INVESTIGATION OF RIVERINE WETLANDS WITHIN THE MUSCOGEE CREEK NATION IN OKLAHOMA UTILIZING THE CALIFORNIA RAPID ASSESSMENT METHOD (CRAM)

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INVESTIGATION OF RIVERINE WETLANDS WITHIN THE MUSCOGEE CREEK NATION IN OKLAHOMA UTILIZING THE CALIFORNIA RAPID ASSESSMENT METHOD

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Abstract: Wetlands are an important part of our natural landscape. Wetland rapid assessments are useful tools for natural resource managers to evaluate existing wetlands. Oklahoma has not completed the development of a custom rapid assessment method (RAM), which hinders other entities interested in pursuing assessments and protection of wetlands, such as Native American Tribes. Recently the Muscogee Creek Nation (MCN), an Oklahoma tribe, has begun to develop a wetland program. This thesis further discusses the justification for all tribes to develop a wetland program, using the MCN as a case study. To further develop their wetland program, the MCN needed a RAM to assess riverine wetlands. The California Rapid Assessment Method (CRAM) was applied and tested on riverine wetlands in East-Central Oklahoma. The CRAM was conducted on 21 wetlands located within the tribal boundaries. An additional, broader assessment using a geographical information system (GIS) for buffers at three different scales was also completed to document land-use type at three buffer scales. The percentage of land-use type at each scale was compared to the CRAM metric scores to determine if a correlation exists. Previous research has shown that land-use impacts the condition of streams and wetlands. This study confirmed the CRAM scored riverine wetlands correlated to degree of disturbance; the correlation was positive with little human impact, and negative with a higher degree of disturbance. Next, three of the 21 wetlands were used in a sensitivity analysis, one each for a low, a moderate, and a high CRAM score. The twelve scenarios where the highest degree of sensitivity on final CRAM results, ranging from 5 – 14.5%, are highlighted. The sensitivity analysis results can be utilized by CRAM practitioners to know which parameters are most sensitive to measurement error. In conclusion, this thesis demonstrates the application of the CRAM on wetlands within the MCN in Oklahoma, and also documents land-use and operational factors that can impact the final CRAM score.

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FOREWARD

This thesis contains a hybrid structure, with a component that is structured as a traditional thesis and a component that is structured as a journal article. The thesis uses the APA style for references. Chapters I, II, III, IV, and VI are written with the traditional structure where Chapter I is an introduction and literature review on wetland assessment methods including the California Rapid Assessment Method (CRAM), chapter II presents justification for tribes to develop wetland programs using the Muscogee-Creek Nation as an example, Chapter III is the methods section, Chapter IV is the results and discussion and VI is the conclusion with recommendations.

Chapter V presents a categorical sensitivity analysis on the CRAM metrics for riverine wetlands, using the wetland assessments of three riverine wetlands within the Muscogee Creek Nation as base cases for the analysis. This chapter will be submitted for publication to the Wetlands Journal of the Society of Wetlands Scientists.

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Society views about wetlands have changed considerably since the continent was settled by the colonists, and especially since the mid-20th century when interest in wetland preservation and protection for the functions and values they serve emerged (Dahl & Allord, 1996). In the 1700's, there were approximately 90-million hectares of wetlands in what is now the conterminous forty-eight states, with a significant proportion of those associated with the nation's river systems (Dahl, Johnson, & Frayer, 1991). Two hundred years later, over half of this area has been lost or significantly modified by some form of conversion or by alteration of the hydrologic regime (Dahl & Allord, 1996; Hauer & Smith, 1998).

Attempts to preserve wetland functions dates back to 1972 with section 404 of the Water Pollution Control Act (Carletti, Leo, & Ferrari, 2004). The regulatory requirements of section 404 establishes a program to regulate wetlands under the premise that no discharge or dredged material may fill waters of the U. S., including wetlands (USEPA, n.d.). The Army Corp of Engineers (ACOE) is the primary agency for the day-to-day implementation of section 404, while the Environmental Protection Agency (EPA) has authority in the administrative capacity to interpret policy, issue guidance and environmental criteria used in evaluating permit applications (U.S. Dept. of Agriculture, n.d.). States and tribes can assume authority to implement section 404 providing approval by EPA (Association of State Wetland Managers Inc., 2010). The process toward approval to assume regulatory responsibility is complex and the EPA wetland grant program cannot be used to run state wetland programs therefore, only two states have assumed the responsibility of regulatory authority for section 404 (Stetson, 2010).

In addition to the federal regulatory requirements, states and tribes can develop wetland programs for monitoring and assessment purposes. Some states have developed a regional rapid assessment method for specific classes or sub-classes of wetlands for monitoring and assessment purposes (Fennessy, Jacobs, & Kentula, 2004). The RAMs are used for a variety of purposes, such as evaluating the success of restoration projects or for routine monitoring of ecological condition of a wetland (Clark, 2008; Solek & Stein, 2012). The design of an assessment method should be based on the information required to make management decisions and what resources (e. g., time, expertise, and equipment) are available to obtain that information (Stein, 2009 *et al*).

Wetland Policy and Regulations

Wetlands have been protected under the Clean Water Act (CWA) since it was enacted into law in 1972. The objective of this act is to restore and maintain the integrity of the Nation's waters by monitoring and restoring, where necessary, the chemical, physical and biological integrity of the Nation's waters. (The Federal Water Pollution Control Act (as amended through P. L. 107-303, November 27, 2002) [33 U. S. C. 1251 et seq.]. Wetlands are considered to be a part of the Nation's waters, therefore, it can be deduced that the chemical, physical, and biological integrity of wetlands are protected by the CWA.

Interest in wetland protection and efforts to stop the loss of wetlands has grown considerably since the 1980's. The 'no net loss' policy established by U. S. President George H. W. Bush that was endorsed by ACOE and the EPA in 1990 justified reasons to fund the study of wetlands and track losses and gains of wetland acreage ("Water Resources Development Act of 1990," 1990). Section 305(b) of the CWA requires all waters of the U. S. to be assessed every two years, yet wetlands have been historically ignored (Wardrop, *et al* 2007). In 1986, Congress enacted the Emergency Wetlands Resource Act, (Congress, 1986) recognizing that wetlands are important national resources and that these resources have been adversely impacted by humans (Dahl, 2011). There are five Federal agencies that share responsibility with the protection of wetlands and they include the U. S. ACOE; the U.S. EPA; the Department of Interior, U. S. Fish and Wildlife Service (USFWS); the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA); and the Department of Agriculture, Natural Resources Conservation Service (NRCS) (Votteler & Muir, 1996).

The EPA, through regional divisions of the agency partially functions to assist states and tribes to build capacity in monitoring, restoration and regulation of wetlands. In 2006, EPA issued "The Elements of a State Wetlands Monitoring and Assessment Program", and since that time EPA regional divisions have actively worked with states and tribes to advance wetland monitoring and the use of assessment data to better manage wetland resources (USEPA, 2013).

In 2008, EPA developed the core element framework (CEF) approach to guide states and tribes with wetland program development. The CEF was designed so states and tribes could focus wetland management and program goals into one or all of four common objectives. These four common objectives are: 1) Monitoring and assessment; 2) Regulatory activities, including 401 certification; 3) Voluntary restoration and protection; and 4) Water quality standards for wetlands (USEPA, 2009a).

With the importance of meeting the regulatory requirements of ‘no net loss’, there is also the obligation to document the ecological condition of wetlands. The EPA monitoring and assessment core element uses a ‘three-tier’ approach that employs a hierarchy of procedures that vary in degree of effort, scale of application, and quality of the data produced (Fennessy, Jacobs, & Kentula, 2007). The ‘three-tier’ approach is also referred to as the Level 1-2-3 framework. The three-tier approach allows for an entity to design their wetland management goals in a manner that is best suited for them. It also allows an entity the time to grow and develop a full range of wetland management strategies (USEPA, 2009a).

The 2008 ACOE and EPA rule on compensatory mitigation promotes the use of conditional or functional assessment in mitigation monitoring and performance evaluation (Stein, Brinson, Rains, Kleindl, & Hauer, 2009). There is a need for comprehensive assessment approaches that evaluate a range of wetland functions (Kusler, 1986). The need is critical as resource agencies begin managing the environment at watershed and basin scales (Hruby, 1999). Only 4% of the wetlands in the U. S. have been monitored for condition and only 10 states provided information on the support of designated uses for 1. 8 million acres of wetlands assessed in their 2004 reports (USEPA, 2009b). The small percentage of wetlands being assessed did not go unnoticed by EPA. In 2011, attention was directed to monitor and assess the ecological condition of the nation's wetlands (USEPA, 2011). The wetland component of the national aquatic resource survey is the national wetland conditional assessment (NWCA). EPA states three goals of the NWCA, 1) Produce a national report of the quality of the nation's wetlands; 2) Help States and Tribes implement wetland monitoring and assessment programs to guide policy development and project decision making; and 3) advance the science of wetlands monitoring and assessment (USEPA, 2009a).

Wetland Assessment

Wetland assessment is described in three levels, each being more involved and requiring more inputs and resources to complete. Level 1 assessment, also referred to as landscape assessment, is an approach that relies on geographical information systems (GIS). GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (Environmental Systems Research Institute, 2014). Utilizing GIS data, the researcher can characterize the type and percentage of land-use within specified boundaries of a wetland. The intensity of human dominated land-uses in a landscape affects ecological processes of natural communities (Brown & Vivas, 2005). A Level 1 assessment provides an initial assessment of wetland condition in a watershed (USEPA, 2006). Assessment at this scale is a method to obtain a coarse measure of the condition a wetland by using only desktop tools (USEPA, 2009a).

Level 2 assessments are referred to as rapid assessment methods. A RAM refines the results of the landscape assessment by incorporating indicators of human disturbance to a site that is meant to evaluate ecological condition (Wardrop *et al.*, 2007). RAMs are based on observable hydrogeomorphic and plant community attributes of wetlands, and they also employ the use of a stressor check list (USEPA, 2006). These methods should provide a single rating or score that shows where a wetland falls on the continuum ranging from full ecological integrity (or at least impacted condition) to highly degraded (poor condition) (USEPA, 2006, p. 8). Level 2 methods assess the existing condition of a wetland relative to its broadest suite of suitable functions, services and beneficial uses (California Wetlands Monitoring Workgroup (CWMW), 2013a). Validation of the Level 2 assessments is accomplished by measuring the metrics against the more intensive Level 3 methods where wetland functions are measured by quantitative technique (Fennessy *et al.*, 2004, 2007). Once the Level 2 method is validated they can be used to infer overall functional capacity of a wetland (Fennessy *et al.*, 2007).

The Level 3 assessment method involves the collection of quantitative biological, physio-chemical, and/or morphological data (Kentula, 2007). Level 3 assessments require the greatest level of effort and produce the most detailed evaluation (Fennessy *et al.*, 2007). The Level 3 scale entails detailed data collection and produces the most complete evaluation (Wardrop *et al.*, 2007). Due to the intensive level of taxonomic skills, and scientific expertise required to complete a Level 3 assessment it is usually cost prohibitive for states and/or tribes to use for routine assessment of wetland condition (Stein, Fetscher, *et al.*, 2009). Because of the expense and the degree and variety of expertise needed for Level 3 assessments states are developing and implementing RAMs for routine monitoring and assessment (Carletti *et al.*, 2004).

Once a RAM has been developed and established it can provide sound, quantitative information on the status of the wetland resource (Fennessy *et al.*, 2004). Validation of a RAM is needed to ensure that the calibration of the wetland holds outside of the network (Sutula, *et al.*, 2006). Validation is defined as the process of documenting relationships between RAM results and independent measures of condition in order to establish defensibility as a meaningful and repeatable measure of wetland condition (Stein, Fetscher, *et al.*, 2009). However, due to the cost and difficulty of collecting or compiling suitable intensive data that represent a gradient of wetland condition, very few RAMs are calibrated or validated (Stein, Fetscher, *et al.*, 2009).

Fennessy et al. (2007) screened 40 RAMs that were available through 2003. The purpose of the Fennessy review of RAMs was to identify those that are most suitable for assessing the ecological condition of wetlands, whether it be for regulatory purposes, to assess the ambient condition of wetlands, or to determine mitigation project success (Fennessy *et al.*, 2004). The Fennessy review determined six of the 40 RAMS met criteria for in-depth review and concluded that the methods reviewed had multiple uses. These uses were: 1) ambient condition monitoring; 2) mitigation planning and establishment of performance criteria; 3) monitoring status and trends; 4) local land-use planning to protect the ecological integrity of wetlands and; 5) use in regulatory decision making (Fennessy *et al.*, 2007). This screening did not include the CRAM since it was still in the development stage.

California Rapid Assessment Method (CRAM)

In 2003, a consortium of Federal, State, and local scientists and managers in California began working to develop a framework to support wetland and riparian monitoring and assessment that resulted in the CRAM (California Wetlands Monitoring Workgroup (CWMW), 2009). The CRAM is a Level 2 assessment method for monitoring the conditions of wetlands throughout the state of California (California Wetlands Monitoring Workgroup (CWMW), 2013a). It is a component of a broader assessment toolkit that has been developed in California based on EPA's Level 1-2-3 framework for wetland monitoring and assessment (California Wetlands Monitoring Workgroup (CWMW), 2009). The CRAM was developed as a single method of use throughout the state with metrics customized by region and wetland class (Sutula *et al.*, 2006). The intent of all rapid assessment methods is to evaluate the complex ecological condition of a selected ecosystem using a finite set of observable field indicators, and to express the relative condition of a particular site in a manner that informs ecosystem management (Stein, Fetscher, *et al.*, 2009; Sutula *et al.*, 2006). CRAM assesses overall condition of wetlands, but does not measure functions, which are rates of characteristic processes or services over time (California Wetlands Monitoring Workgroup (CWMW), 2009). Multiple documents from the California Wetland Monitoring Workgroup state and reiterate the need for wetland managers to be able to track the extent and monitor the condition of the state's wetlands (California Wetlands Monitoring Workgroup (CWMW), 2008, 2009, 2013a).

Applications for CRAM

The applications for which CRAM may be applied are addressed in the *CRAM Technical Bulletin* (California Wetlands Monitoring Workgroup (CWMW), 2009). This technical bulletin lists both appropriate and inappropriate uses of CRAM. A few examples for appropriate use are: Ambient assessment of wetland condition, monitoring of ecological reserves, and evaluation of pre-project conditions at potential impact sites, assessment of performance or success of mitigation or restoration sites, and assessment of mitigation compliance. Inappropriate uses of CRAM are listed as: Jurisdictional determinations, focused species or threatened and endangered species monitoring, evaluation of compliance with water quality objectives, assessment of mechanisms or processes of wetland function, and use of CRAM metric descriptors as stand-alone project design templates (California Wetlands Monitoring Workgroup (CWMW), 2009). CRAM can be used to assist in planning and designing restoration projects (Klimas, 2008). Klimas further states, "one potential limitation of CRAM derives from the effort to encompass all wetlands statewide within a single framework".

Validation and peer review of CRAM

CRAM has been validated for riverine and estuarine wetlands located in California. CRAM metrics were verified by selecting 118 wetlands representing high quality and low quality conditions for each of the wetland classes (Sutula *et al.*, 2006). This verification revealed that refinement was needed in some of the CRAM metrics.

Validation is defined as the process of documenting relationships between CRAM results and independent measures of condition in order to establish CRAM's defensibility as a meaningful and repeatable measure of wetland condition(Stein, Fetscher, *et al.*, 2009). It was validated by applying it to sites where condition had been previously quantified using independent assessment methods (Stein, Fetscher, *et al.*, 2009). CRAM was peer reviewed and the peer reviewers generally agree that CRAM is based on sound scientific knowledge, methods and practices, although some concerns regarding the method were presented (California Environmental Protection Agency, 2011). Some of the concerns the peer reviews listed are: 1) The use of CRAM to evaluate the success of restoration sites without using any Level 3 assessment tools in conjunction with CRAM; 2) The validation of CRAM was confined to two classes, riverine and estuarine, the total sample size was on 95 riverine sites and 38 estuarine sites (with vegetation data only) where the reviewer stated the validation should require gathering of data to include a wide spectrum of wetland characteristics; and 3) The use of a Pressure-State-Response model (PSR) for the buffer and landscape context metric, the reviewer stated that a quantitative assessment or sensitivity analysis would be beneficial. These three items are only a partial list of the CRAM peer reviewers concerns.

CRAM has been used for multiple applications, such as evaluating the success of stream restoration projects in California (Clark, 2008), and assessment of estuarine restoration projects (Solek & Stein, 2012). CRAM was also a component in a demonstration of the application of the three-tier assessment paradigm (Solek, Stein, & Sutula, 2011). CRAM was a monitoring component of a multi-metric approach in a probabilistic monitoring project for the San Gabriel watershed in California (Stein & Bernstein, 2008).

