This is to certify that the
dissertation entitled

ECOLOGICAL AND HUMAN DIMENSIONS OF TRIBAL AND
STATE NATURAL RESOURCE MANAGEMENT

presented by

NICHOLAS J. REO

has been accepted towards fulfillment
of the requirements for the

Ph.D. degree in Fisheries and Wildlife

Major Professor's Signature

5-14-10

Date

ECOLOGICAL AND HUMAN DIMENSIONS OF TRIBAL AND STATE NATURAL RESOURCE MANAGEMENT

By

NICHOLAS J. REO

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Fisheries and Wildlife

2010

func

boun

realit

coope

Some

occur

dimens

the Lac

(WDNF

program

provide

underst

natural

about th

primary

ABSTRACT

ECOLOGICAL AND HUMAN DIMENSIONS OF TRIBAL AND STATE NATURAL RESOURCE MANAGEMENT

By

Nicholas J. Reo

A daunting ecological reality facing natural resource managers is that ecological functions and biotic populations (both native and exotic) do not fit neatly within political boundaries, necessitating broad scale, cross-boundary approaches to their work. This reality is daunting because working beyond one's own jurisdictional borders requires cooperation across cultural and political differences, an inherently complex endeavor. Some of the most challenging cross-boundary natural resource management practices occur at the interface of neighboring tribal and public lands.

This dissertation is an interdisciplinary exploration of ecological and human dimensions of neighboring tribal and state natural resource management systems where the Lac du Flambeau (LDF) Tribe and Wisconsin Department of Natural Resources (WDNR) cooperate extensively while taking distinctly different approaches in certain programs including hunting and forest management. The goal of the dissertation was to provide insights of value within the local study area that also improve general understanding of tribal-state relations, contemporary subsistence hunting, cross-boundary natural resource management and interrelated management of oak forests and deer.

With this goal in mind, I interviewed tribal hunters to help dispel misconceptions about their hunting practices and perspectives. Interviewees provided explanations of the primary purposes of hunting, traditional values related to hunting and human-animal

relatio

subsis

wildli

contin

practic

norther

larger c

on nort

and stat

tribal la

several c

A

forest ma

willingne

years of

officials

their poli

building

elected o

help disp

insights r

managem

relationships among LDF Ojibwe. Primary findings were that LDF Ojibwe hunt deer for subsistence purposes and they value safety, reciprocal sharing of harvested meat and wildlife conservation. They believe deer willingly give up their lives to feed people contingent upon people showing proper respect to deer at all times.

I also studied forest regeneration following LDF-specific forest management practices. My results indicated that residual pockets (clusters of trees <3 ha in area) of northern red oak (*Quercus rubra* L.) produced fewer but faster growing seedlings than larger oak stands (>15 ha). Tribal timber stand improvement practices showed no effect on northern red oak regeneration. Comparison of seedling growth and survival on tribal and state forests indicated that northern red oak was regenerating significantly better on tribal lands where the white-tailed deer population was maintained at a low density for several decades.

Although the LDF Tribe and WDNR took distinct approaches to hunting and oak forest management, they were interested in learning from one another's approaches. This willingness to engage and learn openly from one another resulted from more than 20 years of relationship building and regular communication. I interviewed LDF and WDNR officials to learn how they were able to communicate and cooperate effectively across their political boundaries and cultural differences. Results point to the importance of building cross-boundary personal relationships among field staff, administrators and elected officials through regular, informal interactions. The results from this dissertation help dispel misconceptions about contemporary tribal subsistence hunting, provide insights regarding interrelationships between oak forest management and deer management and provide a case study of cooperative tribal-state relations.

provide
am enc
membe
encoura
Univers
Founda
Endowr
financia

project.
for Syst
Rothste
Kashian
The Uni
camp fo
Kellner
Univers
writing

Highl
their i

ACKNOWLEDGMENTS

I offer my thanks and appreciation to all the people and organizations that provided their support during my doctoral studies. Jack Liu is an amazing advisor and I am enormously grateful for all of his insights, support and mentorship. My committee members, Dan Kramer, Mike Walters and George Cornell provided me with ongoing encouragement and important input on my research ideas and writing. Michigan State University Extension, the College of Agriculture and Natural Resources, the Ford Foundation, the National Aeronautical Space Administration, the Emma Shore-Thornton Endowment and the Sault Ste. Marie Tribe of Chippewa Indians all provided critical financial support for my doctoral program.

