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Endangered and Threatened Wildlife and Plants: Listing Lesser Prairie-Chicken as Threatened Species with Special Rule

Agency: FWS

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COMMON GROUND CAPITAL

June 20, 2013

Public Comments Processing
Attn: FWS-R2-ES-2012-0071
Division of Policy and Directives Management
U.S. Fish and Wildlife Service
4401 N. Fairfax Drive, MS 2042-PDM
Arlington, VA 22203

Subject: Common Ground Capital, LLC Comments in response to USFWS proposal to create a special rule under authority of Section 4(d) of the Endangered Species Act and third draft of the Range-Wide Conservation Plan for the Lesser Prairie-Chicken ("LEPC"), which has been prepared by the LEPC Interstate Working Group, as it relates to the USFWS' determination of status under section 4(a)(1) of the Act

Dear Sir/Madam:

Thank you for the opportunity to comment on both the 4(d) rule proposed by the U.S. Fish & Wildlife Service ("USFWS") and the Third (April 1, 2013) Draft of the Range-Wide Conservation Plan ("Plan") for the Lesser Prairie Chicken ("LEPC") created by the Lesser Prairie Chicken Interstate Working Group ("IWG") and the Western Association of Fish and Wildlife Agencies ("WAFWA").

The Common Ground Capital Team ("CGC") has worked tirelessly over the past fourteen months to create an un-paralleled conservation banking portfolio that will help deliver a sustainable conservation outcome for the LEPC. Specifically, the multiple conservation banks that CGC is developing will play a major role in achieving the Lesser Prairie Chicken Stronghold Strategy (August 2012 USFWS White Paper). CGC has been working extensively with USFWS to establish this conservation banking portfolio.

CGC is grateful to our private landowner partners with whom we have worked for many months to develop relationships anchored in trust, transparency and our team's unique track record of delivering landscape scale conservation to benefit both Greater & Lesser Prairie Chickens in our previous capacities. To date, CGC and its landowner partners have executed letters of intent to pursue conservation banks in four separate locations, across three states, in two different ecosystems totaling 86,000 acres. Over the coming months, we look forward to continued collaboration with the USFWS, other stakeholders and our landowners to continue developing these bank locations with a goal of having conservation bank credits available for purchase at the time of the final listing decision.

Landowners are working with CGC at this scale because CGC has a strong track record of creating and executing on landscape scale conservation solutions for prairie chicken while its team members served in previous capacities at other employers. In total, these past efforts have garnered $11M of voluntary conservation donations from industry and conserved approximately 40,000 acres with both permanent and temporary contracts with landowners in Kansas & Oklahoma from 2007 to the present. No one else that we are aware of has this level of experience of actually negotiating multiple commercially binding agreements with private industry for voluntary conservation offsets for these species in the Southern Plains Region.

We have embraced USFWS's ongoing advice to continue to work with the five states, along with many other major stakeholders, in an effort to achieve a successful conservation plan and mitigation solution for the LEPC. CGC has advocated for a robust, region-wide mitigation framework that is anchored in the USFWS's compensatory mitigation model of conservation banking. More broadly, CGC has also provided input and advocated for a regional conservation plan and free market species credit exchange structure that will provide the best chance of both a successful and sustainable outcome for the LEPC, while also providing a level playing field for industry and creating new income streams for landowners through monetizing the LEPC as a valuable ecosystem service.

CGC has organized its comments into four sections: (1) an executive summary detailing points and issues that warrant careful consideration during the development of the 4(d) rule; (2) a few additional points on the April 1, 2013 version of the Plan; (3) CGC's view of a framework for a combined plan that could possibly achieve a unified, successful 4(d) rule; and (4) responses to the 4(d) rule questions posed by the USFWS. CGC encourages USFWS to read our comments in their entirety, and feels strongly that USFWS must address these points in the final draft of the proposed 4(d) rule.

I. <u>Executive Summary</u>

CGC supports the strategy of using a 4(d) rule simultaneously with a threatened listing decision, but does not believe the Plan proposed by the IWG and WAFWA, as provided in the April 1, 2013 draft, will satisfy USFWS's goals for LEPC conservation. While parts of this Plan such as the conservation strategy in general and the metrics show promise, overall it will likely not achieve a successful outcome for the LEPC for the reasons we detail in the balance of this letter.

CGC also recognizes, that based on detailed discussions with the States after the May 15, 2013 Plan comment deadline, some of these concerns are being addressed in a fourth version which will not be released until sometime after the June 20, 2013 USFWS comment deadline. We look forward to a continued relationship with the states during the drafting of this fourth version and are hopeful that our concerns with the third draft may be reconciled in this new version. We also encourage the states to allow for a post-listing scenario, versus just a non-listing voluntary scenario, in this fourth draft.

CGC offers the following items for consideration, again based on the third draft of the Range-Wide plan and information obtained from public webinars held prior to the May 15, 2013 state comment period deadline.

A. A Voluntary, Range-Wide Conservation Plan and mitigation program will not succeed in achieving certainty for a sustainable outcome for the LEPC or a level playing field for industry.

We respect the States' and some industry members' opposition to listing the LEPC. However, our team has more than a decade of unique experience on both the conservation and industry side of energy and wildlife intersection in the Southern Plains, and that experience has taught us that voluntary conservation planning and mitigation does not work at meaningful scale and will not provide certainty, requisite assurances or a level playing field to all parties involved. While we remain open to new ideas or strategies that might prove otherwise, our observations gained from participating in many venues with different and diverse stakeholders during the LEPC listing process over the past many months has only strengthened our view on this point.

- Under a voluntary conservation plan and mitigation framework, the USFWS will not have certainty that industry will avoid, minimize and mitigate at a scale necessary to achieve a net conservation benefit to the species. Industry will not support a voluntary plan at any meaningful scale first, because the states cannot provide regulatory assurances at the state level to industry members that may want to participate, and second, because the reality is that not all industry members will participate even if this concern could be addressed. The latter situation will mean that industry members who chose to participate in a voluntary plan would have to voluntarily impose an unlevel playing field on themselves and incur a cost that many of their competitors will simply seek to avoid. This creates an unlevel playing field from a development cost structure perspective for industry players who choose to participate in a voluntary plan.

- Landowners and mitigation providers will not have certainty that a mitigation market of any meaningful size, created pursuant to clearly defined mitigation standards will be created to develop a dependable supply of mitigation credits.

- Finally, should a voluntary plan actually be approved, there is a high degree of risk that misguided state legislative activity would put long-term certainty for many stakeholders at risk, undermine state wildlife agency funding and participation, and ultimately catalyze a loss in political and financial support for the Plan over time.

B. The Mitigation market design and credit exchange vehicle must be based on a free market system to work effectively.

- **The mitigation framework proposed by IWG/WAFWA in the April 1 draft, should be eliminated from further consideration.** CGC understands that this is a bold statement. However, any mitigation framework ultimately approved by the USFWS, should be based on a single set of mitigation metrics that account for both direct and indirect impacts to LEPC and the market should determine the price of each respective mitigation product. There should be separate and distinct market for each mitigation credit type (i.e. permanent conservation banking credits and term mitigation credits, if allowed.) in order to prevent an un-level playing field amongst mitigation credit classes/standards that are addressing different impact terms.

- **WAFWA/IWG should consider adopting a free market habitat credit exchange system as contemplated by Environmental Defense Fund (EDF).** While CGC has grave concerns, addressed below, about a large percentage of the mitigation market being served by term credits, the overall design of the Draft EDF Draft Habitat Conservation Exchange ("HCEX") system provides for a free market platform to connect buyers and sellers of both conservation banking standard permanent mitigation credits and short term credits. It connects buyers and sellers directly and operational and administrative costs can be adjusted as needed by the tenor of the market.

- **In Lieu Fees do not deliver a net conservation benefit.** What WAFWA/IWG has proposed in the third draft of the Plan is an enormous In-Lieu Fee mitigation framework/market design that emulates term government payment programs such as the Conservation Reserve Program and Natural Resource Conservation Service LEPCI Programs and these government programs <u>do not qualify as compensatory mitigation</u>. Further, because WAFWA/IWG's mitigation framework sets artificial and ideological caps on administrative overhead, conservation easement, and habitat restoration costs, it does not allow the benefits of a free market economic system to determine the <u>true cost</u> of conservation and the corresponding true cost of mitigation compliance to be determined by the market. This dynamic is predisposed to fail to deliver a net conservation benefit to species (Fleischer and Fox 2008). The WAFWA/IWG mitigation framework does not enable buyers and sellers of credits to consummate transactions directly with each other. In lieu fee approaches have been discouraged in other settings. In lieu fee programs in the wetlands community have performed so poorly that the US Army Corps of Engineers demoted them to second class status to wetland mitigation banks in the 2008 Wetlands Mitigation Rule (33 CFR Parts 325 and 332). From a species perspective, USFWS Region 2 recently went so far as to eliminate in lieu fee as a mitigation option for the American Burying Beetle in eastern Oklahoma. Why then would such a complex in-lieu fee structure be acceptable to the USFWS for use for the LEPC in a 4(d) rule?

- **The WAFWA/IWG mitigation framework is missing a business plan.** How are stakeholders to assess the WAFWA/IWG's mitigation framework without a business plan to review to insure that all the requisite functions, accountability of performance and costs are adequately addressed?

- **Free market mitigation systems can deliver price certainty.** Some industry stakeholders have expressed concerned that a free market system can not deliver mitigation price certainty. A free market species mitigation system can achieve price certainty with longer term, fixed price contracts with one or more mitigation providers, in the same way as many industry energy developers provide similar fixed price contracts with their customers or rate payers today in their respective industries.

C. Proven Mitigation Solutions Must be the Core of any Mitigation Framework.

Conservation Banking is the only mitigation solution that has and will absolutely continue to *deliver certainty* to the LEPC via achieving a net conservation benefit to the species with long term accountability. Long term accountability and funding assurances are lacking in the Plan. Basic business, biological, regulatory, and legal common sense dictates that you do not abandon or demote the best tool in your mitigation tool box, conservation banking, to achieve permanent landscape scale protection across multiple-ecoregions (USFWS August 2012 White Paper), in exchange for new mitigation ideas that are unproven simply to try and reduce compliance cost to industry. These new mitigation ideas should be pursued, but not be relied upon as the backbone of a robust, regional mitigation program to save the species. Just because there is support for an "easier" mitigation model that may get more term acres on board up front, this should not justify lowering the bar from a proven compensatory mitigation tool in conservation banking that has a regulatory track record with requisite performance and financial assurances of delivering certainty of a net conservation benefit to the species.

- **The USFWS has always favored permanent mitigation.** Even for impacts that may be temporary in term, USFWS has dealt with temporary impacts by using lower mitigation ratios backed by conservation banking standards. This policy position has delivered large net benefits to many species. Moving to a new, predominantly term based mitigation framework would be a huge and unnecessary shift in USFWS mitigation policy direction that would have significant impacts on future species nationwide, including the next landscape scale grouse species in peril, the Greater Sage Grouse.

- **Conservation, as defined, cannot be achieved through term mitigation.** Throughout the proposed 4(d) rule, USFWS notes that "conservation" is defined in Section 3(3) of the U.S. Endangered Species Act to mean "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to the Act are no longer necessary. Consistent with USFWS policy (e.g. the PECE policy), USFWS states that it expects that range-wide conservation actions will be implemented with a high level of certainty, and that the program will lead to the long-term conservation of the LEPC. Term mitigation, being temporary in nature, necessarily fails to meet the definition of conservation much less achieve USFWS-stated goal of providing a high level of certainty that it will lead to long-term conservation. It would be difficult, if not impossible, to see how term mitigation could be considered sufficient to support a delisting.

- **Term mitigation should be secondary to permanent mitigation.** Currently, the Plan is proposing 75% of all mitigation to be addressed through term payments of 20 years (May 2013 state wildlife agency webinars) to landowners. EDF and several major oil & gas companies have not made a decision on the make-up of the permanent versus temporary mitigation market break out as of this time, but it is believed to likely be a large percentage in favor of impacts being proposed as term impacts; quite possibly higher than even the five states have proposed. USFWS should support permanent mitigation as a proven mitigation solution in conservation banking as the cornerstone of its mitigation strategy until at least the stronghold strategy is achieved (~200k acres, 50k acres/ecosystem, USFWS August 2012 White Paper). After the stronghold strategy is secured, term credit and other mitigation pilot programs could be pursued, but not preempt conservation banking credits as long as there is an approved conservation bank in the requisite ecosystem/service territory.

  CGC is not opposed to innovative and creative conservation strategies for the LEPC. However, as previously stated, the USFWS should not bet the future of a species that is in triage mode on un-proven mitigation solutions that do not have any regulatory framework or history at this scale to mitigate development impacts on private lands that are by in large almost always permanent. Even if infrastructure is removed it still has legacy impacts that perpetuate into the future that ultimately impact or enable unanticipated impacts on the landscape to the species on a biologically meaningful time scale.

- **Oil & Gas Industry Impacts are largely permanent**: Despite the position by some members of the oil & gas industry, the impacts of this industry, like virtually all other development impacts in our society, are permanent. My family has land in two regions of Texas, which have had multiple leases over generations, and has been in the oil & gas industry for two generations. From personal experience, I am not aware of many oil & gas industry developments that can credibly show that twenty or thirty years after the wells were drilled and production has ceased, the land/habitat and associated species or wetlands resources have been reclaimed to their original ecosystem function. Yes, much of the hardware may be salvaged and the wells plugged per state requirements, but the roads remain, electrical infrastructure to serve the facility often remains, the significant change in predator prey relationships, land coverage change, invasive species introduction and access created via the roads for other, future development impacts remains on that landscape forever. As detailed previously, if the USFWS wishes to allow for some oil & gas activities to be treated as temporary, they should do it with mitigation ratios as they have done with other species listing decisions previously instead of creating a new mitigation credit category and associated significant policy change on compensatory mitigation in general.

- **Term mitigation repeats the unfortunate financial lessons learned from term based government conservation programs.** The government has paid for the land once or more times over and then the species remains at risk of losing those conservation benefits if future funding evaporates or cannot compete with other land uses at the time the term expires and needs to be renewed.

- **The arguments supporting heavy reliance on term mitigation are misguided.** There are many beliefs about why these previously mentioned efforts rely heavily on term mitigation: landowners will not embrace perpetual mitigation at scale, mineral estate challenges, climate change will result in the LEPC migrating over time thus the habitat needs to move, conservation banking credits cost too much and the ag community only likes term payments. Many parties who hold these beliefs do not have much, if any experience in the land trust, conservation banking, compensatory mitigation field in general, or landscape scale conservation community. CGC's long history with these types of stakeholders and progress made to date with landowners indicates that there are ample landowners willing to embrace permanent conservation measures at a price point that recognizes the amount of land management change needed to their operations to meet the contractual management requirements under a conservation banking model that deliver conservation certainty to the species. From a pricing perspective, it is evident from the state webinars that conservation bank credits will very likely be competitive with the cost of mitigation projected by the States and price certainty can be achieved via long term contracts.

- **Clear mitigation standards need to be consistently implemented across the board.** It is of utmost importance that clearly defined mitigation standards are consistently applied to ensure that long term conservation benefits are achieved. Necessary components of these standards are assurances that restoration, enhancement, creation or preservation activities will be conducted to offset all permitted or allowed environmental impacts, uniformity in both methodology and application, and require that mitigation projects offset the impact of an activity for the duration of the impact (not just the activity). We encourage USFWS to hold mitigation projects to the same standard to ensure long-term conservation benefits. Having a single set of mitigation standards and metrics is far more important than selecting a single plan under a 4(d) rule.

II. Issues with the third draft of the Five State Range-Wide Plan.

CGC offers some additional comments to the current version of the Plan here:

- It is our understanding that the Plan will go through another round of revisions. Without having seen the substantive changes to the Plan, it is difficult to gauge the practicability of the Plan for purposes of the 4(d) rule. There is no indication how the Plan would be implemented in the 4(d) context. The newest draft Plan should be made available for review after the states have had time to adequately address stakeholder concerns.

- The WAFWA/IWG strategy does not address indirect, cumulative and landscape-level impacts of development on LEPC at the population and meta-population levels. Instead, it largely assesses impacts and debits on a project-by-project basis. This methodology is well-established in the scientific literature as failing to secure a net conservation benefit to species, particularly for prairie grouse (Naugle et al. 2011 and references therein).

- The WAFWA/IWG has not outlined a detailed strategy of how to address mineral rights under a voluntary plan scenario. Any successful plan included in the final 4(d) rule should detail how these elements and how these challenges will be addressed. For mineral estate challenges, similar review procedures to address mineral estate development on conservation bank locations in a Section 10 process could be applied to industry parties seeking to develop minerals in high value conservation areas for the LEPC as would be defined in a final version of the Plan.