Goals and Objectives

The goal of this research was to investigation the use of a RAM for use on riverine wetlands in the East-Central region of Oklahoma. The work on this project was conducted for the Muscogee Creek Nation as a component in the development of a tribal wetland program. The first objective toward achievement of the goal was to justify the need of a tribal wetland program. The particulars of this goal are addressed in detail in chapter 2 of this document. The second objective was to conduct both Level 1 and Level 2 wetland assessments. The Level 1 assessment used GIS to obtain information for analysis of the percentage of land-use type within specified boundaries around the riverine wetlands. Since Oklahoma has not completed an approved RAM to date, the CRAM was used for the Level 2 assessment in this study. CRAM was designed to be effective whether used to develop a picture of a reference condition for a particular wetland type or to create a landscape-level profile of conditions of different wetlands within a region (California Wetlands Monitoring Workgroup (CWMW), 2013a). California has a wide variety of climatic conditions and ecosystem variability, so it was posited the efficacy of the CRAM will adequately assess riverine wetlands in East-central Oklahoma, but the CRAM has not been documented in this region. The third objective was to investigate whether the percentage of land-use type was correlated to CRAM overall and metric scores. Finally, the fourth objective was to complete a categorical sensitivity analysis to assess the sensitivity of the various inputs on the CRAM results;

the results of the CRAM sensitivity analysis are applicable anywhere that the CRAM is applied, not just Oklahoma.

CHAPTER II

THE NEED AND JUSTIFICATION FOR THE DEVELOPMENT OF A WETLAND PROGRAM FOR THE MUSCOGEE CREEK NATION

Introduction

There are 566 federally recognized tribes, which includes 227 Alaska Native Tribes and Villages (U.S. Department of Interior, Bureau of Indian Affairs (BIA) 2016). Throughout the United States tribes vary in population size and base area. According to a report from the National Congress of American Indians (NCAI) tribes hold more than 50-million acres of land, which is approximately 2% of the United States (National Congress of American Indians, 2000). The land area a tribe may possess varies substantially. The land within a tribe's exterior boundaries may be contiguous or it may be interspersed with land that is no longer in trust status. Indian land that is in parcels within the tribal exterior boundary is referred to as 'checkerboarded'. Regardless of whether tribal land is contiguous or 'checkerboarded', the tribe has the legal authority and responsibility to manage the tribe's natural resources. Therefore, it is in a tribe's best interest to know what natural resources are present, the location, and the ecological condition of those resources. A failure to acquire this data can potentially leave natural resources, such as streams and wetlands, without adequate protection.

The objective of this chapter is to justify the need for tribes to develop wetland programs based upon, 1) Showing how the use of cultural practices connect the Muscogee Creeks to their land and water; 2) The unique sovereign status of federally recognized tribes, which preempts state sovereigns from authority over tribal lands and/or resources; and 3) the legally mandated government to government consultation between tribes and the United States (US) or US federal agencies.

Each tribe has a unique culture. From a cultural aspect, each tribe may have a considerably different belief system in regard to their natural resources. This system of beliefs may be of a religious or spiritual nature. Also, it is often related to the plants and animals that are native to a tribe's region. These plants or animals may be important traditional foods or serve an important role in religious ceremony. This is one of many justifications for a tribe to develop their own management strategy for natural resources. It is often only the tribe that knows the cultural reasons why a specific resource, such as wetlands, needs protection and preservation.

Tribal sovereignty and the jurisdiction of where and to whom a tribe's sovereignty is applied is an Indian law specialty within juris doctorate programs. It is a complex legal topic and tribes have endured arduous challenges to their sovereignty for well over a century. It is not the intent of this author to dissect the legal challenges to sovereignty. However, an omission of a discussion on sovereignty and its role in a tribe's efforts to develop natural resources programs would ignore the foundation of tribal governments. That foundation is the purview of a tribe's role in the protection and management of tribal natural resources.

The government-to-government consultation mandate policy is also included as one aspect to justify the need for tribes to manage their natural resources and wetlands. It is included because the consultation mandate policy is closely connected to tribal sovereignty and is discussed in detail later in this chapter.

The reason to examine why tribes should develop their own wetland programs is based on a 2007 EPA initiative meant to enhance both state and tribal wetland programs. The Enhancing State and Tribal Wetland Programs (ESTP) defined five primary goals: 1) Clearly define core elements of a state or tribal wetlands program, 2) Increase the dialogue between states, tribes and EPA regional offices, 3) Provide targeted technical assistance to states and tribes, 4) Align the Wetland Program Development Grants (WPDG) with a framework that incorporates more clearly defined core elements, and 5) Track programmatic progress. A workgroup consisting of the EPA, States, and Tribes developed the Core Elements of an Effective State or Tribal Wetlands Program Framework, henceforth referred to as the "Core Elements Framework" (CEF). This framework forms the foundation to direct a state or tribe in the development of wetland management goals that fulfill their specific needs and that align with the CEF. The CEF consists of these four core elements: 1) Monitoring and Assessment; 2)

Regulatory Activities Including 401 Certification; 3) Voluntary Restoration and Protection; and 4) Water Quality Standards for Wetlands (USEPA, 2009). The CEF is especially helpful for small entities like tribes, which usually have limited number of staff and small budgets to utilize for wetland protection, projects and other management options.

Muscogee Creek Culture and Connection to Water

The discussion of tribal culture for this thesis is focused on the Muscogee Creek Tribe. There are two reasons I am focusing on this tribe. First, I am a Muscogee Creek citizen. Second, the wetlands that are the focus of this thesis project are located within the exterior boundaries of the MCN. The following section is divided into brief descriptions of Muscogee culture prior to their forced removal from Southeastern region of the North American continent and their culture after settlement in Indian Territory. While the cultural descriptions are brief for this thesis it is relevant and important based on the premise that a people's culture is connected to their geographical location. The subsection on culture corresponds to objective one, which is that culture is one justification for tribes to develop their own wetland protection programs.

Prior to the Removal from the Southeastern North American Continent

The geographic location that demarcates any group of people's culture is innately connected to the ecosystem of the location. The clothes, homes, stories or mythology, diet, religion and language are a few of the elements that distinguish one group of people from another. The Muscogee people were not a single tribe but a group of distinct tribes that formed the Great Muscogee Confederacy probably before European contact (Debo, 1941). The tribes described by multiple historians were the people from each Muscogee Creek town and the towns were permanent establishments. They had two distinct divisions: 1) The Upper Towns along the Coosa and Tallapoosa Rivers, and 2) The Lower Towns along the Flint and Chattahoochee Rivers (Debo, 1941). This region is now the states of Alabama, Georgia and parts of the Florida Panhandle. The origin of the name, Muscogee, is uncertain. It is believed that it may have originated from the Shawnee people who referenced them to swamps or wet ground (Swanton, 1911). Swanton (1911) also states that the earliest records of the Muscogee people had towns located from the Atlantic coast of Georgia in the neighborhood of the Savannah River to Central Alabama. Further, the Lower Creeks had two major divisions between the towns of Cusseta and Coweta that were established after a legendary migration of one body of people from the West (Debo, 1941).

Stories and mythology inherently form the belief system of a group of people. An example of this mythology is from the Lower Creek Town's citizens along the Chattahoochee River. They believe the river was a conduit for the underworld that linked the physical and spiritual worlds. One example of a Muscogee Creek story is of the "tie snake". The tie snake lived in deep holes in the water of the Chattahoochee and he would draw his prey into his den in the Chattahoochee falls (Willoughby, 2012). The

Chattahoochee was a spiritual conduit, but it was also a major transportation artery. The Coweta Falls on the river was one of the major fishing sites for the towns of Coweta and Cusseta (Willoughby, 2012). While the Chattahoochee and Flint Rivers were where the towns of the Lower Creeks were located, the Tuckabatchee Town was an Upper Creek town located near the confluence of the Coosa and Tallapoosa Rivers. Tuckabatchee Town had a mixture of Muscogee Creek and Shawnees as permanent residents and was known to be one of the most militarily powerful towns (Thorton, 2014).

The Muscogee Creek culture prior to the removal from the Southeastern Region of the North American continent was innately connected to water. “The Removal” is common vernacular in reference to The Indian Removal Act of 1830, which was enacted under the administration of Andrew Jackson. The Muscogee Creek’s towns were built on the banks of rivers and some of their stories were associated with those rivers. The cultural connection to water may or may not have been retained when the Muscogee Creeks were removed from the Southeast United States and resettled in what is now Oklahoma. The following section will explore the concept of whether the cultural connection to water remained with the Muscogee Creeks in their new home in the West.

Muscogee Creek Nation Post Forced Removal to Indian Territory

Most of the Muscogee people were removed from their aboriginal homeland in the Southeast US to the new lands in the West during the period from

1836-1837. For historical accuracy, beginning in 1827 there was a group of Muscogee people who immigrated to the area of the ‘three forks’ of the Arkansas, Verdigris and Grand Rivers near Ft. Gibson, what is now Ft. Gibson, OK. This group of Muscogees included Roly McIntosh, the brother of William McIntosh. It was William McIntosh, acting on behalf of the entire Muscogee Creek Confederacy, who sold the remaining lands in the Southeast without having the authority to do so. William McIntosh signed his name to illegal treaties that ceded Creek land on three different occasions, and he formed an alliance with Andrew Jackson (Frank, 2005). The illegal treaty that McIntosh signed with six other Creek leaders was the treaty ceding the remaining lands in Georgia and Alabama, and on April 30, 1825 the Law Menders (the Muscogee Creeks centralized law enforcement) executed William McIntosh (Frank, 2005).

During the early years in the new territory, Colonel Ethan Allen Hitchcock traveled through sections of the Muscogee Nation in 1842. He was sent to investigate accusations of profiteering and fraud being committed by non-Indians who had been contracted to provide subsistence for a year following the removal of the Five Civilized Tribes (Perino, Caffey, Good, Gettys, & Parmalee, 1980). Excerpts from the diary kept by Col. Hitchcock reveal:

> I find the Creeks here a different people than those on the Arkansas and very different from the Cherokees. The Creeks over on the Arkansas with Roly McIntosh for their principal chief who is, indeed the acknowledged principal chief of the Creek Nation, embrace most of those Creeks who

> emigrated under the first treaties with the United States. They appear to be more advanced in intelligence, seem less wild, not to say ferocious than these here.
>
> The area between the Canadian and the North Canadian Rivers from their confluence west to Little River was assigned by the Stokes Commission to the use of the Seminoles who were required by the Federal Government to be merged with the Creeks after removal. But by the time the Seminoles immigrated, [sic] the Upper Creeks who made the move in 1836-1837 had occupied this choice area and the Seminoles were forced to locate as best they could.

One of the concepts to address pertaining to the Muscogee Creek culture post-removal was whether the cultural connection to water was retained. It had been documented by multiple historians that the Muscogee Creeks built their towns on the banks of rivers in their new western home and kept the same names for the towns as they were in the Southeast. Therefore, that aspect of the cultural connection to water was retained. Further in Colonel Hitchcock's diary, he makes the following revelation:

> "The whole Creek Nation is composed of two parties, which were designated in the old Nation east of the Mississippi River, as the Upper and Lower Towns. They are still to a considerable extent distinct; the

Upper Creeks are principally on the Canadian and the Lower Creeks are on the Arkansas. ”

The Muscogee people had over a century of contact with Europeans prior to the removal from the Southeastern homelands to what is now Oklahoma and they still had maintained many of the old traditions. It should be noted that the location where the Upper Creeks first settled and built their towns upon arrival to the new territory was between the north and south forks of the Canadian river with the eastern boundary close to where Eufaula, OK is now located. By the placement of the towns built in the new western home, it can be deduced that the Muscogee Creeks did transplant at least that aspect of the cultural connection to water.

The majority of the riverine wetlands assessed in this project are located on Muscogee Creek Nation trust land that is bounded to the south by the South Canadian river. This property is approximately three miles east of the town of Hanna, OK. The furthest point east of this tribal trust land is partially flooded by Eufaula Lake. This is a section of the region that Colonel Hitchcock documented in his diary entries about where some of the Upper Creek towns were located in post removal. This is culturally significant since it is the location of some of the first settlements upon arrival to the new western home.

Sovereignty of Tribal Nations

Developing programs to manage natural resources on tribal lands, including water resources and wetland programs is particularly important for tribes given their unique status of as sovereign nations within a nation. The scope of a tribe's right to self-governance has been consistently challenged in the federal courts. The legal definition of tribal land types, the law that applies to the types of land, and tribal sovereignty are juris doctorate sub-specialties and will only be briefly discussed. It is a complex topic, but to omit any discussion is to omit the key reason that a tribe not only has the authority to protect and manage their natural resources, but also the responsibility to do so.

The legal case, *Worcester v. Georgia, 1832,* served as the United States Supreme Court Case that first recognized the sovereignty of the tribal nations within the United States (Johnson & Martinis, 1995). When the governmental authority of tribes was first challenged in the 1830's, U. S. Supreme Court Chief Justice John Marshall articulated, "Indian Nations had always been considered as distinct, independent political communities, retaining their original natural rights, as the undisputed possessors of the soil…the very term nation so generally applied to them means "a people distinct from other" (NCAI,2000). The Indian Country preemption analysis of *Worcester* posited that the federal recognition of Indian tribes as separate polities through treaty, or later, through statutes or executive agreements, setting apart and protecting separate tribal communities in reservation or other federally guaranteed lands preempted the exercise of state authority in those areas (R. N. Clinton, 1981). In *Worcester v. Georgia* the separation of state law from Indian country articulated three separate grounds on which to base the opinion: 1) The negative implication of the Indian commerce clause; 2) The preemption of state law under the supremacy clause through recognition of tribal communities as separate self-governing polities within Indian country by treaty (or later by statute or executive order); and 3) The preemption of state law under the supremacy clause caused by the conflict of state rules with national legislation or treaty or by the federal occupation of the field (R. N. Clinton, 1981). The inherent sovereignty of federally recognized tribes to protect and manage tribal resources falls under the authority of the tribe, yet is complicated by various legal status of tribal lands and by numerous legal challenges to tribal sovereignty. Definitions for a select few types of Indian land are listed below. The most basic understanding of the different legal designations of Indian land must be understood to begin to grasp the complexity of Indian lands and tribal sovereignty. These are not exclusive but are the land types that are encountered most often in the state of Oklahoma.

Allotted Land--Reservation land the federal government distributed to individual Indians, generally in 40-, 80-, and 160-acre parcels.

Checkerboarding--Lands within reservation boundaries may be in a variety of types of ownership—tribal, individual Indian, non-Indian, as well as a mix of trust and fee lands. The pattern of mixed ownership resembles a checkerboard.

Fee Simple (Fee Land)--Land ownership status in which the owner holds title to and control of the property. The owner may make decisions about land-use or sell the land without government oversight.

Restricted Fee Land--The ownership is the same as fee simple land, but there are specific government-imposed restrictions on use and/or disposition.

Trust Land--Land owned either by an individual Indian or a tribe, the title to which is held in trust by the federal government. Most trust land is within reservation boundaries, but trust land can also be off-reservation, or outside the boundaries of an Indian reservation(Indian Land Tenure Foundation, 2015).

The rights of any sovereign, whether it is a tribe, a state, or the federal government will vary depending on the type of land on which an activity takes place (Royster, 1991). Supposedly, the law is clear that only Congress has the power to disestablish Indian reservations and destroy tribal sovereignty, but to do this Congress must state its intent clearly and unambiguously (Johnson & Martinis, 1995). Chief Justice Warren Burger (1969-1986) and Chief Justice William Rehnquist (1986-2005) opinions in multiple Supreme Court cases have eroded the sovereignty of tribal nations (R. N. Clinton, 1981; Johnson & Martinis, 1995). When (Johnson & Martinis, 1995) analyzed the opinions of the 79 cases involving Indian interests they found the underlying jurisprudential attitude of Justice Rehnquist was for disestablishment or termination of any Indian tribe or treaty right, even if it was murky or ambiguous. Since the 1970's the Supreme Court has consistently ruled against tribes in having civil jurisdiction over non-tribal members, even on land within reservation boundaries (Kalt & Singer, 2004). Even as far back as the *Worcester* ruling, tribes have always been considered 'domestic dependent nations' subject to certain restrictions upon their national sovereignty (Royster, 1991). Analysis of pre-1970's cases reveal that one or more of the three Worcester doctrines were operating, and while the Burger Court convoluted the issue of tribal sovereignty, it failed to destroy it (R. N. Clinton, 1981). The Supreme Court has repeatedly said that Congress has plenary power in Indian affairs, and the Court has never struck down a federal statute directly regulating tribes on the ground that Congress exceeded its authority to govern Indian affairs (Frickey, 1990).

If a tribe neglects to build a management program for the tribe's natural resources, it is likely those resources will fail to be included in any management strategies. A state lacks the jurisdictional authority over tribal land, and federal agencies generally promulgate management responsibility to a state or a tribe. Because of a tribe's status as sovereigns with the authority over tribal land, it is in the best interest of the tribe to move forward with building the capacity to develop and manage their natural resources and wetlands.

Federal Agencies and Tribal Government-to-Government Consultation Mandate

The government-to-government relationship with Native American tribes is not new. Tribes, as separate sovereign nations, is the foundation of all interactions between them and the United States (U.S.BIA, 2000). The government-to-government relationship between the U. S. government and tribes manifests from the trust responsibility doctrine that was established in the Supreme Court case, *Cherokee Nation v. Georgia* , *1831.* It is a foundational principle of Indian law, and today, it imposes certain substantive duties on the federal government that include the duty to protect tribal sovereignty and the duty to protect tribal resources (Routel & Holth, 2012). There have been many policies used by the United States in the trust responsibility with tribes, but the actual policy of government-to-government consultation was not initiated until nine years after the Indian Self Determination Act of 1974 ("Indian Self-Determination and Education Assistance Act," 1975).

