Exhibit 1

AFFIDAVIT OF VINCENT E. RANDALL

STATE OF ARIZONA)
) ss.
County of Yavapai)

VINCENT E. RANDALL, being first duly sworn, upon his oath deposes and says:

Background

1. I am an enrolled member of the Yavapai-Apache Nation (Nation) and presently serve as the *Dilzhé'e* Apache Culture Director for the Yavapai-Apache Nation of Camp Verde, Arizona.

2. I was born in Clarkdale, Arizona, and to this day, I live on the property where my mother built a house in 1911. I have lived all my life in the Verde River watershed which is my ancestral homeland. All of my life, I have listened to the oral histories of the *Dilzhé'e* Apache as told by my parents, my grandparents, my relations, and our *Dilzhé'e* Apache elders. I am a native *Dilzhé'e* Apache speaker and have extensively studied Apache linguistics.

3. I have a Bachelor's Degree in Education from Northern Arizona University and I was a school teacher at the Clarkdale-Jerome School from 1963-1992. I am an Apache historian and I am regularly used as a consultant with local, state and federal agencies regarding proposed projects and their potential to impact important *Dilzhé'e* Apache cultural, religious and historic sites, many of which are located near springs and rivers throughout Arizona. I am often an invited speaker at events throughout Arizona and the United States to talk about *Dilzhé'e* Apache history, culture and lifeways.

4. I have extensive knowledge of *Dilzhé'e* ethnobiology, particularly pertaining to important plant and animal species which have been relied upon by the *Dilzhé'e* Apache people for millennia.

5. I have served several terms as Tribal Chairman and as a Tribal Council Member of the Yavapai-Apache Nation from 1962 to present, and have served on the boards of several organizations, including the National Association for the Education of Young Children, the Association of American Indian Affairs, the Inter Tribal Council of Arizona, and the Working Group of Allied Apaches for the Native American Graves Protection and Repatriation Act. I am also a member of the Western Apache Coalition, a gathering of elders united in our efforts to maintain and protect Western Apache culture and lifeways.

6. As part of the Western Apache Coalition, I have worked with other tribal elders to map over 1,000 traditional Apache place names across Arizona, including names of places within the Verde Valley watershed. While working on this mapping project, the elders have shared their ancestral knowledge of the places where we visited, remembering how our families referred to these places, what they looked like, and their significance to us and to our Apache ancestors.

7. I was significantly involved in the work to decommission the Childs-Irving hydroelectric power plant and dam on Fossil Creek (a tributary to the Verde River) since it was no longer needed for generating power. Having the water finally return to freely flow though Fossil Creek when the plant was decommissioned in 2010 was a happy day for all *Dilzhé'e* Apaches.

8. Within the Yavapai-Apache Nation's Cultural Resources Department, I and several other staff members collect, review, analyze, and archive information about our Yavapai and Apache People and the history of our Nation. This information is collected from our own Yavapai and Apache people, including our Tribal elders, as well as from other sources, including, but not limited to, the National Archives and Records Administration, various federal, state and local agencies and museums, and from personal collections of people who have interacted with the Yavapai and Apache people over the years.

9. Over the decades, I have personally reviewed thousands upon thousands of written records about our People, many of which were created by the United States military and the United States Indian Service and the Bureau of Indian Affairs. I have reviewed written records beginning as early as the accounts of Spanish explorations in the late 1500's and early 1600's and continuing on until present day, including before and at the time of Arizona Statehood in 1912.

10. I have been told the oral history of the location of the first Apache siting of a Spaniard in our aboriginal territory, which was near Camp Verde at a bend in the Verde River. I have been told the oral history of when my great-grandmother saw her first white man just outside of Flagstaff in the 1850's when she described him as being light-skinned with blue eyes and he had a "box that walks" with him that was pulled by horses and he had some mean and scary looking things with horns. The "box that walks" was a covered wagon and the mean scary looking things were Texas long-horn cattle.

11. For years, I have met with the Nation's elders to talk about the history of our People, along with their and their families' recollections of past events and observations. The elders, including myself, also talk about culturally important matters, including concerns for the health of the Verde River and how the Verde River has been used in the past both by the Yavapai and Apache People, by other tribes, and by the non-Indian new comers to our aboriginal lands. In discussing these matters, they talk to me about their family histories and meaning of the Verde River to them.

Traditional Ecological Knowledge

12. The cultural wisdom and oral history of the *Dilzhé'e* Apache people is Traditional Ecological Knowledge (TEK) and has been widely considered and used in the realm of science to aid in the understanding of the world around all of us. *See* Rinkevich, S. (2012). *Traditional Ecological Knowledge, Endangered Species, and Conservation Biology: A Review, attached as Appendix E to An Assessment of Abundance, Diet, and Cultural Significance of Mexican Gray Wolves in Arizona* (Doctoral Dissertation). University of Arizona, Tucson, attached here as **Exhibit C**.

13. TEK refers to the knowledge base acquired by indigenous and local peoples over many hundreds of years through direct contact with the environment. It is based in the ways of life, belief systems, perceptions, cognitive processes, and other means of organizing and transmitting information in a particular culture. TEK is based upon an accumulation of observations, just as western science is based on observations. The difference with TEK is that this knowledge is transmitted differently. For the *Dilzhé'e* Apache, this knowledge has been transmitted orally for millennia. Our TEK is held within our stories, our songs, our words, our culture and our religion.

14. This Affidavit contains some of the TEK of the *Dilzhé'e* Apache of the Yavapai-Apache Nation as it pertains to our accumulated knowledge of the Verde River and its historic characteristics, along with other observations I have made over the years as a *Dilzhé'e* Apache, historian, educator, ethnobiologist, and lifelong resident of the Verde Valley.

Location of the Verde River in Relation to the Nation's Aboriginal Territory, 1871 Reservation and Current Lands

15. The Yavapai and Apache aboriginal territory spans across Arizona for more than 2,400 square miles. The Verde River travels through the heart of our aboriginal territory. *See* Map of Yavapai and Apache Aboriginal Territory, **Exhibit A**, attached hereto.

16. In the late 1860's and early 1870's, the United States was intent upon subduing our People to allow non-Indian settlement in our territory. As a result, in 1871, the Camp Verde Indian Reservation was established for our People. The Camp Verde Indian Reservation was 800 square miles in size and defined as 10 miles on each side of the Verde River for 45 miles, stretching from Camp Verde to Paulden, Arizona. *See* Map of 1871 Camp Verde Indian Reservation, **Exhibit B**, attached hereto.

17. The Camp Verde Indian Reservation would not last. By 1875, the non-Indians had successfully lobbied the federal government to have us removed and concentrated

on the San Carlos Apache Reservation east of Globe, Arizona, in order to open up our lands for settlement. Even though most of our People were taken to San Carlos, some of our People were never sent to San Carlos because they had managed to make their existence continuing to live off the land without detection.

18. Our People were marched to the San Carlos Reservation in the cold spring of 1875, and many perished along the way. The conditions at San Carlos were difficult for our People and we still longed for our homeland – *Shiikéyaa* – which is the place where God put us to live. Once we were allowed to leave San Carlos beginning in the late 1880's, our People began to migrate back to our homelands.

19. During the period from the l890-1910, many of our Yavapai and Apache families began returning home to the lands where our clans and clan relations had always been from. But when we returned, many non-Indians had had taken over our lands and settled in these places, including, around and near the towns of Clarkdale and Camp Verde.

20. Because of the new economic system that was imposed upon us, we did what we could to survive and began working near these areas as miners, cowboys and housemaids for the local non-Indians who had moved in.

21. By the very early 1900's, there were already 400 Yavapai and Apaches living in and around Camp Verde. This count did not include those Yavapai and Apache who were also living at Clarkdale and Jerome.

22. Upon returning to the Camp Verde and Clarkdale areas, our Reservation was re-established, beginning in 1909, in five areas throughout the Verde Valley, with most of our Tribal members living on Reservation lands near Camp Verde and Clarkdale. The Verde River travels through our present-day Reservation lands in two areas located near Camp Verde. *See* Map of 1871 Camp Verde Indian Reservation with overlay of current Yavapai-Apache Reservation lands, **Exhibit B**.

Importance of the Verde River to the Yavapai and Apache People and Observations

23. Water from the sky and places where water flows upon the earth are vitally important to the *Dilzhé'e* Apache, including places near springs, seeps, rivers and creeks.

24. For millennia, the Yavapai and Apache People have relied on the Verde River and the surrounding springs, seeps and creeks, to provide for all the elements of life. These waters provide us sustenance through our traditional cultural and religious practices. Our origin stories, ceremonies, lessons about the land, how we interact with each other, and our daily lives are all intertwined with these waters.

25. Just as with baptism in Christian religion, the waters of the Verde River form a foundation upon which our religion is based. Without it, the Yavapai and Apache People will not be whole, in body or spirit. In Apache life, *Dilzhé'e* children are born for *Tu* (water). The birth of each child is representative of the first Apache born from water at the beginning of time.

26. Because water is central to who we are as a People, the Yavapai and Apache have always been particularly aware of the condition of the Verde River, including how our elders have observed it in the past and how our families have described it in our oral histories and cultural knowledge base.

27. Our *Dilzhé'e* Apache name for the Verde River in the Camp Verde vicinity above Beasley Flat is called *Tu Cho Lii* (meaning "the big waters"). Below Beasley Flat, our *Dilzhé'e* Apache name for the Verde River is *Tu Cho Linii* (meaning "the really big river"). Words in *Dilzhé'e* Apache are highly contextual and the words themselves convey several layers of descriptive information about a particular thing within one word.

