because they are loitering points, the sands that surround these low areas will now be hammered by the lazy cows right at the reproductive stage of the C4 grasses, further reducing the grazable production in future years. It can quickly become a "double-sucker-punch" to the land manager!



Valentine-Tryon areas are absolutely the hardest areas to manage properly in the Sand Hills. Even the best range managers struggle to keep these areas healthy and productive.

How do we set up or make a 5-year grazing plan during this extending wet oscillation of climate? Good question. Perhaps by evaluating the conditions as of today and writing the plan, with the full understanding that at some point in the future the plan may have to be amended! Remember, at no time in recorded history [since 1895] have we here in the Sand Hills ever had to deal with 12 nearly consecutive years of far-above normal precipitation. How many more are ahead? We are all blazing new ground. "Uncharted waters!"

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