The government-to-government consultation mandate required for all federal agencies has existed as far back as the Johnson Administration in 1968 (Galanda, 2010). In 1983,President Ronald Reagan announced in his Indian policy a major theme of government-to-government relations when dealing with Native American Tribes (Royster, 1991). Yet, it was not until Bill Clinton's Executive Order, 13175 , signed in 2000, that it was required that all federal agencies develop a written process on how the agency would consult tribes in any agency decisions or actions that had the potential to affect Indian tribes (W. J. Clinton, 2000). The EPA was the first federal agency to develop an agency Indian policy and they did so in 1984 after President Reagan announced his Indian policy as a major theme of the government-to-government relationship with tribes (Royster, 1991). EPA recognized tribal governments "as sovereign entities with primary authority and responsibility" for environmental matters in Indian Country (Ruckelshaus, 1984). Both EPA and Congress have expressly provided for the full territorial extent of tribal environmental control, and the courts have declared geographic demarcation to be reasonable. The state could not regulate non-Indian environmental activities without necessarily infringing on federal and tribal environmental regulation of the land (Royster, 1991). EPA amended these pollution control statutes: The Safe Drinking Water Act (SDWA) and the Superfund Act in 1986, and the Clean Water Act (CWA) in 1987 and the Clean Air Act (CAA) in 1990, to include provisions for tribal authority under, "Treatment as States" (TAS) (Royster, 1991). TAS was designed as a method for tribes to address environmental regulation, but it has not been without problems and challenges. One challenge has been the length of time it takes EPA to review and approve tribal applicants for TAS. A tribe is not obligated to apply for TAS to regulate under the pollution control statutes, and can choose to promulgate that authority to EPA. A tribe that chooses to promulgate the regulatory authority to EPA can still manage natural resources for the protection and preservation.

Discussion

Both cultural and legal complexities illustrate the need for tribes to develop tribal specific natural resource and wetland management programs. All natural resources are important; wetlands are of particular concern given that over half have been lost since the time of colonial America (defined as the period of 1620-1776 in the Legal Dictionary) (Dahl *et al.,* 1991).

Natural landscapes influence the culture of any group of people. For the Muscogee people, water, especially streams, rivers and wetlands are innately connected to Muscogee people's culture. Intuitively, this makes sense providing the natural landscape of their aboriginal home in the Southeastern region of the North American continent. Verified historical accounts demonstrate that the Muscogee Creek's cultural connection to water remained after the move to the Western home in what is now Oklahoma. The Muscogee Creeks built their western towns upon the banks or rivers as was the practice in the aboriginal home. Rivers and streams are still used in ceremonial practices. Therefore, the Muscogee are still innately tied to streams and wetlands. The cultural and historical aspect is the strongest connection for the tribe's desire to implement a wetland protection program, it is not the only reason to support a tribal wetland program.

Throughout the history of building the United States as a country, law has evolved in regard to how the U. S. government dealt with indigenous people. Many different treaties, acts, and laws have determined tribal boundaries and the degree of legal authority tribes maintain over their the land and natural resources within those tribal boundaries (R. N. Clinton, 1981; Fletcher, 2006; Royster, 1991). The Supreme Court of the United States defined all tribes in the US as sovereign entities in *Worcester v. Georgia,* although they were defined as 'dependent sovereigns' with restrictions on that sovereignty.

The sovereign status of tribes is the foundation for the existence of tribal governments, and it is what affords a tribe the right to self-governance. Sovereignty is the foundation for the implementation of the government-to-government mandate as defined in Executive Order 13175. As stated in Executive Order 13175:

> Indian nations and tribes ceded lands, water, and mineral rights in exchange for peace, security, health care, and education. The Federal Government did not always live up to its end of the bargain. That was wrong, and I have worked hard to change that by recognizing the importance of tribal sovereignty and government-to-government relations. there is nothing more important in Federal-tribal relations than fostering true government-to-government relations to empower American Indians and Alaska Natives to improve their own lives, the lives of their children, and the generations to come. (W. J. Clinton, 2000).

Even with the multiple legal challenges that eroded certain aspects of tribal sovereignty, the courts have maintained that Congress has plenary over Indian Affairs. Only Congress has the power to disestablish tribal boundaries or a tribe's sovereignty. Therefore, tribes retain the inherent authority to govern their lands and natural resources.

Conclusion

Using the Muscogee Creeks as a case study, this chapter demonstrates that Indian Tribes are justified, and in a sense obligated, to develop tribal wetland programs because of culture, sovereignty, and the government-to-government consultation mandate. The Muscogee Creeks are culturally connected to the streams and wetlands, in part based on the geographical location of their aboriginal homelands and on the cultural practices that they brought to Indian Territory, which is the current state of Oklahoma. Presently, the tribe recognizes that if the wetlands and other natural resources are to be preserved and protected, it is the tribe who must take the initiative to implement a strategy to accomplish that task. The justification for this decision is based on the fact that it is the tribe who maintains authority over those resources as has been legally protected in numerous legal challenges. Federal agencies have increasingly recognized the validity of tribal concerns regarding protection of properties of cultural and religious significance (1968 Johnson Congressional Message, supra note 6; as cited in (Galanda, 2010). EPA was the first federal agency to move forward to develop a written “Indian Policy” that addressed the mandated government-to-government consultation requirements as defined in Executive Order 13175. The amendments to multiple environmental pollution statutes provided a process that directly asserted and affirmed tribes with an avenue for the protection of natural resources because of their sovereignty. With tribes having the legal ability to protect wetlands and other natural resources as a separate entity from states ensures that more natural resources, including wetlands, will be protected from loss and/or degradation.

CHAPTER III

METHODS FOR ASSESSMENT AND COMPARISON

Riverine wetlands located in three different ecosystems in East-central Oklahoma were assessed with Level 1 and Level 2 wetland assessments. The Level 1 assessment is lowest level assessment of the Level 1-2-3 hierarchy of wetland assessments, and is usually done with GIS analysis. A variety of GIS data was utilized to analyze the location and identify the type of land-use surrounding the wetland. The California Rapid Assessment Method (CRAM) methodology was used for the Level 2 assessments, which are more in-depth of an assessment type than the Level 1 assessment. Microsoft Excel 10 was used for analysis of both the Level 1 and Level 2 assessments.

Twenty-one riverine wetlands were assessed for Level 1 and Level 2 assessments. The 21 wetlands were located within three different Level IV ecoregions. There were seven in the Northern Cross Timbers (29a), ten in the Lower Canadian Hills (37e) and four in the Osage Cuestas (40b) (Figure 3. 1, Table 3. 1).

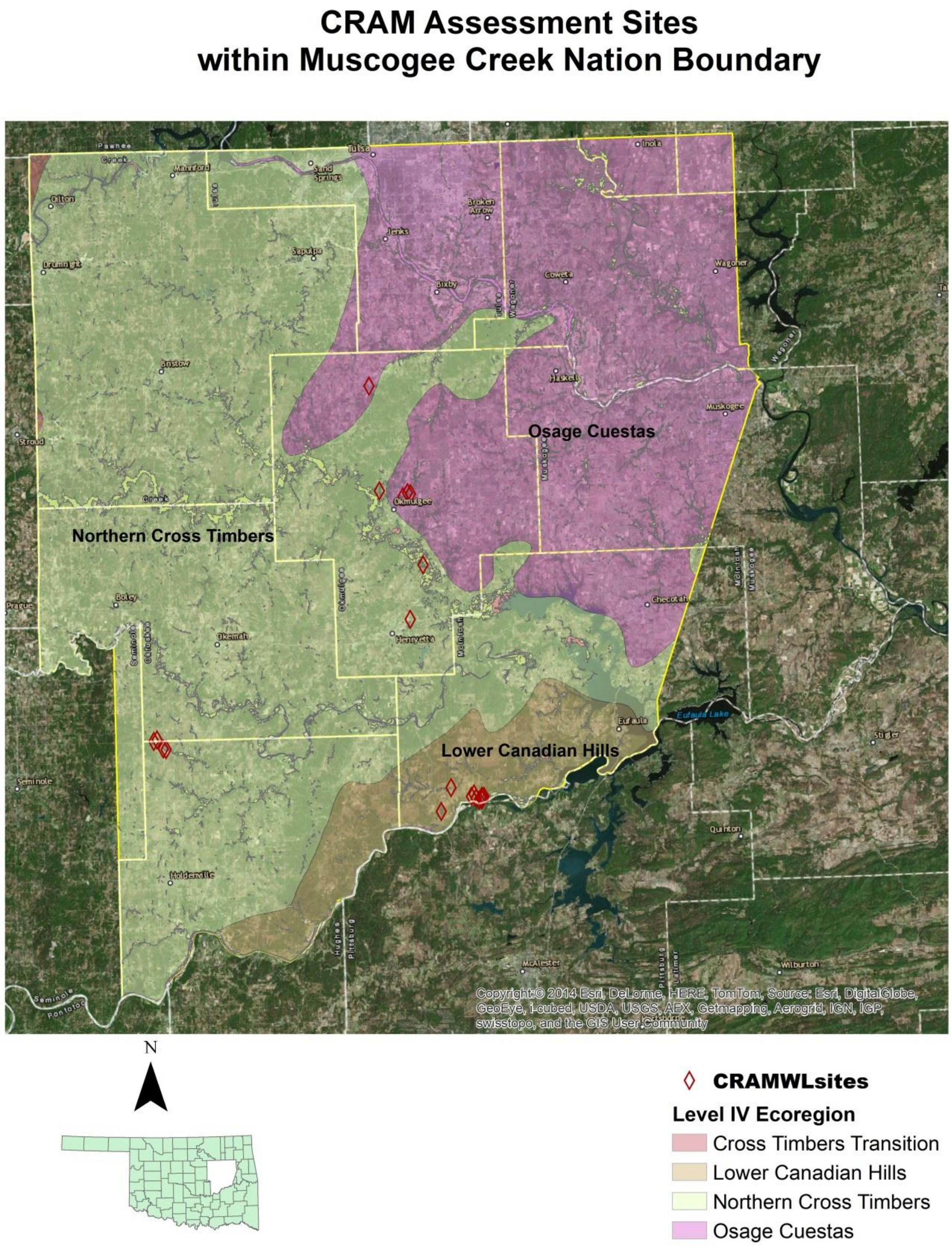

Figure 3.1 Map of CRAM Assessment Sites located within the Muscogee Creek Nation exterior boundary.

CRAM Wetland Assessment Sites
Okmulgee County

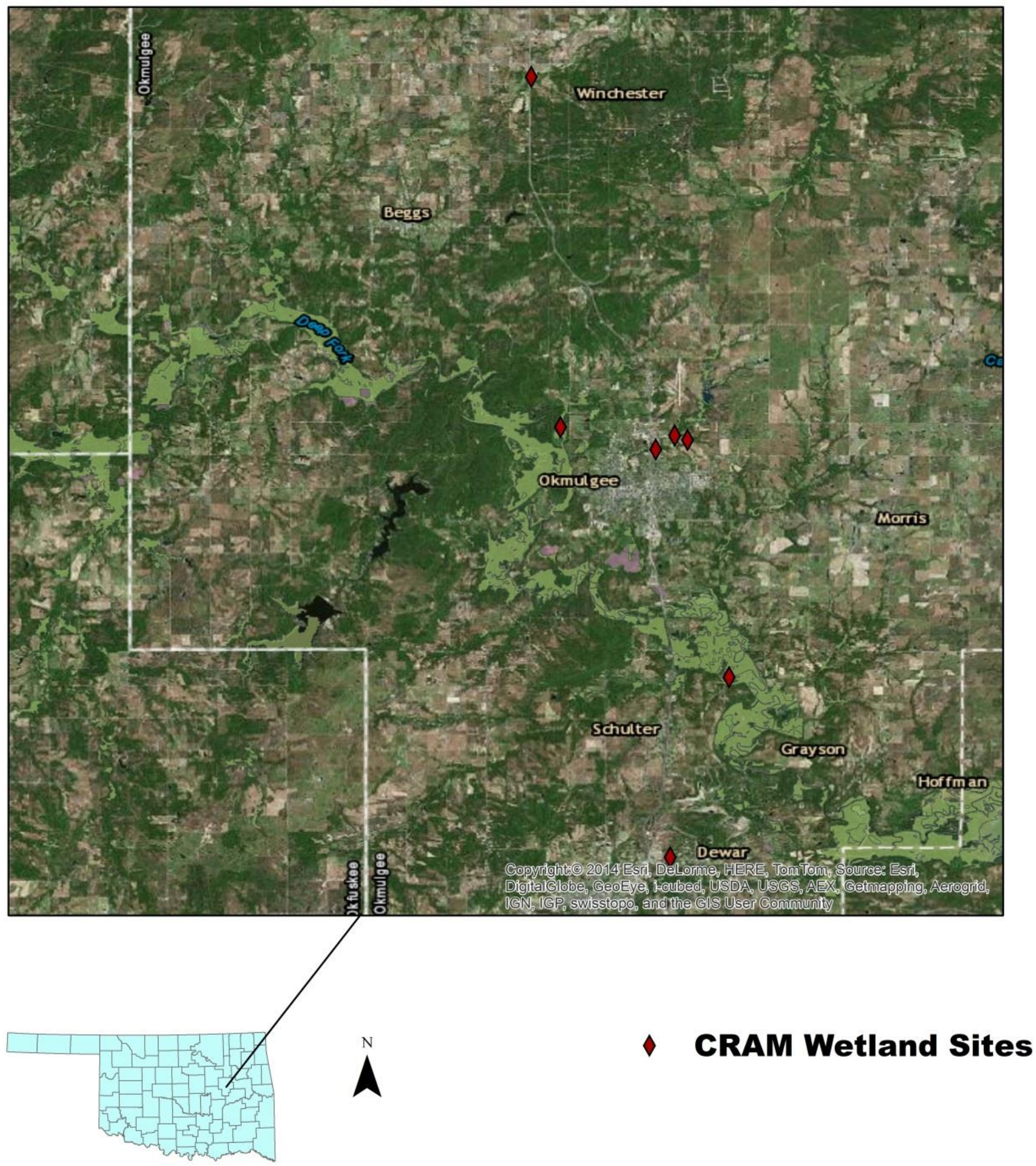

Figure 3.2 Map of CRAM Assessment Sites in Okmulgee County

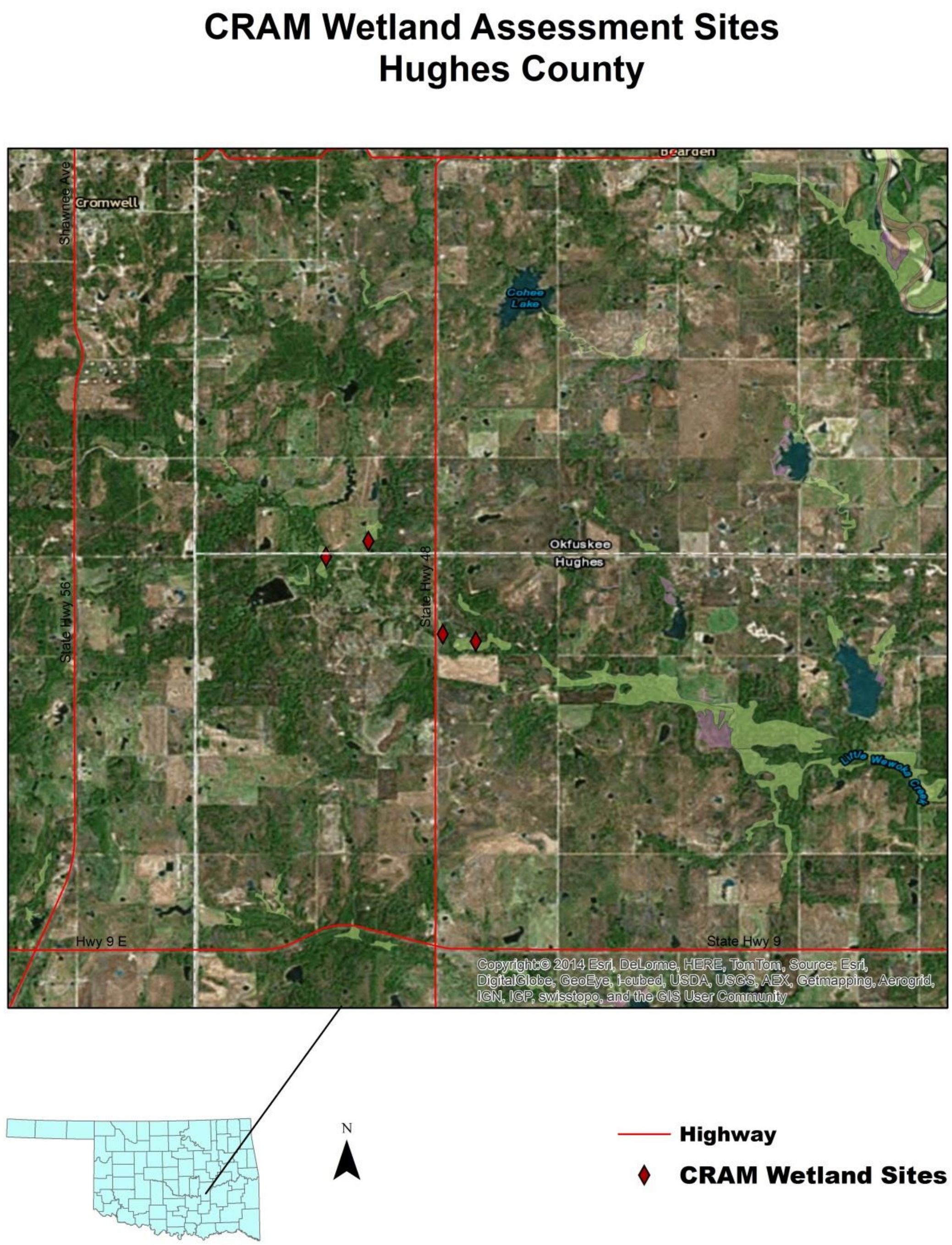

Figure 3.3 Map of CRAM Assessment Sites in Hughes County

Figure 3.4 Map of CRAM Assessment Sites in McIntosh County

Table 3.1 Riverine wetland sites for the Muscogee Creek Nation CRAM assessment project where 29a is the Northern Cross Timbers; 37e is the Lower Canadian Hills and 40b is the Osage Cuestas Level IV ecosystems. County is shown as Cnty and wetland is shown as WL. The wetland ID is the number associated to the wetland as listed in the GIS shape file downloaded from the National Wetland Inventory (NWI) list.

