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Legislature's Planning Committee  
November 03, 2017

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The Legislature's Planning Committee met at 9:00 a.m. on Friday, November 3, 2017, in Room 1003 of the State Capitol, Lincoln, Nebraska, for the purpose of conducting a public hearing. Senators present: Paul Schumacher, Chairperson; Tony Vargas, Vice Chairperson; Matt Hansen; Merv Riepe; Dan Watermeier; and Matt Williams. Senators absent: Jim Scheer and John Stinner.

SENATOR SCHUMACHER: We'll call the meeting of the Planning Committee to order. I'd ask a motion to approve the transcript as our minutes.

SENATOR WATERMEIER: So moved.

SENATOR RIEPE: Second.

SENATOR SCHUMACHER: It stands approved. Purposes of introduction and orientation a little bit for our folks in the audience who haven't been here before, the Planning Committee is an entity that was set up about ten years ago by the Legislature by statute to look at long-range trends, to try to do some long-range planning, and make some recommendations on closer range legislation, all in an effort to try to make sure we don't veer off in the wrong path and try to develop a wise long-range path. We try to sift out some of the echoes of the past from the clatter of the present and listen to what might be the beckoning of the future. To that end, the committee has claimed academic freedom. That means that we can argue against things we are for, against things we are...for things we are against, against things we are for, and even preach a little heresy every once in a while to try to figure out where we should be heading. One of the things that we try to do is take some reasonably safe assumptions based upon some of the data that's been accumulated over the last ten years to guess where we're going. We see strong trends toward depopulation of rural Nebraska, for example. We see strong trends of increased agricultural efficiencies and productivity in beef and grain. We make assumptions that our soil is going to remain good, our water is going to remain good, agriculture is going to continue to be strong, seeds are going to get better, fertilizer is going to get better. And generally, with fewer and fewer people we're going to be able to raise more and more crops and cows and pigs. And we even have...yeah, we have a few sheep, don't we? So that's our assumptions. But one of the

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assumptions that makes all that possible is climate. And over the past few years there's been a lot of talk, controversy, guesstimates of what the climate might look like 50, 75 years from now. And to that end, I asked the university whether or not they could give us a little insight into what might be a reasonable interpretation of some of the climate talk that we've been hearing over the last decade or so. And I asked them if they had a real expert. And they said we do and his name is Tyler Williams and he will be happy to come to talk to you. So, Tyler, tell us a little bit about yourself and tell us about what the weather is going to be like on December 31,...

TYLER WILLIAMS: If I could do that I wouldn't be here, right?

SENATOR SCHUMACHER: ...2099.

TYLER WILLIAMS: Right, yeah. Yeah, so thank you for that. And like I said, my name is Tyler William. I'm actually below the expert because the expert they tried to get was Martha Shulski, the State Climatologist, and she's actually in D.C. this week. And so it trickled down to me and so I'm still happy to be here, still hopefully can fill her shoes. But, yeah, so I've worked for Extension for a number of years and my background is mostly in agriculture. So I work with a lot of farmers. I grew up on a ranch, still have some cows. I got my degrees in meteorology and agronomy, so I kind of tie those things together and, hence, why I'm here today. So I don't know if you want me to continue on or if you...

SENATOR SCHUMACHER: Just go on with your presentation...

TYLER WILLIAMS: Sure.

SENATOR SCHUMACHER: ...and if there's any pressing questions, the panel is free to interrupt.

TYLER WILLIAMS: Please.

SENATOR SCHUMACHER: Either that, or we'll save questions for the end.

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TYLER WILLIAMS: (Exhibit 1) Yeah. Yeah, absolutely. And there's a number of slides in here, mainly just because I wanted to kind of throw things out there. And whatever grabs your attention, please stop me and we can go into it. I'll probably skip over some things, but you'll have those in your handout if you want to refer to them, just because it's not as easy as what's going to happen on December 31 of 2029, as you know. So anyway, so I'll try to give you kind of a rough overview and, at your request, a fairly informal type talk, so interaction would be great. You know, as many of you know, in 2014 there was basically Nebraska Climate Assessment put out by Don Wilhite and others. You're probably familiar with this. This did lay the foundation to sort of kind of bring some of the climate change talk to Nebraska, you know, what are the implications for us? It says it right there in the title. So that's a very good resource and I'll refer to that a few times throughout the discussion today. And I also have a number of other resources: the State Climate Office. I mentioned Martha Shulski. She's the director there. We also have the High Plains Regional Climate Center and the Drought Mitigation Center here at UNL which is one of the only universities I believe to have that sort of connection of a state, regional, and national center. So we have a lot of resources here that can add to this conversation, among the other things, you know, that the university can provide through agronomy and horticulture, entomology, things like that. So I speak a lot with farmers mostly and I always try to address the elephant in the room which is the polar bear standing on ice. Climate change is a global issue, but in this presentation I'll mostly talk about Nebraska. So there aren't very many polar bears or sea ice in Nebraska so I won't dive into that too much. But certainly what happens in other parts of the world does affect and get around to affecting Nebraska and everywhere else. So everything is connected. I just won't get into that. So we'll start...we'll talk pretty much just about the impacts on agriculture and kind of what we think might happen. So again, feel free to stop me anytime. But this is essentially why we're here. These are the U.S. corn yields over the last 50-60 years--you know, general increasing trend line. And the up and down is due to weather and climatic events. We know that drought, flood, all that will impact agriculture and crop yields and that's sort of our concern, among other things here today, is that, you know, how can we reduce that fluctuation and prepare for that for the future? I'm not going to give you a meteorology background. Just understand, and I'm sure you do, that we can be highly variable here. A lot of things connect and converge in the middle part of the U.S. which makes projections very challenging. If we're located pretty close to an ocean, we can project a little bit better on what might happen. Here in the middle of the U.S. it can...the variation often outweighs the long-term

