**Dissertation Title:** Ecological Drought Assessment of a Geologically Complex Region of the Northern Great Plains, USA

**Chapter Titles (completed 2018-01-08):**

Chapter 1. Overview of Hydrological and Ecological Drought Assessment

What it is

What the methods are

Problem – not sufficient data

What can we do to extend records

Chapter 2. Hydrological Drought Assessment for Catchments with a Short Period of Record in a Geologically Complex Region of the Northern Great Plains, USA

Chapter 3. Downscaling Regional Hydrological Drought Assessments to Ungauged Catchments using gSSURGO Data

Chapter 4. Ecological Drought Assessment of a Geologically Complex Region of the Northern Great Plains, USA

Chapter 5: Conclusions and Future Work

## **Next steps - problem statements for each chapter:** What are the problems the research will address?

**Problem Statement Chapter 1**

Comprehensive water resource management planning is ideally conducted by State and Tribal Nation decision makers with a clear understanding of the trade-offs between socioeconomic benefit and environmental cost during times of water scarcity. Indices of Biotic Integrity (IBI) developed from flow-based water quality standards provide information on catchment carrying capacity during predictable droughts for present and proposed future water uses, and on the restoration priorities for impaired catchments. However, streamflow data in rural areas are either unavailable or of a short period of record. The lack of sufficient streamflow data results in a lack of information from which to develop flow-based standards. As a result, IBI metrics are unlinked from the streamflow regime and background pollutant loads. In this dissertation we evaluate methods improve the usability of limited streamflow data to develop flow-based IBI metrics by: model-based clustering of streamflow records for gages of short record to estimate missing data (Chapter 2), streamflow estimation in ungauged catchments by a geospatial model (Chapter 3), and evaluation of biotic stressors before and during precipitation drought (Chapter 4). Conclusions and future work on flow-based IBI development are summarized in the Chapter 5 of the dissertation.

**Problem Statement Chapter 2**

Streamflow records data of sufficient length are the basis for comprehensive water resources planning, including water quality impairment and stream health evaluation and flow-based goal prescription to restore impaired streams (Kannan et al. 2018). For catchments with short periods of record the missing streamflow data is typically estimated from the streamflow record of similar stations using double-mass curves. However, for geologically complex regions with limited available streamflow records, uncertainty may exist in the identification of similar stations. We propose a dimensionality-reduction and model-based clustering approach based on mean daily, seven-day, and thirty-day streamflow discharge volumes to identify clusters of gaged catchments with similar streamflow regimes.

We use an iterative approach to estimate missing flow records using BIC or AIC values

We apply the dimensionality-reduction and clustering approach to a geologically complex region of the Northern Great Plains to characterize catchment response of gaged catchments with short records over an approximately thirty-year time period that includes one of wettest decades followed by one of the driest decades of the period of record.

**Approach**

1. Download streamflow data for the period of interest (water years 1990 – 2016) for both

active and discontinued gages

1. Remove gages recording for part of the year, < 5 years of record, in catchments with incompatible geology or under the influence of upstream flow control
2. Calculate 7-day & 30-day average daily flows (moving average approach)
3. Select a time-period with mostly complete
4. Calculate daily, 7-day, 30-day flow depths by dividing streamflow volume by catchment area

**Flow Chart for Chapter 2**

**Problem Statement Chapter 3**

Streamflow records data of sufficient length are the basis for comprehensive water resources planning, water quality impairment and stream health evaluation, and in prescribing flow-based goals to restore impaired streams (Kannan et al. 2018). In rural regions, however, streamflow records may not exist for catchments of interest. In such areas, Hydrological modeling tools such as HSPF or SWAT are typically used to estimate streamflow data, or reach-scale information is used to identify similar stations. However, hydrological modeling efforts may be prohibitively expensive for States or Tribal Nations, and uncertainty may exist in the identification of similar stations in geologically complex regions. We propose a supervised classification approach using 30-meter gridded data from gSSURGO and topographic maps to pair ungauged catchments with physiologically-similar gaged catchments. We apply the supervised classification approach in a geologically complex region of the Northern Great Plains to identify the key variables for physiographic classification and the membership of ungauged catchments with a group of hydrologically similar stations.

**Problem Statement Chapter 4**

Comprehensive water resource management planning is ideally conducted by State and Tribal Nation decision makers with a clear understanding of the trade-offs between socioeconomic benefit and environmental cost during times of water scarcity. Indices of Biotic Integrity (IBI) developed from flow-based water quality standards provide information on catchment carrying capacity during predictable droughts for present and proposed future water uses, and on the restoration priorities for impaired catchments.

***Part B (The reality):*** *Describes a condition that prevents the goal, state, or value in Part A from being achieved or realized at this time; explains how the current situation falls short of the goal or ideal.*

IBI metrics are unlinked from the streamflow regime and background pollutant loads.

***Part C******(The consequences):*** *Identifies the way you propose to improve the current situation and move it closer to the goal or ideal.*

evaluation of biotic stressors before and during precipitation drought (Chapter 4).

**Writing Checklist**

1. Title – 13 words or fewer
2. Abstract
3. Introduction
   1. Problem Statement
   2. Literature
4. Method
5. Results
6. Discussion
7. Conclusion

**Problem Statements:** *What is the problem that the research will address?*

*The ultimate goal of a statement of the problem is to transform a generalized problem (something that bothers you; a perceived lack) into a targeted, well-defined problem; one that can be resolved through focused research and careful decision-making.*

*The statement of the problem will also serve as the basis for the introductory section of your final proposal, directing your reader’s attention quickly to the issues that your proposed project will address and providing the reader with a concise statement of the proposed project itself.*

*A good research problem should have the following characteristics:*

1. *It should address a gap in knowledge.*
2. *It should be significant enough to contribute to the existing body of research*
3. *It should lead to further research*
4. *The problem should render itself to investigation through collection of data*
5. *It should be of interest to the researcher and suit his/her skills, time, and resources*
6. *The approach towards solving the problem should be ethical*

*A persuasive statement of problem is usually written in three parts:*

***Part A (The ideal):****Describes a desired goal or ideal situation; explains how things should be.*

***Part B (The reality):*** *Describes a condition that prevents the goal, state, or value in Part A from being achieved or realized at this time; explains how the current situation falls short of the goal or ideal.*

***Part C******(The consequences):*** *Identifies the way you propose to improve the current situation and move it closer to the goal or ideal.*

**References**

Kannan, N., Anandhi, A., and Jeong, J. (2018). “Estimation of Stream Health Using Flow-Based Indices.” *Hydrology*, 5(1), 20–20.