Wetland ID	Wetland Assessment Name	Level IV Ecoregion
907	Hughes Cnty WL_907	29a
908	Hughes Cnty WL_908	29a
884	Hughes Cnty WL_884	29a
893	Hughes Cnty WL_893	29a
2021	Coal C Ref WL_2021	29a
2157	DF Refuge N_WL-2157	29a
2635	DF Refuge S_WL-2635	29a
3202	Josie C WL_3202	37e
3232	Mill C Hanna East WL_3232	37e
3238	Hanna WL_3238	37e
3262	Hanna WL_3262	37e
3264	Hanna WL_3264	37e
3267	Hanna WL_3267	37e
3273	Hanna WL_3273	37e
3292	Hanna WL_3292	37e
3300	Hanna WL_3300	37e
3304	Hanna WL_3304	37e
2179	Okmulgee C_2179	40b
2235	Okmulgee C_Hyw56 N_2235	40b
2283	Okmulgee C_Hyw56 S_2283	40b
9999*	Eagle C_WL_9999	40b

*** 9999 was a number arbitrarily assigned to this wetland.**

Level 1 Assessment

For the Level 1 assessment also referred to as a landscape assessment, ArcMap 10.2 was utilized to locate riverine wetlands within the exterior boundaries of MCN. Either shapefiles or geodatabases were obtained to use in the landscape analysis. The National Wetland Inventory (NWI) is the most complete catalog available of wetland type, location and extent (Wardrop *et al.,* 2007). The MCN exterior boundaries and tribal land was obtained from the tribe's geospatial department. Watershed polygons and stream line data was obtained from the United States Geographical Service (USGS) National Hydrography Dataset. The remainder of the GIS data was obtained from the United States Department of Agriculture (USDA) Geospatial Data Gateway. The datalayers needed for the Level 1 assessment were: 1) MCN exterior boundaries; 2) MCN trust lands; 3) Hydrological Unit Code 8 (HUC); 4) Land-use Land Cover (LULC) and the NWI. An aerial base map was obtained from the ArcMap online resource available via the ArcMap software. The LULC is Landsat-based with a 30-m resolution (USGS, U.S. Department of Interior, 2014). The pixilation with a 30-m resolution should have little impact on the accuracy of the 100 and 1,000-m buffers. ArcMap geoprocessing tools were used to apply two sets of buffers around the wetland, a 100-m buffer and a 1,000-m buffer. The 100-m and 1,000-m buffer scales were chosen because different environmental variables are expected to vary in responsiveness to large versus local scale factors (Allan, 2004). The next step in the process was to use the ArcMap 'field calculator' tool with geoprocessing tools to determine the percentage of land-use that fell within the wetland buffer. Additionally, a basin was delineated for each wetland using the United States Geological Survey (USGS) Streamstats.

Figure 3.5 Aerial Map of Three Wetland Assessment Sites with a 100-meter buffer applied.

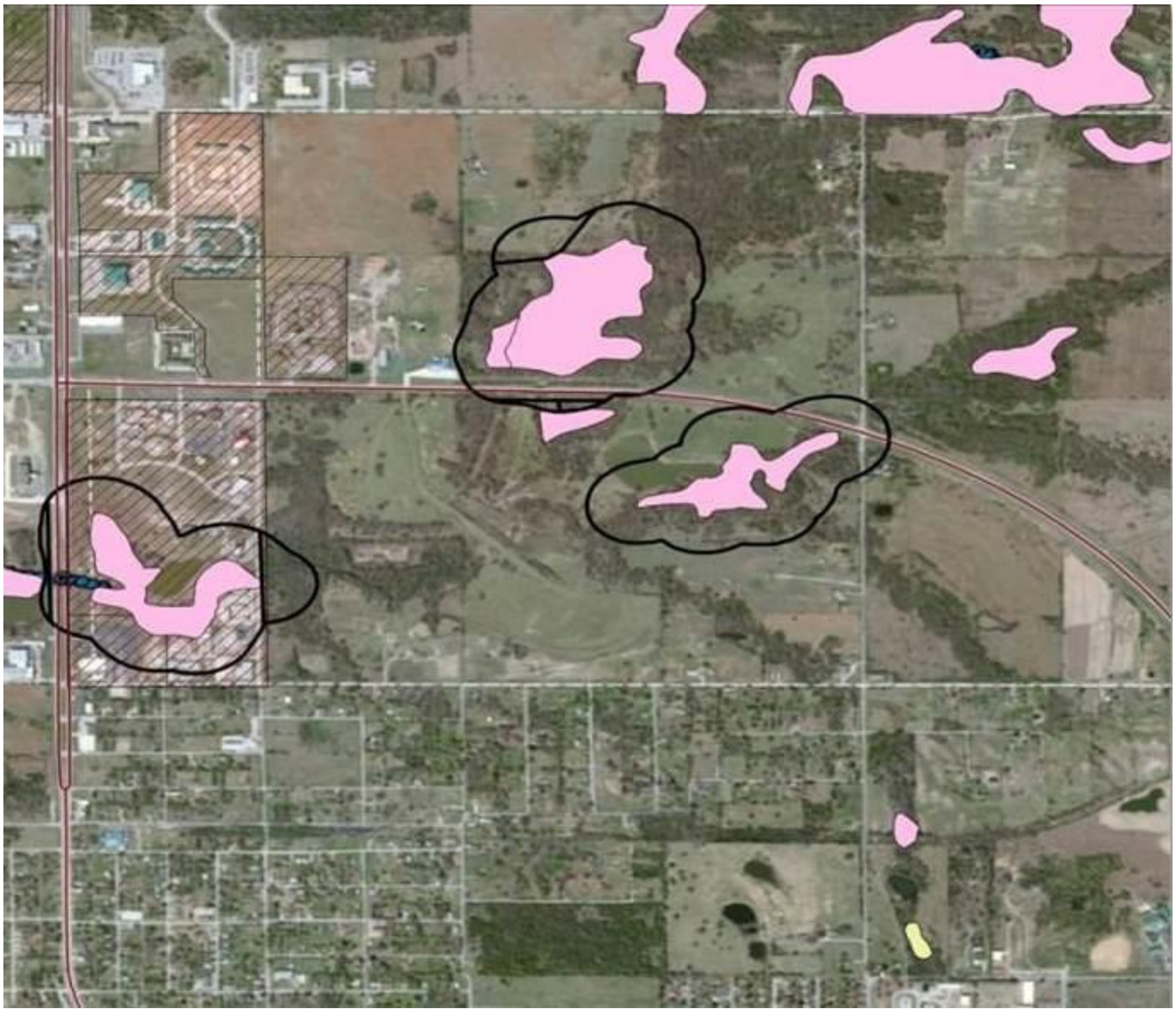

Figure 3.6 Map of three wetland sites with 100-meter buffer with land-use type data layer.

The USGS Streamstats is a Geographic Information System (GIS) web interactive map that provides an multiple analytical tools to be used for a variety of water-resources planning, management, engineering and design purposes(USGS StreamStats, 2015). Once the wetland basin was delineated it was saved as a shapefile that could be used in ArcMap. Utilizing the basin shapefile, the ArcMap procedure used to calculate the percentage of land-use type for the buffers was applied to the basin delineation. All results of the percentage of land-use for each of the buffers and the basin were entered into an MS Excel file.

Level 2 CRAM Assessment

The CRAM Level 2 assessment was conducted on 21 riverine wetlands located within the MCN exterior boundaries. Twelve of the wetlands were located on tribal trust land, two were on the Deep Fork National Wildlife Refuge, two were on private land and five were accessed via road easements

The eight basic steps of the CRAM methodology was followed according to the steps outlined in the California Rapid Assessment Method for Wetlands User's Manual, Version 6. 1 (California Wetlands Monitoring Workgroup (CWMW), 2013a). Steps 1-5 were conducted in the office using ArcMap to locate the target wetland site, determine the subclass of either confined or non-confined, and to estimate the assessment area. Before each field assessment a field packet was prepared that contained the CRAM Riverine Datasheet v. 6. 1. The field packet included aerial maps at scales of 2,000 m, 500 m, and 250 m. Additional field preparation was to estimate the boundary of the assessment area (Turner *et al.,* 2000) using ArcMap with the NWI datalayer on an aerial map background. The AA should be approximately 10x the bankfull width with a minimum length of 100 m and a maximum length of 200 m. Attribute 1, Buffer and Landscape Context, had four metrics which were compiled in the office using the aerial maps, but verified in the field. Steps 5 - 7 were performed in the field at the wetland site. The eight basic steps are outlined in table 3.2, CRAM Basic Steps.

Table 3.2 lists the eight basic steps to conduct a CRAM assessment.

Steps for using CRAM	
Step 1	Assemble background information about management of the wetland.
Step 2	Classify the wetland using CRAM typology and the California Rapid Assessment Methods for Wetlands Manual, Version 6. 1
Step 3	Verify the appropriate season and other timing for field assessment.
Step 4	Estimate the boundary of the AA in the office (subject to field verification)
Step 5	Conduct office assessment of stressors and on-site conditions of AA.
Step 6	Conduct the field assessment of stressors and on-site conditions of the AA.
Step 7	Complete CRAM assessment scores and QA/QC procedures.
Step 8	Enter all data results into Microsoft Excel.

To ensure the CRAM practitioner could accurately locate the AA site, Trimble Juno SB global positioning system (GPS) or a Trimble GEO XH was used to navigate to the AA. Pathfinder software, which is specific for Trimble products, was used with ArcMap. An aerial background was transferred from the GIS to the GPS unit using the Pathfinder software. In the Pathfinder software, a waypoint was placed in the middle of the AA. This waypoint could then be utilized with the background image that was set in the Pathfinder software. With the waypoint set in the GPS, the practitioner could use the navigation function in the Trimble GPS unit. This allowed the practitioner to be confident they were in the correct AA of the riverine wetland. Table 3.3 depicts the attributes, metrics and submetrics in the CRAM methodology.

Table 3.3 List of CRAM attributes, metrics and submetrics.

Attributes		Metrics/Submetrics
Buffer and Landscape		Aquatic Area Abundance: Stream Corridor Continuity (riverine) Aquatic Area Adjacent to Landscape Buffer: Percent AA with Buffer Average Buffer Width Buffer Condition
Hydrology		Water Source Hydroperiod or Channel Stability Hydrologic Connectivity
Structure	Physical	Structural Patch Complexity Topographic Complexity
	Biotic	Plant Community: Number of Plant Layers Present Number of Co-dominant Species Percent Invasion Horizontal Interspersion and Zonation Vertical Biotic Structure

Attribute 1 was field verified while attributes, 2, 3 and 4 were conducted in the field. Attribute 4, Biotic Structure, required the CRAM practitioner to walk the AA to identify plant species and plant layers. Attribute 2, Hydrology, and Metric 3, Hydrological Connectivity (entrenchment ratio) was conducted at three points in the channel and within the AA. Attribute 3, Physical Structure, has two metrics, Structural Patch Richness and Topographical Complexity. Topographic complexity was measured and recorded at each of the three stations where the entrenchment ratio was recorded. Attribute 4, Biotic Structure, Metric 2, has two submetrics: 1) Horizontal Interspersion and; 2) Vertical Biotic Structure. This was the final metrics measured. The CRAM was scored and entered into an MS Excel spreadsheet.

All results of the CRAM assessments were entered into an MS Excel spreadsheet designed to show each of the four attribute scores and the overall CRAM score. The CRAM overall score and each attribute score were used to analyze the effect of the percentage of land-use type within each of the specified buffers and the basin.

Preparation for analysis consisted of using ArcMap GIS to prepare a tabular report that was saved in an Excel format. One report was prepared for each of the 100-m and 1,000-m buffers and one report for the basin delineation. A total of 16 different land-use types were within the buffers and basin delineation. Similar land-use types were combined, which resulted with a field of six land-use types. For example, residential, commercial and transportation land-use type was combined into the urban/suburban land-use type; cropland and pasture and orchards were combined into the agriculture land-use type; and mixed forests and deciduous forests were combined into the forest land-use type. Three additional land-use types were wetlands, water, and other.

Statistical Analysis

The MS Excel 2010 statistical analysis tools for correlation and multiple regression was used for the statistical analysis of the percentage of land-use. A separate correlation was run for the CRAM overall score and each of the four attribute scores. This was repeated for each of the two buffers and the basin. After the correlation results were obtained, a multiple regression was run using the same variables. The variables were the overall CRAM score and each of the four attribute scores. The initial multiple regression included all six of the land-use types as variables. The remaining multiple regressions were run by eliminating, one at a time, land-use variable types that showed insignificance in the first multiple regression. This methodology was repeated for each buffer and the basin and for each of the four attributes. The results of the multiple regression were transferred to a summary table that included only the land-use types that had statistical significance for either of the buffers or the basin.

CHAPTER IV

RESULTS OF A COMPARISON OF THE CALIFORNIA RAPID ASSESSMENT METHOD (CRAM) AGAINST LAND-USE PERCENTAGE FOR RIVERINE WETLANDS

Results are presented for the Level 1 assessment in 100 and 1,000-meter buffers and for a basin delineation of the wetlands and for the Level 2 CRAM Assessment of 21 riparian wetlands within the boundary of the Muscogee Creek Nation in Oklahoma. The percentage of each land-use type around the wetland was compared to the results of the CRAM Level 2 assessment score for each of the four CRAM attributes and the overall CRAM score. The intent of this comparison was to determine whether or not a correlation existed between the type and percentage of land-use around the wetland to the attribute scores and overall CRAM score for each wetland.

Results

Level 1 Assessment

The Level 1 assessment provided a rough gauge on the condition of the wetland based on the percentage of land-use types within the specified buffers. A table with the results of the land-use percentage assessment and the associate CRAM overall score is provided in Appendix B. There were 17 different land-use types that occurred. Of those 18 land-use types several were closely related, such as deciduous forest and mixed forest, or commercial and industrial and industrial. The cropland and pasture and deciduous forest were the predominate land-use type. Both the cropland and pasture, and deciduous forest occurred in at least one of the buffer scales or basin delineation for 20 of the 21 sites. The strip mines and confined animal feeding operation land-use types occurred in one site each. Other land-use types, such as residential, transportation, commercial and industry, orchards and groves, other agriculture, and other urban build-up occurred in varying percentages in at least one of the buffer scales or basin delineation.

Level 2 Assessment

The CRAM was used for the Level 2 assessment of the 21 riverine wetlands with scores that ranges from a low of 48 to a high of 90. The site with the lowest score had 90% commercial and industrial land-use type at the 100-m scale and the highest scored site had 93% deciduous forest and 7% cropland and pasture as the land-use type at the 100-m buffer scale. The highest scoring site was located within the Deep Fork National Wildlife Refuge. Both the median and the mean score was 75 and three sites scored 82, which was the mode.

Multiple Regression

Multiple regression analyses were completed to determine if there were correlations between the Level 1 assessment at any scale and the Level 2 CRAM results. Presented results represent the simplest (i.e., least amount of variables) that contain significant coefficients. The regression results for the overall CRAM score were significant with a moderate R-squared value of 0. 52 at the 100-m scale for the two-variable relationship with percentage of urban/suburban land-use (*p < 0. 01)* and percentage of forest land-use (*p = 0. 05)* (Table 4. 1). At the 1,000-m scale, the regression results for the overall CRAM score were similarly significant with an R-squared value of 0. 54 for the two-variable relationship with percentage of urban/suburban land-use (*p = 0. 01)* and percentage of forest land-use (*p = 0. 02).* At the basin scale, the overall CRAM regression had a low R-squared value of 0. 27 with percentage of urban/suburban land-use *(p=0. 07),* percentage of agricultural land-use *(p=0. 05)*, and percentage of water *(p=0. 05)*.

In table 4.2 the regression results for Attribute 1, Buffer and Landscape Context, at the 100-m scale show a relatively strong R-squared at 0. 79 with a low p value for the two-parameter relationship using percentage of urban/suburban land-use *(p < 0. 01),* and the percentage of forest land-use (*p = 0. 06)*. The 1,000-m scale results showed a two-parameter relationship with a significant p value for the both the percentage of water *(p < 0. 01)* and percentage of other land-use categories *(P<0. 01),* but the R–squared had a lower value than the 100-m scale at 0. 57. The basin scale did not show significance for any of the land-use types. Table 4.3 shows the regression results for Attribute 2, Hydrology. There was no significance for any of the land-use types for the 100-m scale and the basin scale. The 1,000-m scale results had a relatively low R-square at 0. 36 with a significant relationship (*p < 0. 01)* for the percentage of forest land-use. Table 4. 4 show the regression results of Attribute 3, Physical Structure. The results had a relatively low R-square value of 0. 40 for the 100-m and 0.24 for the 1,000-m scales, respectively. At the 100-m scale, the p-value of the coefficients in the two-parameter relationship was significant at for the percentage of urban/suburban land-use *(p=0. 04)* and the percentage of wetlands land-use (*p = 0. 01)*. At the 1,000-m scale, the significant variables were percentage of agricultural lands *(p = 0. 04)* and percentage of forests *(p = 0. 05).* In Table 4.5, Attribute 4, Biotic Structure, had an R-square of 0.56 and three-parameter relationship with significant of the percentage of urban/suburban land-use (*p = 0. 02)*, percentage of forests *(p=0. 01)*, and percentage of other land-uses *(p=0. 05).* Neither the 1,000-m nor the basin scale had any significant coefficients for the multiple regression results for any of the land-use types.