The assistance of a number of individuals contributed to the success of this project. For their support in particular, I thank faculty, students and staff from the Center for Systems Integration and Sustainability as well as Tom Coon, Kim Hall, David Rothstein, Tiffany Muzanenhamo, Michael Nelson, Nick Balster, Burt Barnes, Dan Kashian, Lissy Goralnik, Kyle Whyte, Mary Calcatera, Rique Campa and Brian Maurer. The University of Wisconsin's Kemp Natural Resource Station served as the ideal base camp for all of my field work. I am very grateful to Thom Steele, Karla Ortman, Gary Kellner and Tina Youngquist for supporting my work and welcoming my family. The University of Michigan Biological Station also offered "northwoods solitaire" at a critical writing juncture.

Citizens and staff from the Lac du Flambeau Tribe and staff from the Northern Highland-American Legion state forests made this project possible by welcoming me into their homeplace and helping facilitate this research. In particular, Carl Edwards, Larry

Wawror

Stuart B

technici

insightf

I

parents,

and end

five yea

contribu

who to

jugglin

can nov

Wawronowicz and Steve Petersen provided guidance and input throughout the project. Stuart Burgess, Chuck Burgess and Donald "DJ" Johnson were outstanding field technicians with whom I thoroughly enjoyed working. Leon Valliere Jr. provided insightful and timely review of portions of the dissertation.

Last and most importantly, anything I accomplish occurs on the shoulders of my parents, grandparents and other relatives. My immediate family provided endless support and endured my absences and reduced contribution to family responsibilities for nearly five years. To my best friend and soul mate, Angie, I am eternally thankful for your contributions, sacrifices and patience along the way. To my two sons, Gordon and Oscar, who to date have not known their father without the stress and time commitment of his juggling a fulltime job and a fulltime doctoral program, thank you for your patience. You can now have your dad back.

TABLE OF CONTENTS

Table

Table
Impr

Table
comp

Table
older

Table

Tabl

Tabl

Tabl
sepa
total

Tab

Tab
of n
unit

Tab
for

Tab

Tal

Ta
co
wa

Ta
co
wa

LIST OF TABLES

Table
enhanc
charac

Figu
184.
banc
resei

Figu
expr
vari
safet
dime
orde

Figu

Figu
Impr

Figu

Figu

Figu

Figu
discri

Figu
size (
sized
E) ba

Figu
regim
oak s
north

Figu
veget

Figu
Highl
surro

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Backg

mosaic

ecolog

resour

region

Ricker

politic

ecolog

instanc

improv

strateg

withou

public-

that im

ecosys

ecolog

of ecol

timber

relative

manage

situated

Background

Regional landscapes around the world are composed of complex land tenure mosaics that include private, industrial and governmental land ownership. Because ecological processes and environmental issues do not respect land ownership boundaries, resource practitioners, scientists and policy makers have called for cross-boundary, regional approaches to ecosystem management (Yaffee 1999, Liu and Taylor 2002, Rickenbach and Reed 2002, Schulte et al. 2008). Regional collaborations that transcend political boundaries may be advantageous, or even required, to address a wide range of ecological issues that extend beyond local to regional, continental and global scales. For instance, Fagergren (1998) found that cross-boundary preserve stewardship led to improved protection of native flora, exotic plant control and introduction of management strategies such as prescribed burning that would have been logistically impracticable without cooperation across ownership boundaries. Propst et al. (1998) documented how public-private cross-boundary partnerships can lead to alternative development patterns that improve wildlife habitat, recreation opportunities and scenery and protect riparian ecosystems. Schulte et al. (2008) reported that cross-boundary coordination create ecological benefits (including larger forest and habitat patches and improved restoration of ecologically valued species of oak [*Quercus sp*p.]) as well as economic benefits (e.g., timber harvest economies of scale.) However, despite such documented benefits, relatively few successful examples of effective cross-boundary natural resource management exist (Wondolleck and Yaffee 2000).