28. Before the coming of non-Indians to the Camp Verde area, the Verde River above Beasley Flat was very wide. Our Apache word for the Verde River in this area, *Tu Cho Lii*, conveys that the River was very wide at this location. Our Yavapai and Apache family and cultural histories are all similar in that they all describe this part of the Verde River as being wide and having many shallow places where one could cross on foot. Our Yavapai and Apache People described the bottomlands in Camp Verde before the coming of non-Indians as also being marshy. Before non-Indians settled at Camp Verde, our People avoided living in the Camp Verde area because the area had malaria.

29. Below Beasley Flat, our *Dilzhé'e* Apache place name for the Verde River describes the River as *Tu Cho Linii*. This description refers to the flow and speed of the River at this location because this is where the River has gained more inflow from Beaver Creek and West Clear Creek and the River becomes more channelized and narrow, making the speed of the water faster.

30. From observations of Tribal elders as told to me and from my review of the historical records, the Verde River was a very wide and shallow River near Clarkdale and Camp Verde. The River was unstable and prone to large floods. From all of our Yavapai and Apache elder accounts, it was always that way. It does not flow in a direct path, but rather flows back and forth over the land and in several places, it is a braided channel. This makes for many more river miles than if the Verde River flowed more like the Colorado River, which is more of a straight stretch. The length of time a trip would take to travel from one place to another on the Verde River would be much longer than the same trip taken on an overland route. This is likely why our Yavapai and Apache People have no history or accounts of ever traveling on the River.

31. At Clarkdale, Pecks Lake is a small oxbow lake that was established from a flood of the Verde River that cut off the lake from the Verde River. The name of Tuzigoot National Monument at Clarkdale is named for the *Dilzhé'e* Apache word, *Tu zi woot*, which means "crooked water" which is the *Dilzhé'e* Apache place name for Pecks Lake.

32. At Clarkdale, the Verde River was also very marshy before non-Indian settlement. The Rio Verde Indian agency that was established for the Camp Verde Indian Reservation in 1871 was initially located at Pecks Lake, but because of malaria problems, the agency was relocated to Haskell Springs, a few miles from current day Clarkdale where a fresh supply of running water was available and there was no malaria.

33. From my many decades of research regarding Yavapai and Apache history and culture, including my review of thousands of federal, state and private archival sources, my interviews with Tribal elders, and my interactions and discussions with historians, ethnographers and archaeologists, I have not come across any accounts of the use of the Verde River being used for trade or travel by our Yavapai and Apache People at all.

34. Our Yavapai and Apache People have never used canoes or rafts to travel on the Verde River and our Yavapai and Apache People have no traditional cultural knowledge of how to construct a canoe, boat or raft.

35. No other tribes ever traded with our Yavapai and Apache People using canoes, boats or rafts and all of our trade with other tribes was by land routes.

36. Our People have no oral history of ever seeing a canoe, boat or raft on the Verde River, including when our People returned to the Verde Valley around Camp Verde and Clarkdale in the late 1890's and early 1900's.

37. The only knowledge our Yavapai and Apache People have of people using canoes, boats or rafts on the Verde River is from present day times in the last few decades where they now see people using the River for recreation.

38. Prior to non-Indian settlement and within the Verde Valley, our *Dilzhé'e* Apache ancestors engaged in small scale agriculture within our aboriginal territory, mainly selecting sites near springs and seeps where crops could be planted and left to grow for the season, with occasional trips made to check on the crops throughout the growing season. Our ancestors avoided planting near the Verde River, as it was very unpredictable with flooding and an entire crop could be washed away in a flash flood.

39. Upon my inquiry to Tribal elders, no one has recalled ever hearing about anyone using the Verde River to move goods from one place to another or to use the Verde River to travel from one place to another during the period from the 1890's

to present day. However, they did talk about the fact that there were a few places along the Verde River where the water was so shallow and narrow, that these were the places where their families would cross the Verde River as they were traveling from one place to another, such as from Camp Verde to Clarkdale. One such location was at Bridgeport, near Camp Verde, and the other location was near where Oak Creek joins with the Verde River. This Verde River crossing was for foot travel between the Camp Verde and Clarkdale areas. Our Yavapai and Apache families generally did not travel along the side of the River when traveling from one location to another because the vegetation along the River was too dense.

40. Our Yavapai and Apache People are also aware that the military at Fort Verde, which was established in 1864 for the purpose of engaging in warfare against our People, had a crossing for the Verde River just below White Bridge in Camp Verde. The main buildings at Fort Verde were located on the west side of the Verde River and the Fort had a garden tract located on the east side of the Verde River. *See* Map of 1871 Camp Verde Indian Reservation, **Exhibit B**.

41. The Fort used the crossing to get across the Verde River to fight our *Dilzhé'e* People who were living in the mountains.

42. None of our Yavapai and Apache People have any oral history or recollections of the military at Fort Verde (or anyone else) ever using a boat, canoe or raft on the Verde River to move items or people up or down the River. None of the volumes of written records I have reviewed about Fort Verde and the military campaigns against our Yavapai and Apache People has ever revealed that the military ever used the Verde River in this manner.

43. All factual statements contained in this Affidavit are true and correct to the best of my knowledge.

Vincent E. Randall
Dilzhé'e Apache Cultural Manager

SUBSCRIBED AND SWORN TO before me this 11th day of February, 2015.

Robyn L Interpreter
Notary Public - Arizona
Maricopa County
My Commission Expires
January 11, 2016

Notary Public

My Commission Expires:

1-11-16

Ancestral Yavapai and Apache Homelands and Neighboring Tribes in Arizona

Exhibit A

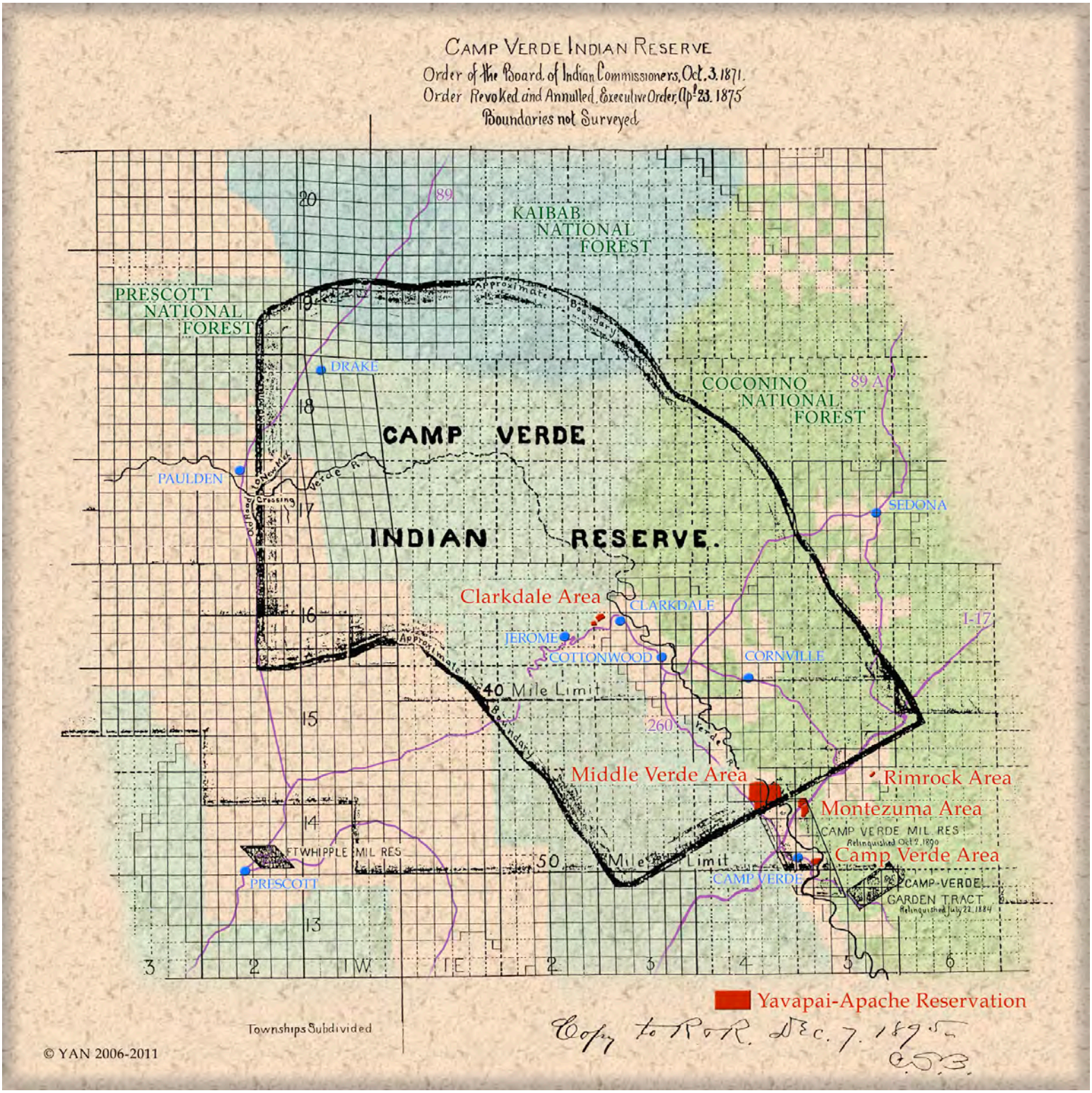
CAMP VERDE INDIAN RESERVE
Order of the Board of Indian Commissioners, Oct. 3. 1871.
Order Revoked and Annulled, Executive Order, Apl 23. 1875
Boundaries not Surveyed
KAIBAB NATIONAL FOREST
PRESCOTT NATIONAL FOREST
COCONINO NATIONAL FOREST
CAMP VERDE
INDIAN RESERVE.
DRAKE
PAULDEN
SEDONA
CLARKDALE
JEROME
COTTONWOOD
CORNVILLE
Clarkdale Area
Middle Verde Area
Rimrock Area
Montezuma Area
Camp Verde Area
CAMP VERDE MIL RES
Relinquished Oct 2, 1890
CAMP-VERDE GARDEN TRACT
Relinquished July 22, 1884
FT WHIPPLE MIL RES
PRESCOTT
CAMP VERDE
40 Mile Limit
50 Mile Limit
Approximate Boundary
Verde R.
I-17
89
89 A
260
Yavapai-Apache Reservation
Townships Subdivided
Copy to R.O.R. Dec. 7. 1895
G.S.B.
© YAN 2006-2011