III. CGC's List of Ingredients for a potentially successful, unified conservation plan and mitigation framework under a final 4(d) rule.

Based upon CGC's participation in both the WAFWA/IWG and the EDF Stakeholder processes, we offer the following framework for a future potential combined plan that incorporates the best elements of both efforts. In order to try and merge the two existing plans, a highly knowledgeable and strong third-party facilitator should be engaged to oversee and direct a highly abbreviated process, ideally no more than a few weeks, to seek agreement from a targeted and well informed group of stakeholders. We believe the following elements are necessary to a successful approach:

- Range-Wide Conservation Plan: Utilize the Plan as the base Range Wide LEPC Conservation Plan, but provide a working session so that stakeholders may offer minor modifications and ask clarification about the plan.

- Governance: Adopt the basic governance structure to oversee the regional administrator from the HCEX plan. This structure currently contemplates representation from NGOs, landowner groups, industry and the states. However, some structural adaptations on the permit holder side of the organization structure may need to be adopted to account for more than a single HCP as currently contemplated.

- Science: Utilize the WAFWA/IWG science for the plan, but a third party facillitator consisting of the scientific community should host a multi-day session that allows the EDF effort to provide a summary of their work product and identify areas where mutual agreement may be possible prior to finalizing the science for the plan. A joint list of research activities should also be agreed too. Final decisions on science related to the plan should rest with the IWG and be reviewed once every five years.

- Mitigation Metrics: Per CGC's comments in Section I above, assuming clarifications and agreement can be achieved on key aspects of the metrics to make them deliver a net conservation benefit to the species and work within a free market permanent (conservation banking standards) and term credit system, the WAFWA/IWG metrics should be utilized. Similar to the Science bullet above, the EDF effort should have an opportunity to share its metrics to see if there are areas of agreement that will further improve the WAFWA/IWG metrics. Finally, it is important that the final metrics address both direct and indirect impacts to the species. Again, a knowledgeable third party facilitator should guide this effort, it should be very brief in nature and ultimately the final decision on metrics should rest with the IWG.

- Market Structure: Free market. As proposed by EDF HCEX or as is may be being contemplated by the five states in the fourth draft of their Range-Wide Plan, a free market structure is necessary.

- Conservation Certainty: CGC supports a base conservation ratio of 2:1 or greater for all industry impacts which will insure that a net conservation benefit is achieved. However, when considering term mitigation, it is an absolute certainty that those benefits will not last if impacts are permanent. <u>Term mitigation will NOT achieve a net conservation benefit, whatever the ratio.</u> Again, mitigation standards should be consistently applied across mitigation projects and the conservation benefits must endure for the duration of the impacts.

- Enforcement: Neither plan seems to have adequately addressed how a range-wide plan will be enforced and this item should be discussed in great detail. Having a viable and stringent enforcement function is critical to insuring industry participation over the long term, providing a consistent signal to mitigation providers that there will be clear need for mitigation credits and USFWS can have confidence in the regional administrator that the plan will have the best chance for conservation success via achieving a net conservation benefit for the LEPC.

- **Delegation of Conservation Banking Approval to a new, single Regional Administrator**. CGC advocates that the USFWS, with adequate and experienced USFWS representation, consider delegating authority for conservation bank approval to the ultimate regional administrator assuming a single 4(d) rule plan is approved. Any conservation banks approved at the time of the listing decision and final 4(d) rule publication should automatically be eligible to serve mitigation needs for this plan thus avoiding the need for a separate approval process by the 4(d) rule regional administrator. Unfortunately, the USFWS conservation bank approval, across the country takes too long; often years. In order for banking to play a valuable role in expeditious species recovery and avoid the unnecessary permittee responsible, one-off, project work load that is created because banks are slow to be approved, CGC believes the USFWS should seriously evaluate this suggestion. This is especially important because parties that are advocating term credit arrangements are taking the position that these programs be approved solely by the regional administrator.

IV. <u>**Responses to USFWS's 14 questions regarding proposed 4(d) Rule**</u>

(1) *The historical and current status and distribution of the lesser prairie-chicken, its biology and ecology, specific threats (or lack thereof) and regulations that may be addressing those threats and ongoing conservation measures for the species and its habitat.*

CGC believes that USFWS has accurately and adequately addressed the factors listed above in their proposed rule, with one exception. Plant diversity and species composition in existing native rangelands, particularly the loss of perennial, seed-producing, and insect larval food plants may be a larger, un-quantified threat to the LEPC than is portrayed in the USFWS's finding. Recent studies on LEPC survivability indicate that optimal brood rearing habitat, containing a diverse and abundant forb population, is limiting through many portions of the species range. Reduced forb and legume abundance and diversity is primarily caused by preferential grazing of palatable forbs and legumes by domestic livestock and broadscale herbicide applications to native rangelands. While quantifying this degree of threat is understandably difficult, we believe USFWS should discuss this threat to a greater degree in any future rules and work with the state wildlife agencies and research community to quantify this threat in the future.

(2) *Information relevant to the factors that are the basis for making a listing determination for a species under section 4(a) of the Act, which are:*

(a) *The present or threatened destruction, modification, or curtailment of the species' habitat or range;*

No comment

(b) *Overutilization for commercial, recreational, scientific, or educational purposes;* (c) *Disease or predation*;

No comment

(d) *The inadequacy of existing regulatory mechanisms*;

CGC believes that the USFWS proposed rule for listing the LEPC as threatened under-represents, and in some cases is silent regarding, the inadequacy of existing state regulatory mechanisms to protect and manage the LEPC and its habitat. We believe this reflects a general desire by the Service to defer to State Wildlife Agencies and avoid offense. We believe the proposed rule also fails to identify cases where existing regulatory policies (such as state listings and LEPC management policies for federal lands) are being ignored, undermined or simply not enforced for the same reason. As an example, the high percentage of RMP-ACEC exceptions that have been granted to oil and gas activities on formerly occupied BLM lands in New Mexico. The very inadequacy of state and federal regulatory or enforcement mechanisms forms the basis for why any "voluntary" mitigation plan will fail to achieve the participation and effectiveness necessary to achieve a net conservation benefit and recovery of the LEPC.

(e) Other natural or manmade factors affecting its continued existence and threats to the species or its habitat.

No Comment

(3) *Application of the Lesser Prairie-Chicken Interstate Working Group's draft rangewide conservation plan to our determination of status under section 4(a)(1) of the Act, particularly comments or information to help us assess the certainty that the rangewide conservation plan will be effective in conserving the lesser prairie-chicken and will be implemented.*

Because the Plan has not been and will not be implemented at the time of listing, the Plan cannot be considered toward precluding listing at the time of status determination. While some aspects the Plan have potential for the future, CGC is most concerned that lawsuits over a precluded finding would be virtually guaranteed, resulting in the loss of precious time toward implementation of meaningful regulatory protection and mitigation measures which the LEPC cannot afford.

(4) *Which areas would be appropriate as critical habitat for the species and why areas should or should not be proposed for designation as critical habitat, including whether any threats to the species from human activity would be expected to increase due to the designation and whether that increase in threat would outweigh the benefit of designation such that the designation of critical habitat may not be prudent.*

CGC does not believe that designation of critical habitat on private, state or federal lands would increase the threats to the continued existence of the LEPC beyond the benefits of doing so. The degree of human effort and expense required to take or destroy individual LEPC and their habitat at a statistically-significant population level is simply too great. While an insignificant number of individual LEPC may be shot by angry landowners, we believe the existing scientific research on direct take via recreational harvest for multiple gamebird species (and other wildlife species such as white-tailed deer females) supports the position that people are not likely to invest the number of gun-man-hours necessary to have a population level effect, particularly since large scale direct take would require baiting or supplemental grain field attractants that should be easily detected by wildlife law enforcement officers from evaluating field conditions and using publicly available aerial photography and satellite imagery. For the same reasons that recreational harvest is not considered to be a population level threat to the LEPC, so are the reasons why the risk of increased take due to critical habitat designations is not significant, despite much emotionally-charged rhetoric to the contrary often repeated at public meetings.

(5) Specific information on:

(a) The amount and distribution of habitat for the lesser prairie-chicken;

CGC believes the maps of “occupied” habitat within the Plan are greatly over-stated. For example, the map of occupied habitat for Oklahoma indicates full occupation over most of several counties when in fact the birds and leks are found only on a small series of highly fragmented parcels of land, and not continuous occupation over much of several counties.

(b) *What may constitute "physical or biological features essential to the conservation of the species," within the geographical range currently occupied by the species;*

CGC will likely provide future input on these habitat characteristics should critical habitat is ever proposed. At present, we support the parameters identified by the IWG for optimal habitat conditions, with the exception that a maximum fragmentation threshold is not identified (i.e. no cap on landscape –scale fragmentation or cumulative effects is identified; impacts are mitigated on a case by case basis with no upper limit).

(c) Where these features are currently found;

See 5(a)-(b).

(d) Whether any of these features may require special management considerations or protection;

See 5(a)-(b).

(e) What areas, that were occupied at the time of listing (or are currently occupied) and that contain features essential to the conservation of the species, should be included in the designation and why;

No comment at this time.

(f) What areas not occupied at the time of listing are essential for the conservation of the species and why.

CGC believes that appropriate, currently un-occupied native rangeland regions between the west Texas/New Mexico population and the remainder of the population should be designated as critical habitat. Otherwise, the lack of gene and population flow between these metapopulations will cause continued differentiation and lack of population resilliance to stochastic events such as climate change and extended drought. In particular, we believe that specific corridors containing and surrounding the Rita Blanca National Grasslands and the South Canadian River Valley should be designated as critical habitat for this purpose. Formerly occupied areas (within the last 30 years) within state and BLM owned lands in New Mexico should also be designated as critical habitat and protected from continued exclusionary development activities.

(6) *Information on the projected and reasonably likely impacts of climate change on the lesser prairie-chicken and its habitat.*

We believe that USFWS has accurately and adequately addressed the potential threat of climate change to the quality of existing LEPC habitat, as defined by the current habitat conditions formed by relatively recent (within the last century) and mesic climatological conditions throughout the Southern Great Plains (Layzell 2012). CGC agrees that increased temperature and decreased rainfall will likely lower population fitness throughout portions of existing range, and will serve to exacerbate the negative effects of other threats such as grazing pressure and anthropogenic fragmentation.

However, truly long term climatological data for the Southern Great Plains indicates that during the period of speciation for the LEPC (at least 10,000 years ago), temperature and rainfall levels predicted due to climate change were not uncommon (Brown et al. 2005; Woodhouse et al. 2010), particularly during the Medieval Warming Period (900-1300 AD; Layzell 2012). In fact, hotter, drier climates – coupled with more frequent fire and intense grazing pressure by bison, prairie dogs and other herbivores, are believed to be the primary factors that caused LEPC speciation by geographic distance and genetic isolation from other prairie grouse species (Drovetski 2003; Hagen et al. 2010). This is supported by the increasing frequency and threat of hybridization between greater and lesser prairie chickens in Kansas, attributable to CRP plantings composed of a taller mix of grass species than were historically present, coupled with protection from sustained grazing pressure.

CGC is strongly opposed to arguments justifying short term conservation measures over the validity of perpetual conservation banks on the basis of global climate change. We do not believe the scientific record supports that LEPC should "migrate north" away from sandy ecological sites and the shrubland plant communities to which they are adapted. The species' recent northward expansion in Kansas is a result of artificially-created and managed nesting cover through the CRP program, not unsuitability of traditionally-occupied habitats. The ecological sites and shrubland communities known to harbor the highest density of LEPC under optimal management conditions - sand shinnery oak and sand sagebrush - were largely formed by wind-deposited eolian sands over thousands of years of drought cycles with temperature and precipitation extremes not unlike what is predicted due to climate change (Layzell 2012). Sand shinnery oak and sand sagebrush distribution will not be moving due to climate change because the soil on which they depend – sand - will not move, at least not at any time scale relevant to the near-term extinction risk to LEPC. For your reference, I have included the Layzell's 2012 document on this issue. Please see attached.

Finally, we want to point out that the predicted negative effects of climate change on LEPC via changes in vegetation structure and microclimate at ground level can both be ameliorated through conservation of shrub cover (Bell et al. 2010) and reduction and management of grazing pressure as part of any long term conservation banking management plan and the binding drought management plan incorporated therein.

(7) *Whether measures outlined in this proposed 4(d) special rule are necessary and advisable for the conservation and management of the lesser prairie-chicken.*

CGC supports the USFWS position that any 4(d) rule must provide a net conservation benefit, have certainty of implementation, and provide for the long term conservation (as defined in section 3(3) of the Act) of the LEPC. We do not believe the avoidance, minimization and mitigation recommendations of the current draft of the Plan achieve these criteria.

(8) *Information concerning whether it would be appropriate to include in the 4(d) special rule a provision that would allow continued enrollment in existing Candidate Conservation Agreements with Assurances for the lesser prairie-chicken. These existing agreements would be recognized as Service-approved conservation plans and their take authorization and continued enrollment would be provided for under this 4(d) special rule.*

CGC does not support continued enrollment in existing regional CCAAs as part of a 4(d) rule because most of these lack crucial elements that will provide sufficient resources, administration, and the requisite contractual obligations to achieve a net conservation benefit to the species, and certainty of implementation.

(9) *Information concerning whether it would be appropriate to include in the 4(d) special rule a provision for take of lesser prairie-chickens in accordance with applicable State law for educational or scientific purposes, the enhancement of propagation or survival of the species, zoological exhibition, and other conservation purposes consistent with the Act.*

CGC is not opposed to allowing for these forms of take under a special 4(d) rule, although we do not understand why this is necessary when, for other species, these types of activities require an incidental take permit. If the LEPC is federally-listed, we do not believe these take activities should occur without some sort of consultation process with USFWS.

(10) *Information concerning whether it would be appropriate to include in the 4(d) special rule a provision for take of lesser prairie-chickens in the course of State-managed hunting programs for the lesser prairie-chicken or incidental to hunting activities directed at greater prairie-chicken (Tympanuchus cupido), including any information about State management plans related to hunting regulations and any measures within those plans that may avoid or minimize the risk of lesser prairie-chicken mortality incidental to lawful hunting for the greater prairie-chicken.*

CGC supports a special provision in the 4(d) rule allowing for direct take of the LEPC as part of a state-managed recreational harvest program, so long as such program demonstrates no negative population-level effect of hunting, such hunting program is permit-based, protective of geographically sensitive sub-populations and the revenue from these hunting programs goes into a dedicated fund to benefit LEPC populations versus general overhead for state agencies.

(11) *Whether and how the Service should expand the scope of this 4(d) special rule to encourage landowners removing their lands from the Conservation Reserve Program to continue managing those areas for the benefit of the lesser prairie-chicken.*

We believe that any landowner who voluntarily confers, with requisite compensation, a perpetual conservation easement prohibiting tillage on any expiring CRP lands should be provided for under the scope of any special 4(d) rule.

(12) *Whether and how the Service should expand the scope of this 4(d) special rule to encourage farmers and ranchers not participating in the Natural Resources Conservation Service's Lesser Prairie-Chicken Initiative to manage their lands for the benefit of the lesser prairie-chicken.*

The net conservation benefits of participation in most NRCS conservation programs and practices within LPCI are temporary, lack adequate enforcement, and are subject to national funding constraints. CGC does not support that take in excess of what is approved through the existing conference opinion between USFWS and NRCS should be provided for under a special 4(d) rule.

(13) *Whether the Service should expand the scope of this 4(d) special rule to allow incidental take of lesser prairie-chickens if the take results from implementation of a comprehensive lesser prairie-chicken conservation program that was developed by an entity other than a State agency or their agent(s).*

So long as any proposed conservation plan applies as single set of effective conservation/mitigation standards that will achieve a net conservation benefit to the species, have certainty of implementation, and will provide for the long term conservation of the LEPC, CGC is not opposed to such plans being provided for under a special 4(d) rule.

(14) *Additional provisions the Service may wish to consider for a 4(d) special rule in order to conserve, recover, and manage the lesser prairie-chicken.*

Please refer to Sections I-III of this comment letter.

We appreciate the opportunity to comment on the proposed 4(d) rule and Plan. Please do not hesitate to contact us should you want to discuss further. We are optimistic that USFWS will choose a solution that best achieves conservation benefits for the LEPC.

Respectfully,

Wayne Walker

Principal

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A thousand years of drought and climatic variability in Kansas: Implications for water resources management

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Kansas Geological Survey

2012

Table of Contents

1. Introduction

Periods of severe drought are one of the greatest recurring natural disasters in North America. In any given year, droughts occur all across North America resulting in significant impacts on local economies, societies, and the natural environment. Drought conditions in the United States cost on average $6-8 billion every year, but have ranged as high as $39 billion during the three-year drought of 1987-89 (Riebsame et al., 1991). In Kansas alone, the recent 2011 drought resulted in losses in excess of $1.7 billion (Kansas Department of Agriculture, 2011).