In the United States (U.S.), the reservations of American Indian Tribes are often situated nearby or adjacent to public lands such as national and state forests. Tribal and pub

prac

natic

1) tri

relati

of cro

tribal

Riem

betwe

contur

states i

federal

contine

Alaska

lands,

Alaska

flowag

of othe

many t

with th

agreem

making

public land adjacency presents opportunities for enacting cross-boundary management practices. These opportunities are common in the U.S. where there are 562 distinct tribal nations. However, cross-boundary cooperation is challenging in these instances because 1) tribal communities are political entities with complicated and often ambiguous legal relationships with federal and state governments (Wilkins 2002, Deloria 2006); 2) a lack of cross-cultural understanding often interferes with relationships between tribal and non-tribal resource managers as well as tribal and non-tribal citizens (Jones Jarding 2004, Riemer 2004, Silvern 2008); and 3) the history of contentious interactions and relations between tribes and states has created obstacles to cooperation partly because states have contumaciously characterized tribal rights to fish and wildlife harvests as an affront to states rights (Wilkins 2002, Jones Jarding 2004).

Yet cross-boundary resource management cooperation between tribal, state and federal entities is important because tribes manage over 56 million acres of land in the continental U.S. (Henson et al. 2008, BIA 2010). Including Native land holdings in Alaska, there are approximately 100 million acres of tribal and Native Alaskan-controlled lands, or about 4% of lands in the U.S. (Henson et al. 2008). These tribal and Native Alaskan land areas are interconnected with the U.S. public land system via water flowage, fish and wildlife migrations, transportation routes, pollution drift and a myriad of other ecological and anthropogenic factors. Coordination is also important because many tribes have rights to harvests resources in large territories ceded through treaties with the United States. In some cases, these rights have resulted in co-management agreements with state and federal land management entities (Ebbin 2002, Nie 2009) making tribes partners in public lands management.

mar

be a

futu

Mil

tow

thos

mar

Abo

mar

eco

199

incl

leve

vari

biot

Jr. 1

prin

Gun

Yet,

are t

(199

Another rationale for cross-boundary assessments of tribal and public resource management is that incorporating the knowledge and experience of Native peoples may be an important step towards creating healthy societies and healthy ecosystems in the future (Berkes 1998, Klubnikin et al. 2000, Trosper 2002, Becker and Ghimire 2003, Millennium Ecosystem Assessment 2005, Xu et al. 2005). Much progress has been made toward understanding the ways that American Indian resource management systems (and those of other Native peoples around the world) can contribute to sustainable resource management and development. For example, previous research has provided examples of Aboriginal natural resource management systems that use disturbance and succession as management tools (Folke et al. 1998, Turner et al. 2000); focus on the preservation of key ecosystem functions (Pinkerton 1998); support resilience and sustainability (Berkes et al. 1994, Trosper 2002); manage ecosystems at multiple spatial scales (Folke et al. 1998) including scales sufficiently large to "plan for whole ecosystems at a genuinely landscape level" (Pinkerton 1998); and, recognize that neighboring ecosystems, ecosystems at various spatial scales and individual ecosystem components (including air, water, soil, biota) are all interconnected and interdependent (Berkes et al. 1998, Berkes 1999, Deloria Jr. 1999, Salmon 2000, Fixico 2003).

These characteristic of Aboriginal resource management systems coincide with principles emerging from research on ecosystem management (e.g.,Yaffee 1999, Gunderson and Holling 2002, Ostrom 2004, Millennium Ecosystem Assessment 2005). Yet, if Aboriginal and non-Aboriginal ecological knowledge and management systems are truly distinct, yet complimentary, as suggested by Ford and Martinez (2000), Berkes (1999), and Agrawal (1997), then it is important to disentangle the complex social and ec

th

co

be

cr

Oh

the

this

res

ecological relationships that exist in areas of tribal and public land adjacency to sort out the specific ways that these autonomous, neighboring management programs can best complement one another. Such a process could provide important insights and lead to beneficial shifts in both tribal and public resource policy and management and increase cross boundary management.

Objectives

Because of the importance of cross-boundary management involving tribes and the lack of documented examples of successful tribal-state natural resource cooperation, this dissertation focuses on a specific example of tribal-state cross-boundary natural resource management with the following objectives in mind:

1. Document Lac du Flambeau Ojibwe hunting practices and explore how Ojibwe-specific traditional values influence those practices (Chapter 2);
2. Evaluate whether 25+ years of timber stand improvement work by the LDF Tribe have lead to significant increases in the density of northern red oak seedlings and small overstory trees on LDF Reservation forests (Chapter 3);
3. Compare northern red oak regeneration outcomes following tribal and state resource management practices that have led to widely divergent white-tailed deer densities (Chapter 4);
4. Identify factors that enabled the LDF Tribe and the Wisconsin Department of Natural Resources to navigate contentious regional natural resource conflicts and develop a highly cooperative cross-boundary working relationship (Chapter 5).