Exhibit B

AN ASSESSMENT OF ABUNDANCE, DIET, AND CULTURAL SIGNIFICANCE OF MEXICAN GRAY WOLVES IN ARIZONA

by

Sarah E. Rinkevich

A Dissertation Submitted to the Faculty of the

SCHOOL OF NATURAL RESOURCES AND THE ENVIRONMENT

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

WITH A MAJOR IN WILDLIFE AND FISHERIES SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2012

Exhibit C

APPENDIX E

TRADITIONAL ECOLOGICAL KNOWLEDGE, ENDANGERED SPECIES, AND CONSERVATION BIOLOGY: A REVIEW

ABSTRACT

The term traditional ecological knowledge has been used to describe the knowledge held by indigenous cultures about their immediate environment and the cultural practices that build on that information. I present an overview of traditional ecological knowledge, its relationship to western science, examples of convergences with western science, challenges with using it, and its legal bases. Within this overview, my ultimate objective was to present how traditional ecological knowledge has enhanced the field of conservation biology but also the challenges of collecting and incorporating it with western science. The study of traditional ecological knowledge has its roots in cultural anthropology. Local biological knowledge, collected and sampled over these early centuries, informed the early development of modern biology. Contemporary naturalists and biologist also acknowledged the importance of traditional ecological knowledge as it relates to western science. Western science and traditional ecological knowledge are fundamentally based in different worldviews with their own philosophy, institutions, and methods but similarities exist. Observation of an ecological pattern is the starting point of the scientific method in the field of ecology as well as indigenous knowledge. As a way of knowing, is based on an accumulation of empirical data resulting from patient observation of the natural world, its patterns, and interspecific relationships among species of wildlife and plants. The depth of indigenous knowledge

rooted in long inhabitation of a particular place offers lessons that can benefit scientists. Convergence of traditional ecological knowledge and western science suggests that there may be areas in which traditional ecological knowledge can contribute insights, possibly new concepts and/or connections between species unknown to, or unrecognized by western ecologists. Laws and policies regarding Native Americans articulate the need to seek out information from indigenous peoples. The use of traditional ecological knowledge represents such an approach, with the potential to greatly augment existing conservation programs and help shape new ones.

INTRODUCTION

One of the most powerful indicators of human impact on the biosphere is loss of biodiversity. Natural resources have been the basis of trade and commerce by dominant societies causing a loss of biodiversity which challenges the very bases of human life on this planet (Westly 2003). According to Wilson (1985), we are witnessing the greatest rate of extinction of species in the last 60 million years due to human intervention in the biosphere. In 1973, the Endangered Species Act was passed in direct response to the loss of biodiversity in the form of federal legislation designed to protect threatened and endangered plant and wildlife species and the habitats for which they depend (National Research Council 1995). The field of conservation biology emerged in the 1980s as a response by the scientific community to the biodiversity crisis throughout the world and often referred to as a mission-oriented discipline (Soulé and Wilcox 1980). Conservation biology's foundation is in science, however, it is a heterogeneous discipline in that it also

combines the principles of ecology, population biology, genetics, natural resource management, social sciences, and philosophy (Soulé 1995, Meffe and Carroll 1997).

Wilson (1998) highlighted the need to find integration between social and biological sciences to address the magnitude and complexity of world's environmental problems. A model that could be considered a convergence of biological and social sciences is the use of indigenous knowledge by conservation biologists (see Johannes 1989, Inglis 1993, Berkes 1999). Based on centuries of *in situ* sustainable existence, indigenous peoples living close to their ecosystem for long periods of time have garnered an enormous degree of descriptive and applied ecological knowledge (Plotkin and Forsyth 1997). The term traditional ecological knowledge has been used to describe the knowledge held by indigenous cultures about their immediate environment and the cultural practices that build on that information (Menzies and Butler 2006).

Here, I present an overview of traditional ecological knowledge, its relationship to western science, examples of convergences with western science, challenges with using it, and its legal bases. Within this overview, my ultimate objective was to present how traditional ecological knowledge has enhanced the field of conservation biology but also the challenges of collecting and incorporating it with western science. Published literature on the subject of traditional ecological knowledge is vast (see Inglis 1993, Berkes 1999, Menzies 2006, Berkes et al. 2000, Huntington 2000, Nabhan 2000, Klubnikin et al. 2000, Gadgil 2000, Pierotti and Wildcat 2000, Pierotti 2010) and extends globally with the majority of case studies from Canada, Australia, South America, and Asia (e.g., Fernadez-Gimenez 2000, Donovan and Puri 2004, Chambers and Fabricius 2007, Wehi 2009, Rist et al. 2010). I, therefore, chose to focus on literature from North America that

involved Native American and Alaskan Native people and studies that addressed threatened and endangered species across taxon.

Tradition Ecological Knowledge

Traditional Ecological Knowledge is an academic term and is far from new. The use of the term is now commonplace in the discourse concerning natural resource management across the North American Arctic and Subarctic (Nadasdy 2003). A variety of terms have been coined that are analogous to traditional ecological knowledge including indigenous knowledge (Warren et al. 1995), local knowledge (Berkes 1999), Native science (Cajete 2000), Aboriginal science (Aikenhead 2006). I used the term traditional ecological knowledge because academically speaking, it is the term most widely used in the literature (see Johannes 1989, Berkes 1999, Pierotti and Wildcat 2000, Pierotti 2010). Traditional ecological knowledge would not be an axiom used in Native American or other Indigenous culture however, but the concept would be simply considered "knowledge" (S. Pilsk, pers. comm. 2012). This knowledge encompasses practical and empirical aspects of understanding and is both information itself and a way of knowing (Mailhot 1994, Pierotti 2010). Aboriginal people themselves will further point out that traditional ecological knowledge is not so much knowledge as it is a "way of life" (Nadasdy 2003).

The concept of traditional ecological knowledge is not a panacea (Hunn 1993) and thus no universally accepted definition exists for traditional ecological knowledge (Berkes 1993, Johnson 1992). Importantly, traditional ecological knowledge is not a uniform concept across indigenous peoples (Battiste and Henderson 2000). Traditional

ecological knowledge includes an intimate and detailed knowledge of plants, animals, and natural phenomena, as well as the development and use of appropriate technologies for hunting, fishing, trapping, agriculture, and forestry (Berkes 1993). One characterization of traditional ecological knowledge is the sum of the data and ideas acquired by a human group on its environment resulting from the group's use and occupation of a specific region over many generations (Mailhot 1994). Berkes et al. (2000) describes traditional ecological knowledge as a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (humans and nonhumans) with one another and with their environment. Traditional ecological knowledge is a useful construct that represents knowledge gathered from undertaking several different pursuits such as hunting, medicinal collection, preparation for spiritual ceremonies, or maintenance of a household economy. These pursuits are generalized activities found in many traditional societies and characterize ways in which indigenous people interact with the natural world. These interactions carried out over countless generation are the genesis of traditional ecological knowledge (Drew 2005, Drew and Henne 2006).

Although the term traditional ecological knowledge is widely accepted, the axiom is somewhat problematic (Lertzman 2010). The terms *traditional* and *change*, for example, have been seen has contradictory concepts to non-indigenous people. According to Pierotti (2010), however, the term *traditional* clearly implies that such knowledge and related concepts have been in existence for a considerable length of time precisely because of the ability to incorporate new observations and information which has kept

them fresh and relevant. Traditions are transmitted from one generation to the next generations of people living in a local area and are the products of generations of intelligent reflection tested in a rigorous laboratory of survival (Hunn 1993). The standard epistemological account for traditional ecological knowledge is trial and error over time (Greneir 1998) similar to western science's adaptive management. Prescriptions of traditional knowledge and practice are generally consistent with adaptive management as an integrated method for resource and ecosystem management (Holling 1978). Traditions include a great sum of *knowledge* about local environments that include plant and animal species, soils, weather, and a detailed map of the local topography. The proximity of traditional users to natural resources confers an ability to observe *ecological* patterns and processes (Berkes 1999, Pierotti 2010). The "data" collected using this approach are basically an understanding of relationships between specific biological entities such as plants and wildlife and among the biological and physical features such as bodies of water and mountains (Pierotti 2010).