Table 4.1 Simplest form of multiple regression results with significant variable coefficients for CRAM overall scores for 21 riverine wetlands for 100-m, 1,000-m and basin scales.

CRAM	R-squared	Intercept	P-value	Coefficient 1	Variable 1	P-value V1	Coefficient 2	Variable 2	P-value V2	Coefficient 3	Variable 3	P-value V3
100-m	0. 52	73. 03	< 0. 01	-0. 25	Urban Suburban	< 0. 01	0. 10	Forests	0. 05	NA	NA	NA
1000-m	0. 54	73. 65	< 0. 01	-0. 46	Urban Suburban	0. 01	0. 21	Forests	0. 02	NA	NA	NA
Basin	0. 27	90. 90	< 0. 01	-0. 20	Urban Suburban	0. 07	-0. 19	Agricultural Lands	0. 05	-7. 28	Water	0. 05

[CRAM is the acronym for California Rapid Assessment Method and NA is the abbreviation for not applicable.]

Table 4.2 Simplest form of multiple regression results with significant variable coefficients for CRAM Attribute 1-Landscape and Buffer Context scores for 21 riverine wetlands for 100-m, 1,000-m and basin scales.

A-1	R-squared	Intercept	P-value	Coefficient 1	Variable 1	P-value V1	Coefficient 2	Variable 2	P-value V2	Coefficient 3	Variable 3	P-value V3
100-m	0. 79	90. 27	< 0. 01	-0. 38	Urban Suburban	< 0. 01	0. 08	Forests	0. 06	0. 14	Wetlands	0. 01
1000-m	0. 57	92. 53	< 0. 01	1. 69	Water	0. 001	-0. 83	Other	0. 00	NA	NA	NA
Basin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[CRAM is the acronym for California Rapid Assessment Method and NA is the abbreviation for not applicable.]

Table 4.3 Simplest form of multiple regression results with significant variable coefficients for CRAM Attribute 2-Hydrology scores for 21 riverine wetlands for 100-m, 1,000-m and basin scales.

A-2	R-squared	Intercept	P-value	Coefficient 1	Variable 1	P-value V1	Coefficient 2	Variable 2	P-value V2	Coefficient 3	Variable 3	P-value V3
100-m	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1000-m	0. 36	62. 69	< 0. 01	0. 39	Forests	0. 004	NA	NA	NA	NA	NA	NA
Basin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[CRAM is the acronym for California Rapid Assessment Method and NA is the abbreviation for not applicable.]

Table 4.4 Simplest form of multiple regression results with significant variable coefficients for CRAM Attribute 3-Physical Structure scores for three test site riverine wetlands for 100-m, 1,000-m and basin scales.

A-3	R-squared	Intercept	P-value	Coefficient 1	Variable 1	P-value V1	Coefficient 2	Variable 2	P-value V2	Coefficient 3	Variable 3	P-value V3
100-m	0. 40	56. 49	< 0. 01	-0. 31	Urban Suburban	0. 04	-0. 32	Wetlands	0. 01	NA	NA	NA
1000-m	0. 24	25. 20	< 0. 01	0. 31	Agricultural Lands	0. 04	0. 43	Forests	0. 05	NA	NA	NA
Basin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[CRAM is the acronym for California Rapid Assessment Method and NA is the abbreviation for not applicable.]

Table 4.5 Simplest form of multiple regression results with significant variable coefficients for CRAM Attribute 4-Biotic Structure scores for three test site riverine wetlands for 100-m, 1,000-m and basin scales.

A-4	R-squared	Intercept	P-value	Coefficient 1	Variable 1	P-value V1	Coefficient 2	Variable 2	P-value V2	Coefficient 3	Variable 3	P-value V3
100-m	0. 56	76. 93	< 0. 01	-0. 30	Urban/ Suburban	0. 02	0. 24	Forests	0. 01	0. 51	Other	0. 05
1000-m	0. 48	92. 36	< 0. 01	-1. 04	Urban/ Suburban	< 0. 01	NA	NA	NA	NA	NA	NA
Basin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[CRAM is the acronym for California Rapid Assessment Method and NA is the abbreviation for not applicable.]

Discussion

Ecological condition is expected to be negatively correlated with extent of human disturbance (Wardrop *et al.,* 2007). The Level 1 assessment of the 21 wetlands in this project provided a gauge for how the wetland may score on the Level 2 assessment based on the type and percentage of land-use at 100-m, 1,000-m and basin scales. The expectation being that the wetlands within land-use types with more disturbance would be inversely correlated with the overall CRAM score. Our multiple regression analysis indicated that the highest R-squared values generally at the 100-m and the 1,000-m scales, and most commonly inversely correlated with urban/suburban land-use and directly correlated to the forest land-use type. This indicates the influence of land-use type is most likely predominately localized. However, the only attribute with multiple regression relationships with an R-squared greater than 0.70 was Attribute 1, Landscape and Buffer Context, which was inversely correlated to the percentage of urban/suburban and directly correlated to the percentage of forests. At an R-squared level between 0.50 and 0.70, the overall score was correlated to urban/suburban land-use (inversely) and forest land-use (directly) at both the 100-m and 1,000-m scales. Similarly, the Biotic Structure metric (Attribute 4) was inversely correlated to urban/suburban and directly correlated to forests and water and the 100-m scale.

Conclusion

The results of the multiple regression statistical analysis for the 21 riverine wetlands in this study revealed a correlation between CRAM scores and two of the land-use types. The negative correlation between the overall CRAM score to the urban/suburban land-use confirmed that that CRAM assessment will usually result in a lower overall score to a higher percentage this land-use type that has a significant adverse effect wetland condition. On the other side, the result of the higher overall CRAM score was expected with a higher percentage of land-use type, such as forests, where there is less human disturbance. The results of the multiple regression of the Level 1 assessment comparing the percentage of land-use type surrounding a specified scale to the scores of a Level 2 assessment showed that the percentage of land-use surrounding a wetland can be a good tool for preliminary analysis, especially at the local scale of 100-m.

CHAPTER V

CATEGORICAL SENSITIVITY ANALYSIS OF THE CALIFORNIA RAPID ASSESSMENT METHOD ON RIVERINE WETLANDS

Abstract: The California Rapid Assessment Method (CRAM) was developed to be used on multiple hydrogeomorphic method (HGM) classes of wetlands across the state of California. The metrics were designed to be broad enough to capture the condition of different classes of wetlands with minimum adjustments to the methodology between wetland classes. This approach allows the method to be used across a variety of ecosystem conditions, but it may also limit the ability of the rapid assessment method in the evaluation of riverine wetland ecosystems. A categorical sensitivity analysis was designed to capture the most sensitive points in the CRAM scoring system. The model was designed on a hypothetically scored CRAM riverine wetland. Three wetlands in Oklahoma that had been assessed with the CRAM were chosen to test the categorical sensitivity analysis model. The three selected represented a low, moderate, and high CRAM score. The riverine wetland with the lowest CRAM score consistently had a higher percentage of sensitivity with all of the CRAM attributes and metrics. In general, the CRAM attributes and metrics that were most sensitive to the overall score were structural topography and hydrological connectivity.

Introduction

The first step towards preservation and restoration of riverine wetlands, which provide multiple functions on the landscape including flood mitigation, water quality improvements, habitat diversity and connectivity, is an accurate, economical, and comparable assessment of their ecological condition. Riverine wetlands are defined as wetlands that occur in riparian corridor and floodplains of stream channels (Smith, *et al.*

1995). A Level 2 rapid assessment method has been defined as taking two people no more than one half day total in the field and requiring no more than one half day of office preparation and data analysis to obtain a result (Fennessy *et al.,* 2007). Because it is less time consuming and relatively inexpensive, Level 2, or rapid assessment, is emerging as a key element of many wetland monitoring programs (Stein, Fetscher, *et al.,* 2009).

The California Rapid Assessment Method (CRAM) has been developed as a Level 2 assessment model to meet the needs of wetland assessment in California. The conventional framework for the CRAM began as early as 2003, and a pilot program began implementation in 2006. That was when the California Natural Resources Agency was awarded a USEPA Wetland Demonstration Program (WDP) Pilot grant to begin a phased implementation of a statewide wetland monitoring program, building on the existing conceptual framework and statewide wetland monitoring toolkit (Southern California Coastal Water Research Project (SCCWRP)), 2008). CRAM was developed to provide a scientifically defensible and rapid assessment for routine wetland monitoring (Collins *et al.,* 2006). CRAM was developed to be used for multiple wetland classes throughout the state of California and uses the HGM classification system with broadly defined sub-classes of wetlands for each appropriate HGM class, including riverine wetlands. The CRAM method manual lists multiple applications for which CRAM can be applied. A partial list of these applications are: 1) preliminary assessments to determine the need for more traditional intensive analysis or monitoring; 2) providing supplemental information during the evaluation of wetland condition to aid in regulatory review under Section 401 and 404 of the Clean Water Act; and 3) assisting in the monitoring and assessment of restoration or mitigation projects by providing a rapid means of checking progress along restoration trajectories (California Wetlands Monitoring Workgroup (CWMW), 2013b).

Primarily, states have assumed the lead role in management of wetlands for monitoring of restoration projects and for ambient monitoring to obtain a baseline ecological condition or to determine which wetlands can be used as reference sites. States have approached the wetland management challenge with multiple strategies. These strategies have ranged from basic inventory and classification of wetlands to developing rapid assessment methods. All assessment methods attempt to consider a variety of factors, some more easily and accurately measurable than others, and to derive a single overall score representing ecosystem health or integrity, will be obliged to deal with the problem of combining unlike metrics (Klimas, 2008). Aggregating data into an overall single score is necessary to distill the large amounts of information associated with individual metric scores (Sutula *et al.,* 2006). CRAM uses a single conditional score that combines multiple ecosystem processes and components and this approach tends to cause a loss of information, such that it is not apparent which components of the overall score are changing as a result of some action (Klimas, 2008). One tool that could be used to alleviate some degree of the lack of precision is a sensitivity analysis. The use of a sensitivity analysis for the invasive plant metric was suggested by Wardrop in the peer review of CRAM (California Environmental Protection Agency, 2011).

The objective of this study was to apply a categorical sensitivity analysis model for use on the CRAM metrics for riverine wetlands. Then intent of using a tool like the categorical sensitivity analysis is to answer what break-points in the CRAM scoring system are most sensitive to human error, thus, having the greatest impact on the overall CRAM score. The categorical sensitivity analysis has the potential to identify the alpha categories within a metric that are most sensitive, thus, having a significant effect to the overall CRAM score.

Methods

CRAM assessment metrics and scoring

There are eight basic steps to CRAM where 1-5 are office preparatory work that includes, assembling background information about the site, classifying the wetland typology, verifying the appropriate season to conduct a field assessment, and conducting an office assessment of stressors. Steps 6-8 involve the actual field CRAM assessment, scoring the assessment, and finally, the data entry of the CRAM assessment score(California Wetlands Monitoring Workgroup (CWMW), 2013b). There are four attributes in the CRAM method. Each attribute is a category: Attribute 1 (A1), Landscape Context; Attribute 2 (A2), Hydrology; Attribute 3 (A3), Physical Structure, and Attribute 4 (A4), Biotic Structure. Within each attribute is a set of measurable metrics designed to assess the condition for of that attribute (California Wetlands Monitoring Workgroup (CWMW), 2013b). They also identify key stressors that may be affecting wetland condition (California Wetlands Monitoring Workgroup (CWMW), 2009). Each metric is categorized by an alpha unit of either A, B, C, or D. The alpha units represent a level of condition for the particular metric and are converted to a numeric score where, A=12, B=9, C=6, D=3. For each attribute, except A1, the raw score is the sum of the numeric score for the metric, divided by the maximum possible score for the particular attribute. Once each of the attribute scores are derived, the CRAM overall score is obtained by averaging each of the four attribute scores. To obtain the score for A1, the submetric scores relating to the buffer metric are combined into an overall buffer score that is added to the score for the Stream Corridor Continuity (California Wetlands Monitoring Workgroup (CWMW), 2013c). The formula on page 60 depicts how to derive the final metric score.

(Buffer Condition * (% AA with Buffer * Avg Buffer Condition)$^{1/2}$))$^{1/2}$.

Table 5.1 California Rapid Assessment Method Attributes, Metrics and Submetrics for Riverine Wetlands

Attribute		Metric and Submetric *	Abbreviation for Attribute, Metric and Submetric
Buffer and Landscape Context		Stream Corridor Continuity, aka aquatic area abundance	A1 M1 (D)
		Buffer: *Percent AA with Buffer *Average Buffer Width * Buffer Condition	A1 M2 A1 M2 (SM-A) A1 M2 (SM-B) A1 M2 (SM-C)
Hydrology		Water Source Hydroperiod or Channel Stability Hydrologic Connectivity	A2 M1 A2 M2 A2 M3
Structure	Physical	Structural Patch Complexity Topographic Complexity	A3 M1 A3 M2
	Biotic	Plant Community: *Number of Plant Layers Present *Number of Co-dominant Species *Percent Invasion Horizontal Interspersion and Zonation Vertical Biotic Structure	 A4 M1 (SM-A) A4 M1 (SM-B) A4 M1 (SM-C) A4 M2 A4 M3

Categorical Sensitivity Analysis

A sensitivity analysis (SA), broadly defined, is the investigation of potential changes and errors to the impact on the conclusions that can be drawn to a model (Pannell, 1997). In this study, a categorical SA was designed in relation to the alpha score categories and the associated numerical scores in the CRAM scoring system. A categorical SA does the sensitivity analysis on a scale that is not continuous, but instead changes to a new categorical rating at predefined points along a finite scale.

Per the CRAM assessment framework, all attributes have metrics and attribute (A1) and attribute (A4) have metrics that contain submetrics. When scoring a CRAM assessment each metric and submetric has an alpha category applied--either A, B, C, or D. With each alpha category there is a constant numerical score that is associated: A = 12, B = 9, C = 6 and D = 3. A categorical sensitivity analysis (SA) model was designed to capture the sensitivity to the metric and to the overall CRAM score based upon which alpha unit and its associated numerical score is applied to the metric. The categorical SA captures the difference in the overall CRAM score and the percentage the CRAM score changes when a category error occurs. A category error is simply when the CRAM practitioner scores the metric with one of the four alpha units incorrectly, i. e., scoring the metric with an ‘A’ when the conditions at the wetland are a ‘B’ or any of the other alpha units. The categorical SA captures the sensitivity of the metric to the error by showing the difference in the attribute points and the percentage of that difference to the overall score.

A hypothetical CRAM assessment was created and used to test the categorical SA model. Two of the CRAM alpha score categories, either ‘B’ or ‘C’ was used to achieve a mid-range overall CRAM score. Scoring the hypothetical CRAM assessment gave an overall CRAM score of 64.6, a mid-range score. Using the Stream and Corridor metric in attribute 1 (A1) as an example: A ‘B’ category with its associated constant numerical score of 9 was applied. If that category is changed to an ‘A’ with its numerical constant of 12 is applied it changes the overall CRAM score to 67.7, a 3.1 point difference and a 4. 6% difference in the overall CRAM score. This scenario in the categorical SA was applied to each of the metrics or submetrics. The objective of the model is to depict the regions in a metric that are most sensitive to change between the alpha categories and which have the most impact to the overall CRAM score.

Test Case Site Descriptions

In addition to the hypothetical case, three riverine wetlands were selected for the categorical SA to represent wetlands with low, medium, and high CRAM scores. Figure 5. 1 is a map of the location of the three riverine wetlands where the CRAM score was applied to the categorical SA. Pictures of the three sites used for the SA are located in Appendix A. The site with the low score is located in a developed area with the land-use in the 100-m scale listed as commercial and industrial. The site with the moderate score is located in a rural area with virtually no development, but with agricultural land-uses. The site with the high score is located within the Deep Fork National Wildlife Refuge.