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change. So that's something that we just often have to remind ourselves as we talk about it. This is just an example of that. Nebraska's annual precipitation, as you all are pretty aware, it decreases quite rapidly from east to west. That's a...every tick mark is a two-inch change in annual precipitation. And if you cross that up with temperature it's a two-degree temperature decrease as you go north from each bar. So when we talk about what impacts might have on the future, we essentially need to look at each one of those polygons and address it, not necessarily separately but be cognizant of the differences in temperature and precipitation just across our state so that all impacts won't be the same from Falls City to Harrison. So we just have to keep those in mind as we move forward. These are just the extremes from last year that we dealt with. So agricultural producers are pretty good at understanding the extremes that we do get and have come up with ways to reduce the impact. You know, 130-some degree temperature difference in six months poses challenges, but it's not a challenge that they haven't met before. So this first part I'll talk about some of the trends. It's good to look at the trends to sort of know where we're going. Some of the things to keep in mind when I go through these trends is there's always a temporal or spacial variability with it, so it changes. Maybe each season might behave a little differently. There's also from North Platte to West Point, there might be some differences there too, so. And we won't necessarily talk about single stations. We'll talk mostly about regions, so sort of an average of what might be happening. And also we'll use some different time scales and comparisons, but we just need to be...make sure that we're looking at exactly what we do. And I'll show you an example of that from the National Climate Assessment of some of the time scales might skew what the map might be showing a little bit, so. And most of the sources that I use here is all from NOAA or university data. So I have pretty safe sources here. So this is straight from the Nebraska Climate Assessment that I showed you in the beginning. Overall, since 1895, average temperature has increased about 1 degree. That's not much because we know any given year will change quite a bit from that, although we...the last 30 years has been a little bit of a different trend. The frost-free season increased by 5 to 25 days. That's quite a wide range and that's primarily due because eastern Nebraska is closer to that 5-day increase in frost-free days and western Nebraska is closer to that 25. So you see definitely a state difference from east to west. When we look at...split it up into winter and summer that's probably where we see the most difference and why that trend is sort of not very strong is because most of our warming has occurred in the winter. Minimum temperatures during the winter have increased by 2-4.5 degrees while maximum temperatures have just increased slightly but, nonetheless, an increase. But if

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you look at summertime, really we haven't seen much change in overall average summertime temperatures. Our minimum temperatures have increased slightly. It's actually a fairly steady trend and is more consistent from year to year is that minimum temperature. But our maximum temperatures are fairly steady. And we'll talk about that here in a minute of what's going to flip flop that. But generally, our maximum temperatures outside of 2012 or something like that have generally been fairly moderate. This is just a map, just to sort of show you kind of what's happening across the U.S. This came from the Climate Assessment as well. Most of the warming is happening in northern latitudes and drier areas. So as you can see, the southeast U.S. is actually cooling a little bit. But most of the warming is occurring in the west and the north. And that's fairly consistent with most places across the globe. But again, you can see just the visual of what that might look like. An easy way to visualize this, I've shown this to a number of people and this sort of resonates with them a little bit, is the hardiness zone map. If you're a gardener or like flowers and plants, you often use a hardiness zone to know what type of plant will survive the winter. These maps are based off of the extreme minimum temperature that we reach in Nebraska during the wintertime. And that's...you can see just from 1990 to 2006 we've increased basically a zone. And that's, again, just based off the extreme minimum temperature that we get in the wintertime. It moves around a lot because it's only based off of a 30-year average. So if you get five, six years of fairly cold or fairly warm weather it can fluctuate that quite a bit. But we're seeing a fairly consistent trend from 1990 to 2006 and even to the 2012 map has increased a little bit. But it sort of brings home the point of we have sort of seen that warming, especially in the wintertime. I'm not going to talk much about this frost-free lengths. We kind of touched on that, but just to visualize that it is mostly across the U.S. that we've seen general increase in frost-free season length. Again, the regions there are quite large to put anything into concrete number like a plus ten, that's not the same case for every place in that region. But it gives you an idea.

SENATOR WATERMEIER: Back, Tyler, on that last...

TYLER WILLIAMS: Yeah.

SENATOR WATERMEIER: ...slide there, if you don't mind me interrupting.

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TYLER WILLIAMS: Yes.

SENATOR WATERMEIER: You had said the southeast was actually cooling but yet it still shows a growing number of degrees of...days of frost-free season, so.

TYLER WILLIAMS: Yep. I think most of the cooling there is occurring during the summer. So cooling is sort of tough, right, because it's averaging all days across all seasons. So in the...the frost-free season is typically in the spring and fall, that fluctuation. And we've seen sort of the same thing here in Nebraska as well of that spring, fall we're seeing a little bit of a shift, but in the summertime, we've even been cooling here, especially kind of the eastern part of the state. That's what they're seeing there in the southeast is cooler, a little bit cooler during the summer.

SENATOR WATERMEIER: Okay.

TYLER WILLIAMS: If that helps explain it a little bit.

SENATOR WATERMEIER: Yeah, thinking it through.

TYLER WILLIAMS: This map might help a little bit, too, with the Nebraska on this. This is...Martha Shulski did this, put this data together and reported about two years ago, and this looks at growing season length. Again, this is average across Nebraska from 1895 to 2010 or '11, I believe. And you can see the annual fluctuation and then you can see the long-term trend. That's sort of our challenge here in Nebraska. As you can see, from 1939 to 1940 we went from a growing season length of 178 days down to 139 days just in one single year, back to back. So any long-term change of five, you know, five days doesn't match what we see from a year-to-year variability. But what you'll also notice in this is if you look sort of the inflection point of this graph, around 1950 or '55, before that point we'd had nine years where we had less than 140 days of a growing season. Since that day we've only had two that dropped below that point. So I think that's sort of where we can take a graph like this and maybe use that trend a little bit is, you know, we know that the year-to-year variation is quite high, but our overall trend is that we're still on the uptick, right? So can we decrease the low points in that? Can we expect now that the odds of getting below 140 days for a growing season might be quite low? So it's sort of a risk