Foundations of Traditional Ecological Knowledge

Indigenous people throughout the world have and have always had "science," defined as a body of practical empirical knowledge of their environment because without it, a society could not survive (Cajete 2000, Nadasdy 2003). Traditional ecological knowledge has in it a foundation that includes a process of environmental learning in order to survive and then passing learned knowledge to the next generation. Indigenous people who have been living for generations in a particular environment develop intimate

familiarity with the land. Knowledge and experience of the land and its flora and fauna is gained through learning (Stoffle et al. 2003). Native peoples depended upon the animals and plants of these environments for food, clothing, shelter, and companionship, and as a result developed strong ties to the fish and land animals, the forests, the grasslands (Pierotti and Wildcat 1999). As Native American peoples developed through observations of their fellow beings, they noted that each species had characteristics that set them apart from other species, and enhanced their chances of survival (Marshall 1995). The way for humans to survive and prosper was to pay careful attention, and learn as much as possible about strengths and weakness of all the other organisms, so that they could take them as food and avoid being taken by them as food. The body of knowledge acquired through careful observations was passed on to others through detailed conversations and stories, which had to be repeated constantly so that the knowledge would be passed on to future generations (Pierotti and Wildcat 1997,1999; Pierotti 2010).

The study of traditional ecological knowledge has its roots in cultural anthropology. Research in traditional ecological knowledge as it related to management of fisheries resources dates to the early 1970s (Wheeler and Craver 2005) but came into widespread use only in the early 1980s (Berkes 1999). Increasingly, the published scientific literature and convening of conferences reflects the growing awareness that there is a legitimate file of environmental expertise know as traditional ecological knowledge (Freeman 1995). In 2000, the journal Ecological Applications produced an invited feature focused on traditional ecological knowledge, ecosystem science, and environmental management (see Berkes et al. 2000; Huntington 2000, Nabhan 2000, Klubnikin et al. 2000, Gadgil 2000, Pierotti and Wildcat 2000).

Traditional Ecological Knowledge Informing Modern Biology

Local biological knowledge, collected and sampled over these early centuries, informed the early development of modern biology. During the 17th century, for example, the German born botanist Georg Eberhard Rumphius benefited from local biological knowledge in producing his catalogue, *Herbarium Amboinense* (Sillitoe 1998). The catalogue covers more than 1,200 species of the plants, 930 with definite species names, and another 140 identified to genus level from Indonesia but also China, Japan, South Africa, Madagascar, South America, Mexico, Peru, and Brazil (Beekman 2003). Rumphius' index included the plant's name, illustrations, description for nomenclature, place, a discussion of the plant's use to the local inhabitants, stories, folklore, and religious practices. Rumphius' nomenclature was based on original Indonesian nomination and his ethnobotany was almost purely Indonesian (Beekman 2003). During the 18th century, Carl Linnaeus referenced and relied upon Rumphius's work, and also corresponded with other people all around the world when developing the biological classification scheme that now underlies the arrangement of much of the accumulated knowledge of the biological sciences. All of Linnaeus' voyages were mediated by indigenous people (Koerner 1999).

Contemporary naturalists and biologist also acknowledged the importance of traditional ecological knowledge as it relates to western science. C. Hart Merriam, for example, was an amateur anthropologist who spent decades spent five to six months each year traversing the country interviewing aged Native Americans and writing down voluminous records of what they were still able to tell him. He remained a natural

historian recording the distribution of words as a means to ascertaining the precise distribution of dialects, languages, tribes, families, and their beliefs and customs, similar to the way he recorded the distribution of song sparrows, grizzly bears, and wolves in order to delimit life zones (Kroeber 1955). Diamond (1966) documented the extensive knowledge of the natural world by the New Guinean people as reflected in the local names for plant and animal species. Diamond (1966) found that the Foré people of the Eastern Highland Providence of New Guinea apply 110 different Foré names to the 120 different bird species. Of these 110 names, 93 correspond to bird species recognized by western taxonomists (Diamond 1993).

Western Science

Although the field of conservation biology is multidisciplinary, its fundamentals are grounded in science (Soulé 1985). Simpson (1964) concluded that attempts to define science would fill a whole library and that many definitions were contradictory but ultimately settled on a definition that, science is an exploration of the material universe that seeks natural, orderly relationships among observed phenomena and that is self-testing. Carey (1994) defined the scientific method as "a rigorous process whereby new ideas about how some part of the natural world works are put to the test." Science has a number of objectives (Mayr 1982). Ayala (1968) describes these objectives as the following: (1) science seeks to organize knowledge in a systematic way, endeavoring to discover patterns of relationship among phenomena and processes; (2) science strives to provide explanations for the occurrence of events; and (3) science proposes explanatory hypotheses that must be testable, that is, accessible to the possibility of rejection.

There is no single, all-purpose scientific method (Romesburg 1981), although the hypothetico-deductive (H-D) method is widely accepted (Romesburg 1991). The H-D method employs three steps: (1) observation of an ecological pattern (i.e., induction); (2) generating potential explanations (i.e., hypotheses testing) and predictions for the pattern observed and; (3) experimentation (i.e., testing potential explanations by comparative, correlative, or experimental manipulations). Wildlife science uses step one and two but almost never step three (Romesburg 1981, Matter and Mannan 1989, Nudds and Morrison 1991, Mayr 1997). Despite the apparent necessity of deduction in hypothesis testing, the H-D method can be prone to error and ambiguity in ecology (Guthrey 2007) and falsification is sometimes as difficult to provide as positive proof and thus is not considered the only measure for obtaining scientific acceptability (Nadasdy 1993). When used, the H-D method, however, has two advantages: first, it fits into the conviction that there is no absolute truth and that our conclusions and theories should continually be tested and; second, is encourages the search for new observations and experiments to refute new hypothesis (Mayr 1982).

Differences between Traditional Ecological Knowledge and Western Science

Western science and traditional ecological knowledge fundamentally are based in different worldviews with their own philosophy, institutions, and methods (Lertzman 2010). Western scientific information is highly dynamic and is advancing rapidly. In contrast, the body of data typical for indigenous knowledge is based on long-term personal observations and elder's memories, and thus changes very slowly (Krupnik and Ray 2007). Indigenous residents also had to cope with and adapt to environmental

variability which may have occurred rapidly (Huntington 2002). Indigenous people have a considerable body of empirically derived knowledge about the natural world in combination with philosophical approach that is quite different from that found in any western philosophical tradition (Mander 1991, Suzuki and Knudtson 1992, Barsh 2000, Pierotti and Wildcat 2000, Pierotti 2010). The two bodies of knowledge can thus be thought of as two different epistemologies. The term epistemology refers to the theory of knowledge, that is, the study of the origins, limits, and meaning of knowledge (Lertzman 2010) and "how we know what we know" (see Landesman 1997, Audi 1998). Traditional ecological knowledge, for example, consists not only of 'ecological data' but also spirituality, values, normative rules, and cultural practices (Casimirri 2003). In contrast, western science has been detached from religion and spiritually beginning with the Enlightenment movement in the 18th century (see Mayr 1982).

Traditional ecological knowledge is equivalent to Western Science in its usefulness and insight but differs in its approach (Berkes 1999, Berkes et al. 2000, Barsh 2000, Pierotti 2010). Although overlap exists, the two systems of knowledge (i.e., traditional ecological knowledge and western science) comprise distinct knowledge systems incorporating different methods and ways of knowing (Lertzman 2010). The obvious difference is that traditional ecological knowledge is recorded and transmitted though oral tradition (often through stories) while western science employs the written works (Barnhardt and Kawagley 2005). Traditional ecological knowledge is rooted in social context that views the world in terms of social and spiritual relations between all life-forms. Western science tend to be hierarchically or organized and the environment is reduced to conceptually discrete components that are managed separately (Johnson

1992). Ingold (1996) discusses the latter difference further by stating that Native peoples do not subscribe to the dichotomy of nature and culture but view the world as an integrated entity. One gets to know the forest, and the plants and animals that dwell therein in the same way that one becomes familiar with other people, by spending time with them, investing in one's relationships with them the same qualities of care, feeling and attention. Knowledge of the world is gained by moving about in it, exploring it, attending to it, ever alert to the signs by which it is revealed. Native people do not construct the environment but acquire skills to engage with the environment (Ingold 1996).

Convergence of Traditional Ecological Knowledge and Western Science

Observation of an ecological pattern (i.e., induction) is the starting point of the scientific method in the field of ecology (Romesburg 1981). An indigenous knowledge system is usually drawn from local observations similar to the way western science uses induction. Western science and indigenous ecological knowledge also are similar in that both generate potential explanations and predictions for the pattern observed (i.e., deduction). Traditional knowledge, as a way of knowing, is based on an accumulation of empirical data (Berkes et al. 2000) resulting from patient observation of the natural world, its patterns (Pierotti 2010), and interspecific relationships among species of wildlife and plants which mirrors western science. Nabhan (2000) reported on the oral traditions of the O'odham and Comcáac oral traditions in the southwest United States containing over 20 interspecific relationships encoded in their biosystematic lexicon. The Comcáac, for example, had four species of desert plants referred to as "desert tortoise's forage" in their native language. Importantly, a key issue regarding conservation

management of the desert tortoise (*Gopherus agassizii*) had been providing protected habitat with sufficiently diverse forage is available. Despite 60 years of incidental reports on desert tortoise feeding behavior, stomach contents, and fecal pellet analysis, knowledge of the species' dietary needs of desert tortoise had remained fragmentary (Van Devender and Schwalbe 1998). Further, the Comcáac associate an ephemeral legume to the endangered Sonoran pronghorn (*Antilocapra americana sonoriensis*) calling the plant "pronghorn - its wild bean." The Comcáac have a name for a wild onion translated as "desert bighorn eats it" in reference to a plant that desert bighorn sheep (*Ovis canadensis mexicanus*) were observed eating. These are tangible examples of how indigenous ecological knowledge can be used to guide empirical or experimental studies to learn more about plant-animal interactions. Additionally, indigenous experts that hold this type of traditional ecological knowledge could inform endangered species recovery efforts and habitat restoration planning (Nabhan 2000).