Droughts impact both surface- and ground-water resources and often result in reductions in water supply and crop failure particularly in agriculturally sensitive areas such as the High Plains of western Kansas. This region is becoming increasingly vulnerable to drought due to a variety of factors including the increased cultivation of marginal lands and the increased use of ground-water resources from the High Plains aquifer (Woodhouse and Overpeck, 1998), where water withdrawal has exceeded recharge for many years (e.g. McGuire, 2009).

The droughts of the 1930s and the 1950s remain the benchmarks in terms of duration, severity, and spatial extent for Kansas in the 20th century. Therefore, determining how representative these historic droughts have been in terms of drought occurrence is vitally important. The key question is how unusual are severe droughts, such as the Dust Bowl? Was this drought a rare event or should we expect droughts of similar or even greater magnitude in the future?

Direct observations of temperature and precipitation from instrumental records are largely restricted to the past 100 years and are therefore too short to adequately answer these questions. Therefore, in order to assess the full range of drought variability, it is important to place historic droughts in a longer-term context by utilizing paleoclimate proxy records.

This report investigates past drought occurrences from paleoclimate records over the last 1000 years. In particular, we focus on Palmer Drought Severity Index (PDSI) reconstructions calculated from annual tree-ring chronologies. Additional paleoclimate proxies and historical records are also examined to lend further support to reported past drought variability.

2. Types and Measures of Data

2.1 Drought Indices

The Palmer Drought Severity Index (PDSI) is one of the most widely used indices to measure drought in North America. The PDSI was developed by Palmer (1965) to measure the intensity and duration of long-term drought. It uses precipitation and temperature data to determine how much soil moisture is available compared to average conditions. PDSI values therefore provide data on both relative wetness and dryness over a given period. The index typically ranges between -4 (extremely dry) and 4 (extremely wet) but the range limit is not explicitly bound. As the index is standardized to local climate, it may be applied to any part of the country to demonstrate relative wetness and dryness.

2.2 Paleoclimate Data

PDSI values calculated from instrumental data provide a valuable means to assess drought variability over the instrumental record (i.e. the past 100 years). Recently, the Kansas Geological Survey has published historic climate and PDSI data (1895 to 2011) online in the form of the Kansas High Plains Aquifer Atlas (http://www.kgs.ku.edu/HighPlains/HPA_Atlas/Climate%20and%20Climate%20Trends/index.html#). Based on these data alone, the droughts of the 1930s and 1950s appear to be anomalous in terms of their severity and duration (Fig. 1).

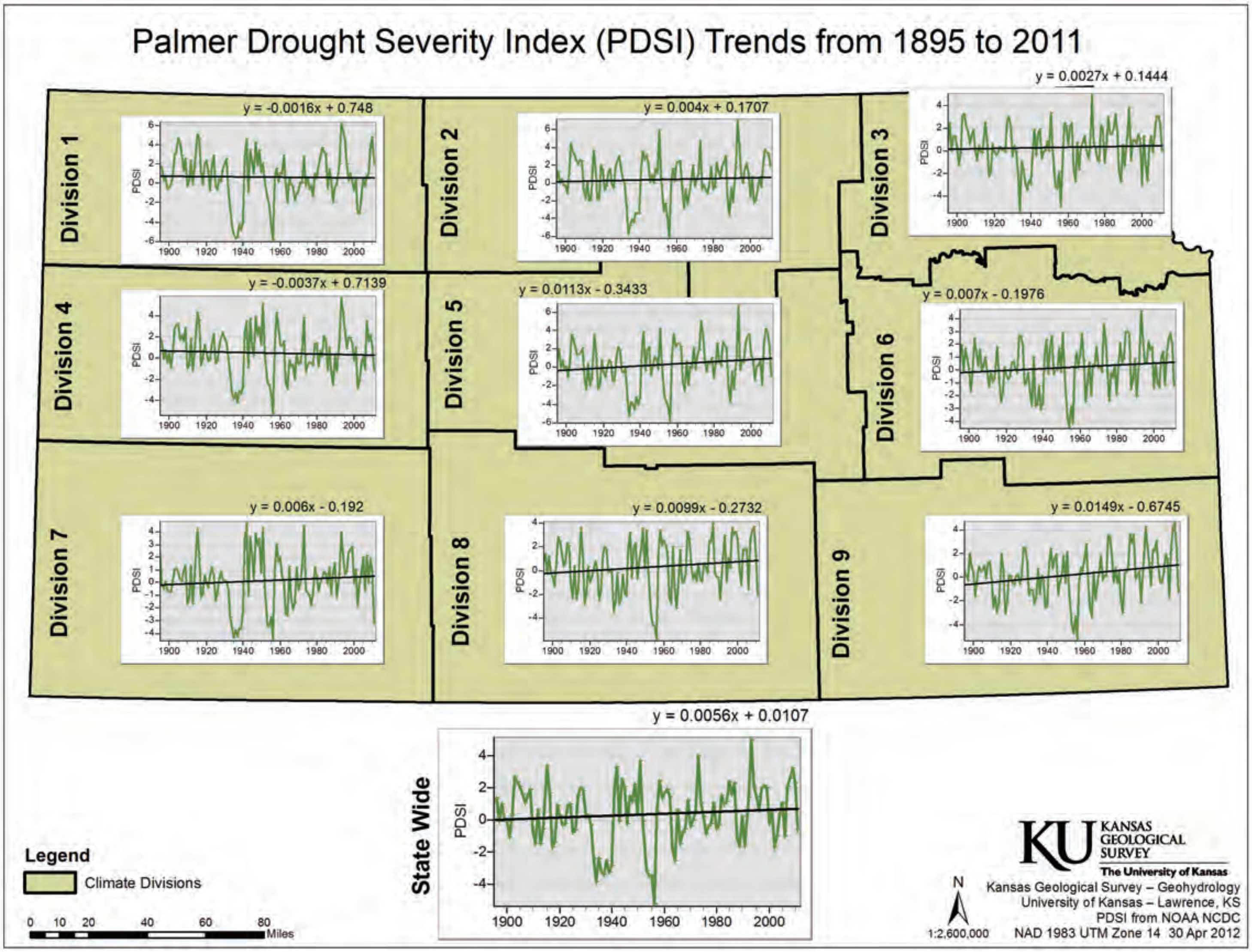

Figure 1. Instrumental PDSI trends for Kansas from 1895 to 2011. Image from the High Plains Aquifer Atlas (www.kgs.ku.edu/HighPlalins/HPA_Atlas/index.html).

However, paleoclimatic records allow one to assess the full range of drought variability by utilizing data that span longer periods of time. Long-term records have been developed from a variety of different proxies that span a range of time periods from hundreds to thousands of years. Proxies include tree-rings, sediments from lakes, sand dunes, and rivers, as well as historical and archeological records. These proxies record natural variability in drought occurrence and allow us to compare historic droughts of the 20th century with those of the past.

This report will focus on the paleoclimatic record developed from tree-ring studies. However, it is important to note that when used together, multiple proxy records provide a more complete picture of past change than that offered by any one proxy or instrumental data alone. Therefore, this report will supplement tree-ring reconstructions with data from historical, archeological, and geomorphic records in order to more fully investigate past drought variability.

2.2.1 Long-term PDSI Reconstructions

Tree-rings chronologies are based on the actual growth rate of highly drought-sensitive trees and therefore function as an important indicator of past droughts. Adequate moisture and a long growing season result in wide tree rings while drought years create very narrow rings. Importantly, individual tree-rings can be dated to the exact calendar year using cross-matching techniques.

Recently, an extensive network of annual tree-ring chronologies has been developed and made publically available through the International Tree-Ring Data Bank (http://www.ncdc.noaa.gov/paleo/treering.html). Utilizing these data, annual PDSI reconstructions have been developed for 286 grid points across most of North America (Cook and Krusic, 2004). Reconstructions utilized the nearest available tree-ring chronologies to each grid point and were produced with a well-tested point-by-point principal-components regression procedure. See Cook et al. (1999) for detailed methodology used to develop PDSI reconstructions. PDSI reconstructions are evaluated using four statistics, which indicate high overall calibration and verification (see appendix for more details).

Regression based tree-ring PDSI reconstructions tend to underestimate extreme values, although dry extremes are better represented than wet extremes, but are reasonably accurate in terms of extent and duration (Woodhouse and Overpeck, 1998). Therefore, such reconstructions facilitate accurate assessment of the relative severity of 20th-century droughts compared to droughts in the more distant past.

A previous paleoclimate report for the Ogallala region by Young and Buddemeier (2002) utilized PDSI reconstructions by Cook et al. (1999), which were developed from 425 tree-ring chronologies and extended from ~1170 to 1978 AD for western Kansas. Since the publication of this report, new PDSI reconstructions have been produced that represent a substantial spatial and temporal improvement and enable us to better assess the nature of past drought variability. New reconstructions are now based on almost twice as many tree-ring chronologies (835 in total) and extend over longer time periods (from 837 to 2003 AD for western Kansas). PDSI estimates are based on instrumental data after 1978. PDSI data are available publically in the form of the North American Drought Atlas (http://iridl.ldeo.columbia.edu/SOURCES/.LDEO/.TRL/.NADA2004/.pdsi-atlas.html). Data were obtained for six grid points in Kansas, thereby dividing the state into six regions (Northwest, Southwest, North-central, South-central, Northeast, Southeast) for analysis in this report.

3. Analyses

3.1 Drought Severity

Figure 2 contains plots of annually resolved PDSI tree-ring reconstructions for six regions in Kansas. *These plots highlight numerous years in the past where drought conditions exceeded the severity of the 1930s and 1950s droughts in each region*. The peak individual drought years during the 1930s and 1950s droughts were determined to be 1934 and 1956 respectively. PDSI values for these years are highlighted with dashed lines on figure 2 and provide a benchmark by which to assess drought occurrence within each region. This type of analysis, however, does not favor regional comparisons as different PDSI thresholds are used in each region.

In order to facilitate regional comparison, we averaged the six regional PDSI values for 1934 and 1956 respectively, generating two thresholds by which to compare the different regions. These thresholds enable us to determine the number of years where droughts of a similar or greater magnitude occurred (i.e. years where PDSI is less than the threshold values). The averaged PDSI values for 1934 and 1956 are -4.9 and -5.9 respectively. Figure 3 highlights the total number of drought years in each region where PDSI values were less than or equal to the threshold values. Note that data were unavailable for some regions between 837-1000 AD and therefore, in order to facilitate fair comparison between regions, this analysis was restricted to data post 1000 AD.

The PDSI data indicate that western Kansas has experienced more severe droughts than eastern Kansas over the past 1000 years. Furthermore, the data also indicate that northern Kansas has typically experienced more severe droughts than southern Kansas. The west to east trend is not surprising given the strong latitudinal

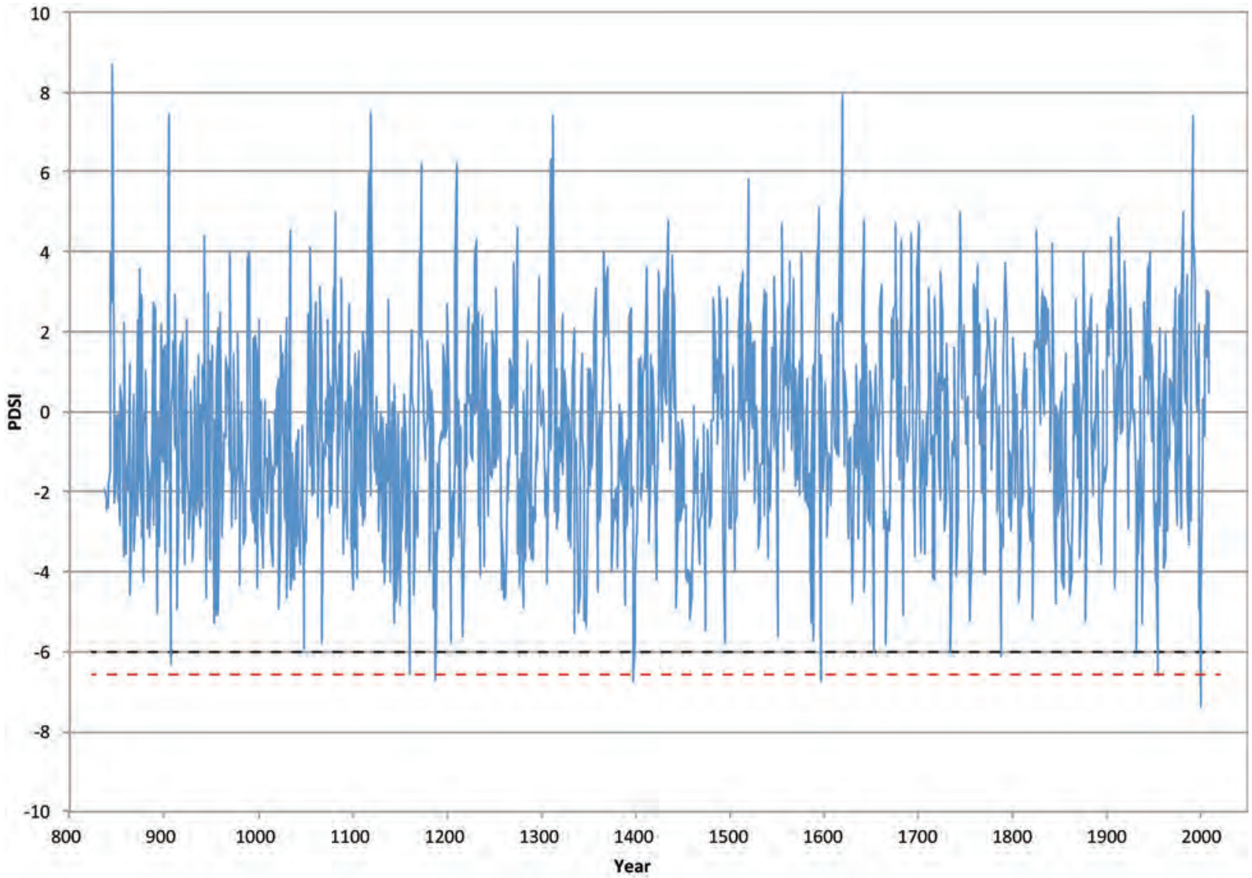

Figure 2a. Annual PDSI reconstructions from tree rings for northwestern Kansas. Dashed lines indicate the 1934 (black) and 1956 (red) PDSI values.

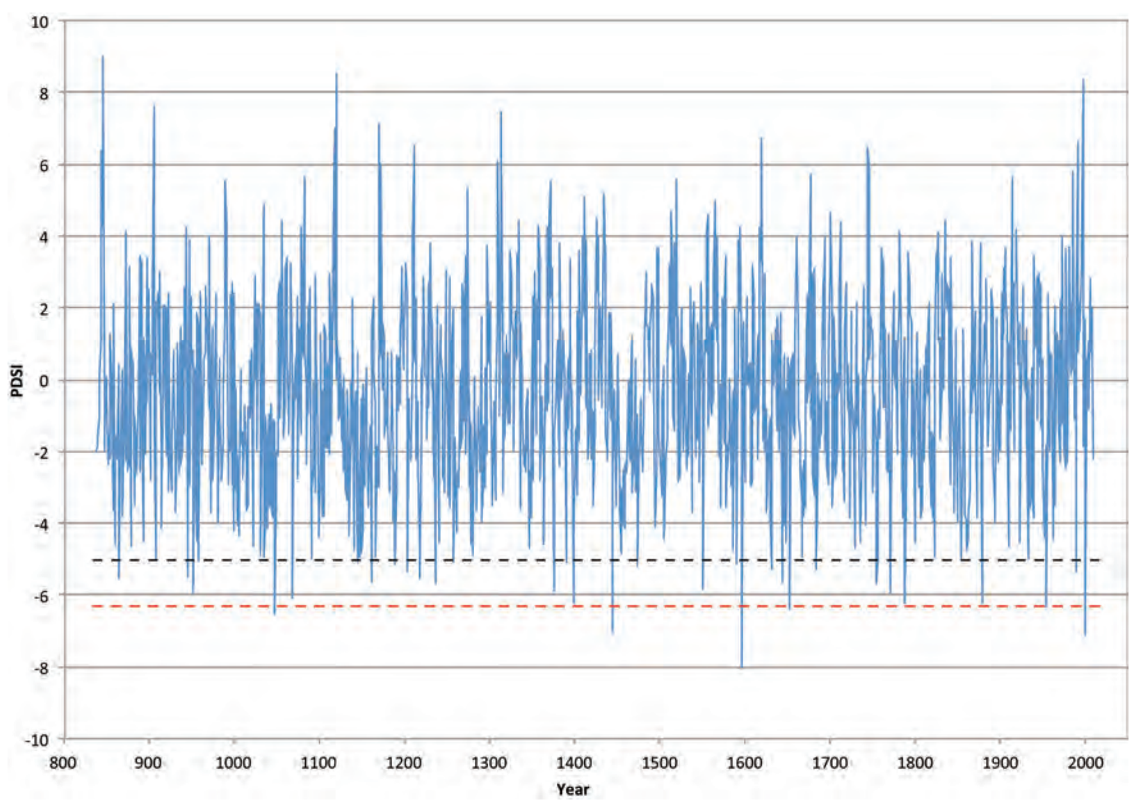

Figure 2b. Annual PDSI reconstructions from tree rings for southwestern Kansas. Dashed lines indicate the 1934 (black) and 1956 (red) PDSI values.