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management probability type standpoint as opposed to it will never happen. So I think that's how it's something that we can use a graph like this. This is just the one-time soil temperature I pulled from March 31, so just what was the soil temperature on March 31 at these locations. The soil is a great memory bank for when it comes to weather and climate. It stores moisture and it stores heat, so it sort of...it doesn't take a day-to-day variation very...it doesn't show those changes. So it's a good memory bank of maybe what's going on. And again, this...I'm not going to go through these but you have that there and you see generally we're increasing soil temperatures at the end of March. This graph I'm definitely not going to go through for you. I don't want to put you to sleep yet. But you can generally see that these are the climate normals for Ashland. This is the one-site Ashland site. Normals are 30-year averages of precipitation and temperature. And you can generally see that compared to the normals that we're in right now and maybe normal temperatures that we'd had in the past, you can generally see that everything is red on that map. So most all of our climate normals are warming. And again this is just Ashland. And also you can see green so we're generally becoming wetter too. So just you see the green and red there and if you want to look through that you have a copy of that. So most of that has been about temperature, precipitation. We haven't really seen a lot of difference in our long-term trend in precipitation. Generally, we've been seeing a little bit of increase in heavy rainfall events, which increases your flood risk. But, in general, it's still the same statement across most of the U.S., is that the dry areas will get drier and the wet areas will get wetter is sort of what they think will probably happen. This map here shows you a little bit of what that might look like. As you can see in Nebraska, you see some browns and you see some greens. So one broad statement about Nebraska: Precipitation probably wouldn't be accurate. But when you look at across the whole year you're just not seeing a lot of change. And this graph here sort of illustrates that. This is the long-term annual precipitation for Nebraska. Generally not seeing much of a trend, a slight uptick possibly. But if you break it down, like on the right-hand side there, break it down by season, that's where you start to notice a little bit of differences. Our spring precipitation has increased quite a bit, as you can see, from 1895 increasing a little over an inch. If you look at the last 30 years--and I think I have a graph coming up here in a second--that's actually increased quite a bit more, especially in the month of April. April has sort of been quite a bit wetter than a lot of the other months. In March we've actually seen a drying trend. So at somewhere in there, there's an inflection point. But nonetheless, our spring precipitation has increased and summer has decreased over the long term so you can see a little bit of difference there. But again, a lot of

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that is regional as well. This graph I always find useful. This basically is saying that the number of wet days we have, so a number of days with measurable precipitation, has increased over the...since 1895. Martha, again, looked at some of this data and 68 percent of the stations showed an increase of an average of eight days in the spring where it's considered a wet day. I look at that as a day that we're not in the field. And so eight less days to farm is not always easy, especially when we're trying to get things done in a hurry. So that trend has not relayed down to southeast Nebraska. I think it's because we have been fairly wet over the long term anyway. But generally across the state we're seeing an increase in number of wet days which, like I said, turns to less field days to me because that doesn't necessarily mean a lot more precipitation. This one I'm not going to bore you with either. I just wanted you to have this in your book. This basically is showing a long-term trend versus a short-term trend and different seasons that would be changing. So looking at back to 1895, how does that compare to looking back just to 1980? What are the differences in trends there? I'll let you look through that and I can answer questions if you want to know more about that. But generally we're seeing different trends recently than we are for over the long term. This is again just another way to visualize some of those trends. That one of the right is showing basically a 30-year average April precipitation. And if you're into statistics, the triangle basically says it's statistically significant. And anything in Nebraska weather that we can get that's statistically significant is a positive thing because usually our standard deviation is quite high with anything that we're trying to measure here. So you see that just visually the increasing trend in April precipitation. And that's a Midwest thing. That's not just for Nebraska. This came from the National Climate Assessment showing the change in heavy rainfall events, basically saying the amount of precipitation that is coming in the heaviest 1 percent of events. Again, you can see it's mostly an eastern and northeast change of precipitation heavy event, but it does stretch out to the Midwest and Great Plains as well. So what are the projections? That's what you really want to talk about, right? It comes down to modeling and I am not a modeler, so I am going to refer to this graph to show you a little bit about that. Essentially they use climate models to replicate past climate and try to change the model so they...because they already know what happened in the last 100 years. They use models to replicate that and so then they try to project going forward how that might look. You see the four different RCPs, which RCP stands for representative concentration pathways. Basically, it's different greenhouse gases in the atmosphere and what sort of radiative forcing they have on the amount of radiation that's coming in that's not going out. The red line is the highest. Basically, if



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we don't do anything to change greenhouse gas emissions, we continue sort of just what we're doing now, they say that's the projection for sort of the worst-case scenario, if you will, of what things might look like, down to the RCP 2.6 which is the lower version, which basically is saying that we're going to reduce emissions going forward so there won't be as big an impact from greenhouse gases going forward. So again, there's a lot in that and I...again, there's a lot of science to that and I'm, again, not a modeler so I'll leave that for some of the books I can reference you to. But from those they project temperature, right? So the lower emissions, like I mentioned, if we improve emissions, the projections shown here--this is from the National Climate Assessment again--as roughly a 4-5 degree increase in temperature by the end of the century. For the high emission scenario that I mentioned, they're projecting and 8-9 degree difference in temperature. So there's quite a range there. But if we sort of sparse that out per decade, if we look at that, you know, maybe what's going to happen in the next 20, 30, 40, 50 years, like you want to look maybe a little more short term, that is looking at about an increase of .5-1 degree temperature...degree Fahrenheit increase per decade. So currently we're on basically a .1, a tenth of a degree increase right now. If their projections hold through, they would say that we're going to increase that 1 to even .4 degrees per decade as we go forward. So as I mentioned there, the trend since 1980 is, again, an increase compared to the long-term trend of .4 degrees per decade. They're also projecting the number of days over 100 degrees to increase and those come from the Climate Assessment as well. That's an average of...an increase of two to three days per decade. So if that's averaged out over the next 75, 80 years, that's what we would be looking at. Our current trend in 100-degree day temperatures is we're actually decreasing that trend. We're losing about a half a day per decade on number of days over 100 degrees. So that's sort of one trend that they expect to flip. Instead of a decreasing trend, eventually it will increase. And I think a lot of that deals with irrigation. I think that there's an anticipation that maybe irrigation won't be quite as prevalent going forward and that moderates our summer temperatures some. And so that's just my guess, but we're on a decreasing trend there and they expect that to turn around. When it comes to increasing number of nighttime temperatures, I talk about that, an average of three to five nights per decade of nights above 60 degrees. Doesn't do a lot for you, but again, it just knows that that's the trend going forward. So if we look at the frost-free season, again, we talked about that and they're expecting an additional two weeks of frost-free season by the end of the decade. That's only about a two-day increase per decade to take a look at. So these are just, again, just breaking it down per decade for you that you can have there if you like think