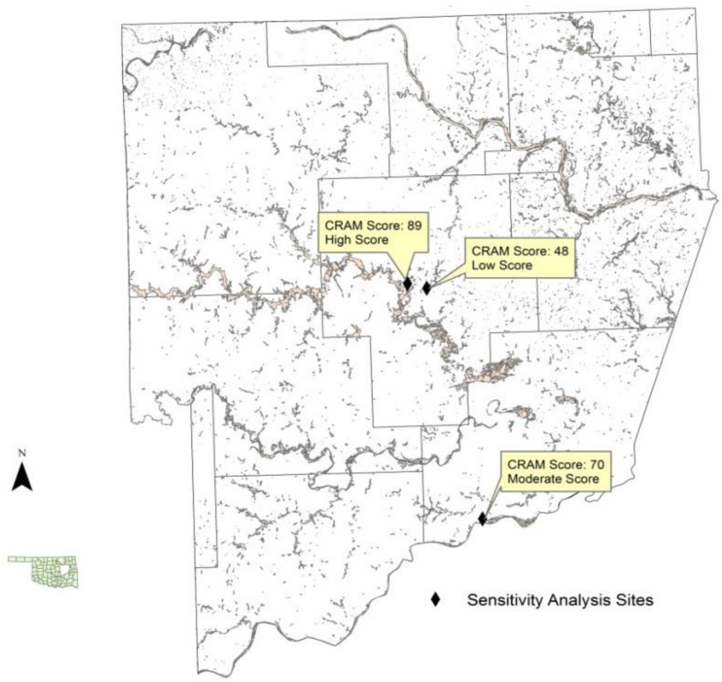

Figure 5.1 Map of three wetlands in Oklahoma used for the categorical sensitivity analysis. [CRAM is the acronym for California Rapid Assessment Method]

Results and Discussion

Table 5.2 depicts the hypothetical and the three riverine test wetland CRAM assessments. Scores are shown for each of the four attributes and the overall CRAM score.

Table 5.2 CRAM overall score and attribute scores for the three riverine wetland test sites and the hypothetical CRAM wetland-used as the base case for the categorical sensitivity analysis.

Wetland	CRAM Score	Attribute 1 Buffer and Landscape	Attribute 2 Hydrology	Attribute 3 Physical Structure	Attribute 4 Biotic Structure
Hypothetical	64. 6	65. 2	66. 7	62. 5	63. 9
Low	47. 8	52. 4	66. 7	25. 0	47. 2
Moderate	69. 9	92. 0	50. 0	37. 5	100. 0
High	88. 5	100. 0	91. 7	62. 5	100. 0

[CRAM is the acronym for California Rapid Assessment Method.]

A one-way sensitivity analysis, in which only one metric score is deviated by the alpha units used in the CRAM scoring system, was completed. All other metrics remain constant.

Table 5.3 Sensitivity Analysis Percent Score Change for Attribute 1, Buffer and Landscape Context. [cont.]

Attribute / Metric / Submetric		Low CRAM Score: 48	Mid CRAM Score: 70	High CRAM Score: 89	Hypothetical Score: 65	Mean
A1 M1 (D)	A <-> B	6. 1%	4. 4%	3. 5%	4. 6%	4. 7%
A1 M1 (D)	B <-> C	6. 5%	4. 8%	3. 6%	5. 0%	5. 0%
A1 M1 (D)	C <-> D	6. 9%	4. 9%	3. 8%	5. 0%	5. 2%
A1 M1 (D)	A <-> C	12. 2%	9. 0%	7. 0%	9. 0%	9. 3%
A1 M1 (D)	B <-> D	13. 0%	9. 4%	7. 3%	9. 8%	9. 9%
A1 M2 (SM-A)	A <-> B	0. 6%	1. 0%	0. 9%	3. 0%	1. 4%
A1 M2 (SM-A)	B <-> C	0. 8%	1. 4%	1. 3%	3. 3%	1. 7%
A1 M2 (SM-A)	C <-> D	1. 3%	2. 1%	2. 0%	3. 4%	2. 2%
A1 M2 (SM-B)	A <-> B	0. 8%	1. 3%	0. 9%	3. 0%	1. 5%
A1 M2 (SM-B)	B <-> C	1. 0%	1. 5%	1. 3%	3. 3%	1. 8%
A1 M2 (SM-B)	C <-> D	1. 4%	2. 4%	2. 0%	1. 6%	1. 9%
A1 M2 (SM-C)	A <-> B	2. 5%	2. 0%	1. 8%	0. 8%	1. 8%
A1 M2 (SM-C)	B <-> C	2. 2%	2. 5%	2. 3%	1. 1%	2. 0%
A1 M2 (SM-C)	C <-> D	3. 2%	3. 3%	3. 1%	3. 3%	3. 2%
A1 M2 (SM-C)	A <-> C	4. 6%	4. 4%	4. 1%	4. 2%	4. 3%

[CRAM is the acronym for California Rapid Assessment Method. A1 is Attribute 1, Buffer and Landscape Context; M1 is Metric 1 where (D) is the Stream Corridor Continuity; M2 is Metric 2, Buffer where (SM-A) is Submetric – A, Percent of Assessment Area with Buffer; (SM-B) is Submetric – B, Average Buffer Width; and (SM-C) is submetric C, Buffer Condition. A = 12, B = 9, C = 6, and D = 3, are the CRAM scoring categories.]

Attribute 1: Buffer and Landscape

Attribute 1 (A1), Buffer and Landscape Context, metric (D), Stream Corridor Continuity, showed the highest degree of sensitivity when the metric was changed by only one unit. The worst case scenario for A1 M1 (D) is when the alpha score is changed by two units where B <-> D. The potential of this scenario is when one of the corridors (either the upstream or the downstream) is less than 100 m and the other corridor is close to 200 m. Submetrics SM-A and SM-B have a relatively low sensitivity with a sensitivity range of 0.6 – 3.4 %. Submetric SM-C, was most sensitive when the score was missed by two units. This could potentially happen if the CRAM practitioner misjudges the amount of disturbance to the area, fails to identify invasive plants or counts areas in the buffer condition that were not scored as being part of the buffer in SM-B, buffer width.

Table 5.4 Sensitivity Analysis Percent Score Change for Attribute 2, Hydrology

Attribute / Metric / Submetric		Low CRAM Score: 48	Mid CRAM Score: 70	High CRAM Score: 89	Hypothetical Score: 65	Mean
A2 M1	A <-> B	4. 0%	2. 8%	2. 3%	3. 0%	3. 0%
A2 M1	B <-> C	4. 2%	2. 9%	2. 3%	3. 3%	3. 2%
A2 M1	C <-> D	4. 4%	3. 0%	2. 6%	3. 4%	3. 3%
A2 M2	A <-> B	4. 2%	2. 9%	2. 3%	3. 0%	3. 1%
A2 M2	B <-> C	4. 4%	3. 0%	2. 3%	3. 3%	3. 2%
A2 M3	A <-> B	4. 2%	2. 6%	2. 3%	3. 1%	3. 1%
A2 M3	B <-> C	4. 4%	2. 8%	2. 3%	3. 0%	3. 1%
A2 M3	C <-> D	4. 6%	2. 9%	2. 4%	3. 3%	3. 3%
A2 M3	A <-> C	8. 4%	5. 4%	4. 5%	6. 0%	6. 1%
A2 M3	B <-> D	8. 8%	5. 7%	4. 6%	6. 2%	6. 3%
A2 M3	A <-> D	13. 8%	8. 6%	7. 2%	9. 6%	9. 8%

[CRAM is the acronym for California Rapid Assessment Method. A1 is Attribute 1, Buffer and Landscape Context; M1 is Metric 1 where (D) is the Stream Corridor Continuity; M2 is Metric 2, Buffer where (SM-A) is Submetric – A, Percent of Assessment Area with Buffer; (SM-B) is

Submetric – B, Average Buffer Width; and (SM-C) is submetric C, Buffer Condition. A = 12, B = 9, C = 6, and D = 3, are the CRAM scoring categories.]

Attribute 2: Hydrology

Attribute 2 (A2), is the hydrology attribute where metric 1 (M1), is water source. A2 M1 assesses the immediate watershed contribution by viewing the 2 km of the surrounding watershed upstream from the assessment area. The range for A2 M1 is 2. 3 – 4. 4 % for the low, moderate and high scores but with the low scoring wetland an error by even one alpha unit will cause a greater than 4% change in the overall CRAM score. A2 metric 2 (M2) is the metric used to determine stream-channel stability, or its state as being in either aggradation, degradation or equilibrium. A one-unit deviation is possible with this metric and would change the overall CRAM score of anywhere between 2.3% - 4.4%. The largest percent difference in the overall CRAM score occurs when the 'B' and 'C' categories are misapplied. A2 M2 is scored in the field by referencing a list of indicators used to determine aggradation, degradation or equilibrium of the stream channel. Missing this metric score by one category could occur if the practitioner fails to determine the severity of impact based on the list of field indicators. A2, metric 3 (M3), is hydrologic connectivity. It is possible for a CRAM practitioner to miss this metric by one, two, or three categories. The range of percent difference in the CRAM overall score is 2.3 % - 13.8 %. Riverine wetlands that have a lower overall CRAM score are more sensitive to this metric. This metric requires the practitioner to identify the bankfull stage. It is difficult to accurately determine bankfull stage in degraded channels that may have significant channel incision or that are not stable (Copeland, Biedenharn, &

Fischenich, 2000; Simon *et al.,* 2007). The categorical SA results for A3, M3 indicates a higher percent change in the overall CRAM score with the low scored wetland than for either the mid-range or high score. However, all three CRAM score categories have a high degree of sensitivity. The CRAM Riverine Field Manuel suggests that a field sensitivity analysis be conducted in channels where the location of bankfull is uncertain. The field sensitivity-analysis test requires that the entrenchment ratio be calculated at both 10% above, and again, at 10% below the location of the initial bankfull estimate. If either of the alternative bankfull locations changes the metric score the CRAM guidelines require adding three additional cross-section measurements to factor into the final metric calculation.

Table 5.5 Sensitivity Analysis Percent Score Change - Attribute 3 Physical Structure

Attribute / Metric / Submetric		Low CRAM Score: 48	Mid CRAM Score: 70	High CRAM Score: 89	Hypothetical Score: 65	Mean
A3 M1	A <-> B	5. 4%	4. 0%	3. 3%	4. 4%	4. 3%
A3 M1	B <-> C	5. 9%	4. 1%	3. 5%	4. 6%	4. 5%
A3 M1	C <-> D	6. 1%	4. 2%	3. 5%	5. 0%	4. 7%
A3 M1	A <-> C	11. 0%	7. 9%	6. 6%	8. 8%	8. 6%
A3 M1	B <-> D	11. 6%	8. 1%	7. 0%	9. 3%	9. 0%
A3 M2	B <-> C	5. 4%	4. 1%	3. 5%	4. 6%	4. 4%
A3 M2	C <-> D	5. 9%	4. 2%	3. 5%	5. 0%	4. 7%
A3 M2	A <-> C	6. 1%	4. 4%	3. 6%	5. 0%	4. 8%
A3 M2	B <-> D	11. 0%	8. 1%	6. 9%	9. 3%	8. 8%
A3 M2	B <-> D	11. 6%	8. 5%	7. 0%	9. 8%	9. 2%
A3 M2	A <-> D	18. 5%	13. 3%	11. 0%	15. 3%	14. 5%

[A3 is Attribute 3, Physical Structure. M1 is Metric 1, Structural Patch Richness; and M2 is Metric Topographic Complexity. A = 12, B = 9, C = 6, and D = 3, are the CRAM scoring categories. WL is wetland and ID is identification.]

Attribute 3: Physical Structure

Attribute 3, (A3) physical structure, and metric 1 (M1), structural patch richness, SA results was a range of percent difference in the overall CRAM score of 3. 3 % - 11. 6%. The CRAM Riverine Field Manuel provides a reference table with a list of structural patch types for both riverine wetland subclasses, the confined channel and, the unconfined channel. The CRAM practitioner counts the patch type as present in the assessment area if it is a minimum of 3 square meters. A3, M1 is most likely to be incorrectly scored when the CRAM practitioner misidentifies the patch type by five or more for an unconfined riverine wetland or seven or more features in a confined channel.

A3, metric 2 (M2), topographic complexity, is most sensitive when there is no microtopography present or when benches are misidentified. The range of percent difference in CRAM score is 3.5 % - 18.5%. The 18.5% change in score occurred with the low scoring wetland on M2 when the alpha unit was scored as an A when it should have been a D, or vice versa.

Table 5.6 Sensitivity Analysis Percent Score Change - Attribute 4 Biotic Structure.

Attribute / Metric / Submetric		Low CRAM Score: 48	Mid CRAM Score: 70	High CRAM Score: 89	Hypothetical Score: 65	Mean
A4 M1 (SM-A)	A <-> B	1. 4%	1. 0%	0. 8%	1. 1%	1. 1%
A4 M1 (SM-A)	B <-> C	1. 4%	1. 0%	0. 7%	1. 1%	1. 1%
A4 M1 (SM-A)	C <-> D	1. 4%	1. 0%	0. 8%	1. 1%	1. 1%
A4 M1 (SM-A)	A <-> C	2. 8%	2. 0%	1. 5%	2. 1%	2. 1%
A4 M1 (SM-A)	B <-> D	2. 8%	2. 0%	1. 5%	2. 2%	2. 1%
A4 M1 (SM-B)	A <-> B	1. 4%	1. 0%	0. 8%	0. 9%	1. 0%
A4 M1 (SM-B)	B <-> C	1. 4%	1. 0%	0. 7%	1. 1%	1. 0%
A4 M1 (SM-B)	C <-> D	1. 4%	1. 0%	0. 8%	1. 1%	1. 1%
A4 M1 (SM-B)	A <-> C	2. 8%	2. 0%	1. 5%	2. 0%	2. 1%
A4 M1 (SM-B)	B <-> D	2. 8%	2. 0%	1. 5%	2. 1%	2. 1%
A4 M1 (SM-C)	A <-> B	1. 4%	1. 0%	0. 8%	1. 1%	1. 1%
A4 M1 (SM-C)	B <-> C	1. 5%	1. 0%	0. 7%	1. 1%	1. 1%
A4 M1 (SM-C)	C <-> D	1. 5%	1. 0%	0. 8%	1. 1%	1. 1%
A4 M2	A <-> B	4. 0%	3. 0%	2. 3%	3. 1%	3. 1%
A4 M2	B <-> C	4. 2%	3. 1%	2. 4%	3. 0%	3. 2%
A4 M2	C <-> D	4. 4%	3. 2%	2. 5%	3. 3%	3. 3%
A4 M3	A <-> B	4. 0%	3. 0%	2. 3%	3. 0%	3. 1%
A4 M3	B <-> C	4. 2%	3. 1%	2. 4%	3. 3%	3. 2%
A4 M3	C <-> D	4. 4%	3. 2%	2. 5%	3. 4%	3. 4%

[A4 is Attribute 4, Biotic Structure. M1 is Metric 1, Plant Community Composition; (SM-A) is Submetric A – Number of Plant Layers; (SM-B) is Submetric B – Number of Co-dominate species; and (SM-C) is Submetric C – Percent Invasion (of invasive plants). M2 is Metric 2, Horizontal Interspersion; and M3 is Metric 3, Vertical Structure. A = 12, B = 9, C = 6, and D = 3, are the CRAM scoring categories. WL is wetland and ID is identification.]

Attribute 4: Biotic Structure

Metric 1, (M1) of Attribute 4 (A4) is the plant community composition. There are three submetrics within M1: (SM-A), number of plant layers; (SM-B), number of co-dominate species; and (SM-C), the percent of invasive plant species. Each of the submetrics work in concert, and the metric score is derived by averaging the three scores of the submetrics. Therefore, when the SA model is run the results for the three different submetrics are the same. While the sensitivity score is the same for all three submetrics, if the plant layer metric is missed the co-dominate layer will also be missed and the percent invasion will be unreliable. The range of percent difference in overall CRAM score is 0.9 - 2.8 %. Attribute 4, M2, horizontal interspersion, and A4, M3, vertical biotic structure had results with sensitivity score results that were identical when within the same scenarios in the SA model. To determine the score of these two metrics the practitioner must use best professional judgment. The horizontal interspersion metric uses patches of relatively constant species to determine the score. Higher scores are obtained with higher diversity of patch types that occur within the AA. The CRAM riverine manual uses a schematic for the practitioner to reference and the categories to score are qualitative in relation to the schematic. Therefore, it is reasonable to assume that the A4, M2 could be only missed by one or two categories. A4, M3, Vertical Biotic Structure, captures the degree of overlap between plant heights and uses a schematic for reference. The practitioner must determine the percentage of overlap.

All three of the test wetlands had results on the categorical SA with a relatively small percentage of difference in the overall CRAM score. The range of percent difference for all three of the test wetlands was 2.3 % - 4.4 %.

Overall comparison of percentages

Table 5.7 includes the average percentage change of the three test riverine wetlands and the hypothetical model for those scenarios that effect an average change in the CRAM score of 5% or higher. Attributes A1, A2, and A3 all have scenarios with an average percent of 5% or higher, but all of the SA scenarios in A4 are below the 5% threshold. The table is sorted by percentage change based on high to low scores. Of the 12 SA scenarios, two have a three-unit separation, eight have a two-unit separation, and two have a one-unit separation. Each of the three attributes have at least two scenarios with a two-unit separation between the alpha categories.

Table 5.7 Sensitivity analysis mean results of 5% or more for test wetlands and hypothetical wetland. [cont.]

Attribute / Metric / Submetric	Sensitivity Analysis CRAM Score Scenario	Average of Sensitivity Analysis Results	When Specifically Could This Happen?
A3 M2 Physical Structure/Topographic Complexity	A <-> D	14. 5%	The most likely scenario is when there is no microtopography and benches are misidentified.
A1 M1 (D) Buffer and Landscape Context/Stream Corridor Continuity	B <-> D	9. 9%	This metric extends the assessment area (Turner et al.) 500 feet both upstream and downstream. The most likely case for error is when one AA extension is < 100 feet and the other side is very close to 200 feet.
A2 M3 Hydrology/Hydrologic Connectivity	A <-> D	9. 8%	This is likely to occur when the bankfull stage is misidentified. This could happen when a channel is very entrenched and bankfull cannot be identified.
A1 M1 (D) Buffer and Landscape Context/Stream Corridor Continuity	A <-> C	9. 3%	This metric extends the assessment area (Turner et al.) 500 feet both upstream and downstream. The most likely case for error is when one AA extension is < 100 feet and the other side is very close to 200 feet.