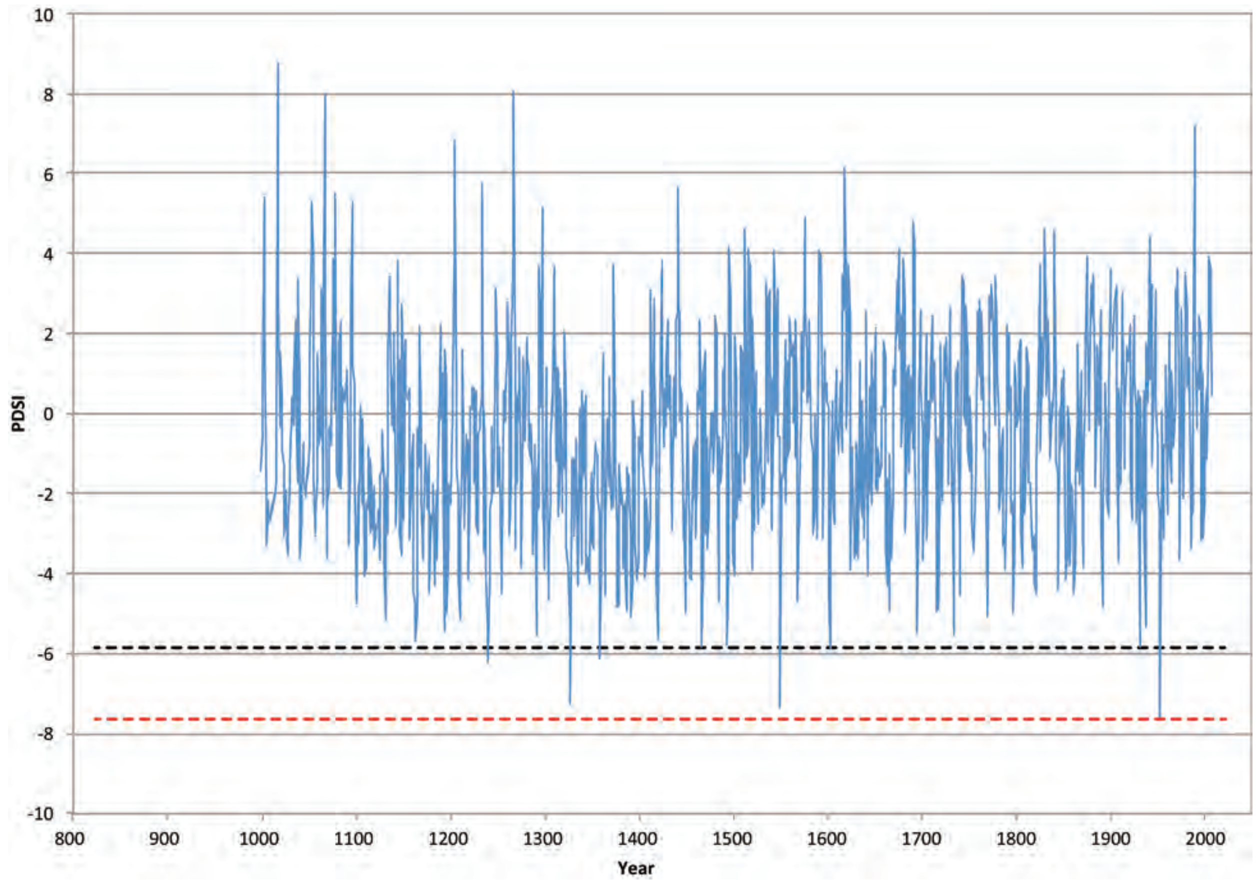

Figure 2c. Annual PDSI reconstructions from tree rings for north-central Kansas. Dashed lines indicate the 1934 (black) and 1956 (red) PDSI values.

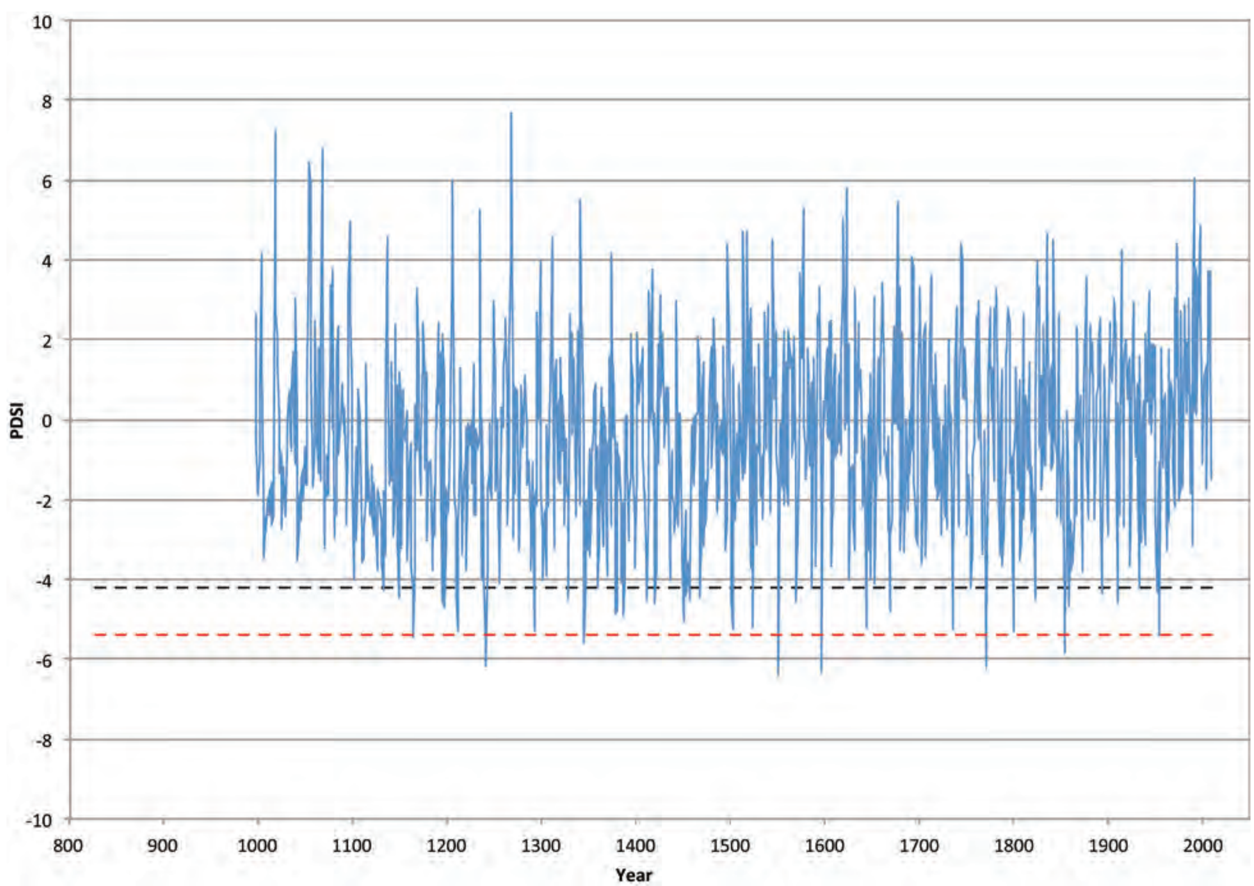

Figure 2d. Annual PDSI reconstructions from tree rings for south-central Kansas. Dashed lines indicate the 1934 (black) and 1956 (red) PDSI values.

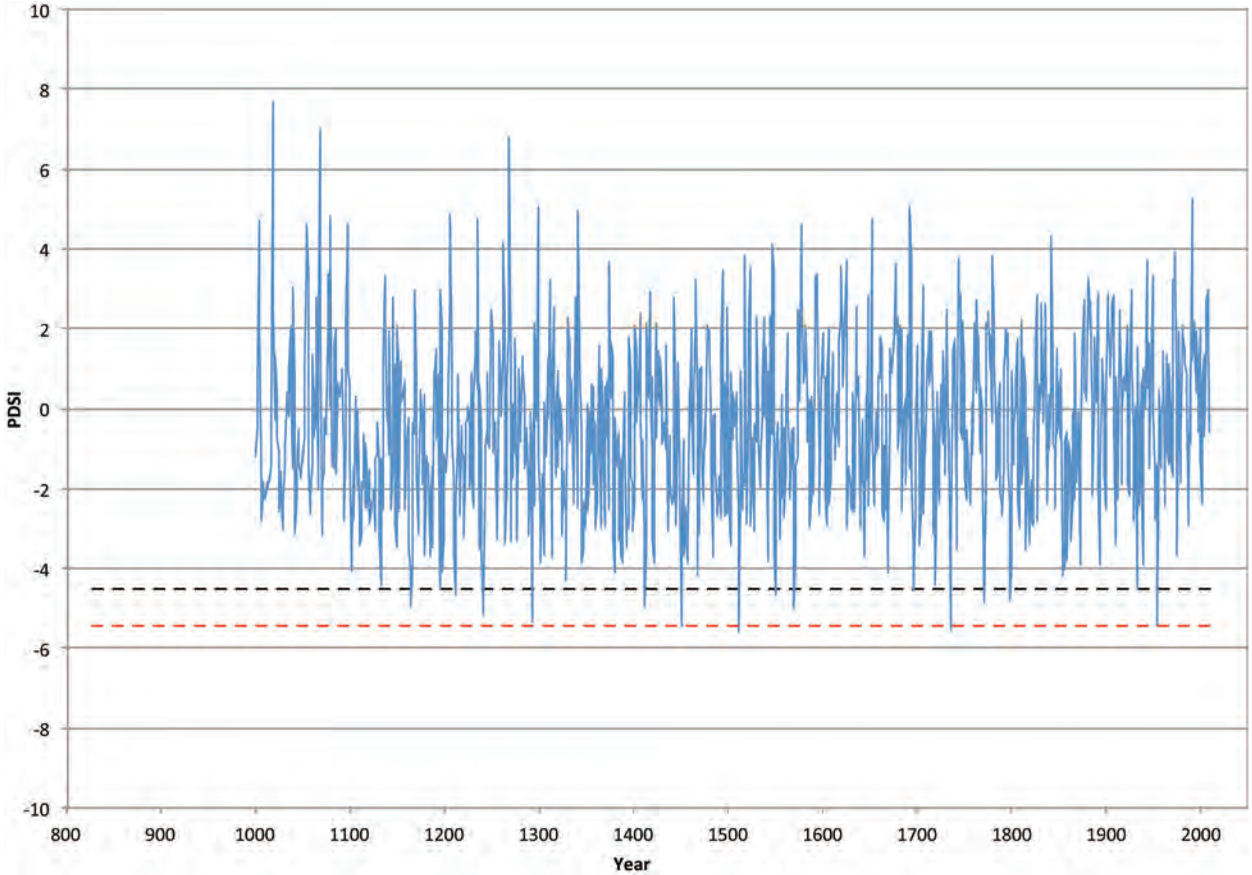

Figure 2e. Annual PDSI reconstructions from tree rings for northeastern Kansas. Dashed lines indicate the 1934 (black) and 1956 (red) PDSI values.

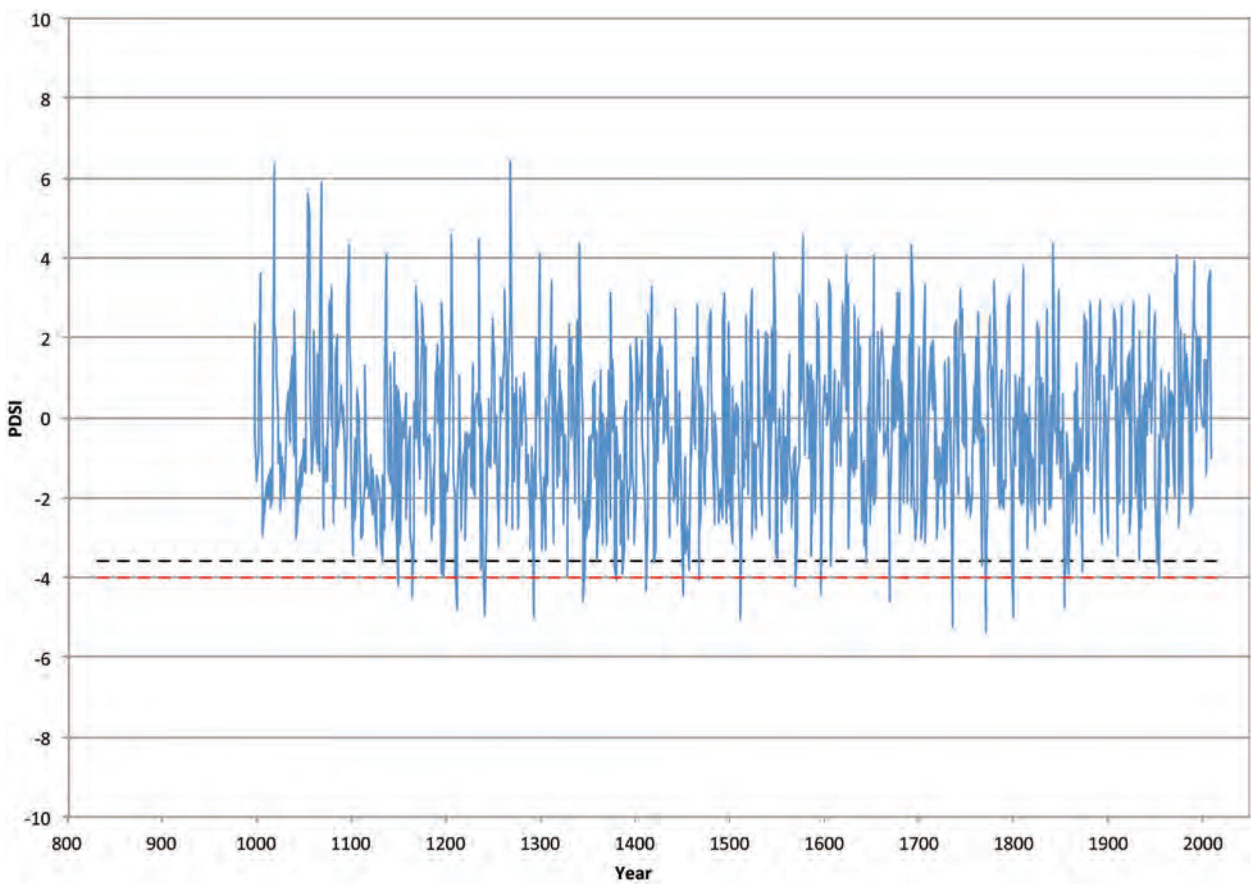

Figure 2f. Annual PDSI reconstructions from tree rings for southeastern Kansas. Dashed lines indicate the 1934 (black) and 1956 (red) PDSI values.

climate gradient in Kansas. The north to south trend can be explained by investigating the spatial patterns of historic 20th-century droughts. For example, the Dust Bowl drought was spatially centered over the Pacific Northwest and later over the northern Plains while the 1950s drought, in contrast, was centered over the southern Great Plains and later shifted into the southwest US (e.g. Stahle et al., 2007; Fig. 4). Hoerling et al. (2009) suggest that the 1950s drought was driven by changes in sea-surface temperatures, more specifically the El Niño-Southern Oscillation. They found that during La Niña years, characterized by cold sea-surface temperatures in the equatorial Pacific, droughts are common in the southern Plains. In contrast, they suggest that the Dust Bowl drought was caused by random atmospheric variation rather than changes in ocean temperatures. Therefore, the PDSI data appear to suggest that the random forcing mechanisms of the Dust Bowl drought have been more common over the past 1000 years than those that resulted in the 1950s drought.