The depth of indigenous knowledge rooted in long inhabitation of a particular place offers lessons that can benefit scientists (Barnhardt and Kawagley 2005). Ferguson et al. (1998), for example, reported that detailed observations of caribou (*Rangifer tarandus*) had been preserved in Inuit oral traditions and was corroborated by scientific written records (Ferguson et al. 1998, Ferguson and Messier 1997). The written records from the 1800s although limited spatially and temporally support Inuit knowledge that South Baffin caribou populations follow a regular abundance and movement cycle over periods of 60-80 years. Huntington (1998) interviewed Alaskan Natives in Point Lay, Buckland, and Norton Bay gathering ecological information about beluga whales (*Delphinapterus leucas*) including overall description of migratory patterns, local

movement, feeding behavior and prey patterns, predator avoidance, calving, bathymetry, ecological interactions, human influences, and other information. The descriptions were broadly in accordance with current scientific understanding although the overlap was not complete. Huntington (1999) reported that the traditional ecological knowledge collected provided more specifics on interactions with humans and anthropogenic influences such as noise with regard to beluga whales than published scientific research (e.g., Frost and Lowry 1990, Frost et al. 1993). Fraser et al. (2006) reported that traditional ecological knowledge revealed long-term trends on the viability of divergent of brook charr (*Salvelinus fantinalis*) populations in the region that were not achievable with scientific data. Gilchrist et al. (2005) reported that Inuit correctly identified aspects of Harlequin Duck (*Histrionicus histrionicus*) including the species' biology, including preferred habitats and seasonal movements. Krupnik and Ray (2007) report detailed information about Pacific walrus (*Odobenus rosmarus divergens*) migration patterns by local Yupik hunters in Alaska. Walrus hunters had knowledge of walrus biology and ecology including seasonal differences in distribution and abundance, separation of different groupings, and two seasonal peaks of abundance around St. Lawrence Island (Krupnik and Ray 2007:7).Convergence of traditional ecological knowledge and western science suggests that there may be areas in which traditional ecological knowledge can contribute insights, possibly new concepts and/or connections between species unknown to, or unrecognized by western ecologists (Pierroti and Wildcat 2000). During a study of beluga whales, for example, researchers confused over why belugas no long entered certain rivers where told by indigenous people that it was because of beavers (*Castor canadensis*). Beavers build dams in certain streams inhibiting salmon movements and

thus, belugas which feed on salmon, had ceased to use these rivers (Huntington and Myrmin 1996). Convergence of traditional ecological knowledge and western science has also proved to lead to better estimates of populations. Huntington (2000), for example, reported Alaskan Native whaler's knowledge of bowhead whale (*Balaena mysticetus*) population numbers proved more accurate than scientists' census estimates in 1977. Combining the data from scientific census and Alaskan whaler's traditional ecological knowledge of bowhead whales therefore provided the International Whaling Commission with a robust population estimate.

Indigenous people in arctic communities who still rely on fish and wildlife as a means of subsistence continue to recognize patterns of nature such as shifts in wildlife populations. Inuit people from the community of Sanikiluaq, for example, reported regional Common Eider (*Somateria mollistima sedentaria*) populations had recently declined (Gilchrist et al. 2005). Inuit stated that extensive sea ice formed during the winter of 1991-1992 and had limited the locations where eiders could feed in open water resulting in their mass starvation. Although the ultimate cause of the severe winter ice conditions was unknown to them, local Inuit knowledge correctly detected both a change of sea ice conditions and the mass die-off of eiders that resulted. Gilchrist et al. (2005) also documented Inuit residents accurately reported declining populations of Ivory Gulls (*Pagophila eburnean*) and Thick-billed Murre (*Uria lomvia*). Fully incorporating indigenous voices into research regimes and policy debates would be a major step toward a more equal dialog and a partnership built on data-sharing and mutual respect (Berkes 2002, Fenge 2001).

Challenges Surrounding Traditional Ecological Knowledge

Traditional ecological knowledge has two immediate strikes against it. First, western scientists believe that traditional cultures are unscientific because they are based on perceived myths and stories. Second, traditional ecological knowledge lacks the benefit of the western scientific method of empirical observation and experiment (Hunn 1993). The latter has been discussed above with ample evidence of the contrary. A common criticism directed at traditional ecological knowledge is that it fails to adhere to the scientific canon of validity and reliability (LeCompte and Goezt 1982). Examples of western science validating traditional ecological knowledge exist however (see Nabhan 2000, Gratani et al. 2011). Regarding the first strike, in the western tradition, it is considered to be a problem that traditional ecological knowledge combines empirically based observations and conclusions with spiritual, religious, philosophical ideas (Pierotti 2010). Philosophy, however, has always been part of western science (see Mayr 1982, Wilson 1998, Pierotti 2010). The land ethics and thinking like a mountain of Leopold (1949), deep ecology (Naess 1989), and Gaia (Lovelock 1979) are examples in which scientists concerned with environmental ethics have searched for the personal and spiritual element missing ecology (Berkes 1999).

One cannot examine the issue of using traditional ecological knowledge without confronting the barrage of dual comparisons of their differences. In contrast to traditional knowledge which is assumed to be qualitative, intuitive, holistic, and oral, western science is seen as quantitative, analytical, reductionist, and written (Barnhardt and Kawagley 2005, Nadasdy 2003). Although these differences seem to imply the two knowledge systems are incommensurable, most of the problems relate to difficulties in

gaining access to and collecting traditional ecological knowledge or with translating it into a form that can be utilized by resource managers (Nadasdy 2003). Although the tenets and procedures of western science can be learned at a university, the philosophy and practices of traditional ecological knowledge are not readily available to those with formal science training (Berkes 1993, Lertzman 2010).

Information encoded in lexicons of Native American and Alaskan Native peoples can be difficult and time consuming to understand and interpret. Nabhan (2000) demonstrated that O'odham and Comcáac oral traditions include many ecological insights but are known only once the language is understood. Understanding a culture and learning indigenous language takes years, if not decades (K. Basso, pers. comm., 2010). Cultural traditions such as only being able to share stories or information about a certain species during culturally appropriate seasons or times of the year can limit data collection of traditional ecological knowledge. Toupal (2003), for example, found that Tohono O'odham elders who were interviewed outside of winter months provided limited information. Challenges also exist when managers are confronted with statements such as "it is sacred to us." The word sacred may have many implications to an Indigenous person but may not provide enough information for a biologist to incorporate the information into a decision-making document (Toupal 2003). Because the methods for documenting traditional ecological knowledge derive from the social sciences (Huntington 2000), conservation biologist seeking to collect this type of information would need to be trained in ethnographic methodologies. Lastly, collecting traditional ecological knowledge may not be appropriate in every situation especially in instances where the information cannot be shared with people outside of the culture.

Although an integration of indigenous and western scientific ways of knowing and managing wildlife is difficult to achieve (Nakashima 1993), successful integrations have occurred. During the 1989 Exxon Valdez oil spill disaster in Prince William Sound, Alaska, Federal and state agencies recognized the vast traditional knowledge of the Native community who could provide detailed information on conditions in the years prior to the spill. A project was designed to make optimal use of the complementary nature of scientific data and traditional knowledge, while increasing the involvement of spill area communities in oil spill restoration. Traditional knowledge of the native community provided detailed information on conditions in the years prior to the spill. The Native community had knowledge of the historical population sizes and ranges of many of the species injured by the spill as well as observations concerning the diet, behavior, and interrelationships of injured species (Huntington 2000). Optimal use of the complementary nature of scientific data and traditional knowledge while increasing the involvement of communities in oil spill restoration enhanced the success of restoration effort (Miraglia 1998).

Legal Basis for Using Traditional Ecological Knowledge

Laws and policies regarding Native Americans articulate the need to seek out information from indigenous peoples. The Alaska National Interest Lands Conservation Act (ANILCA) was passed in 1980 with the purpose of preserving and managing fish and wildlife and their ecosystems in the State of Alaska. Section 812 (Research) of ANILCA states that the Secretary, in cooperation with the State and other appropriate Federal agencies, shall undertake research on fish and wildlife and subsistence uses on the public

lands, seek data from, consult with and make use of, the special knowledge of local residents engaged in subsistence uses. The Marine Mammal Protection Act of 1972 states that the Secretary of Commerce shall utilize, where appropriate, traditional local knowledge and may contract with a qualified Alaska Native organization to conduct such research. The Endangered Species Act of 1973 prohibits the taking of any listed species by any person subject to the jurisdiction of the United States but exempts Alaska Natives. Section 10(e)(1) of the Endangered Species Act states that provisions of the Endangered Species Act shall not apply with respect to the taking of any endangered or threatened species by "any Indian, Aleut, or Eskimo who is an Alaskan Native who resides in Alaska or any non-native permanent residents of Alaskan native villages if such taking is primarily for subsistence purposes". The Endangered Species Act is silent, however, as to regulation on Native American lands in the lower 48 states (Coggins and Modrcin 1979) as well as traditional ecological knowledge.