St

La

Su

For

this

WD

can

and

profe

the c

to co

hecta

Iron).

Study Area

I conducted the research for this dissertation in north central Wisconsin on the Lac du Flambeau Reservation, homelands of the Lac du Flambeau (LDF) Band of Lake Superior Chippewa Indians and the Northern Highland-American Legion (NH-AL) State Forests operated by the Wisconsin Department of Natural Resources (WDNR). I chose this location for several reasons. First, this case is unique in that the LDF Tribe and WDNR have established a highly cooperative working relationship that tribes and states can benefit from learning about in other regions. Second, I was familiar with the ecology and flora of the region. Third, as a member of a Michigan Chippewa tribe with professional experience working with Great Lakes tribes, I was relatively familiar with the cultural context in LDF. Lastly, tribal and state representatives generously invited me to conduct the project on their lands.

The NH-AL state forest was established in 1925 and encompasses over 95,000 hectares (ha) of land including portions of three Wisconsin counties (Vilas, Oneida and Iron). The vision statement of the NH-AL State Forest reads:

> The Northern Highland-American Legion State Forest is a dynamic environment comprised of a variety of biological communities that contribute to the diversity of ecosystems in the region. The state forest provides a range of cultural, social, economic and ecological benefits, within its capabilities, for present and future generations. The unique, aesthetic character of the NH-AL State Forest and the quality of its waters are perpetuated and enhanced. The forest is managed in consultation with federal, tribal, local and other governments, and with other people who care about the forest, including those who live, work and recreate in and around it (WDNR 2005).

in

so

ec

ac

C

u

n

a

s

h

r

r

r

t

a

t

The landscape of the NH-AL is predominantly comprised of upland forests, inland lakes and wetland ecosystems which are managed for a variety of ecological, social and economic values including conservation of biological diversity and functional ecological systems, timber production, recreation, education, subsistence harvests, natural aesthetics, and protection of cultural resources.

The LDF Reservation is the homeland of the LDF Band of Lake Superior Chippewa Indians. The reservation is approximately 350 km^2 including 16,889 ha of upland forest, 9,712 ha of wetlands and 7,243 ha of lakes and rivers (LDF internal management document). Of this area, the tribe owns and manages 13,467 ha, an additional 5,720 ha are owned by individual tribal citizens or families and 9,313 ha are so-called "fee lands" (i.e., in fee simple property status) owned by non-Indians. The tribe has just over 3,100 enrolled citizens, with over 1,700 living on the reservation. The reservation population is just under 3,000 people, including just under 1,300 Indian and non-Indian individuals who are not LDF tribal citizens.

The forests of the LDF Reservation are managed for a variety of commercial, recreational, subsistence, and cultural purposes. A growing number of tribal citizens on the reservation places significant development pressure on reservation forests to accommodate housing, infrastructure and human service needs. The vision statement of the LDF Tribe reads:

> The Lac du Flambeau Tribal Council has the responsibility to create a sustainable community for Tribal members, descendents, and the seventh generation. The Tribal Government will improve the quality of life by following our Ojibwa culture and philosophy: A holistic and well-balanced approach will be

incorporated into the following program areas: Health, Education, Welfare, Economic Development and Natural Resources. Long range planning and goal setting will be implemented using community input. Our culture and heritage will be the focal point on our way to our vision of the community. Healthy lifestyles, wellness, family values and spirituality will guide our long-range planning and implementation. We will protect our sovereignty and treaties, while moving forward for present and future generations (LDF Integrated Resource Management Plan, 2007).

Comparison of these vision statements is revealing. The NH-AL state forest places ecosystems at the center of its vision statement, which are managed for human and ecological benefits/values. The LDF tribal vision statement focuses its tribal citizenry, the importance of their culture and on protecting/sustaining reservation resources for future generations. The LDF and NH-AL vision statements reflect the different purposes of these tribal and public land areas. The reservation is the homeland of Lac du Flambeau citizens and is managed to accommodate the wide range of community needs and land uses. The NH-AL, as part of the Wisconsin public land system, is managed to protect ecological attributes including biotic communities while providing places for recreation and other human-centered values. Because it is managed as a public natural area, development pressures on the NH-AL are comparatively lower than on the LDF reservation.