Table 5.7 Sensitivity analysis mean results of 5% or more for test wetlands and hypothetical wetland.

A3 M2 Physical Structure/Topographic Complexity	B <-> D	9. 2%	This could occur when there is no microtopography and benches are misidentified.
A3 M1 Physical Structure/Structural Patch Richness	B <-> D	9. 0%	This could occur when the practitioner misidentifies 5 or more features for the confined subclass and 7 or more features in the unconfined subclass.
A3/M2 Physical Structure/Topographic Complexity	B <-> D	8. 8%	This could occur when there is no microtopography and benches are misidentified.
A3 M1 Physical Structure/Structural Patch Richness	A <-> C	8. 6%	This could occur when the practitioner misidentifies 5 or more features for the confined subclass and 7 or more features in the unconfined subclass.
A2 M3 Hydrology/Hydrologic Connectivity	B <-> D	6. 3%	This is likely to occur when the bankfull stage is misidentified.
A2 M3 Hydrology/Hydrologic Connectivity	A <-> C	6. 1%	This is likely to occur when the bankfull stage is misidentified.
A1 M1 (D) Buffer and Landscape Context/Stream Corridor Continuity	C <-> D	5. 2%	This metric extends the assessment area (Turner et al.) 500 feet both upstream and downstream. The most likely case for error is when one AA extension is < 100 feet and the other side is very close to 200 feet.
A1 M1 (D) Buffer and Landscape Context/Stream Corridor Continuity	B <-> C	5. 0%	This metric extends the assessment area (Turner et al.) 500 feet both upstream and downstream. The most likely case for error is when one AA extension is < 100 feet and the other side is very close to 200 feet.

[CRAM is the acronym for California Rapid Assessment Method; CRAM Scores: A = 12, B = 9, C = 6, and D = 3]

Discussion and Recommendation

A categorical SA model has been used to test the CRAM metric score categories for their sensitivity to impact in the overall CRAM score. The categorical SA was designed to utilize the qualitative alpha-units in the CRAM scoring system to capture the most sensitive break-points in the quantitative scale that corresponds to the CRAM alpha-units.

An important finding was the riverine wetlands with the most ecological disturbance and lower CRAM scores had a higher percentage of impact to the overall CRAM score if an alpha category was erroneously applied to the metric. We expected to find a high percentage of sensitivity in the hydrological connectivity metric due to the difficulty in accurately identifying bankfull stage in stream channels that are highly incised. This was verified in the categorical SA model. Both metrics in the physical structure attribute had the highest average for percentages of sensitivity, thus, having the greatest degree of impact to the overall CRAM score. The stream corridor continuity metric in the buffer and landscape context attribute had the most categories within the SA scenarios with a sensitivity percentage over 5%. Finally, the hydrological connectivity metric was sensitive to the categorical SA. This metric measures the entrenchment ratio which necessitates obtaining an accurate bankfull stage, which is difficult to identify in incised channels. A recommendation is to use regional curve data which will provide the practitioner with an indication of the height of the bankfull stage.

The categorical sensitivity analysis demonstrated the utility of analyzing the CRAM metrics and attributes. By quantitatively determining the break-points in the categories that where the largest percentage of change occurs we can determine which metrics will have the largest degree of impact on the overall CRAM score if the metric is incorrectly evaluated.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Wetlands are an important resource and various entities have pursued strategies to protect them. Many Native American tribes are currently developing their own wetland programs. This thesis discusses the justification of all tribes to develop wetland programs and uses the MCN as a case study. Rapid assessment method (RAM) for wetlands has been shown to be an important component of wetland protection programs in other parts of the United States. However, Oklahoma has not developed a RAM that is customized for the ecoregions in the state. This hinders tribes and other entities in Oklahoma in the development of their wetland protection programs. The California Rapid Assessment Method (CRAM), a Level 2 RAM, was used to assess 21 riverine wetlands in East-Central Oklahoma within tribal boundaries of the MCN. Additionally, a broader assessment, a Level 1, was used with GIS to place buffers of three different scales around the wetland to document the percentage of land-use type within the buffer. The percentage of land-use type at each scale was compared to the CRAM metric scores, showing correlations to some land-use types at smaller scales. Finally, a categorical sensitivity analysis was completed to test the sensitivity of the CRAM metrics. The twelve scenarios where the average degree of sensitivity on the overall CRAM score was greater than 5% are highlighted. These results can be referenced by CRAM practitioners to know those situations where the metrics are most sensitive to measurement error.

In Chapter II, evidence was presented to support the justification and need for the development of a tribal wetland program based on three major arguments: 1) Cultural aspects; 2) Tribal sovereignty; and 3) Government-to-government consultation. The need and justification of a tribal wetland program provided the basis and driver for the remainder of the work conducted. This thesis used the California Rapid Assessment Method (CRAM), a Level 2 method, to assess ecological condition of 21 riverine wetlands in the East-central region of Oklahoma. Based upon the conclusions of multiple regression analysis of land-use percentage compared to the CRAM scores and, a categorical sensitivity analysis conducted on three of the 21 riverine wetlands, several recommendations can be made.

Multiple regression analyses of the percentage of land-use type within specified buffers for 21 riverine wetlands revealed a significant correlation between CRAM scores and two of the land-use types—urban/suburban and forests—especially at the smaller 100-m scale. There was an inverse correlation between the overall CRAM score and the urban/suburban land-use type at the 100-m and 1000-m scale. This indicates that the CRAM score will be lower with a higher percentage of urban land-use within the buffer. Conversely, there was a positive correlation between the forest land-use and the overall CRAM score within the 100-m buffer. This indicates that the CRAM score will be lower with a higher percentage of urban land-use within the scale. Multiple regressions were also applied to each of the four attributes in CRAM. Only two of the four attributes, the Landscape and Buffer Context, and the Biotic Structure attributes showed any correlation to the percentage of land-use within the buffers. These results are in line with what is generally expected given the concept that ecological condition will be negatively correlated with the higher the extent of human disturbance. There were no strong relationships at the basin scale for the overall CRAM score or for each of the attributes.

A categorical sensitivity analysis was applied to the each of the CRAM attributes for three of the 21 wetlands. Each of the three wetlands had a CRAM score in a different range. Of the three wetlands, one was a low score, (48), one was a mid-range score (70) and one was a high score (89). The highest degree of sensitivity was the low scoring wetland and it also had more metrics with higher sensitivity. This is useful information for CRAM practitioners since it indicates the wetlands that are the most challenging to correctly score are also the wetlands that will most significantly impact the overall CRAM score if a category is incorrectly scored.

CRAM is not validated for use on Oklahoma riverine wetlands. This is one limitation to the results of this study. Level 3 assessments are needed to validate CRAM for the East-central region of Oklahoma, but that would entail collecting data that measures wetland functional condition. That is beyond the scope and resources of this study. There are a number of approaches that could be utilized for a Level 3 assessment.

Studies that collect measurable data on hydrology or index of biological integrity for plants or animals are typical for Level 3 assessments. The sub-classifications used for CRAM riverine wetlands are broad. The CRAM sub-classes are either confined or unconfined for riverine wetlands. It is recommended that refinement for a set of sub-classifications of riverine wetlands specific to the East-central Oklahoma region be conducted before testing CRAM methodology for efficacy in East-central Oklahoma.

The categorical sensitivity analysis, on the other hand, is a useful tool regardless of where the CRAM assessment was conducted. The attributes that were most sensitive to category score error affecting the overall CRAM score was attribute 2 and 3; hydrology and physical structure, respectively. The hydrological connectivity metric was sensitive. This is the metric that measures entrenchment ratio. In channels where the disturbance has caused significant channel incisement it will be difficult to accurately determine bankfull stage. A recommendation is to use regional curve data which will provide the practitioner with an indication of where to expect to find the bankfull stage.

This study was conducted for the Muscogee Creek Nation Tribe in Oklahoma. Tribes develop programs for natural resource management that is separate from state programs because they of tribe’s sovereign status. This sovereignty provides them the authority to assume responsibility for their natural resources over tribal land. One problem that tribes encounter is they generally have a small pool of staff and much lower funds available to manage programs. It is recommended that while the tribe is in the development phase of a wetland program that they consider collaboration with universities. A university will have a wide variety of expertise to draw upon and graduate students who may need a project. This will increase the chance that the tribe is utilizing appropriate methods for their assessment needs. Such an approach is beneficial to both entities. The tribe gains information and develops skills to manage their programs, and the university also gains information with this type of collaboration.

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APPENDICES

APPENDIX A

SITE PICTURES

SITE PICTURES

Appendix A, Figure 1, Sensitivity Analysis High Score Wetland CRAM Score: 89

Appendix A, Figure 2 Sensitivity Analysis High Score Wetland CRAM Score: 89

Appendix A, Figure 3, Sensitivity Analysis Moderately Scored Wetland CRAM Score: 70

Appendix A, Figure 4, Sensitivity Analysis Moderately Scored Wetland CRAM Score: 70

Appendix A, Figure 5, Sensitivity Analysis Low Scored Wetland CRAM Score: 48

APPENDIX B

RESULTS FOR LEVEL 1 ASSESSMENT: LAND-USE PERCENTAGE WITH CALIFORNIA RAPID ASSESSMENT METHOD (CRAM) SCORE

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
884	Cropland/Pasture	100	92	96	82
	Orchards, Groves		3		
	Deciduous forest		4	4	
893	Industrial			1	75
	Cropland and Pasture	56	71	57	
	Orchards, Groves	1	5	0. 5	
	Deciduous forest	42	20	42	
	Reservoirs		4	0. 5	
907	Cropland and Pasture	36	79	68	79
	Deciduous forest	64	21	32	
908	Cropland and Pasture	100	69	66	74
	Orchards, Groves			1	
	Deciduous forest		29	32	
	Reservoirs			1	

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
2021	Residential	4	23	13	76
	Commercial and Industry		3	3	
	Transportation			4	
	Other Urban or build-up			3	
	Cropland/Pasture	61	34	48	
	Deciduous forest		7	24	
	Mixed forest		11	1	
	Strip mines, quarries	35	22	4	
2157	Residential		2		89
	Transportation			2	
	Cropland/Pasture	7	23	2	
	Confined feeding operation			1	
	Deciduous Forest	84	74	95	

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
2179	Residential	0	24	5	48
	Commercial & Services	88	15	4	
	Industrial	2	21		
	Transportation			2	
	Other Urban or build-up		6	1	
	Cropland/Pasture	10	27	85	
	Deciduous forest		3	3	
	Reservoirs		2	1	
2235	Residential		2		73
	Commercial and Industry		15	2	
	Transportation		3	2	
	Cropland/Pasture	8	62	91	
	Deciduous Forest	91	14	4	
	Reservoirs	1	2	1	

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
2283	Residential		20		63
	Commercial and Industry		8	10	
	Transportation			4	
	Other Urban or build-up		1		
	Cropland and Pasture	100	59	86	
	Deciduous forest		11		
	Reservoirs		3		
2635	Cropland/Pasture	7	29	74	90
	Deciduous forest	93	71	26	
3202	Transportation		6		82
	Cropland and Pasture	49	64	55	
	Deciduous Forest	51	30	45	
	Residential		14	1	
	Commercial and Industry		2		
	Transportation			1	
	Cropland and Pasture	100	82	58	
	Deciduous forest		2	40	

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
3238	Cropland and Pasture	12	72	80	64
	Deciduous forest	88	14	13	
	Streams and canals		7		
	Forested wetland			1	
	Non-forested wetlands		0. 5	6	
3262	Cropland and Pasture	31		80	70
	Deciduous Forest	49		13	
	Mixed forest		2		
	Streams and canals		8		
	Forested wetland		8	1	
	Non-forested wetland	20	14	6	
	Sandy areas other than beach		13		

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
3264	Cropland and Pasture	8	16	80	73
	Deciduous Forest		19	13	
	Mixed forest		5		
	Streams and canals		9		
	Forested wetland	21	14	1	
	Non-forested wetland	71	28	6	
	Sandy areas other than beach		9		
3267	Cropland and Pasture	9	34	80	82
	Deciduous Forest	16	13	13	
	Mixed forest		2		
	Streams and canals		9		
	Forested wetland		10	1	
	Non-forested wetland	70	18	6	
	Sandy areas other than beach		14		

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
3273	Cropland and Pasture	6	28	92	89
	Deciduous Forest	13	12	8	
	Mixed forest		11		
	Streams and canals		10		
	Forested wetland		10		
	Non-forested wetland	52	20		
	Sandy areas other than beach	29	11		
3292	Cropland and Pasture	50	84	81	82
	Deciduous Forest	50	14	19	
	Streams and canals		2		
3300	Cropland and Pasture		19		71
	Deciduous forest		7		
	Mixed forest		26		
	Streams and Canals	18	11	2	
	Forested wetland	52	6		
	Non-forested wetland		16	97	
	Sandy areas other than beach	30	15	1	

Appendix B, Table 1 Percentage Land-use with CRAM Score

Percentage Land-use and California Rapid Assessment Method (CRAM) Score. [ID is the acronym for identification; m is the abbreviation for meter. CRAM is the acronym for California Rapid Assessment Method] (cont.)

Wetland ID	Land-use	Land-use Percentage 100 m	Land-use Percentage 1000 m	Land-use Percentage of Basin	CRAM Score
3304	Cropland and Pasture		18		77
	Deciduous forest		7		
	Mixed forest	4	27		
	Streams and Canals	26	10	3	
	Forested wetland	54	6	97	
	Non-forested wetland		14		
	Sandy areas not Beach	16	10		
9999	Transportation		3		68
	Other Agricultural land	10	3		
	Cropland and Pasture	90	82	78	
	Deciduous forest		12	22	

Appendix B, Table 2 Wetland Basin and HUC 8 Drainage Area in Sq km

Percentage land-use type in wetland basin by square kilometers and drainage area of hydrological unit code 8 in square kilometers. [ID is the acronym for identification; sq km is the abbreviation for square kilometer; and HUC is the acronym for hydrological unit code.] (cont.)

Wetland ID	LAND-USE	Land-use Percent	Wetland Basin Sq km	Land-use Type Sq km	HUC 8 ID	HUC 8 Name	HUC 8 Drainage Sq km
884	Cropland and pasture	96	6	6	11100302	Lower North Canadian	3425
884	Deciduous forest	4	6	0. 23			
893	Industrial	1	47	0. 30	11100302	Lower North Canadian	3425
893	Mixed urban	0. 11	47	0. 05			
893	Cropland and pasture	57	47	26			
893	Orchards, groves	0. 49	47	0. 23			
893	Deciduous forest	42	47	19			
893	Reservoirs	0. 48	47	0. 22			
907	Industrial	0. 4	75	0. 30	11100302	Lower North Canadian	3425
907	Mixed urban	0. 1	75	0. 05			
907	Cropland and pasture	67. 7	75	2			
907	Orchards, groves	0. 3	75	0. 23			
907	Other agricultural	0. 1	75	0. 11			
907	Deciduous forest	31. 8	75	0. 13			
907	Reservoirs	0. 6	75	0. 19			
908	Mixed urban	0. 07	72	0. 05	11100302	Lower North Canadian	3425
908	Cropland and pasture	66	72	15			
908	Orchards, groves	0. 32	72	0. 23			
908	Deciduous forest	32. 46	72	23			
908	Reservoirs	0. 58	72	0. 41			

Appendix B, Table 2 Wetland Basin and HUC 8 Drainage Area in Sq km

Percentage land-use type in wetland basin by square kilometers and drainage area of hydrological unit code 8 in square kilometers. [ID is the acronym for identification; sq km is the abbreviation for square kilometer; and HUC is the acronym for hydrological unit code.] (cont.)

Wetland ID	LAND-USE	Land-use Percent	Wetland Basin Sq km	Land-use Type Sq km	HUC 8 ID	HUC 8 Name	HUC 8 Drainage Sq km
2021	Residential	13. 00	60	8	11100303	Deep Fork	6570
2021	Commercial and Industry	3	60	2			
2021	Transportation	4	60	2			
2021	Mixed urban	0. 33	60	0. 20			
2021	Other urban or built-up land	2. 00	60	1			
2021	Cropland and pasture	48	60	29			
2021	Deciduous forest	24	60	15			
2021	Mixed forest land	1	60	1			
2021	Reservoirs	0. 32	60	0. 19			
2021	Strip mines, quarries	3. 74	60	2			
2157	Deciduous forest	100	1	1	11100303	Deep Fork	6570
2179	Residential	5	41	2	11100303	Deep Fork	6570
2179	Commercial and Industry	4	41	2			
2179	Industrial	0. 10	41	0. 04			
2179	Transportation	2	41	1			
2179	Other urban or built-up land	1	41	0. 23			
2179	Cropland and pasture	85	41	35			
2179	Confined feeding operations	1	41	0. 45			
2179	Deciduous forest	3. 18	41	0. 03			
2179	Reservoirs	1. 26	41	0. 48			
2235	Residential	0. 25	33	0. 08	11100303	Deep Fork	6570
2235	Commercial and Industry	0. 12	33	0. 04			
2235	Transportation	2	33	1			
2235	Cropland and pasture	91	33	30			
2235	Confined feeding operations	1	33	0. 45			
2235	Deciduous forest	4. 12	33	1			
2235	Reservoirs	1	33	0. 37			
2283	Residential	10	3	0. 34	11100303	Deep Fork	6570
2283	Commercial and Industry	4	3	0. 15			
2283	Cropland and pasture	86	3	3			
2635	Cropland and pasture	74	0	0. 16	11100303	Deep Fork	6570
2635	Deciduous forest	26	0	0. 06			

Appendix B, Table 2 Wetland Basin and HUC 8 Drainage Area in Sq km

Percentage land-use type in wetland basin by square kilometers and drainage area of hydrological unit code 8 in square kilometers. [ID is the acronym for identification; sq km is the abbreviation for square kilometer; and HUC is the acronym for hydrological unit code.] (cont.)