Another way to analyze the PDSI data is to determine how many years exceed the threshold in a given century. By this method *we should expect individual drought years at least as severe as 1934 on average 3-4 times a century in western Kansas, 2-3 times in central Kansas, and about once a century in eastern Kansas*.

However, this analytical method (i.e. using averaged PDSI thresholds) can be misleading. For example, figure 3 indicates that there are no droughts in the paleorecord that exceed the 1956 threshold in eastern Kansas. This is misleading because of the strong regional expression of drought in the state. For example, in southeastern Kansas the 1956 PDSI was -4.0, which indicates extreme drought. However, because drought conditions were more severe elsewhere in the state, the regionally averaged threshold for 1956 is skewed to -5.9. While there are no past drought years with PDSI values less than -5.9 in southeastern Kansas, there are at least 22 past drought years with PDSI values less than -4.0 (see Fig. 2f). We therefore suggest that both methods of analysis (i.e. assessing drought severity *within* and *between* regions) should be used in conjunction when assessing the variability of drought severity across Kansas.

3.2 Drought Duration

One of the key characteristics of the 1930s and 1950s droughts was not only their severity in a given year but their *duration*. Individual drought years are therefore not necessarily good indicators of cumulative socioeconomic or environmental impacts as one dry year may be accommodated if it is sufficiently offset by wetter conditions the following year (Cook et al., 2007). For example, the 2002 drought year in southwestern Kansas was more severe than the peak year of the Dust Bowl (PDSI values of -7.1 and -5.0 respectively). However, 2002 was bounded by years of positive PDSI values whereas the Dust Bowl drought consisted of several consecutive years of drought conditions. It is therefore important to assess the duration of past periods of drought.

The duration of droughts is more difficult to estimate because climatic variability tends to punctuate dry multi-year intervals with occasional wet years (Cook et al., 2009). Furthermore, there is no unique solution for calculating drought duration. For example, the 1930s and 1950s droughts have been estimated to have lasted 12 and 14 years (Stahle et al., 2007) or 7 and 8 years (Andreadis et al., 2005) respectively. One method to determine drought duration is to utilize a low-pass filter, such as a moving-average, which allows for analysis of decadal to multi-decadal changes in aridity.

Figure 5 contains plots of PDSI values smoothed over 10- and 50-year periods. For this analysis we determine the beginning and end of a drought period from the smoothed data by identifying when it is preceded or followed by more than two consecutive years of positive PDSI values. Using this technique we identify the duration of the 1930s and 1950s droughts in Kansas as lasting 13 and 18 years respectively.

Using these durations we are able to identify several periods of past drought with durations similar (i.e. 10-20 years) to the severe historic droughts of the 20th century. These droughts are highlighted in figure 5 by light gray bars. Figure 6 shows the number of droughts of similar duration to the historic 20th century droughts over the past 500 years. We limit this analysis to the past 500 years because the majority of droughts prior to this appear to be of much greater duration. Drought duration over the past 500 years illustrates a similar pattern to

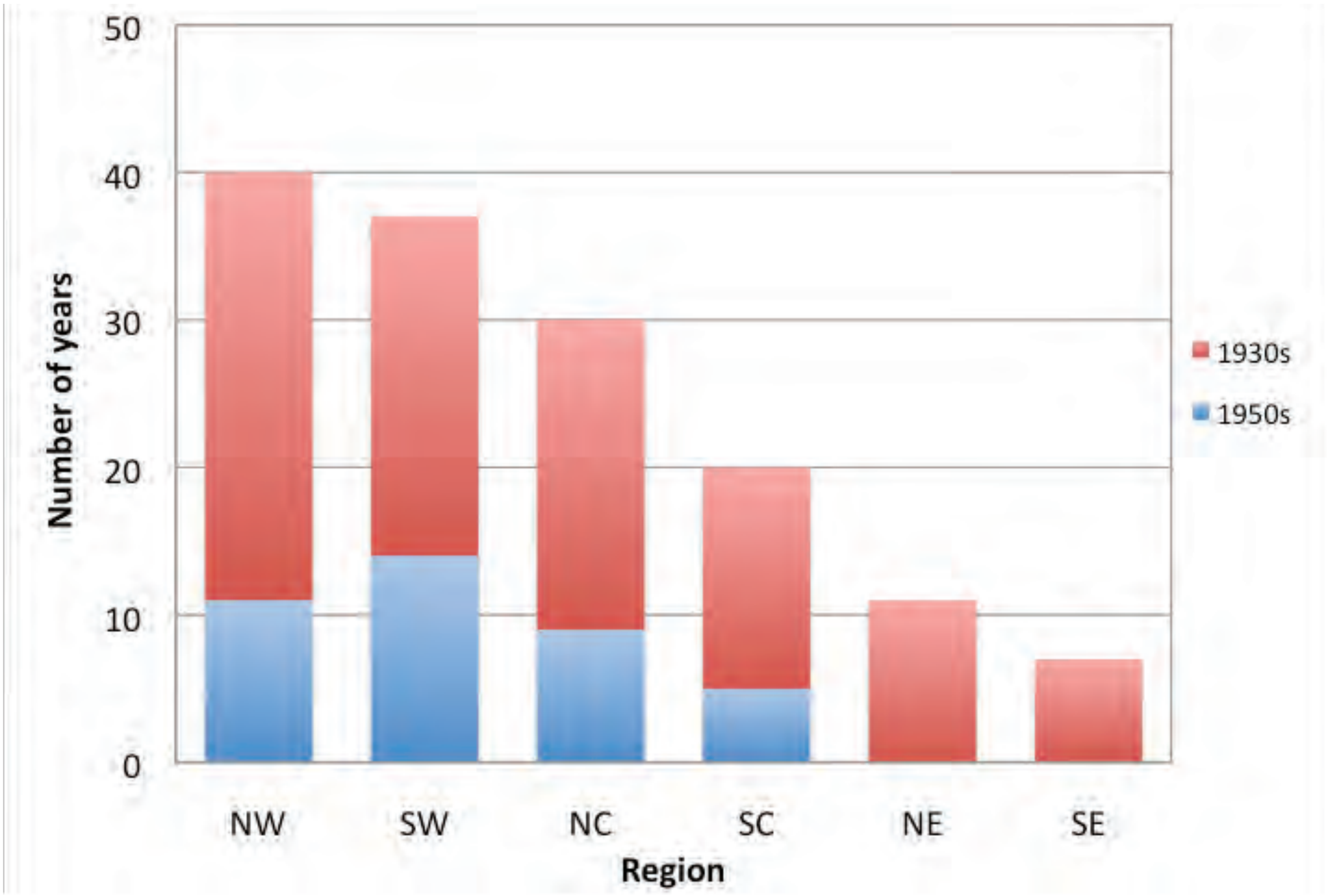

Figure 3. Number of drought years more severe than the peak years of the 1930s and 1950s droughts. Note that this analysis uses threshold PDSI values averaged across all six regions.

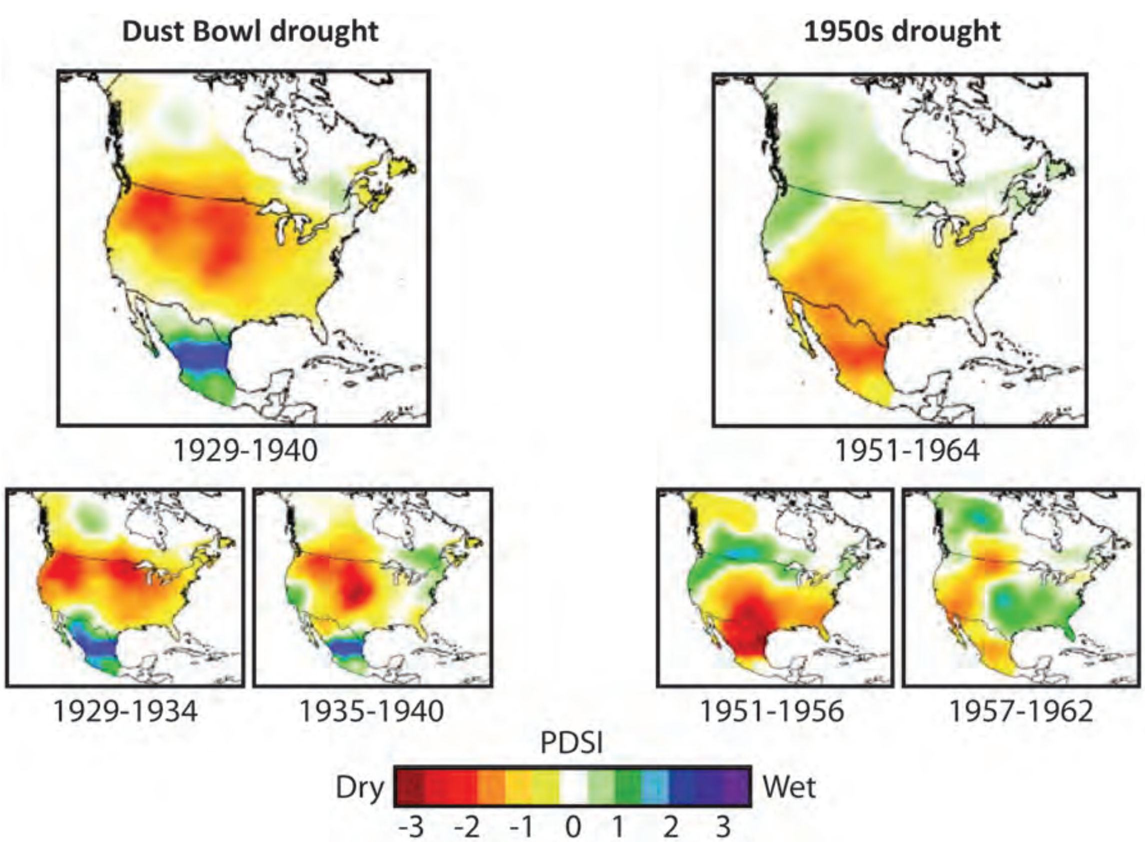

Figure 4. Mapped spatial patterns of the 1930s and 1950s droughts using instrumental PDSI data. Figure modified from Stahle et al. (2007).

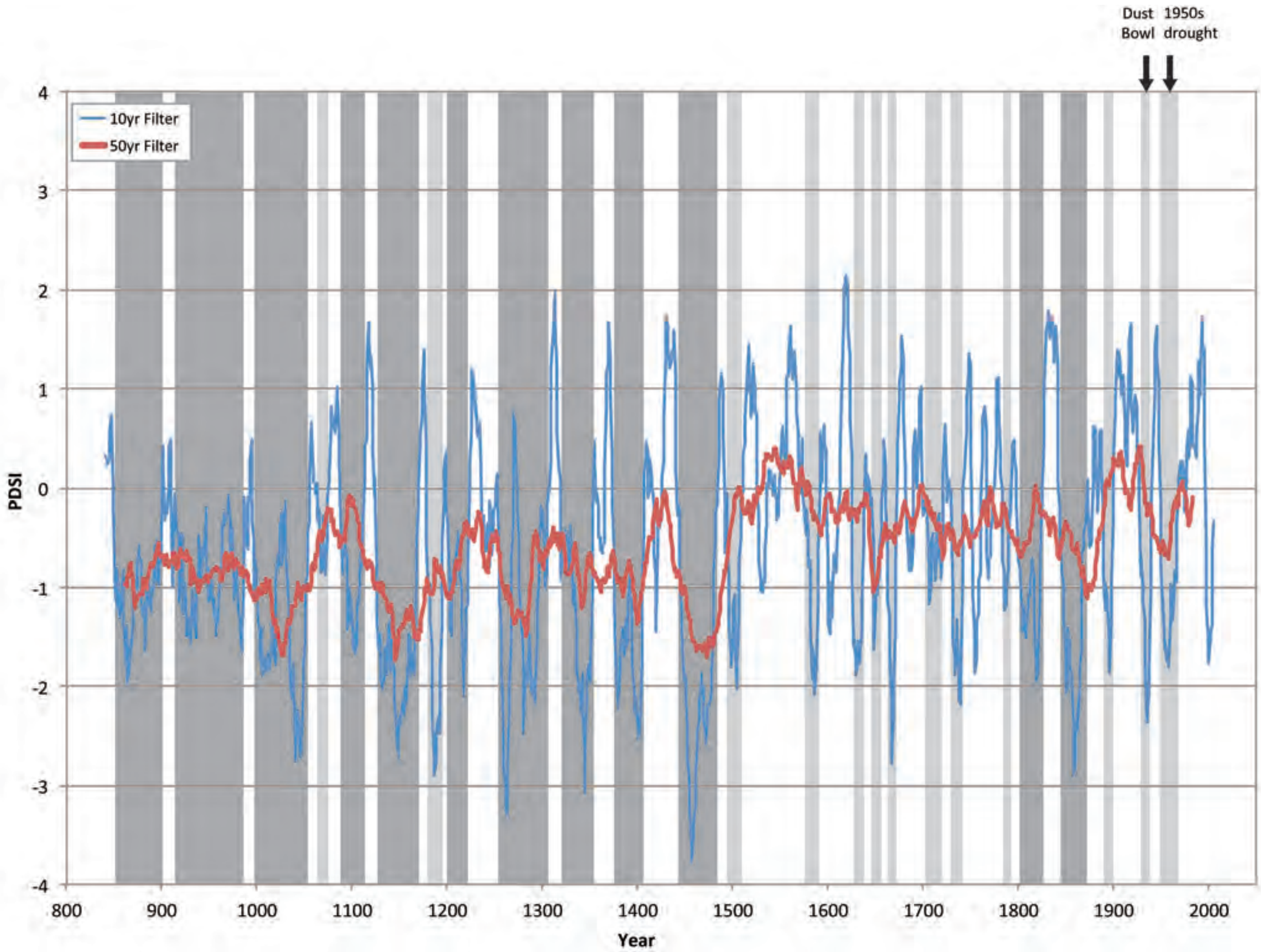

Figure 5a. Smoothed PDSI reconstructions for northwestern Kansas. Light-gray bars indicate droughts of similar duration to the 1930s and 1950s droughts while dark-gray bars indicate droughts of greater duration.

drought severity with western and northern Kansas experiencing more decadal drought periods than eastern Kansas. From these data *we should expect decadal droughts on average two times a century in western Kansas and about once a century in eastern Kansas*.

3.2.1 Megadroughts

Droughts of unusually long duration compared to those observed in the instrumental record are often called 'megadroughts.' In order to constitute a megadrought, a past multi-year drought must exceed the duration of the most extreme droughts in the 20th century. Therefore, for this study, a megadrought is defined as a drought lasting more than 20 years in duration.

PDSI reconstructions highlight several periods of extreme drought in the past with much longer durations compared to those of the 20th century, particular prior to 1500 AD. These multi-decadal droughts are highlighted in figure 5 by dark gray bars. Additionally, documented megadroughts are typically at least as severe as the 1930s and 1950s droughts.

It is important to validate the occurrence of past megadroughts by utilizing other proxy records. Figure 7 synthesizes the records of drought variability shown in figure 5 and in addition highlights different lines of environmental and societal evidence that support drought conditions during documented megadroughts.