Forest ecosystems on the LDF Reservation and NH-AL have similar bio-physical conditions. Climate in both areas is characterized by a 121-day growing season, average temperatures range from -6.7 to 35^{o} C and average annual precipitation ranges from 76.2 to 86.4 cm (Albert 1995). Elevation ranges from 442-590m. The most common phy

con

call

Res

abu

and

physiographic systems in both sections of the study area are pitted outwash and ice contact-derived landform systems. The study area falls within one regional ecosystem called the "Lac Veaux Desert Outwash Plain" (Albert 1995). The NH-AL and LDF Reservation have a similar mix of forest cover types with aspen types as the most abundant followed by red/white pine followed by northern hardwoods, forested wetlands and northern red oak (WDNR 2005).

CHAPTER 2

“I DID TAKE THAT DEER’S LIFE”: LAC DU FLAMBEAU HUNTING PRACTICES AND TRADITIONAL VALUES

Abstract

In the 1960's and 1970's, citizens of tribal nations in the United States began openly re-asserting rights to harvest fish and game off reservations in lands ceded to the U.S. through 19th Century treaties, resulting in overt and sometimes violent anti-Indian backlash. Through the 1900's and 2000's, non-Indians gradually came to accept that treaty rights and treaty harvests were here to stay and the overtly hostile responses subsided. Yet, understanding of the purposes and practices of contemporary American Indian subsistence harvests is still lacking.

I interviewed 14 of the most active white-tailed deer (*Odocoileus virginianus*) hunters from the Lac du Flambeau (LDF) Reservation in north central Wisconsin to document their hunting practices and determine how traditional Ojibwe or LDF-specific values influence those practices. Interviewees provided explanations of the primary purposes of hunting, traditional values related to hunting and human-animal relationships among LDF Ojibwe. Primary findings were that the LDF Ojibwe hunt deer for subsistence purposes and they value safety, reciprocal sharing of harvested meat and wildlife conservation. They believe deer willingly give up their lives to feed people contingent upon people showing proper respect to deer at all times. Tribal citizens hunt off-reservation whenever it is financially feasible, preserving on-reservation hunting opportunities for tribal citizens who have less money. These results should help dispel misconceptions about contemporary tribal subsistence hunting, which could in turn help improve relations between tribal and non-tribal citizens on and near reservations by improving cross-cultural understanding.

Int

trib

Lak

agre

harv

cede

agree

share

examp

impro

treaty-

overt ra

threats

made th

non-trib

underst

establis

often st

negativ

1997, R

Introduction

Since the mid 1970's, the treaty-guaranteed harvest rights of American Indian tribes from areas of the United States (US) including the Pacific Northwest and Great Lakes regions have been re-affirmed through court rulings and inter-governmental agreements (McCorquodale 1999, Silvern 2008). As tribal citizens began to more openly harvest fish and game off their reservations where they have retained rights to use treaty-ceded lands, harvesters were targeted by sportsmen who felt treaties were out-of-date agreements supporting unfair "race-based" rights. Conflicts erupted and lingered over shared interest in fish and wildlife harvests on public lands and waters, lasting, for example, for nearly a decade in north central Wisconsin.

Relationships between Indians and non-Indians on and around reservations have improved considerably since the historic conflicts that occurred in the 1970's-1990's over treaty-based salmon, walleye and whitefish harvests. Communities have moved past the overt racism and heated conflicts that included rock throwing, effigy hanging and death threats against American Indian harvesters (Loew In Review). Improvements have been made through the work of tribes, non-tribal governments, inter-tribal organizations and non-tribal community members who have implemented educational programs that foster understanding of treaty rights and the resource management arrangements that have been established to facilitate off-reservation harvests. However, the non-Indian general public often still lacks a basic understanding of the purposes and practices of Indian harvesters, negatively impacting social relations between Indians and non-Indians (McCorquodale 1997, Riemer 2004).

20

an

ec

19

lac

of N

am

Flam

objec

tradit

wheth

and cr

from i

provid

hunters

tribal c

Metho

Study

Chippe

Other authors have investigated conflict over subsistence fish harvests (Nesper 2002, Riemer 2004), connections between the cultural contexts of subsistence hunting and tribal wildlife management (McCorquodale 1997) and how socio-political and ecological changes have influenced modern subsistence hunting practices (Brightman 1993, Brody 1997, Fienup-Riordan 2000, Guilmet and Whited 2002). However there is a lack of detailed information about the contemporary hunting activities and perspectives of North American Indians that could be used to build cross-cultural understanding among tribal and non-tribal citizens.