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of it in those numbers as opposed to what might happen by the end of the century. Again, these are all estimates based off what might happen going into the future. So when we look at precipitation, there's a general consensus that precipitation will increase, especially in the northern latitudes. And most of it will impact us in the winter and probably the spring and fall, and a slight decrease during the summer. So there's not really a lot of hard, concrete numbers for Nebraska on those just because our precipitation is so highly variable. They'll...currently we're seeing a little change in winter and early spring precipitation, but the later spring is when we're seeing most of that. There are some projections of the summer and fall. Again, and they're expecting the heavy precipitation events to continue going forward. Again, just some of the water projections, I'm not going to go into too much detail on that but you'll have some of that there. Generally speaking, they're expecting a decrease in soil moisture over the long term just based off an increase in temperature and fairly steady precipitation. But it will alter a little bit about the snowpack and when that snowmelt might happen, thus, some of the surface water we get coming into our state from that. Other water projections, again, we're advantaged with irrigation here in Nebraska and that they're expecting that to continue certainly in the short term, but that does have an impact on moderating our temperatures a little bit during the summer and increasing our humidity. So what are the impacts? I'm going to go through this pretty quick as well, so I can open up some questions. But you guys are all aware we have center pivots in Nebraska. It's an amazing resource that we have. That's a map from 2005, so certain it's larger now. But we're fortunate enough in Nebraska that we can sort of mitigate the impact that droughts might have on our crops especially through the use of pivots and irrigation; 2012 we saw the value of that firsthand. But we also saw the risk of droughts have on irrigation. We know that if we would have had two 2012s in a row, irrigation might not be the same now as it could have been. So anyway, irrigation is quite a benefit to our state. I'm not going to go through the water resources. A couple of the authors up there of the Nebraska Climate Report that you saw, they wrote some potential changes for water resources. Generally, people say that climate is water essentially. Anything that does...has to do with climate, we're always concerned about water, where it's at, when we can use it, those sorts of things. Groundwater as well, you know, groundwater reaches out to the public water systems as well as agriculture. As we go (inaudible) we reduce recharge and increase irrigation, obviously there will be decreases in groundwater levels. That certainly would be a concern for anyone. So if we look at crops and beef, this is the land cover in Nebraska. As you can see, generally eastern Nebraska is corn, soybeans rotation so

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there's very little crop diversity. That poses some risk to at least...even right now to weather events. Not having that diversity in your operation puts you at risk to hail events, severe weather, things like that. You go further out west there's a lot more grassland. So the risk there will be primarily to that forage and to livestock. We always deal with the warmest day of the year. Our crops pollinate during the climatological warmest week of the year. So we always try to defy nature a little bit when we...we don't want heat but yet we have our crops mature or go through reproduction during the warmest time of the year. So altering from that time frame might not be a bad risk management strategy. We also get severe weather here in Nebraska as you know. And we're the target of severe weather in June, which a lot of our crops are in the vegetative growth stage, so we really don't want hail that time of the year. Again, the projection is for severe weather to continue and maybe even increase through the future, so it's something that we can do that would be impactful right now as well as into the future. So increased temperature on crops, what would be the impact of that--obviously stress, water stress. There's some ear development issues that may arise with warm temperatures. Nighttime respiration takes up energy and doesn't often increase yield. Pesticides don't work quite as well when it's warmer, warmer temperatures. Will we see that shift in a growing season? One thing I will mention on the growing season is even though we've seen it be warmer in the springs and the falls, our frost dates really haven't changed all that much. So we still have a pretty high risk for receiving a freeze in May as we may have had in the past. So even though we may have been a little bit warmer in the early part of the growing season, we still really can't take advantage of that with crops just due to the freeze risk. So there's always that risk that's out there. So I know a lot of people think that with the longer growing season then you might be able to take advantage of that, but it's still about managing risk. We talked about the shift in hardiness zones and also freeze/thaw. Freeze/thaw is pretty important to our soils, relieving compaction, things like that. So a few of the impacts, things that can respond to: changing your growth stages, narrowing your rows, change varieties. A lot of people want to look to the South, you know, what are they doing in the South? Can we mimic that? Increased temperature on beef, we know that decreases forage and range but also heat stress in livestock and overwintering pests. What can we do? You can provide shade. You can calve earlier in the year. You can change some of your plants going forward. Again, I'm going to roll through these pretty quick if it's okay with you guys. Please just jump in if you have questions. Heavy rainfall events, the impact on the crops, we know erosion, loss of nutrients, those are all big problems, loss of field work days. Any time you get wet periods, especially in

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spring and during the growing season, you have disease issues, crop emergence, you name it, it can trickle down. Things we can do: cover crops/no-till. No-till is still the number one thing that I tell people to try to do. If you're not no-tilling, you probably should, or at least try if you can. Some places it doesn't work all that well, but there's not a single practice that we can do that probably minimizes our impact from heat waves and heavy rainfall events than no-till. So, talk about residue, a number of impacts from heavy rainfall events. Beef, muddy lots, I talked to...we had some discussions with some feedlot producers up in northeast Nebraska and they told me that the worst thing that they can have is a wet December. And that's one of the things that we do expect to increase is rain and less snow in the early part of the winter because it makes the lots very muddy and it doesn't dry out. So one of their big concerns is that, and obviously storage, runoff, and things like that. So what can you do? You can make your storage facilities larger, hoop barns. Hoop barns are becoming fairly popular, putting cattle inside hoop barns to minimize the impact that weather would have on those animals. We know what happens during dry periods. I probably don't need to tell you the impact of that. What can you do? A lot of these things we are doing, we're getting better at: monitoring soil moisture, conserving that moisture, water meters on irrigation systems, a number of things like that that would help that response. The impact on beef is mostly for forage and grass growth and also water. A lot of...you get out west, there's not a lot of water out there obviously, so ponds become important, submersibles, windmills, things like that become pretty important when it comes to trying to keep that water there. Obviously, there's a number of things you can do: reducing stocking rate, reducing herd size, cow size, things like that to alleviate drought. Severe weather and snow, just kind of combining some of those, that pivot flipped over is actually from Christmas last year. So again, a warmer winter would mean that severe weather can again encroach a little bit later and earlier into the year. It's not very often you have a pivot going over on a hot wire, you know, watering cows in the corn fields. So it was a little odd. But nonetheless, severe weather impacts us now and will into the future as well. So insurance is probably one of the best things we can do when it comes to severe weather just because there's not a lot you can do to prepare for that. So this is the last slide and probably what I could have just done in a minute, but I wanted to give you at least a little bit of overview and background of the complexity of it a little bit. So generally, thinking more precipitation in April, May, and June and less in the months of March and July. Rain would be falling in less frequent but heavier events, so less half-inch events and maybe more one-inch events. Increasing the growing season length, that trend will probably continue.