Wetland ID	LAND-USE	Land-use Percent	Wetland Basin Sq km	Land-use Type Sq km	HUC 8 ID	HUC 8 Name	HUC 8 Drainage Sq km
3202	Cropland and pasture	55	2	1	11090204	Lower Canadian	5131
3202	Deciduous forest	45	2	1			
3232	Residential	1. 02	86	1	11090204	Lower Canadian	5131
3232	Commercial and Industry	0. 07	86	0. 06			
3232	Transportation	1	86	1			
3232	Cropland and pasture	58	86	50			
3232	Deciduous forest	39. 91	86	35			
3232	Reservoirs	0. 16	86	0. 13			
3238	Cropland and pasture	100	2	2	11090204	Lower Canadian	5131
3238	Deciduous forest	0. 03	2	0			
3262	Cropland and pasture	80	7	6	11090204	Lower Canadian	5131
3262	Deciduous forest	13	7	1			
3262	Forested wetland	1	7	0. 06			
3262	Non-forested wetland	6	7	0. 40			
3262	Sandy areas other than beach	0. 15	7	0			
3264	Cropland and pasture	80	7	6	11090204	Lower Canadian	5131
3264	Deciduous forest	13	7	1			
3264	Forested wetland	1	7	0. 06			
3264	Non-forested wetland	6	7	0. 40			
3264	Sandy areas other than beach	0. 15	7	0. 01			
3267	Cropland and pasture	80	7	6	11090204	Lower Canadian	5131
3267	Deciduous forest	13	7	1			
3267	Forested wetland	1	7	0. 06			
3267	Non-forested wetland	6	7	0. 40			
3267	Sandy areas other than beach	0. 15	7	0. 01			

Appendix B, Table 2 Wetland Basin and HUC 8 Drainage Area in Sq km

Percentage land-use type in wetland basin by square kilometers and drainage area of hydrological unit code 8 in square kilometers. [ID is the acronym for identification; sq km is the abbreviation for square kilometer; and HUC is the acronym for hydrological unit code.] (cont.)

Wetland ID	LAND-USE	Land-use Percent	Wetland Basin Sq km	Land-use Type Sq km	HUC 8 ID	HUC 8 Name	HUC 8 Drainage Sq km
3273	Cropland and pasture	92	4	4	11090204	Lower Canadian	5131
3273	Deciduous forest	8	4	4			
3292	Cropland and pasture	81	1	0. 42	11090204	Lower Canadian	5131
3292	Deciduous forest	19	1	0. 10			
3300	Non-forested wetland	98	0	0. 18	11090204	Lower Canadian	5131
3300	Sandy areas other than beach	2	0	0			
3304	Streams and Canals	3			11090204	Lower Canadian	5131
3304	Forested Wetlands	97					
9999	Residential	0. 2	16	0. 03			
9999	Cropland and pasture	78	16	12			
9999	Other agricultural	0. 22	16	0. 03			
9999	Deciduous forest	22	16	3			

APPENDIX C

CALIFORINA RAPID ASSESSMENT METHOD (CRAM)

RESULTS

Appendix C, Figure 1, Assessment Site 884, Hughes County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

884_Hughes County				
CRAM Score 82				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		27	**(Raw Score/36) *100**	**75.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	B	9		
Raw Attribute Score:		15	**(Raw Score/24) *100**	**62.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		11		
Submetric 4: Horizontal Interspersion	B	9		
Submetric 5: Vertical Structure	A	12		
		32	**(Raw Score/36) *100**	**88.9**
Overall AA Score (avg of four final Attribute Scores)				**82**

Appendix C, Figure 2, Assessment Site 893, Hughes County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

893_Hughes County				
CRAM Score 75				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	D	3		
Raw Attribute Score:		21	**(Raw Score/36) *100**	**58.3**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	B	9		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		12	**(Raw Score/24) *100**	**50**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	B	9		
		33	**(Raw Score/36) *100**	**91.7**
Overall AA Score (avg of four final Attribute Scores)				**75.0**

Appendix C, Figure 3, Assessment Site 907, Hughes County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

907_Hughes County				
CRAM Score 79				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		27	**(Raw Score/36) *100**	**75.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	B	9		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		12	**(Raw Score/24) *100**	**50**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	B	9		
		33	**(Raw Score/36) *100**	**91.7**
Overall AA Score (avg of four final Attribute Scores)				**79**

Appendix C, Figure 4, Assessment Site 908, Hughes County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

908_Hughes County				
CRAM Score 74				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	B	9		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		23.2	**(Raw Score/24) *100**	**96.5**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	D	3		
Raw Attribute Score:		21	**(Raw Score/36) *100**	**58.3**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	B	9		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		12	**(Raw Score/24) *100**	**50**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	B	9		
		33	**(Raw Score/36) *100**	**91.7**
Overall AA Score (avg of four final Attribute Scores)				**74**

Appendix C, Figure 5, Assessment Site 2012, Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2021_Okmulgee County				
CRAM Score 76				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	C	6		
Submetric C: Buffer Condition	B	9		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		20.7	**(Raw Score/24) *100**	**86.4**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	C	6		
Raw Attribute Score:		21	**(Raw Score/36) *100**	**58.3**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	B	9		
Submetric 2: Complexity	B	9		
Raw Attribute Score:		18	**(Raw Score/24) *100**	**75**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	B	9		
Plant Community Composite Metric ***(numeric avg of submetrics)***		10		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	B	9		
		31	**(Raw Score/36) *100**	**86.1**
Overall AA Score (avg of four final Attribute Scores)				**76**

Appendix C, Figure 6, Assessment Site 2157 Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2157_Okmulgee County				
Cram Score 89				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	A	12		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		33	**(Raw Score/36) *100**	**91.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	B	9		
Raw Attribute Score:		15	**(Raw Score/24) *100**	**62.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**89**

Appendix C, Figure 7, Assessment Site 2179 Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2179_Okmulgee County				
CRAM Score 48				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	B	9		
Submetric A: Percent AA with Buffer	C	6		
Submetric B: Average Buffer Width of AA	D	3		
Submetric C: Buffer Condition	D	3		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		12.6	**(Raw Score/24) *100**	**52.4**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		6	**(Raw Score/24) *100**	**25**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	D	3		
Submetric 2: Number of Co-dominant species	D	3		
Submetric 3: Percent invasion	B	9		
Plant Community Composite Metric ***(numeric avg of submetrics)***		5		
Submetric 4: Horizontal Interspersion	C	6		
Submetric 5: Vertical Structure	C	6		
		17	**(Raw Score/36) *100**	**47.2**
Overall AA Score (avg of four final Attribute Scores)				**48**

Appendix C, Figure 8, Assessment Site 2235 Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2235_Okmulgee County				
CRAM Score 73				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	B	9		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		23.2	**(Raw Score/24) *100**	**96.5**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	C	6		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		21	**(Raw Score/36) *100**	**58.3**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		12	**(Raw Score/24) *100**	**50**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		10		
Submetric 4: Horizontal Interspersion	B	9		
Submetric 5: Vertical Structure	A	12		
		31	**(Raw Score/36) *100**	**86.1**
Overall AA Score (avg of four final Attribute Scores)				**73**

Appendix C, Figure 9, Assessment Site 2283 Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2283_Okmulgee County				
CRAM Score 63				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	C	6		
Submetric C: Buffer Condition	B	9		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		20.7	**(Raw Score/24) *100**	**86.4**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	C	6		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		21	**(Raw Score/36) *100**	**58.3**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		12	**(Raw Score/24) *100**	**50**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	B	9		
Plant Community Composite Metric ***(numeric avg of submetrics)***		9		
Submetric 4: Horizontal Interspersion	C	6		
Submetric 5: Vertical Structure	C	6		
		21	**(Raw Score/36) *100**	**58.3**
Overall AA Score (avg of four final Attribute Scores)				**63**

Appendix C, Figure 10, Assessment Site 2635 Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2635_Okmulgee County				
CRAM Score 90				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	B	9		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		23.2	**(Raw Score/24) *100**	**96.5**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	A	12		
Submetric 3: Connectivity	A	12		
Raw Attribute Score:		36	**(Raw Score/36) *100**	**100.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	B	9		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		15	**(Raw Score/24) *100**	**62.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**90**

Appendix C, Figure 11, Assessment Site 3201 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3202_McIntosh County				
CRAM Score 82				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	B	9		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		21.0	**(Raw Score/24) *100**	**87.5**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	C	6		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	B	9		
Submetric 2: Complexity	B	9		
Raw Attribute Score:		18	**(Raw Score/24) *100**	**75**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**82**

Appendix C, Figure 12, Assessment Site 3232 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3232_McIntosh County				
CRAM Score 63				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	C	6		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		20.5	**(Raw Score/24) *100**	**85.4**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		27	**(Raw Score/36) *100**	**75.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		9	**(Raw Score/24) *100**	**37.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	C	3		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		8		
Submetric 4: Horizontal Interspersion	C	6		
Submetric 5: Vertical Structure	C	6		
		20	**(Raw Score/36) *100**	**55.6**
Overall AA Score (avg of four final Attribute Scores)				**63**

Appendix C, Figure 13, Assessment Site 3238 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3238_McIntosh County				
CRAM Score 70				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	C	6		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		22.1	**(Raw Score/24) *100**	**92.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	D	3		
Raw Attribute Score:		18	**(Raw Score/36) *100**	**50.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		9	**(Raw Score/24) *100**	**37.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**70**

Appendix C, Figure 14, Assessment Site 3232 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3232_McIntosh County				
CRAM Score 73				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		30	**(Raw Score/36) *100**	**83.3**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		9	**(Raw Score/24) *100**	**37.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		10		
Submetric 4: Horizontal Interspersion	C	6		
Submetric 5: Vertical Structure	B	9		
		25	**(Raw Score/36) *100**	**69.4**
Overall AA Score (avg of four final Attribute Scores)				**73**

Appendix C, Figure 15, Assessment Site 3264 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3264_McIntosh County				
CRAM Score 69				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	D	3		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		6	**(Raw Score/24) *100**	**25**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		10		
Submetric 4: Horizontal Interspersion	B	9		
Submetric 5: Vertical Structure	A	12		
		31	**(Raw Score/36) *100**	**86.1**
Overall AA Score (avg of four final Attribute Scores)				**69**

Appendix C, Figure 16, Assessment Site 3267 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3267_McIntosh County				
CRAM Score 82				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	C	6		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	A	12		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		15	**(Raw Score/24) *100**	**62.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**82**

Appendix C, Figure 17, Assessment Site 3273 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3273_McIntosh County				
CRAM Score 89				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	A	12		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		33	**(Raw Score/36) *100**	**91.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	B	9		
Raw Attribute Score:		15	**(Raw Score/24) *100**	**62.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**89**

Appendix C, Figure 18, Assessment Site 3292 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3292_McIntosh County				
CRAM Score 82				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	D	3		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		20.5	**(Raw Score/24) *100**	**85.4**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	A	12		
Raw Attribute Score:		27	**(Raw Score/36) *100**	**75.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	A	12		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		18	**(Raw Score/24) *100**	**75**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	B	9		
Submetric 5: Vertical Structure	A	12		
		33	**(Raw Score/36) *100**	**91.7**
Overall AA Score (avg of four final Attribute Scores)				**82**

Appendix C, Figure 19, Assessment Site 3300 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3300_McIntosh County				
CRAM Score 71				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	C	6		
Submetric 3: Connectivity	C	6		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		6	**(Raw Score/24) *100**	**25**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	B	9		
Submetric 5: Vertical Structure	A	12		
		33	**(Raw Score/36) *100**	**91.7**
Overall AA Score (avg of four final Attribute Scores)				**71**

Appendix C, Figure 20, Assessment Site 3304 McIntosh County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3304_McIntosh County				
CRAM Score 77				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	C	6		
Raw Attribute Score:		27	**(Raw Score/36) *100**	**75.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		9	**(Raw Score/24) *100**	**37.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	B	9		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		10		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		34	**(Raw Score/36) *100**	**94.4**
Overall AA Score (avg of four final Attribute Scores)				**77**

Appendix C, Figure 21, Assessment Site 9999 Okmulgee County

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

9999_Okmulgee County				
CRAM Score 68				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	B	9		
Submetric C: Buffer Condition	C	6		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		19.9	**(Raw Score/24) *100**	**82.9**
Attribute 2: Hydrology				
Submetric 1: Water Source	B	9		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	C	6		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		12	**(Raw Score/24) *100**	**50**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	B	9		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric ***(numeric avg of submetrics)***		11		
Submetric 4: Horizontal Interspersion	C	6		
Submetric 5: Vertical Structure	B	9		
		26	**(Raw Score/36) *100**	**72.2**
Overall AA Score (avg of four final Attribute Scores)				**68**

APPENDIX D

CRAM RESULTS for CATEGORICAL SENSITIVITY ANALYSIS

Appendix D, Figure 1, Sensitivity Analysis CRAM High Score

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2157_DFN				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	A	12		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		24.0	**(Raw Score/24) *100**	**100.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	A	12		
Submetric 2: Stability	A	12		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		33	**(Raw Score/36) *100**	**91.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	C	6		
Submetric 2: Complexity	B	9		
Raw Attribute Score:		15	**(Raw Score/24) *100**	**62.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric (***numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**89**

Appendix D, Figure 2, Sensitivity Analysis CRAM Moderate Score

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

3238_HannaP				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	A	12		
Submetric A: Percent AA with Buffer	A	12		
Submetric B: Average Buffer Width of AA	C	6		
Submetric C: Buffer Condition	A	12		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		22.1	**(Raw Score/24) *100**	**92.0**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	D	3		
Raw Attribute Score:		18	**(Raw Score/36) *100**	**50.0**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	C	6		
Raw Attribute Score:		9	**(Raw Score/24) *100**	**37.5**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	A	12		
Submetric 2: Number of Co-dominant species	A	12		
Submetric 3: Percent invasion	A	12		
Plant Community Composite Metric (***numeric avg of submetrics)***		12		
Submetric 4: Horizontal Interspersion	A	12		
Submetric 5: Vertical Structure	A	12		
		36	**(Raw Score/36) *100**	**100.0**
Overall AA Score (avg of four final Attribute Scores)				**70**

Appendix D, Figure 3, Sensitivity Analysis CRAM Low Score

[CRAM is the acronym for California Rapid Assessment Method, AA is the acronym for assessment area, avg is the abbreviation for average.]

2179_OC				
	Alpha Score	**Numerical**		**Final Attribute Score**
Attribute 1: Buffer and Landscape Context				
Submetric D: Stream Corridor Continuity	B	9		
Submetric A: Percent AA with Buffer	C	6		
Submetric B: Average Buffer Width of AA	D	3		
Submetric C: Buffer Condition	D	3		
Formula to compute Raw Attribure Score:				
D +[C * (A * B) ^1/2] ^1/2				
12 + [6*(12*9)^1/2]^1/2 =		12.6	**(Raw Score/24) *100**	**52.4**
Attribute 2: Hydrology				
Submetric 1: Water Source	C	6		
Submetric 2: Stability	B	9		
Submetric 3: Connectivity	B	9		
Raw Attribute Score:		24	**(Raw Score/36) *100**	**66.7**
Attribute 3: Physical Structure				
Submetric 1: Structural Richness	D	3		
Submetric 2: Complexity	D	3		
Raw Attribute Score:		6	**(Raw Score/24) *100**	**25**
Attribute 4: Biotic Structure				
Submetric 1: Number of plant layers	D	3		
Submetric 2: Number of Co-dominant species	D	3		
Submetric 3: Percent invasion	B	9		
Plant Community Composite Metric (***numeric avg of submetrics)***		5		
Submetric 4: Horizontal Interspersion	C	6		
Submetric 5: Vertical Structure	C	6		
		17	**(Raw Score/36) *100**	**47.2**
Overall AA Score (avg of four final Attribute Scores)				**48**

VITA

Donna Yvette Wiley

Candidate for the Degree of

Master of Science

Thesis: INVESTIGATION OF RIVERINE WETLANDS WITHIN THE MUSCOGEE CREEK NATION IN OKLAHOMA UTILIZING THE CALIFORNIA RAPID ASSESSMENT METHOD (CRAM)

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Biographical:

Education:

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Experience:

- Demonstrated strength in grant writing for tribal water resource programs.
- Analyze and calculate data from stream monitoring programs.
- Experienced with writing reports related to stream monitoring.
- Experienced with the collection of field data related to streams and wetlands.
- Experienced with stream habitat assessments.
- Trained to conduct wetland delineation.
- Trained and experienced with the California Rapid Assessment Method for Riverine and Depressional Wetlands.

Professional Memberships: Society of Wetland Scientists