The lack of guidance within the Endangered Species Act, as well as within the Code of Federal Regulations that implement the law, with regard to Native Americans in the lower 48-States prompted the Federal Government to enact Native American policies in the form of Executive and Secretarial Orders. Executive Order 13175 titled Consultation and Coordination with Indian Tribal Governments, for example, directed agencies to establish regular and meaningful government-to-government relationships with Native peoples. Secretarial Order 3206 titled American Indian Tribal Rights, Federal –Tribal Trust Responsibilities, and the Endangered Species Act directed the U.S. Fish and Wildlife to recognize, respect, and consider the value that traditional knowledge provides to tribal and federal land management decision-making and management

activities. In 2001, the Secretary of Interior and Commerce jointly signed Secretarial Order 3225 titled Endangered Species Act and Subsistence Uses in Alaska Supplement to Secretarial Order 3206 which established a consultation framework for ensuring the participation of affected Alaska Natives in all aspects of the managing subsistence species that are proposed or listed under the Endangered Species Act including research design, data collection, and use of traditional knowledge. Most recently, Secretary of the Interior Salazar signed Secretarial Order 3305 titled Ensuring Scientific Integrity within the Department of the Interior which established a policy to ensure the integrity of science in decision making and in the creation of policy to protect our heritage and honor native cultures and tribal communities.

The U.S. Fish and Wildlife Service and National Marine Fisheries Service referenced traditional ecological knowledge in several proposed and final rules concerning threatened and endangered species in Alaska. Alaskan Native indigenous knowledge, for example, was cited with regard to polar bear (*Ursus maritimus*) population trends (U.S. Fish and Wildlife Service 2008), spectacled eider (*Somateria fischeri*) habitat for describing the legal designation of critical habitat (U.S. Fish and Wildlife Service 2001), and subsistence harvest regulations for migratory birds. The National Marine Fisheries Service worked extensively with Native hunters to use traditional knowledge with regard to proposing the Cook Inlet beluga whale (*Delphinapterus leucas*) as a distinct population segment (National Marine Fisheries Service 2007a). The traditional ecological knowledge of Alaska Natives along with systematic aerial survey data documented a contraction of the summer range of Cook Inlet belugas over the last two decades (National Marine Fisheries Service 2009a). The

National Marine Fisheries Service used Alaskan Native traditional ecological knowledge in developing the Eastern Pacific Northern Fur Seal Stock Conservation Plan (National Marine Fisheries Service 2007b). Further, numerous ethnographic studies regarding the First Nations' traditional ecological knowledge of eulachon (*Taleichthys pacificus*), a small, anadromous ocean fish, were used to describe the species' historical distribution and abundance in the proposed rule to list the fish (National Marine Fisheries Service 2009b). In addition, Federal and State biologists and managers in Alaska collect and use traditional ecological knowledge for research and monitoring fish populations under the Federal Subsistence Management Program (see U.S. Fish and Wildlife Service 2010a). One example of the Federal Government referencing traditional ecological knowledge in the lower 48-states is occurred in the 12-month petition finding for the Sonoran Desert population of Bald Eagle (*Haliateetus leucocephalus*). The Western Apache and Salt River Pima-Maricopa Indian Community provided the U.S. Fish and Wildlife Service with their knowledge about Bald Eagle populations and habitat information within Arizona (see U.S. Fish and Wildlife 2010b).

DISCUSSION

Traditional ecological knowledge is a young term used to describe something ancient (Westley and Miller 2003) and offers ecological information and insight relevant to ecological management and research that cannot be obtained from other sources (Huntington 1998). For thousands of years, indigenous peoples have used biological knowledge of their local environment to sustain themselves and to maintain their cultural identity (Johnson 1992). Indigenous peoples around the world possess a broad knowledge

base of complex ecological systems in their own localities (Gadgil et al. 1993). Much more then data, this information characteristically functions within time-tested resource management systems of long-resident peoples. Yet the involvement of indigenous people remains elusive and western science often overlooks and disparages these indigenous systems and associated traditional ecological knowledge (Westley and Miller 2003).

According to Berkes (1993), traditional ecological knowledge parallels the scientific discipline of ecology because both traditional ecological knowledge and western science share observation and description of the empirical world. Traditional ecological knowledge is conceptually holistic, however, in that indigenous knowledge systems consider the biotic and abiotic as being connected and thus it cannot be compartmentalized like western science (McGregor 2004, Pierotti 2010). Many examples of holistic approaches that consider ecological relationships exist in western science such as community ecology (Krebs 2009), macroecology (Brown 1995), and ecosystem management (Grumbine 1994). Other disciplines outside of ecology recognize the importance aspect of holism in that it emphasizes relationships. According to Mayr (1982:67), Einstein based his entire relativity theory on the consideration of relationship. Similarities between indigenous knowledge and quantum theory, which stresses the irreducible link between the observer and observed and the basic holism of all phenomena, have been discussed Peat (1994, 2005).

Collecting traditional ecological knowledge has challenges and limitations. Language and cultural norms can prevent traditional ecological knowledge from being collected. English terms such as “spirits”, “sacred”, and “prayer” are inadequate to translate the actual meaning of the concepts in Indigenous cultures (Marshall 2005,

Pierotti 2010:8). Although these differences appear severe, traditional ecological knowledge combined with western science provides the best chance of sustainable natural resource use and management (Toupal 2001). Using traditional ecological knowledge allows a mutually beneficial relationship to be created between conservation biologists and local people (Drew 2005, Drew and Henne 2006). The holders of both traditional and science knowledge can benefit by mutual exchange of information and interpreting the information collaboratively (Huntington et al. 2002).

Alaskan Natives have been at the forefront in bringing Indigenous perspectives into a variety of policy arenas through a wide range of research and development initiatives (Barhhardt and Kawagley 2005). Traditional ecological knowledge, however, is underutilized in natural resource management in the lower 48-states, however, with only a few examples. Long et al. (2003) used cultural foundations and the wealth of Western Apache knowledge of ecologically functioning riparian areas to guide modern restoration techniques which improved wetland habitats for several listed species on the Fort Apache Indian Reservation. Additional, the Glen Canyon Dam Adaptive Management Work Group which is considering using traditional ecological knowledge for defining desired future conditions in the Colorado River corridor.

Professionals in applied ecology and resource management fields have been slow to embrace traditional ecological knowledge. Traditional ecological knowledge could assist in many threatened and endangered species recovery efforts. A biologist working for the Arizona Game and Fish Department, for example, was informed by a Navajo elder that he was searching for signs of the endangered black-footed ferret (*Mustela nigripes*), a mammal that was once thought to be extinct in North America, in the wrong place (Van

Pelt, pers. comm., 2007). Native American elders and practitioners hold much knowledge about the natural world and what plants and animals are now missing from various landscapes (Anderson 2010).

Understanding the ecology and population dynamics of key species in particular ecosystems needs to be multidisciplinary due to the complexity and magnitude of the problem (Westley 2003). The need to find integration between social and biological sciences has been discussed in detail by Wilson (1998). Using the term "consilience", Wilson (1998) argued that sound environmental policy can only be formed at the juncture of ethics, social science, and biology. Consilience, or the unity of knowledge, literally means a "jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation (Whewell 1847). Such a merger could draw Indigenous peoples into a dialogue that could generate a truly integrated understanding of complex ecological processes and concepts. According to Lertzman (2010) that traditional ecological knowledge and western science represent parallel, potentially complementary knowledge systems. Rather than trying to "integrate" traditional ecological knowledge into science, however, traditional ecological knowledge could also be thought of as a parallel science.

Recognition of the scientific importance of traditional ecological knowledge should lead to more co-operative relations between researchers and local communities in which local people who are repositories of knowledge and skills become an integral part of a research program as consultants or collaborators rather than merely guides or assistants (Healey 1993:26). The incorporation of traditional ecological knowledge may enhance Western society's appreciation of the cultures that hold the ecological

knowledge about a specific species which could result in less controversy and more mutual respect. An obvious benefit of using local knowledge is that involvement provides a sense of work and pride which may be instrumental in fostering great responsibility to the recourse (Hobbs 2003). The results of ethnographic studies show that by engaging the people who live in local areas of interest, resource managers can obtain cultural information for management purposes while building relationships between local communities. Scientific investigations which make use of this local knowledge are likely to be particularly successful.

As the pace of ecological changes increases, so too does the need for baseline information with which to direct conservation and restoration activities (Ford and Martinez 2000). Species are becoming extinct and ecosystems are being dramatically altered (Casey and Myers 1998, Drew 2005). The field of conservation biology is constantly evolving to better address a complex and dynamic suite of threats to biodiversity. The use of traditional ecological knowledge represents such an approach, with the potential to greatly augment existing conservation programs and help shape new ones (Drew 2005). Listening to Indigenous peoples as well as respecting and understanding their desires and aspirations will help scientists partner more effectively in wildlife and habitat conservation. Traditional ecological knowledge and western science offer each other externally derived, independent reference standards that provide a basis for bicultural verification. The two represent complementary knowledge systems with their own methods, philosophical foundations, and communities of respected experts. Indigenous peoples' knowledge could be key to developing a sound basis for conservation planning and action (Westley and Miller 2003). With regard to climate

change in the Canadian Arctic, for example, it is only recently that a number of projects have begun to engage northern Aboriginal people and focus on Indigenous knowledge of climate processes, changes and impacts. It is argued that in order to better understand the complex nature of northern ecosystems all available knowledge must be considered and valued (Furgal et al. 2002).The elders have knowledge attained over multiple generations that could likely save us many years of learning if we listen (Cary 2002).