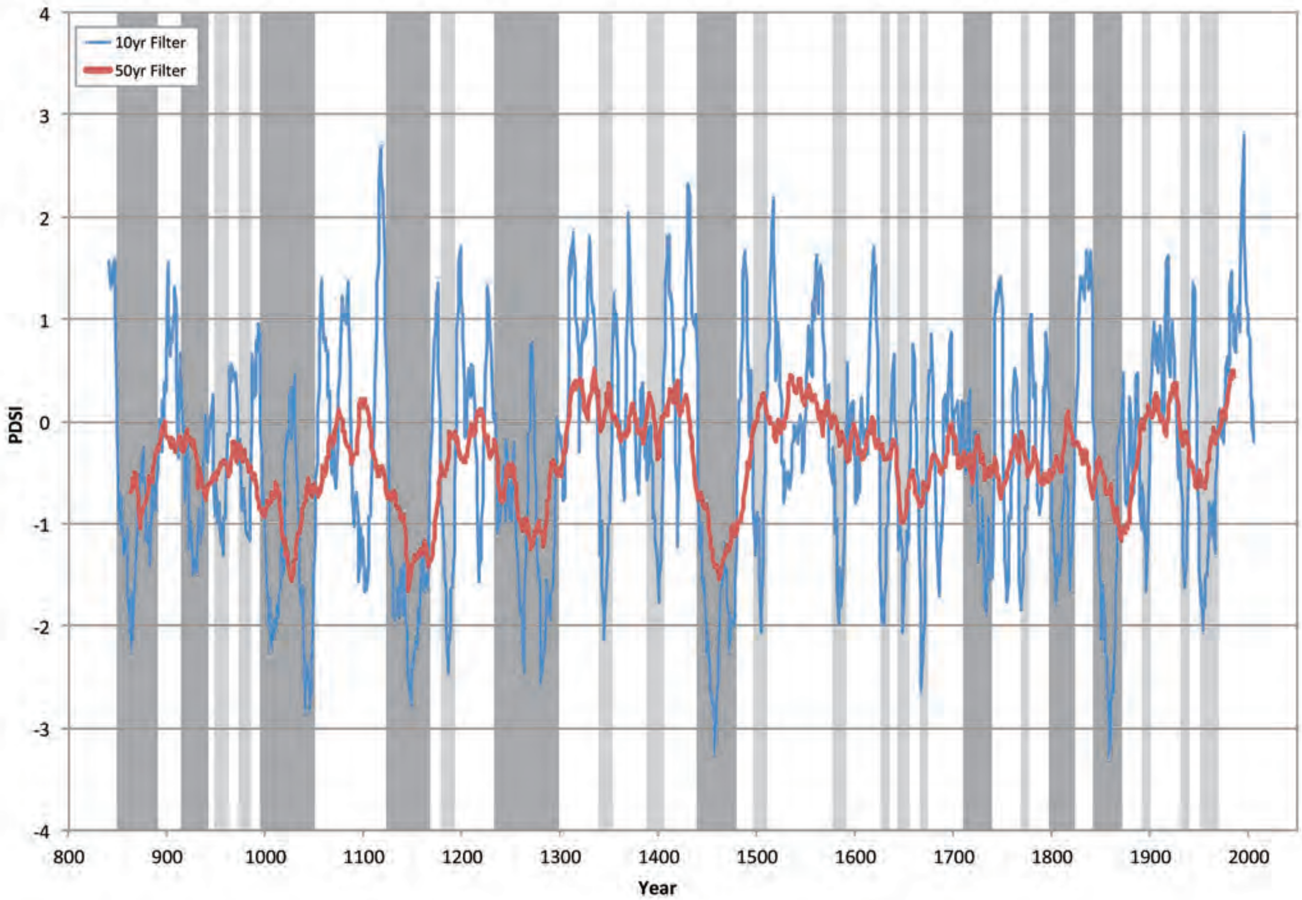

Figure 5b. Smoothed PDSI reconstructions for southwestern Kansas. Light-gray bars indicate droughts of similar duration to the 1930s and 1950s droughts while dark-gray bars indicate droughts of greater duration.

3.2.2. Megadroughts from 1500 to 2011 AD

PDSI reconstructions indicate the likely occurrence of megadroughts in the beginning and middle part of the 19th century, which persisted on average for 30 years (Figs. 5 and 7). Drought conditions around 1850 are noted in a variety of historical data, including early meteorological records (Ludlum, 1971). Stahle et al. (2007) cite evidence from the Kiowa of the southern Great Plains that cites 1855, known among the Kiowa as the "sitting summer," as a year of severe drought. Woodhouse and Overpeck (1998) note that drought conditions were also documented in Kansas newspapers in 1860. Woodhouse et al. (2002) used streamflow reconstructions from eastern Colorado to document a period of remarkable sustained drought from approximately 1845 to 1856. This period of drought, together with human impacts, may have also resulted in a severe decline in the populations of the Great Plains bison (Woodhouse et al., 2002). Historical accounts from early explorers in the region during the 19th century report periods of blowing sand indicative of eolian activity and sand-dune activation for an area extending from northern Nebraska to southern Texas (Muhs and Holiday, 1995). Eolian activity is primarily driven by droughts severe enough to remove the stabilizing effects of vegetation. Forman et al. (2008) observed discrete episodes of sand deposition in the Arkansas River valley of southwestern Kansas between 1620-1680 and 1800-1820 AD (Fig. 6).

3.2.3 Megadroughts from 850 to 1500 AD

PDSI data highlight several likely past megadroughts from 850 to 1500 AD (Figs 5 and 7). Although these mega-droughts were punctuated with wet intervals, overall they suggest protracted aridity lasting on average 40-50 years in duration. The longest megadrought on record occurred in north-central Kansas and lasted 110 years

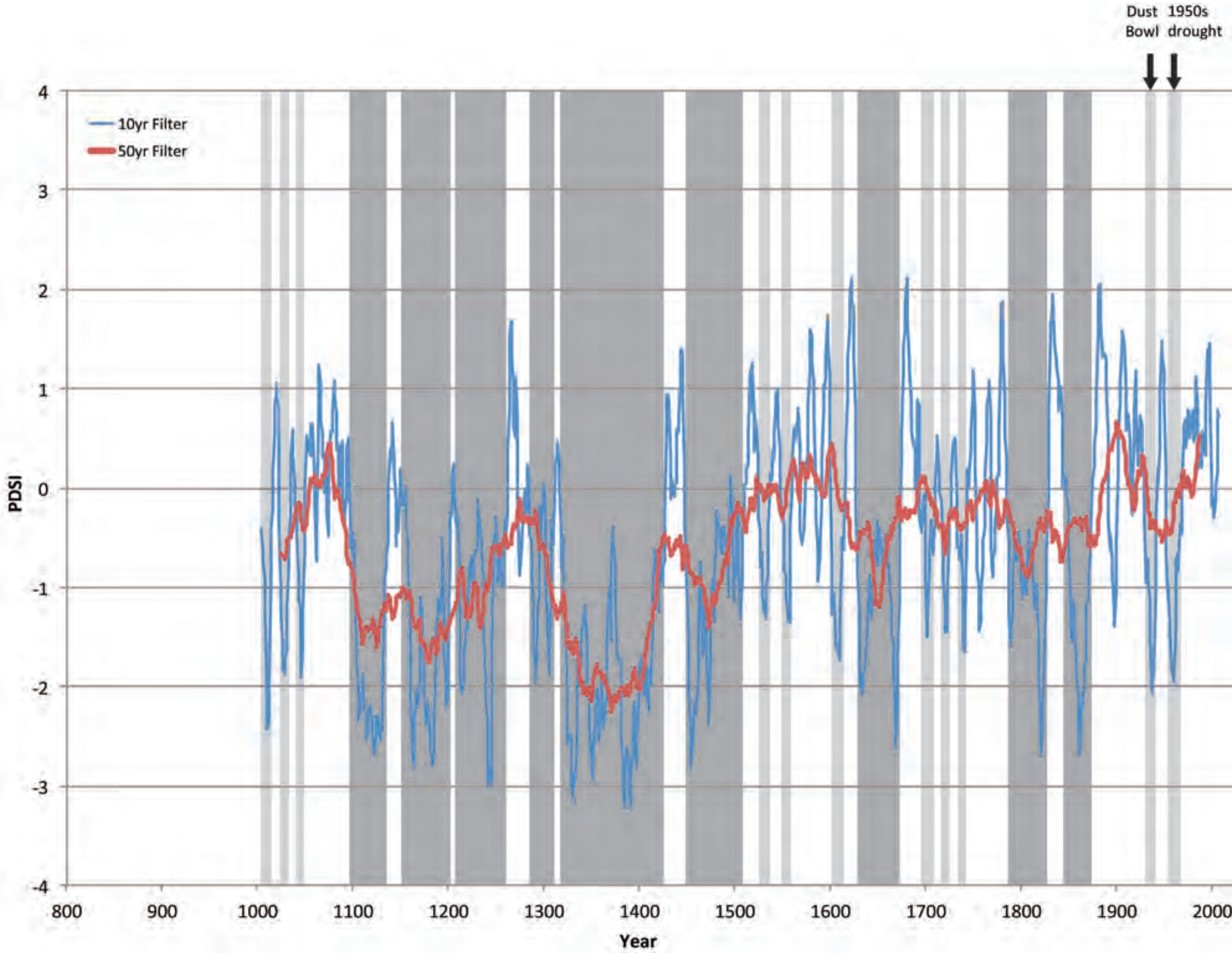

Figure 5c. Smoothed PDSI reconstructions for north-central Kansas. Light-gray bars indicate droughts of similar duration to the 1930s and 1950s droughts while dark-gray bars indicate droughts of greater duration.

from 1317 to 1427 AD. This megadrought was also much more severe than historic 20th-century droughts. Figure 7 highlights the spatial variability of megadroughts across the state. For example, the protracted 110-year megadrought in north-central Kansas was separated into two separate decadal droughts in western Kansas.

Most dune records from the central Great Plains show significant sand-dune activation due to increasing aridity and reductions in vegetation cover between 950-1350 AD. Evidence of sand-dune mobilization from the Great Bend Sand Prairie in south-central Kansas – the largest dune field in Kansas – has been documented between 1050-1250 and 1450-1650 AD (Arbogast, 1996). Halfen et al. (2011) also identified active dune migration in south-central Kansas between 1000-1100 AD. Dunes in the Cimarron River valley of southwestern Kansas were active between 1050 and 1250 AD (Lepper and Scott, 2005) while dunes in the Abilene dune field of north-central Kansas were active more broadly between 890-1490 AD (Hanson et al., 2010). The time intervals for dune activation overlap periods of megadroughts identified from PDSI reconstructions.

Support for the occurrence of megadroughts between 850 and 1500 AD can also be gleaned from the archeological record, which highlights the destabilizing effects of past severe droughts. Benson et al. (2007) suggest that multi-decadal droughts between 990-1060, 1135-1170, and 1276-1297 AD had significant impacts on a variety of prehistoric populations in the Southwest, including Anasazi and Fremont cultures, and the Midwest, such as the Mississippian society.

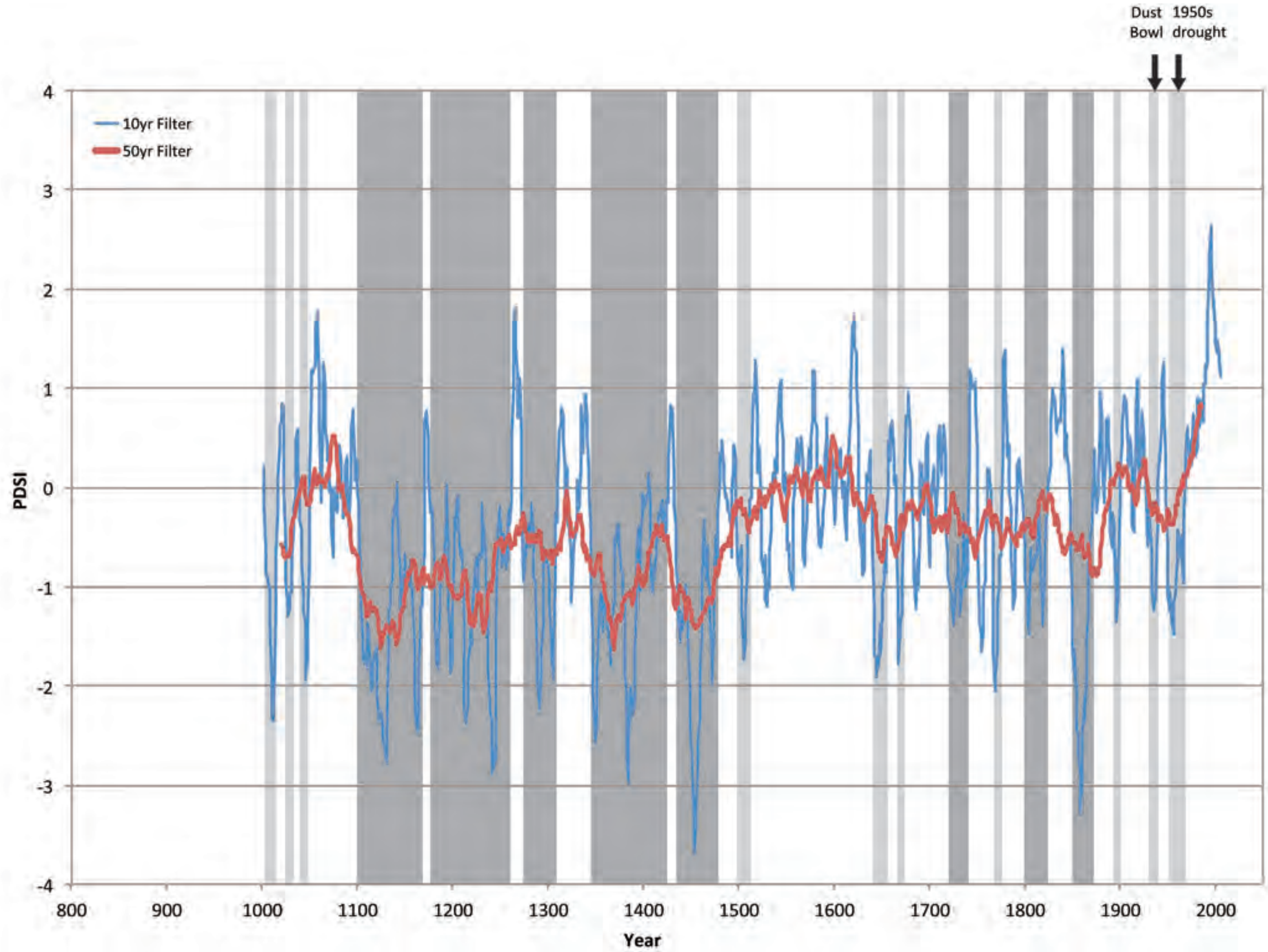

Figure 5d. Smoothed PDSI reconstructions for south-central Kansas. Light-gray bars indicate droughts of similar duration to the 1930s and 1950s droughts while dark-gray bars indicate droughts of greater duration.

The 13th century drought is commonly referred to as the "Great Drought" in the southwest and contributed to significant social change in the Four Corners region through severe population loss and the abandonment of Anasazi settlements. This megadrought would have strongly impacted maize agriculture, which had become the dietary staple of the Anasazi (Benson et al., 2007). Rapid population declines have been documented from archeological sites starting at 1130 and 1280 AD. Studies have also reported population declines in the Fremont cultures located in the Four Corners region around 1000 AD, which may be attributable to the 990-1060 drought.

Severe multi-decadal droughts during the 14th and 15th centuries likely contributed to the decline of Mississippian agricultural societies (e.g. Cobb and Butler, 2002; Cook et al., 2007). Cook et al. (2007) suggest that widespread droughts at this time would likely have caused a sequence of poor harvests that would have proved disastrous. Several Mississippian settlements were abandoned by 1450 including Cahokia, located near the confluence of the Mississippi and Missouri rivers, and Spiro, situated in eastern Oklahoma. Evidence also suggests that the late 13th century megadrought also impacted the Cahokia region (e.g. Benson et al., 2007).

Overall the paleoclimate record suggests that Kansas has experienced droughts of far greater duration in the past than any experienced in the 20th century. This conclusion is supported by several historic, geomorphic, and archeological studies.