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Especially in the west and western Nebraska will probably see the brunt of that. Again, severe, extreme weather events, we talked about those increasing. Warm temperatures in the winter and fall, warmer nights in the summer, pretty confident that those will continue. Freeze risk, freeze is a tough one because we can be highly variable here. So even though we warm up in the spring or later in the fall, that early frost and late frost will have an impact. Nighttime temperatures, more growing degree days. A lot of the growing degree days that we're accumulating, those are increasing. They're occurring outside of your typical growing season. So we're accumulating growing degree days in March and in October, but we a lot of times can't capture that or utilize that. So even though we're having that increase in growing degree days, might...taking advantage of that would be a challenge. Annual "flash" droughts, I think we need to be concerned about flash droughts, you know, 2012 type droughts. Not to sound catastrophic or anything like that, but I think it is a concern of those quick onsets of droughts and being able to reduce the impact from those. So what can we focus on? A lot of the things that we do, we talk about, is a lot of it's protecting and enhancing the soil. One of the things that can again alleviate the impact from a drought is having a good structured soil that's holding moisture. Heavy rainfall events, if it can soak in instead of run off, keeping those nutrients and even the soil particles on the field is probably the number one thing we can do. When it comes to a risk management standpoint for farms and ranchers is diversifying. Our system is sort of set up to become large for corn or soybeans, or all in livestock. Diversifying can still have its benefits and I think even more so in the future. Converting marginal acres back to grass and forage, the marginal farm ground is usually the first place that floods out in a heavy rainfall event and the first place that burns up when you get a drought. So putting those back to grass and forage would be one way that we could do that. Reducing water loss in general is a plus, erosion runoff reduction, and then planting trees. That might be one way that might help offset some of the long-term drought projections. The hard part about farming around trees is a lot of times trees use water, so the first few rows around a treeline oftentimes don't get the best yield. But a lot of times stopping the wind would have a benefit as well too. So that's outside of my knowledge of tree impact, but it's definitely something I think could be looked into. So with that, I am done. (Laugh) So that's all I have prepared, so I would be happy to go through anything and everything you would like for me to talk about.

SENATOR SCHUMACHER: Senator Williams.

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SENATOR WILLIAMS: Thank you, Chairman Schumacher, and thank you, Tyler, for being here and taking your time. One of the...I'll ask this in a question. When we're looking over lengthy periods of time--10 years, 20 years, 100 years--and we're seeing these minor changes, how do you feel we'll be equipped from a technology standpoint to address those? We've...over the last years we've seen significant hybrid change. We've seen how we utilize water differently and how we we've created hybrids that don't need the same amount of water.

TYLER WILLIAMS: Uh-huh.

SENATOR WILLIAMS: So should we really be worried about slight changes in temperature and what that might do to...you know, we're comparing those changes in temperature to what our technology is today with that versus what an evolving technology will be able to do. I'd like to hear your thoughts on that.

TYLER WILLIAMS: Uh-huh. Yeah. So I talk about that a lot with farmers. And there was even a survey done across the corn belt I think from a gal from Purdue. And the number one response from ag advisers to who should...what should we do about dealing with climate or climate change? And a lot of it was technology. And you're right. The corn we grow can...the yields are quite high, especially we know that the drought tolerant corn and things like that. So I think technology is one of the answers. I think the concern from a lot of people is, will that technology keep up? And, yeah, I mean from my perspective that technology, it's going to do a lot for us. It will be very helpful. You don't know...any given year, technology can't do everything for us and I think that's where I look at is the year-to-year variation is so much larger than our long-term trend. But there are things that we can do to deal with that year-to-year variation we could do this year, that we could do in 20 years, in 30 years. I think my concern is just overall just water probably. You know, we can't make any more of it. We can use less of it for crops and that's I think a benefit for agriculture. But in the really bad years is it enough? I mean you kind of get my drift. You know, in 2012, we had great hybrids, did a good job, but it wasn't enough. And those years, can we be ready for those years? And I think there are probably lots of things that we can do above and beyond technology. But you're right, technology is going to get us quite a ways.

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SENATOR SCHUMACHER: Senator Watermeier.

SENATOR WATERMEIER: Thank you, Chairman Schumacher. I appreciate, Tyler, your point you made earlier where you're not a modeler and that I am kind of a modeler. I appreciate that with all the work I've done with NRDs and different water issues. But the thing that I've always been concerned about when we look about climate change...and I'm not against or for climate change. I believe that the climate is changing. But when we look at it as a modeler or a mathematician, we're looking at this tiny point in time. And we know the weather has been going on for thousands and millions of years on the planet. So that's the thing I've always been concerned about is--and I appreciate your perspective as an ag producer and Extension person--how do we put a common-sense look at these numbers when we're starting from a single point in time? I appreciate you even going back to 1895, but we could go back 10,000 years.

TYLER WILLIAMS: Uh-huh.

SENATOR WATERMEIER: And 1 percentage point off and that can be off so much. What's your perspective on that as an ag producer or as Extension agent?

TYLER WILLIAMS: Right, and I sort of...I hear that a lot, right, is we've got a pretty small sample size of what we can see, right?

SENATOR WATERMEIER: Yeah.

TYLER WILLIAMS: And of all the numbers that I've seen, Nebraska is showing probably the smallest change as compared to a lot of places in the globe.

SENATOR WATERMEIER: Nebraska is showing the smallest changes?

TYLER WILLIAMS: Yeah. So, you know, like if you look up in Alaska and things like that, their change over the last 100 years is quite a higher than ours. So we're moderated a little bit just, again, a lot of it because of our extreme nature of our weather that we get here. But I think from what I've seen it's...the recent rate of change is what has a lot of people concerned,

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especially from a global temperature type perspective. Even though it's a pretty small sample size, the increase in the last 30 years, I don't...I probably shouldn't even say. Don't quote me on the number but something like the last 360 months have been...global temperature has been higher than the average temperature. So again, there's a number like that. So globally it's the rate of change. In Nebraska, I mean we're not seeing quite that rate of change. So it's hard to, at least for me in a lot of cases, it's hard to visualize, like, well, that small change was very small compared to the eight-degree warmer year we might have had two years ago. A one degree temperature difference doesn't make much difference when you're dealing with eight-degree increase. It might have been a four-degree decrease from back-to-back years. So I think it's...we have a pretty small sample size and it's changed along in the past, you're right. I think it's just the rate of change that we'll have to look at and pay attention to.