LITERATURE CITED

Aikenhead, G. S. 2006. Science education for everyday life: evidence-based practice. Teacher's College Press, New York, USA.

Audi, R. 1998. Epistemology: A contemporary introduction to the theory of knowledge. Routledge, New York, USA.

Ayala, F. J. 1968. Biology as an autonomous science. American Scientist 56:207-221.

Barnhardt, R., and A. O. Kawagley. 2005. Indigenous knowledge systems and Alaska Native ways of knowing. Anthropology and Education Quarterly 36:8-23.

Barsh, R.L. 2000. Taking Indigenous science seriously. Pages 152-173 *in* S.A. Bocking, editor. Biodiversity in Canada: ecology, ideas, and action. Broadview Press, Toronto, Canada.

Battiste, M., and Y. Henderson. 2000. Protecting Indigenous knowledge and heritage: a global challenge. Purich Publishing, Saskatoon, Sadkatchewan, Canada.

Beekman, E.M. 2003. Rumphius Orchids: Geogius Everhardus Rumphius. Yale University Press, New Haven, Connecticut, USA.

Berkes, F. 1993. Traditional Ecological Knowledge in perspective. Pages 1-10 *in* Inglis, J. T., editor. Traditional ecological knowledge: concepts and cases. International Program on Traditional Ecological Knowledge and International Development Research Centre, Ottawa, Canada.

Berkes, F. 1999. Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Taylor and Francis, Philadelphia, Pennsylvania.

Berkes, F. 2002. Epilogue: making sense of Arctic environmental change? Pages 335-349 *in* I., Krupnik, and D. Jolly, editors. The earth is faster now: Indigenous

observations of Arctic environmental change. Arctic Research Commission of the United States, Fairbanks, Alaska, USA.

Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10:1251-1262.

Brown, J. H. 1995. Macroecology. The University of Chicago Press, Illinois, USA.

Cajete, G. 2000. Native science: natural laws of interdependence. Clear Light Publishers, Santa Fe, New Mexico, USA.

Carey, S. S. 1994. A beginner's guide to scientific method. Wadsworth, Belmont, CA.

Casey, J., and R.A. Myers. 1998. Near extinction of a large, widely distributed fish. Science 281:690.

Casimirri, G. 2003. Problems with integrating traditional ecological knowledge into contemporary resource management. International Institute Sustainable Development, XII World Forestry Congress, September 21-28, 2003, Quebec City, Canada.

Chambers, N., and C. Fabricius. 2007. Expert and generalist local knowledge about land-cover change on South Africa's wild coast: can local ecological knowledge add value to science? Ecology and Society 12:10.

Coggins, G. C., and W. Modrcin. 1979. Native American Indians and Federal Wildlife Law. Stanford Law Review 31: 375-423.

Diamond, J. 1966. Zoological classification system of a primitive people. Science 151:1102-1104.

Diamond, J. 1993. New Guineans and their natural world. Pages 251-271 *in* S.R. Kellet, and E.O. Wilson, editors. The biophilia hypothesis. Cambridge University Press, Cambridge, Massachusetts, USA.

Donovan, D., and R. Puri. 2004. Learning from traditional knowledge of non-timber forest products: Penan Benalui and the autecology of Aquilaria in Indonesian Borneo. Ecology and Society 9:3.

Drew, J. A. 2005. Use of traditional ecological knowledge in marine conservation. Conservation Biology 19(4):1286-1293.

Drew, J. A., and A. P. Henne. 2006. Conservation biology and traditional ecological knowledge: integrating academic disciplines for better conservation practice. 2006. Ecology and Society 11:34.

Fenge, T. 2001. Inuit and climate change: perspectives and policy opportunities, Isuma. Canadian Journal of Policy Research 2:79-85.

Ferguson, M.A.D., and F. Messier. 1997. Collection and analysis of traditional ecological knowledge about a population of Arctic tundra caribou. Arctic 50:17-28.

Ferguson, M. A. D., R. C. Williamson, and F. Messier. 1998. Inuit knowledge of long-term changes in a population of Arctic tundra caribou. Arctic 51:201-219.

Fernadez-Gimenez, M.E. 2000. The role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. Ecological Applications 10:1318-1326.

Ford, J., and D. Martinez. 2000. Traditional ecological knowledge, ecosystem science, and environmental management. Ecological Applications 10:1249-1250.

Fraser, D. J., P. Duchesne, and L. Bernatchez. 2005. Migratory charr schools exhibit population and kin associations beyond juvenile stages. Molecular Ecology 14:3133-3146.

Freeman, M. M. R. 1995. The nature and utility of traditional ecological knowledge. Pages 39-46 *in* C. Gaffield, editor. Consuming Canada: readings in environmental history. Copp Clark, Ltd, Toronto, Canada.

Frost, K. J., Lowry, L. F., and G. M. Carroll. 1993. Beluga whale and spotted seal use of a coastal lagoon system in the northeastern Chukchi Sea. Arctic 46:8-16.

Furgal, C., Martin, D., Gosselin, P. 2002. Climate change and health in Nunavik and Labrador: lessons from Inuit Knowledge. Pages 266-300 *in* Krupnik, I., and Jolly, D., editors. The earth is faster now: indigenous observations of arctic environmental change. Arctic Research Consortium of the United States, Arctic Studies Centre, Smithsonian Institution, Washington, D.C., USA.

Gadgil, M., F. Berkes, and C. Folke. 1993. Indigenous knowledge for biodiversity conservation. Ambio 22:151-156.

Gilchrist, G., M. Mallory, and F. Merkel. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. Ecology and Society 10:20.

Gratani, M., J. R. A. Butler, F. Royee, P. Valentine, D. Burrows, W. I. Canendo, and A. S. Anderson. 2011. Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the wet tropics, Australia. Ecology and Society 16(3):25 (online).

Grenier, L. 1998. Working with indigenous knowledge: a guide to researchers. International Development Research Centre, Ottawa, Ontario, Canada.

Grumbine, R. E. 1994. What is ecosystem management: Conservation Biology 8:27-38.

Guthrey, F. S. 2007. Deductive and inductive methods of accumulating reliable knowledge in wildlife science. Journal of Wildlife Management 71:222-225

Healey, C. 1993. The significance and application of traditional ecological knowledge. Pages 21-26 *in* N.M. Williams, and G. Bains, editors. Traditional ecological knowledge. Centre for Resource and Environmental Studied, Australian National University.

Hobbs, N. T. 2003. Challenges and opportunties in intregrating ecological knowledge across scales. Forest Ecology and Management 181:223-238.

Holling, C.S. 1978. Adaptive environmental assessment and management. Wiley, London, UK.

Hunn, E. 1993. What is traditional ecological knowledge. Pages 13-15 *in* N.M. Williams, and G. Bains, editors. Traditional ecological knowledge. Centre for Resource and Environmental Studied, Australian National University, Australia.

Huntington, H. P. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51:237-242.

Huntington, H. P. 1999. Traditional knowledge and ecology of Beluga whales (*Delphinapteus leucas*) in the eastern Chukchi and northern Bering Seas, Alaska. Arctic 52:49-61.

Huntington, H. P. 2000. Using traditional ecological knowledge in science: methods and applications. Ecological Applications 10:1270-1274.

Huntington, H. P. 2002. Human understanding and understanding humans in the Arctic system. Pages xxi-xxvii *in* I., Krupnik, and D. Jolly, editors. The earth is faster now: Indigenous observations of Arctic environmental change. Arctic Research Commission of the United States, Fairbanks, Alaska, USA.

Huntington, H. P., and N. I. Myrmin. 1996. Traditional ecological knowledge of Beluga Whales: an Indigenous knowledge pilot project in the Chukchi and Northern Bering Seas. Inuit Circumpolar Conference, Anchorage, Alaska, USA.

Huntington, H. P., Brown-Schwalenberg, K. J. Frost, M. E. Fernandez-Gimeniz, D.W. Norton. 2002. Observations on the workshop as a means of improving communication between holders of traditional and scientific knowledge. Environmental Management 30:778-792.

Inglis, J. T. 1993. Traditional ecological knowledge: concepts and cases. International Program on Traditional Ecological Knowledge and International Development Research Centre, Ottawa, Canada.

Johannes, R. E. 1998. Traditional ecological knowledge: a collection of essays. Gland Switzerland, International Conservation Union.

Johnson, M. 1992. Lore: Capturing Traditional Environmental Knowledge. Dene Cultural Institute, International Development Research Centre, Ottawa, Canada.

Klubnikin, K., C. Annett, M. Cherkasova, M. Shishin, and Irina Fotieva. 2000. The sacred and the scientific: traditional ecological knowledge in Siberian River conservation. Ecological Applications 10:1296-1306.

Koerner, L. 1999. Linnaeus: nature and nation. Harvard University Press, Cambridge, Massachusetts, USA.