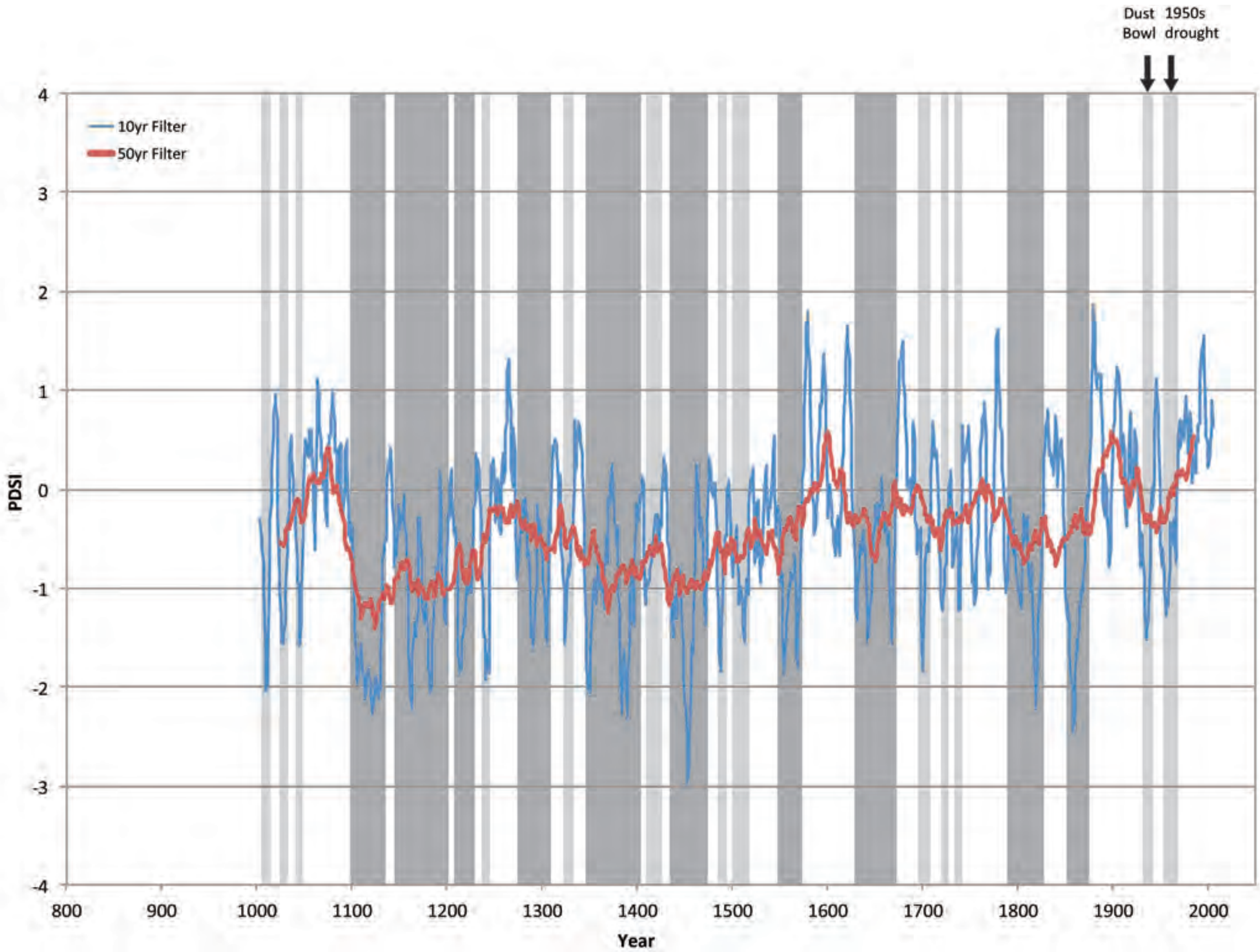

Figure 5e. Smoothed PDSI reconstructions for northeastern Kansas. Light-gray bars indicate droughts of similar duration to the 1930s and 1950s droughts while dark-gray bars indicate droughts of greater duration.

3.3 The Medieval Warm Period

Many of the past megadroughts documented in the paleoclimate record occurred during an era known as the Medieval Warm Period (MWP). The occurrence of several megadroughts during the MWP is troubling as it suggests that the climate system has the capacity to get 'stuck' in drought-inducing modes over the Great Plains that can last several decades to a century or more (Cook et al., 2009).

The MWP has been suggested as an approximate analog for likely future warming and drought conditions (e.g. Woodhouse et al., 2010) and thus serves as an important period to investigate. The MWP lasted from approximately 900 to 1300 AD and was characterized by significant climatic variability compared to the modern period. This period was identified by Lamb (1965) as a period of unusual warm temperatures in northern Europe but has since been documented in proxy records from across the globe (e.g. Graham et al., 2011). Other paleoclimate studies record a series of severe droughts across western North America (Cook et al., 2004) during this period, extending eastward into the central Great Plains (e.g. Daniels and Knox, 2005). In addition, the paleoclimatic data suggest a drought-regime change about 500 years ago (Fig. 7). The shift around 1500 AD to droughts of shorter duration may coincide with the onset of cooler climatic conditions during the Little Ice Age.

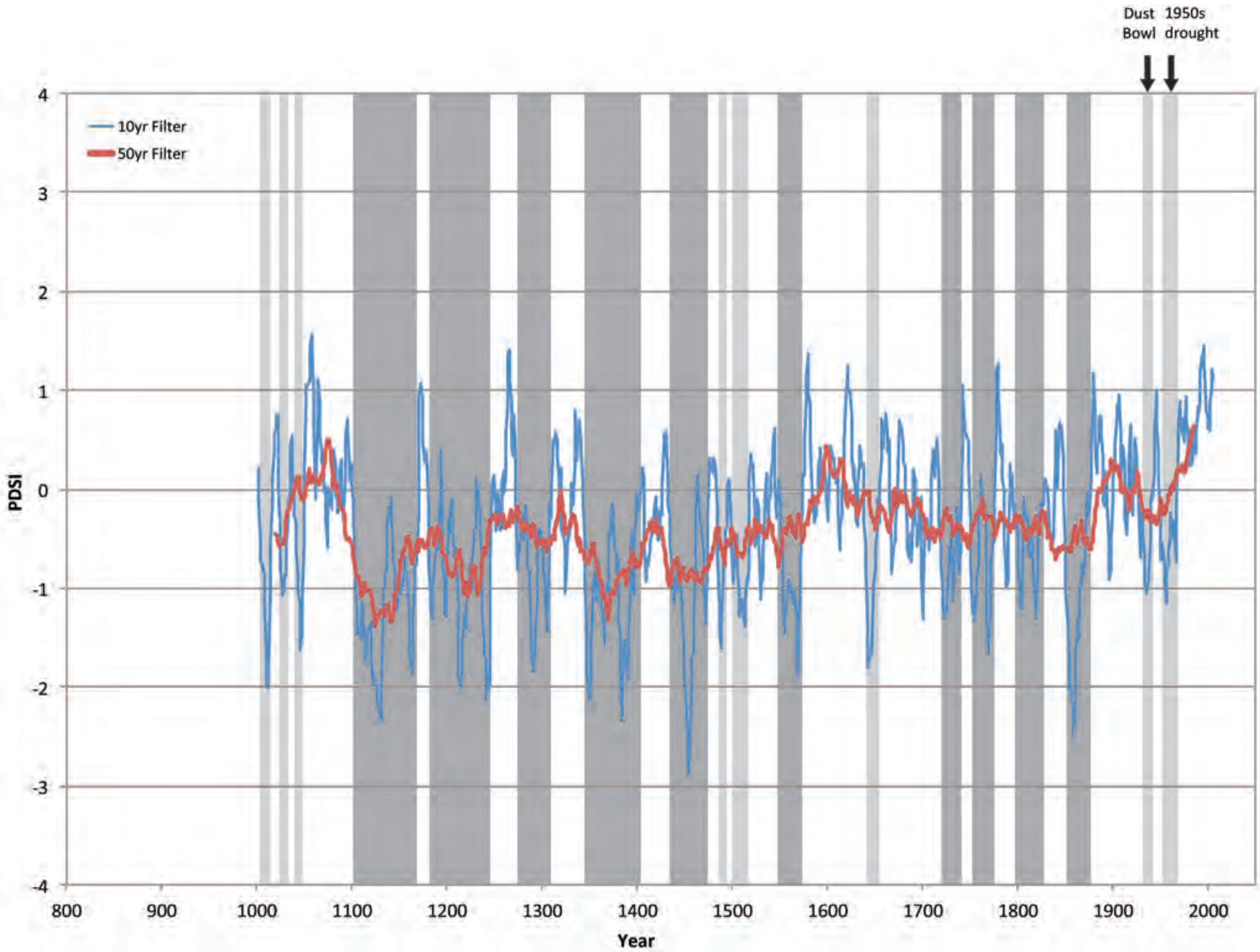

Figure 5f. Smoothed PDSI reconstructions for southeastern Kansas. Light-gray bars indicate droughts of similar duration to the 1930s and 1950s droughts while dark-gray bars indicate droughts of greater duration.

3.4 Risk analysis

Utilizing a similar approach to a previous paleoclimate report published by the Kansas Geological Survey (Young and Buddemeier, 2002), we can provide a quantitative analysis for assessing the risk of drought in Kansas. The paleoclimate data indicate that for western Kansas a drought as severe as the Dust Bowl has occurred on average 3 to 4 times a century. If “3 to 4 times a century” means that there has been on average 3.5 droughts more severe than the Dust Bowl per 100 years, then there is a 3.5% chance that any given year within a 100-year period will have such a severe drought. We can further estimate probabilities for shorter periods using simple arithmetic. For example, there is a 35% chance of a severe drought year in any decade, a 70% chance over a 20-year planning horizon and, in terms of probability, a 100% chance over the estimated 40-year working lifetime of an individual farmer in western Kansas. In eastern Kansas the probabilities are lower as droughts as severe as the Dust Bowl have only occurred about once every century.

We can do a similar analysis for drought duration. For western Kansas, decadal-length droughts have occurred on average twice a century. Therefore, there is a 20% chance of a Dust Bowl length drought in a given decade, a 40% chance over a 20-year period, and an 80% chance over a 40-year period in western Kansas.

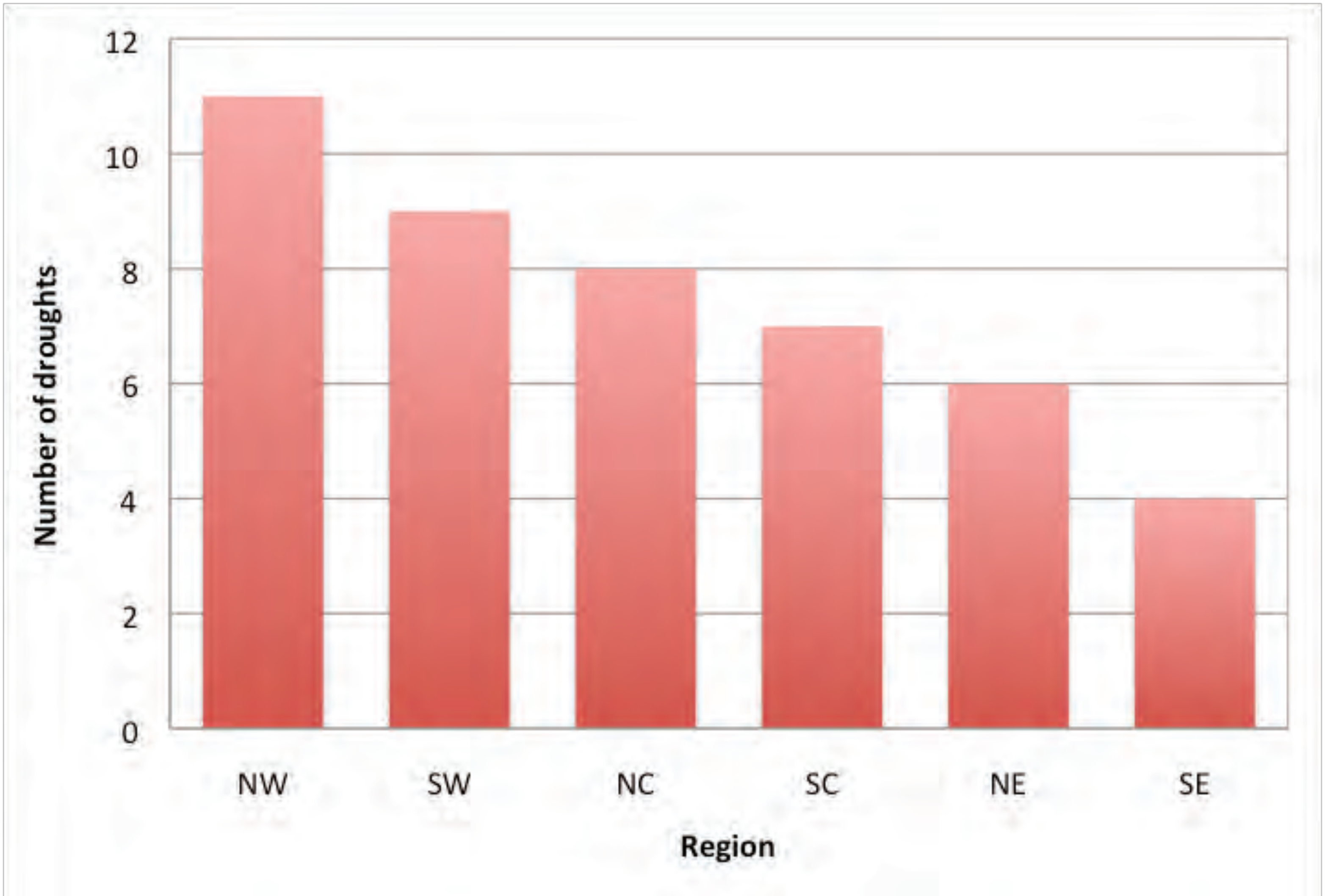

Figure 6. Number of drought periods from 1500 to 2011 AD of similar duration to the 1930s and 1950s droughts (i.e. lasting 10-20 years) by region.

4. Policy and Management Implications

Drought conditions have a significant impact on surface- and ground-water resources through heightened demand and reductions in water supply. Water systems are commonly designed to handle the "drought of record," identified as the most severe hydrological event from the instrumental record. For the state of Kansas, the 1950s drought (1952-57) remains the planning benchmark and is used to calculate reservoir yield through droughts with a 2% chance of occurrence in any one year (K.A.R. 98-5-8). However, this report provides multiple lines of evidence to support the conclusion that drought variability in the 20th century is just a subset of the full range of variability that one should expect under naturally occurring climatic conditions. In other words, in terms of the long-term record of drought variability, the 1930s and 1950s droughts are not unusual. In fact, the paleoclimatic record indicates that droughts of greater severity and longer duration have occurred in the past. Furthermore, it is possible that the conditions that led to past megadroughts, such as those that occurred during the MWP, could occur in the future. Such severe drought conditions are of great concern because modern-day agricultural and water systems may not have the resilience to survive droughts beyond the "worst case scenario" droughts of the past 100 years (Cook et al., 2007).

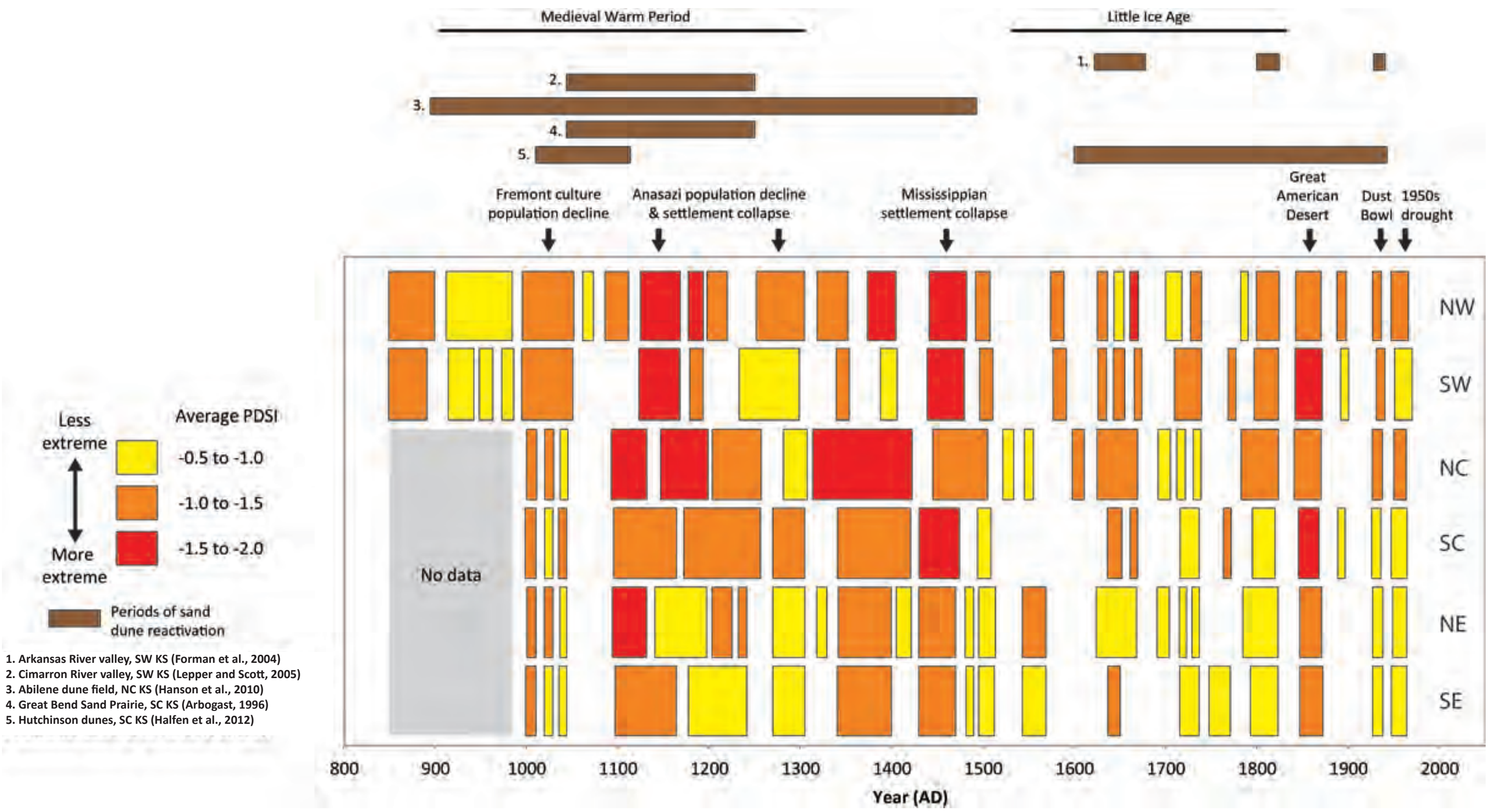

Figure 7. Synthesis of regional reconstructed PDSI data with additional paleoenvironmental proxy data from geomorphic and archeological sources.