SENATOR WATERMEIER: And I did appreciate that. I didn't realize that the Alaska number that was in one of these slides, too, was dramatically higher and obviously that concern for the ice melt, the ice pack is that. Maybe the second question just simply is you had mentioned climate is water. Is that because of the amount of BTUs that water can hold in the atmosphere? That's what you mean as far as that term? I've heard that term before.

TYLER WILLIAMS: Right.

SENATOR WATERMEIER: So I assume it's the amount of energy.

TYLER WILLIAMS: It's mainly because why you care about climate is because of water.

SENATOR WATERMEIER: Okay. It's not necessarily scientifically because the energy held in water.

TYLER WILLIAMS: No. Right.

SENATOR WATERMEIER: It's just that the two...

TYLER WILLIAMS: Yeah. I mean, sure, water impacts climate, absolutely.



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SENATOR WATERMEIER: Right.

TYLER WILLIAMS: But it's mainly the theoretical side of...

SENATOR WATERMEIER: Okay.

TYLER WILLIAMS: ...we're concerned about climate because water. I mean the temperature increase is impactful, but it's mainly of how that changes our water within our system, right?

SENATOR WATERMEIER: Certainly.

TYLER WILLIAMS: Does it displace it? Does it use more of it? You know, that. I think that's what I was referencing there, so.

SENATOR WATERMEIER: Okay. But then that comes back to Nebraska though with the irrigation that you did mention. We're artificially putting that much extra water in the air; we're putting the extra BTUs in the air and the energy. It certainly does change our environment.

TYLER WILLIAMS: Uh-huh. Sure. Absolutely.

SENATOR WATERMEIER: Thank you.

SENATOR SCHUMACHER: Senator Vargas.

SENATOR VARGAS: Thank you very much, Chairman. This is really helpful. I just had a couple questions about...I recognize that these last couple of...we're looking at a small moment in time. And I was a former science teacher. I'm looking at...and a biology major. I'm looking at this and I'm worried about the same thing that you just said, that there's a small moment in time, we're seeing a larger increase, at least when we're looking across the nation. And I'm trying to think about some of the other compounding factors that are impacting this issue. I mean we talk about population growth. We talk about this...not only the changes in temperature, but compounding population growth. What impact can you potentially see that having on issues of

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emissions, issues that are also going to have a larger strain on what we're seeing here in terms of rising temperatures?

TYLER WILLIAMS: Yeah, so as we increase population, especially in like eastern Nebraska if we focus just on Nebraska, I mean I believe that Lincoln, most all of its water comes from the Platte River, a lot of the drinking water. So I mean I think that will have an impact. That's more water that needs to be coming down to the end of the Platte. There are a number of people upstream that use that water for irrigation. I always talk about if 2012 would have happened twice, irrigation on the Platte might be different because Lincoln can't run out of water. So I think that's a concern at least to agriculture there. When it comes to...I believe the second part of your question was on like emissions and things like that. Obviously, the more people we have, the more emissions we're probably going to produce. Again, that's another way that technology can be beneficial is reduce the emissions. But you can go stand on an asphalt parking lot and know that we have some sort of impact on our temperature, right? I mean you can feel it, the difference of...the urban heat island effect and all that where it's warmer on asphalt than grass. So I mean that's all going to have an impact. And the larger we stretch out and convert farmland to cities and things like that, that will have an impact locally on that. But after a while it will stretch out get bigger and start to impact regionally. So, yeah, there's...you know, outside of agriculture there's a whole other world of energy and greenhouse gas production and all that. And agriculture in the northern plains is actually, among the climate world, is expected to possibly benefit from the projected changes if done correctly. An increase in precipitation, not as cold in the winter time is good for a lot of producers. So I know that people up in Canada and things like that, people have been telling me that they're buying land up there and growing soybeans and things like that. So there's that. So I think that's part of the response, too, is there might not be a terribly negative effect when it comes to adapting to climate short term in Nebraska. Again, a lot of that hinges on water and droughts. I think that's probably our big concern is drought. But, again, that's only the adapting part. That's not doing things on the mitigation side. So there's always things that can be done on that side.

SENATOR VARGAS: Yeah, because I worry...one of the things I worry the most about is this doesn't just live in agriculture.

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TYLER WILLIAMS: Right.

SENATOR VARGAS: I mean we...we're looking at technology. And we are finding more innovative ways to solve problems and that's the right thing to do. We're always going to do that. But then there's also, you know, what from our own human impact are we also doing to then contribute to a decline so we don't have to overly rely on technological advancements in agriculture only. I think about that as well and I'm just wondering what that's going to look like. And also the other thing that I'm seeing is we do need to be prepared for severe weather. And that's a hard factor to prepare for. It's like insurance.

TYLER WILLIAMS: Right.

SENATOR VARGAS: It's diversifying. What do you see as the larger correlation here with some of these extreme increases in temperature, the data you're seeing, and severe weather in Nebraska?

TYLER WILLIAMS: Uh-huh. So a warmer atmosphere will hold more moisture. That's more moisture available for precipitation. That has a number of influences. You get...in a warmer atmosphere you're sort of generating up a lot of energy. We get...here in the Midwest we get combined...I showed a map earlier with the converging of cold air from the north and warm air from the south. If our air is warmer you're going to generate more severe weather. Most of that is probably going to come in form of again just more rainfall just because of more moisture in the air. I don't think that it will probably translate to more tornadoes or high wind events and things like that. So I...there's not really a strong connection there. It might just move them a little bit where they might not typically get them. But we get them here. So I think mostly it's coming in the form of severe weather when it comes to rain, I think just the heavy rainfall events and what can we do to reduce the impact of those.

SENATOR VARGAS: Last question, just I'm curious as somebody that lives outside of a more agricultural area. What advice would you give to individuals that are living in some of these more urban areas given some of the impact of all of this to try to figure out ways to better support this issue of agriculture?