Kroeber, A. L. 1955. C. Hart Merriam as Anthropologist. Pages vii-xiv *in* C. Hart Meriaum and the staff of the Department of Anthropology of the University of California, editors. Studies of California Indians. University of California Press, Berkeley, USA.

Krebs, C. J. 2009. Ecology: the experimental analysis of distribution and abundance. The University of British Columbia, Canada.

Krupnik, I., and G. C. Ray. 2007. Pacific walruses, Indigenous hunters, and climate change: bridging scientific and Indigenous knowledge. Deep-Sea Research II 54:2946-2957.

Landesman, C. 1997. An introduction to epistemology. Blackwell Publishers, Cambridge, Massachusetts, USA.

LeCompte, M. D., J. P. Goetz. 1982. Problems of reliability and validity in ethnographic research. Review of Educational Research 52:31-60.

Leopold, A. 1949. A sand county almanac. Oxford University Press, London, UK.

Lertzman, D. A. 2010. Best of two worlds: traditional ecology knowledge and western science in ecosystem-based management. BC Journal of Ecosystems and Management 10:104-126.

Long, J., A. Tecle, and B. Burnette. 2003. Cultural foundations for ecological restoration on the White Mountain Apache Reservation. Conservation Ecology 8(1):4 (online).

Lovelock, J. E. 1979. Gaia: a new look at life on earth. Oxford Press, London, UK.

Mailhot, J. 1994. Traditional ecological knowledge: the diversity of knowledge systems and their study. Great Whale Environmental Assessment 4. Great Whale Review, Montreal, Canada.

Mander, J. 1991. The absence of the sacred. Sierra Club Books, San Francisco, California, USA.

Marshall, J., III. 1995. On behalf of the wolf and the First Peoples. Red Crane Books, Santa Fe, New Mexico, USA.

Mayr, E. 1982. The growth of biological thought: diversity, evolution, and inheritance. The Belknap Press of Harvard University Press, Cambridge, Massachusetts, USA.

Mayr, E. 1997. This is biology: the science of the living world. The Belknap Press of Harvard University Press, Cambridge, Massachusetts, USA.

McGregor, D. 2004. Traditional ecological knowledge and sustainable development: towards coexistence. Pages 72-91 *in* Blaser, M., and J. A. Feit, and F. McRae, editors. In the way of development: indigenous peoples, life projects and globalization. International Development Research Centre, Zed Books, London, UK.

Meffe, G. K., and C. R. Carroll. 1997. What is conservation biology? Pages 3-21 *in* Meffe, J. K., and C. R. Carroll, editors. Principles of Conservation Biology. Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA.

Menzies, C. R. 2006. Traditional ecological knowledge and natural resource management. University of Nebraska Press, Lincoln, USA.

Menzies, C. R., and C. Bulter. 2006. Understanding ecological knowledge. Pages 1-20 *in* C. R. Menzies, editor. Traditional ecological knowledge and natural resource management. University of Nebraska Press, Lincoln, USA.

Matter, W. J., and R. W. Mannan. 1989. More on gaining reliable knowledge: a comment. Journal Wildlife Management 53:1172-1176.

Miraglia, R. A. 1998. Traditional Ecological Knowledge Handbook: A training manual and reference guide for designing, conducting, and participating in research projects using traditional ecological knowledge. Alaska Department of Fish and Game, Division of Subsistence, Anchorage, Alaska, USA.

Nabhan, G. P. 2000. Interspecific relationships affecting endangered species recognized by O'odham and Comcáac cultures. Ecological Applications 10:1288-1295.

Nadasdy, P. 1999. The politics of TEK: power and the "integration" of knowledge. Arctic Anthropology 36:1-18.

Nadasdy, P. 2003. Hunters and bureaucrats: power, knowledge, and Aboriginal-state relations in the southwest Yukon. UBC Press, Vancouver, Toronto, Canada.

Naess, A. 1989. Ecology, community, and lifestyle: outline of an ecosophy. Translated and edited by D. Rothenberg. Cambridge University Press, Massachusetts, USA.

Nakashima, D. J. 1993. Astute observation on the sea ice edge: Inuit knowledge as a basis for Arctic co-management. Pages 99-110 *in* Inglis, J. T., editor. Traditional ecological knowledge: concepts and cases. International Program on Traditional Ecological Knowledge and International Development Research Centre, Ottawa, Canada.

National Marine Fisheries Service. 2007a. Endangered and threatened species: proposed endangered status for the Cook Inlet beluga whale. Federal Register 72:19854-19862.

National Marine Fisheries Service. 2007b. Notice of availability of final Eastern Pacific northern fur seal stock conservation plan. Federal Register 72:73766-73770.

National Marine Fisheries Service. 2009a. Endangered and threatened species: designation of critical habitat for Cook Inlet beluga whale. Federal Register 74:63080-63095.

National Marine Fisheries Service. 2009b. Endangered and threatened species: proposed threated status for southern distinct population segment of eulachon. Federal Register 74:10857-10876.

National Research Council. 1995. Science and the Endangered Species Act. National Academy Press, Washington, D.C., USA.

Nudds, D., and M. L. Morrison. 1991. Ten years after "reliable knowledge": are we gaining? Journal of Wildlife Management 55:757-760.

Pierotti, R. 2010. Indigenous knowledge, ecology, and evolutional biology. Taylor and Francis, New York, USA.

Pierotti, R., and D. Wildcat. 1997. The science of ecology and Native American traditional. Winds of Change 12:94-98.

Pierotti, R., and D. Wildcat. 1999. Traditional knowledge, culturally based worldviews and western science. Pages 192-1999 *in* D. Posey, editors. Cultural and spiritual

values of biodiversity. U.N. Environment Program Intermediate Technology Publications, London, UK.

Pierotti, R., and D. Wildcat. 2000. Traditional ecological knowledge: the third alternative (commentary). Ecological Applications 10:1333-1340.

Peat, F. D. 1994. Lighting the seventh fire: the spiritual ways, healing, and science of the Native American. A birch Lane Press Book, Secaucus, New Jersey, USA.

Peat, F. D. 2005. Blackfoot physics: a journey into the Native American universe. Weiser Books, Boston, Massachusetts, USA.

Plotkin, M. J., and A. Forsyth. 1997. Retaining indigenous knowledge systems as a management tool. Pages 355-356 *in* Meffe, G. K., and C. R. Carroll, editors. Principles of conservation biology. Sinauer Associates, Inc., Publishers, Sunderland Massachusetts, USA.

Romsberg, H. C. 1981. Wildlife science: gaining reliable knowledge. Journal of Wildlife Management 45:293-313.

Romsberg, H. C. 1991. On improving the natural resources and environmental sciences. Journal of Wildlife Management 55:744-756.

Rist, L., R. U. Shaanker, E.J. Milner-Gulland, and J. Ghazoul. 2010. The use of traditional ecological knowledge in forest management: an example from India. Ecology and Society 15:1 (online)

Sillitoe, P. 1998. The development of indigenous knowledge: a new applied anthropology. Current Anthropology 39:223-252.

Soulé, M. 1985. What is conservation biology? Bioscience 35:727-734.

Soulé, M., and B. A. Wilcox. 1980. Conservation biology: an evolutionary-ecological perspective. . Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA.

Suzuki, D., and P. Knudtson. 1992. Wisdom of the elders: sacred native stories of nature. Bantam Books, New York, USA.

Toupal, R.S. 2003. Cultural landscape as a methodology for understanding natural resource management impacts in the western United States. Conservation ecology 7:12 (online).

U.S. Fish and Wildlife Service. 2001. Endangered and threatened wildlife and plants: final determination of critical habitat for the Spectacled Eider (*Somateria fischeri*). Federal Register 66: 9146-9185.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants: determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range; final rule. Federal Register 73:28212-28303.

U.S. Fish and Wildlife Service. 2010a. 2010 Fisheries Resource Monitoring Plan. http://www.fws.gov/nativeamerican/graphics/traditional ecological knowledge_Fisheries_Resource_Monitoring_Plan.pdf

U.S. Fish and Wildlife Service. 2010b. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the Sonoran Desert population of the bald eagle as a threatened or endangered distinct population segment. Federal Register 75:8601-8621.

Van Devender, T.R., and C.R. Schwalbe. 1998. Diet of free-ranging desert tortoises (*Gopherus agaaizii*) in the north-eastern Sonoran Desert, Arizona. Arizona Game and Fish Department Final Report 195043, Phoenix, USA.

Warren, D. M., L. J. Slikkerveer, and D. Brokensha. 1995. The cultural dimension of development: indigenous knowledge systems. Intermediate Technology Publications, London, UK.

Wheeler, P., and A. Craver. 2005. Office of Subsistence Management and issues and challenges of integrating traditional ecological knowledge into subsistence fisheries management. Practicing Anthropologist 27:15-19.

Wehi , P. M. 2009. Indigenous ancestral sayings contribute to modern conservation partnerships: examples using *Phormium tenax*. Ecological Applications 19(1):267-275.

Wesley, F. R., and P. S. Miller. 2003. Experiments in consilience: integrating social and scientific responses to save endangered species. Island Press, Washington D.C., USA.

Wilson, E. O. 1985. The biological diversity crisis. BioScience 35:700-706.

Wilson, E. O. 1998. Consilience: the unity of knowledge. Alfred A. Knoff, Inc., New York, USA.