In terms of water-resource management, paleoclimatic data have important implications. For example, reservoirs are typically designed with conservation pools to specific meet water demand during drought conditions. However, would these designs be adequate under megadrought conditions? Additionally, management of aquifer resources must be designed to accommodate high demand during protracted droughts while sustaining or extending the usable lifetime of the resource.

Woodhouse and Overpeck (1998) highlight two factors that may compound the susceptibility of the Great Plains to future drought: 1) increased vulnerability due to land-use practices, specifically the use of irrigation to bring marginal lands into agricultural production, and 2) the enhanced likelihood of drought due to global warming. Furthermore, certain factors present challenges to effective water-resource management including 1) current levels of uncertainty in predicting future drought occurrence, 2) the assumption of climatic stationarity by water-resource planners, and 3) competing management interests (e.g. Lins and Stakhiv, 1998; Hartmann, 2005).

Given these challenges, it would be wise to adopt a probabilistic approach to drought forecasting and planning that incorporates the full range of drought variability indicated in the paleoclimatic record.

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Appendix: Calibration and Verification Statistics

The data used in this report were obtained from the North American Drought Atlas (Cook and Krusic, 2004). Cook and Krusic used four statistics as measures of association between the actual and estimated PDSI in order to test the fidelity of PDSI reconstructions.

1) Calibration R-SQuare (CRSQ). This statistic measures the percent PDSI variance explained by the tree-ring chronologies at each grid point over the 1928-1978 calibration period, based on a regression modeling procedure described in Cook et al. (1999). As defined here, CRSQ is equivalent to the “coefficient of multiple determination” found in standard statistic texts. It ranges from 0 (no calibrated variance) to 1.0 (perfect agreement between instrumental PDSI and the tree-ring estimates). The former represents complete failure to estimate PDSI from tree rings and the latter is not plausible if the model is not seriously over-fit.

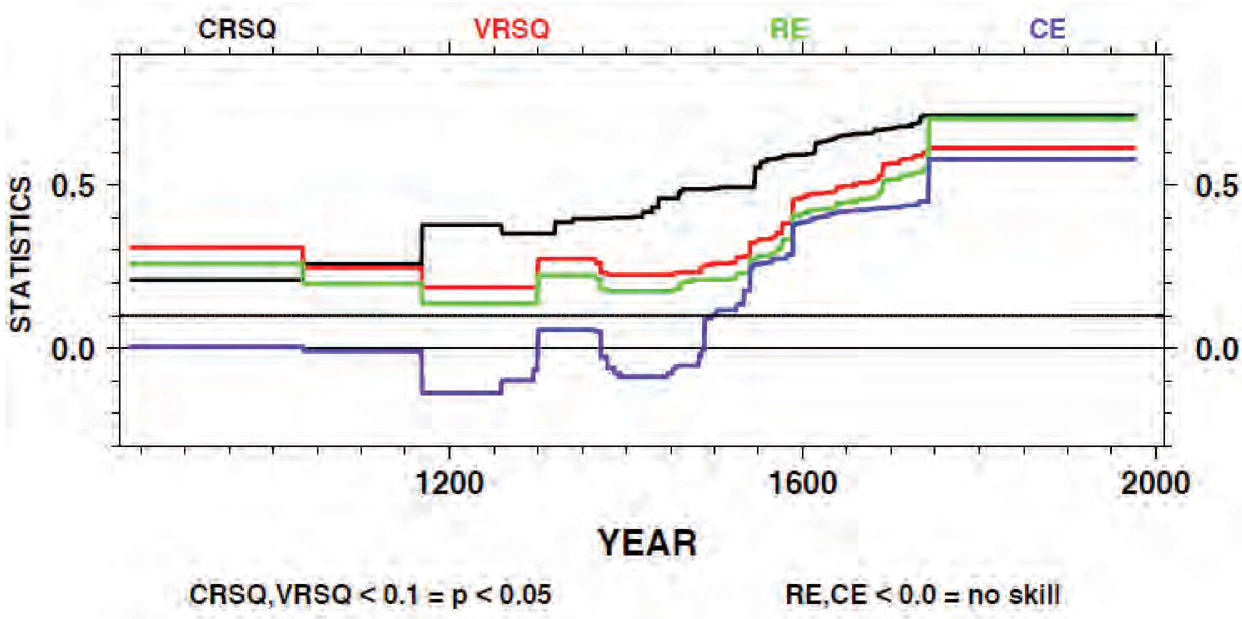
2) Verification R-SQuare (VRSQ). This statistic measures the percent PDSI variance in common between actual and estimated PDSI in the 1900-1927 verification period. It is calculated as the square of the Pearson correlation coefficient, which is a well known measure of association between two variables. VRSQ also ranges from 0 to 1.0 (VRSQ is assigned a 0 value if the correlation is negative). Roughly speaking, VRSQ>0.11 is statistically significant at the 1-tailed 95% level using our 28-year verification period data.

3) Verification reduction of error (RE). This statistic was originally derived by Edward Lorenz as a test of meteorological forecast skill. Unlike CRSQ and VRSQ, RE has a theoretical range of -infinity to 1.0. Over the range 0-1.0, RE expresses the degree to which the estimates over the verification period are better than “climatology,” i.e. the calibration period mean of the actual data. So, a positive RE means that the PDSI estimates are better than just using the calibration period mean as a reconstruction of past PDSI behavior. A negative RE is generally interpreted as meaning that the estimates are worse than the calibration period mean and, therefore, have no skill. The use of the calibration period mean as the “yardstick” for assessing reconstruction skill makes this statistic more difficult to pass than VRSQ. However, it is also less robust, meaning that it is very sensitive to even a few bad estimates in the verification period. Therefore, RE>0 is interpreted as evidence for a reconstruction that contains some skill over that of climatology.

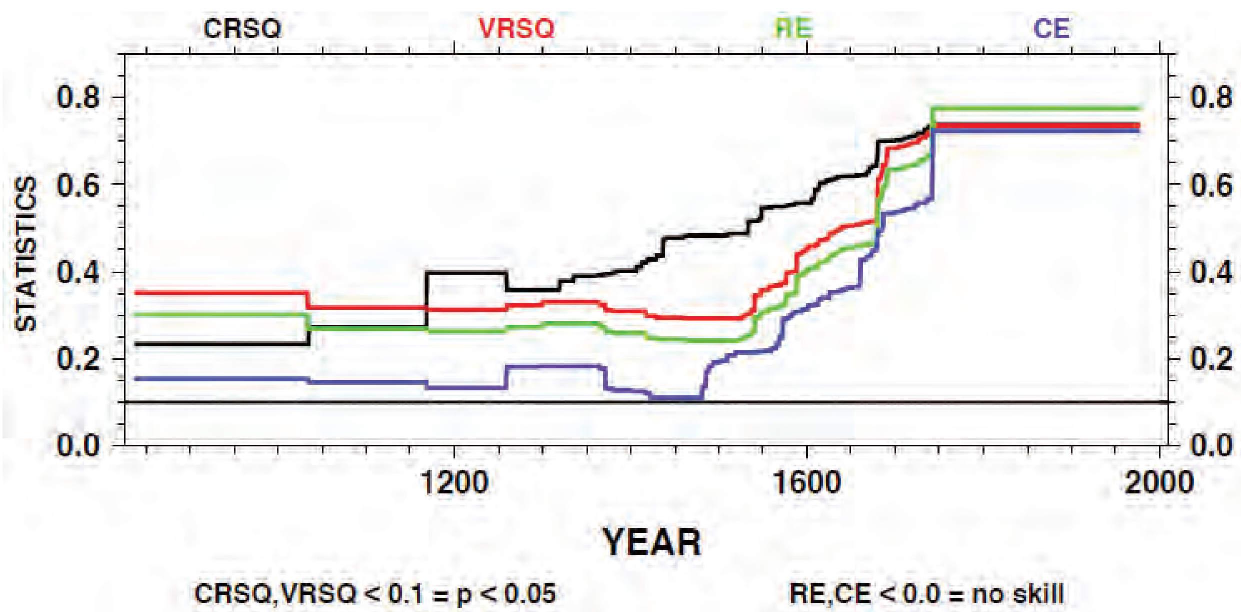
4) Verification coefficient of efficiency (CE). This statistic comes from the hydrology literature and is very similar to the RE. It too has a theoretical range of -infinity to 1.0. The crucial difference is that the CE uses the verification period mean of the withheld actual data as the “yardstick” for assessing the skill of the estimates. This seemingly minor difference is important because it results in the CE being even more difficult than the RE to pass (i.e., a CE>0).

Here we include the calibration and verification statistics for the six gridpoints utilized in this report. Note that all data are statistically significant for the period of record with the exception of northwestern Kansas, which fails the notoriously hard-to-pass CE test before 1500 AD. Overall the PDSI data are well calibrated and verified.

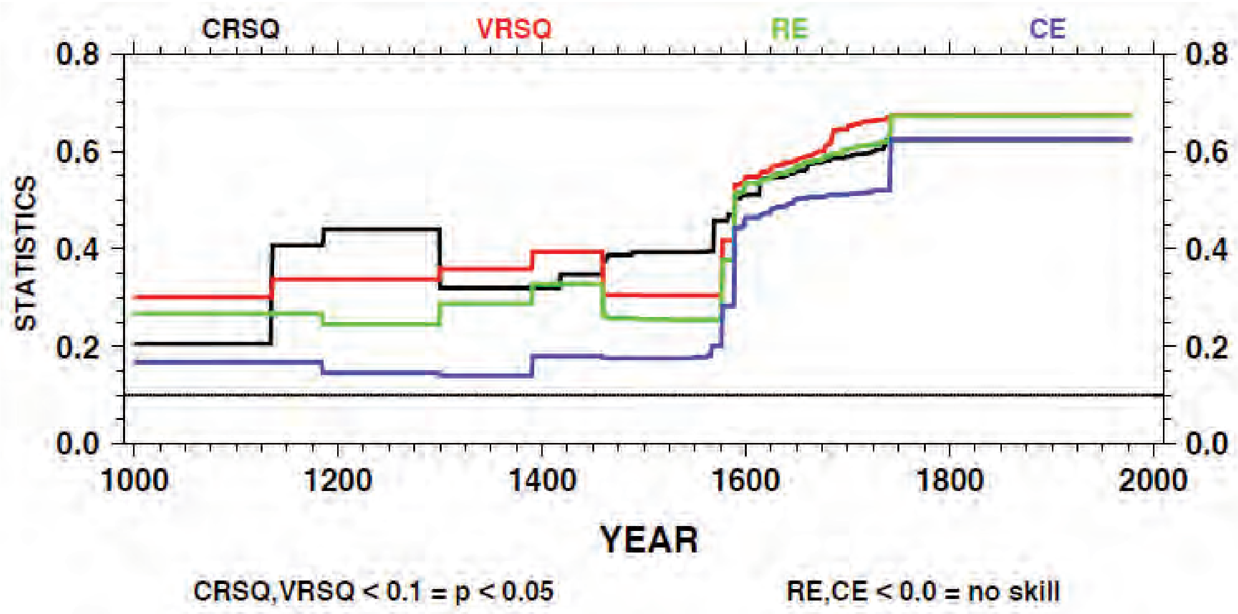
Northwestern Kansas



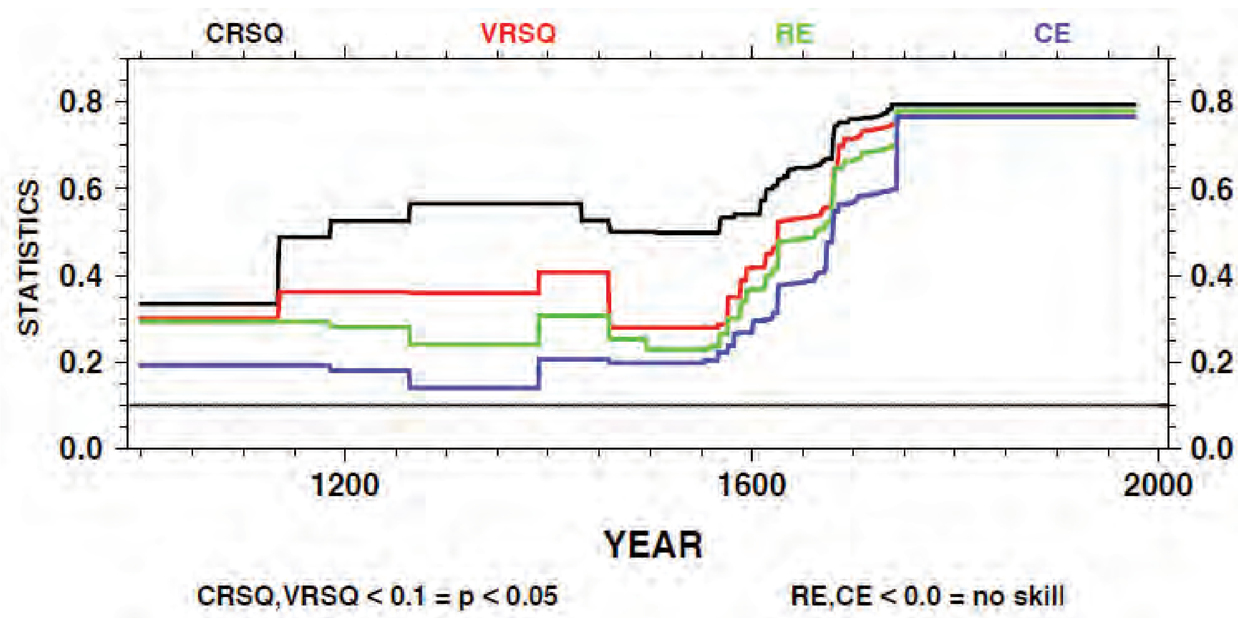
Southwestern Kansas



North-central Kansas



South-central Kansas



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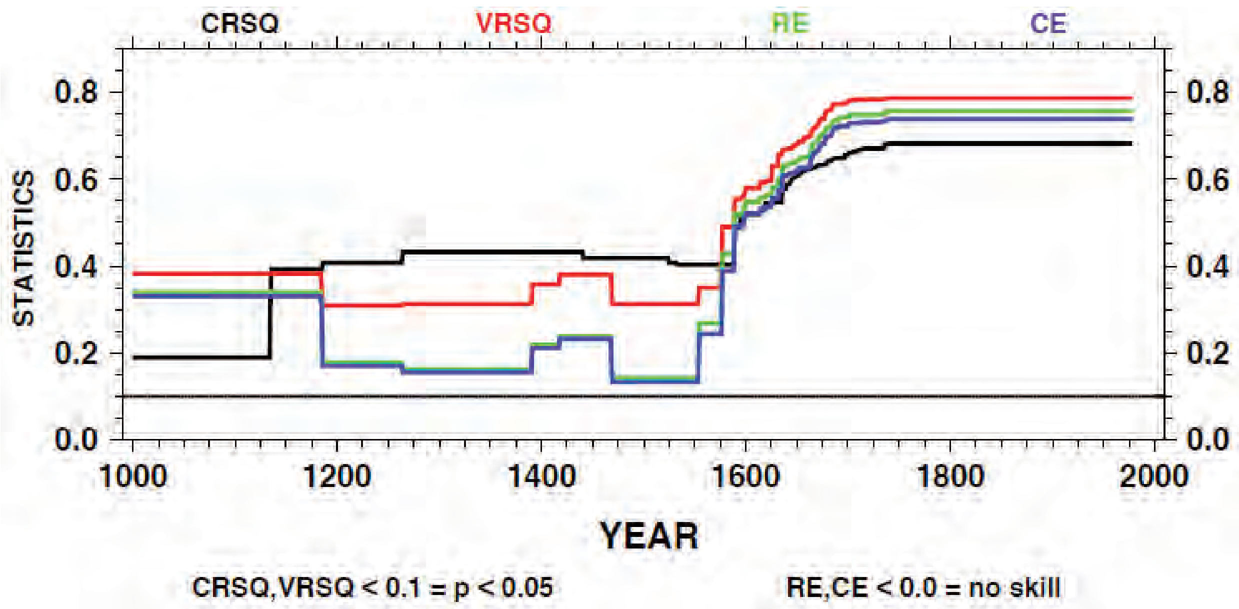

Southeastern Kansas