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TYLER WILLIAMS: Yeah. Most people, because I talk to all ranges of people, and most of the time I talk to people, tell them to keep an open mind. We could all do stuff that's probably better to help with this. I mean we all can. But a lot of times...I mean you're in politics, right, so it becomes a political subject really quick. In most cases it doesn't have to be. The changes we've seen, the projections are...they're pretty rooted in pretty good science. So I always tell people kind of believe the science and do what you can to be better for it. But I know just again coming from the agricultural side I know there's lots of things that people are doing better on the adaptation, on the mitigation side. Water use side, reducing water use is...when I lived in Holdrege and they used to pump a lot of water. And they replaced a lot of irrigation equipment with pivots, right, and they can pump half the water. So technology, things like that that...I think that...just know that's going on. So someone from the...maybe from the urban side, just know that people are doing things outside in the agriculture side. But I think in agriculture side people need to understand that urban side is concerned, right? A lot of people in the cities I talk to are concerned, water supply, just emissions, things like that. So, yeah, there's definitely a concern, but I think there's some positive things going on.

SENATOR VARGAS: Thank you very much.

SENATOR SCHUMACHER: You mentioned a couple of different times that life might have been a little different if 2012 had been followed by a similar event in 2013. Historically, the stories from the pioneer days talk about the Great American Desert being here. And we...those of us in my age category, most of the folks in your age category heard our folks talk about the '30s and the dry year after dry year for several years. What have we...have things changed enough dynamically from the '30s that we don't have to worry about a series of three or four terribly dry years? And what if 2013 had been a repeat of 2012?

TYLER WILLIAMS: Uh-huh.

SENATOR SCHUMACHER: What do we need to be prepared for if there's any chance of that happening between now and the end of this century? What do we need to do?

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TYLER WILLIAMS: Right. Well, I think there's always a chance of that happening. It happened once and it could probably happen again. Yeah, but the '30s were unprecedented. Even...and most of them don't...you know, 2012 doesn't rival what happened in the '30s. A lot of things have happened since then--irrigation, technology, no-tilling, things like that have helped. I think the concern with having that again--even though we have no-till, we've come up with all these practices that reduce soil erosion and things like that--is if we had two or three years like they had back then, would we even be able to produce enough residue to cover the ground? I mean I think that's a concern. Do we reduce our irrigation? Do we have to reduce our irrigation? I mean I remember in 2012 out around Holdrege all my friends were redigging out wells, right, because they weren't deep enough so they had to go down deeper to get the water because the water table dropped that far. It's since bounced back up to above where it was probably before 2012. But nonetheless, that would be a concern and I think that's...I think the concern from a lot of people is if we don't have that irrigation to do that, to reduce that, the dust, the dryness, the "Dirty Thirties," if you will, I think that's of concern. And I think it's something that we probably should at least be thinking about preparing for. I know I was at a meeting last week with NEMA and they're working on their drought management plan. They're upgrading that. And one of the things they look at is, can we survive a five-year drought? And even though it might not ever happen, it's probably good to know what to do in the case of a five-year drought because it would have huge impacts here in Nebraska, whether it's water, agriculture, communities, things like that. So planning for that I think is a good thing. Is it likely? I'm not sure. Is it possible? Yeah.

SENATOR SCHUMACHER: Well, had 2012 become a two- or three-year event, what would we have seen as far as Lincoln's water supply?

TYLER WILLIAMS: I'm not sure if I'm qualified enough to talk about that, but most of the...like I said, I believe a lot of the water comes from the Platte River. And so it would be necessary to make sure that the Platte River were still flowing enough to provide water to Lincoln because we need water to drink. And I believe that's even in our state statute someplace, that people are first, then agriculture, but. So, yeah, so then my fear is then they would start shutting off upstream, that there would be...it would come down through regulation. And I always talk to farmers like if we can prevent regulation, let's do it, right? So if we don't need the water, let's not pump it. And I know people that will add that extra water just in case. So if we can prevent regulation before it

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comes I think everyone would be happier. So I think that was probably my fear of having 2012 back to back to back was shutting off irrigation or dramatically reducing irrigation or enacting laws to reduce pumping. And the Republican River Valley, if you're familiar, they've allocated how much water they can pump in any given year on their crops. And so if that was statewide, it would have an impact because I think it probably does reduce yields in some of those years of not being able to pump as much water as the crop needs. So that would be the concern from a state revenue standpoint and a water standpoint. I mean I don't think anyone wants to see that. So again, most of it...most of my concern I think would be around water and obviously pasture growth. Most cases you can't irrigate pasture, so our cow numbers, we'd probably have to do what Texas did in 2011--sell them all and they moved them up here. They next year we sent a lot of them back. So from a cow side I think that would be a concern would be getting rid of cows.

SENATOR SCHUMACHER: Are you in a position to explain to us the physics of the carbon dioxide problem, how the carbon dioxide results in the heating of the air?

TYLER WILLIAMS: A little bit, yeah. I mean it can be quite complex. But essentially what they do is, as we know that greenhouse gases moderate and allow our temperature to remain to be habitable. So without those greenhouse gases I believe they say the average global temperature would be something like minus 20 degrees. So we need those...need greenhouse gases to keep our temperatures warm. So essentially what happens is the sun comes down as a shortwave radiation and it warms up objects, warms up the earth, ground, buildings, things like that. But it emits off long-wave radiation. And those greenhouse gases, they basically can trap long-wave radiation but they don't resist shortwave radiation coming in, just similar to a greenhouse where that shortwave radiation allows it to warm up. So the amount of greenhouse gases, the more of those, the more heat trapping you will capture towards the surface of the earth. So you would keep more of that long-wave radiation that can no longer escape back out to the atmosphere to maintain a balance. And so, again, there's a lot of complex things in there, like water vapor is a greenhouse gas, a pretty important one. Carbon dioxide, methane, nitrous oxide, all those greenhouse gases and they all have different amounts of sort of absorption or greenhouse power, if you will. They all behave differently in what they admit in and what they let back out. Again, I'm not an atmospheric scientist to that level, so it's certainly more complex. But CO2 is...even though you...because a lot of people say like, well, why doesn't it just...why isn't it worse over

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the cities where most of the CO<sub>2</sub> is coming from, from transportation, things like that? And CO<sub>2</sub> mixes very well in the atmosphere so you get sort of a blanket that evens out as opposed to high concentrated areas of CO<sub>2</sub> just because of the way it mixes in the atmosphere. Again, it can be quite complex and I'm probably not smart enough to tell you all about it. But in general that's what it is.

SENATOR SCHUMACHER: Well, you know, we've been talking about the records going back to 1890 or something like that. But globally the record goes back a long way, doesn't it, with the tree rings, with the ice cores?

TYLER WILLIAMS: Yep.

SENATOR SCHUMACHER: And so we've got a little better perspective. But what I'm almost hearing you say, as far as the water situation, the level of the Ogallala Aquifer, that's probably not going to see a whole lot of variability between now and the end of the century?

TYLER WILLIAMS: That depends a lot. I would say that it will see some variability because we will go through droughts that will make an impact on that. We have...we're fortunate enough that we're probably going to be the last state to run out just because of the amount of water that we have underneath there. But it's...the recharge rate is quite slow. The Sandhills, the recharge rate is pretty good. But in most part of the state our soils, our recharge rate is quite low. So if we're...again 2012 was 2013 and 2014, we would have seen dramatic decreases in our groundwater that we would have had dry wells and towns dry and things like that. I believe in...from 2012 the average statewide groundwater dropped a foot just in that one year. So there's a...you multiply that by another year, another year, you'd probably have some concern. Luckily the NRDs do a pretty good job of monitoring groundwater, put allocations in where they need. There are some spots in the state that are increasing groundwater and other spots that are decreasing. A lot of that is because of the recharge rate or the recharge mechanism. The Tri-County Canals around Holdrege, Lexington, if you're familiar with that, recharge the groundwater quite well because surface water is allowed to seep through in the canal. So I think...there will be fluctuations in groundwater, but it will severely depend on irrigation probably.

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SENATOR SCHUMACHER: One of the focuses here is, how will any climate variability affect our crops and our livestock in Nebraska? But that same variability on a global scale will obviously affect crops globally, in South America and wherever else they raise corn and beans and cows and pigs. And we're going to have...we've got 7 billion now. We're going to have pretty soon 9 billion. By the end of the century the World Health Organization says 11 billion people. When we look at this and try to strategically position ourselves on the international market, if kind of the gist of this is we might be helped more likely than hurt by the little longer growing season or the warmer temperatures or whatnot, how is that going to affect internationally and what can we anticipate that affecting the demand for our exported grain and livestock? I mean are we...should we be doing something to structure where we can export to or relationships with areas that may be on the short end of the stick rather than the longer end of the stick?

TYLER WILLIAMS: Uh-huh. That can get quite complex pretty quick. (Laughter) So I don't know if I would be able to tell you who the winners and losers will be, but there will definitely be some winners and losers as things change and shift a little bit. Especially with the growing population, there has to be probably more winners and losers. But placing yourself strategically for marketing and things like that is important. I don't know who would be able to grow better crops now and who won't be. I don't if I've studied it that much. But it will probably shift, you know, who can grow crops and who can grow them well and who's hurting, things like that. Generally what I've heard is developing countries will...they won't be probably able to keep up when it comes to technology, because that what we're going to have to use, will be, you know, technology will be quite important. Even just producing more crops we need technology. So I don't know if I have a good answer for you when it comes to global marketing or positioning ourselves. There's probably someone a lot smarter than me that would have a better answer, so.

SENATOR SCHUMACHER: Do we have any other...?

TYLER WILLIAMS: So I'll plead the Fifth on that one. (Laugh)

SENATOR SCHUMACHER: So what is the weather going to be like on (laughter) December 31, 2099?



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TYLER WILLIAMS: Cold.

SENATOR SCHUMACHER: Okay, good.

TYLER WILLIAMS: Relative, right?

SENATOR SCHUMACHER: Well, thank you for your presentation today.

TYLER WILLIAMS: Sure.

SENATOR SCHUMACHER: It is helpful as we try to piece together what we should be doing long term in the state to develop our agriculture, to make sure that Lincoln doesn't run out of water, to see if we can sell some international grain if we get a little extra here. Thank you very much for your presentation.

TYLER WILLIAMS: Sure. Yeah, no problem.

SENATOR SCHUMACHER: The record should reflect that Senator Hansen, Williams, Watermeier, Vargas, Riepe, and Schumacher were here today. I didn't do that at the beginning, and so we've got that done. Next kind of item to talk about just a little bit...first of all, do we have any committee discussion on what we just talked about? December, we're coming up on the beginning of the session. One of the things the statute says that we should do or is among the things we can do is to make recommendations as to legislation, propose legislation is I think what the statute says. So what we might do between now and then is think about if there's anything we've learned here, if there's anything that we anticipate coming up in the session that we could put some input into and more or less in December focus a bit on whether or not we want to do anything next session. I don't know if the Fiscal Office is going to have their enhanced version of their projections ready to do show time in December or not. If they are, we might have a bit of a presentation on that. I think Senator Watermeier has asked that there be a little session at the Legislative Council meeting where folks who are interested in what we've been talking about can come in hear. Jerry Deichert, I've asked him to make a bit of a

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presentation in those little panel sessions we're going to have. Jerry, do you have anything that you want to touch base with us here?

JERRY DEICHERT: Well, I mean if you want us to do...we've done projections by county to the year 2050. If you'd like us to...we presented that I think last year or the year before. I don't remember when it was. If you'd like some of that, we can do that as well as the population projections for the state as a whole.

SENATOR SCHUMACHER: That data I think would be helpful, at least representative counties. This is what your...I don't think we have time to go through all 93 counties, but so that we get a general feel for what's happening out there...

JERRY DEICHERT: By population type and by...yeah.

SENATOR SCHUMACHER: Right, because I think the demographics of the...are just an important driver in what we've got to plan for and where we would place our bets with limited resources.

JERRY DEICHERT: That would be the one thing. And then the other part was what I've done before. I think this was at the...in July I believe it was where I just looked at the three major trends that are influencing the state.

SENATOR SCHUMACHER: And those we can be fairly certain of those and it would take some fairly dramatic event in order for those to change very much over the next two decades.

JERRY DEICHERT: They've been going on for decades.

SENATOR SCHUMACHER: Okay. Any other discussion, folks? If not, if someone would move to adjourn.

SENATOR WILLIAMS: So move.

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SENATOR HANSEN: Second.

SENATOR SCHUMACHER: We'd be adjourned.