To help address this knowledge gap, I interviewed active hunters from the Lac du Flambeau (LDF) Band of Lake Superior Chippewa Indians with the following specific objectives in mind: 1) document LDF Ojibwe hunting practices, 2) determine how traditional Ojibwe or LDF-specific values influence those practices and 3) evaluate whether their traditional values system is changing amid increasing outside influences and cross-cultural integration. Based on emergent themes from the interviews, insight from individual interview participants and relevant background knowledge, I then provide an evaluation of the differences and commonalities between tribal and non-tribal hunters as a way to increase mutual understanding and acceptance among tribal and non-tribal citizens and resource managers.

Methods

Study Area Background

The LDF Reservation is the homeland of the LDF Band of Lake Superior Chippewa Indians (Figure 2.1). The reservation is approximately 350 km^2 including

16.8

area.

indiv

simp

citize

unde

not L

docu

Wisc

Chip

Ojibv

to wh

cedec

north

rights

territ

activ

for w

India

Ojib

Spea

16,889 ha of upland forest, 9,712 ha of wetlands and 7,243 ha of lakes and rivers. Of this area, the tribe owns and manages 13,467 ha, an additional 5,720 ha are owned by individual tribal citizens or families and 9,313 ha are so-called "fee lands" (i.e., in fee simple property status) owned by non-Indians. The tribe has just over 3,100 enrolled citizens, with over 1,700 living on the reservation. The reservation population is just under 3,000 people, including just under 1,300 Indian and non-Indian individuals who are not LDF tribal citizens (LDF internal integrated resource management planning document, 2008).

The LDF Reservation and reservations of neighboring tribes in northern Wisconsin were created through a series of treaties in the mid 1800's between various Chippewa (also known as Ojibwe) bands and the U.S. Through these same treaties, the Ojibwe bands of this region ceded large land areas to the United States, opening them up to white settlement, but retaining rights to hunt, fish and gather plant materials in their ceded territories. These treaties are the basis of modern off-reservation tribal harvests in northern Wisconsin. Today, the LDF Tribe and five other Ojibwe bands actively use their rights to harvest fish and game in the Wisconsin portion of the 1837 and 1842 ceded territories (Figure 2.1).

In the mid 1980's hunters and fishers from the northern Wisconsin bands began actively and publicly asserting their treaty rights through off-reservation spring spearing for walleye (*Sander vitreus*). The spearing activities spurred serious conflict between Indian harvesters and non-Indian sportsmen, which centered on boat landings where Ojibwes launched their spearing boats. Protestors threw rocks and racial slurs at the spearers, detonated pipe bombs, speared and hung effigies of Indians from trees and

mad
atten
the is
Revi
mid
regio
feder
about
Light
relati
incluc
non-N
staff,
Chapt

betwe
white-
pervas
when
the co
surrou
with t
The v

made death threats. The conflicts drew ongoing national, regional and local media attention, though the media rarely covered substantive political or biological aspects of the issue, focusing instead primarily on boat launch clashes (Nesper 2002, Loew In Review). Heated conflicts lasted for nearly ten years through the mid 1990's. From the mid 1990's to the late 2000's, the conflicts calmed considerably. To help resolve these regional conflicts, the northern Wisconsin tribes and WDNR worked together with federal officials, inter-tribal organizations and local community groups to educate people about the legitimacy of treaty rights (Loew In Review). Two programs called "Casting Light on the Waters" and "Gathering of the Guides" were established to build relationships among parties vested in natural resource management and conservation including tribal, federal and state resource managers, policy makers and local Native and non-Native fishing guides. Through these programs and regular interactions among field staff, the WDNR and tribal officials gradually built functional working relationships (see Chapter 5).

Despite this progress, disagreements and misunderstandings continued to occur between tribal citizens and non-tribal citizens over fish and wildlife issues including white-tailed deer (*Odocoileus virginianus*) hunting. Although not as explosive or pervasive as in the mid 1980's to mid 1990's, confrontations and arguments occurred when hunters encountered one another in the woods and during everyday interactions in the communities surrounding LDF and other reservations. The "northwoods" region surrounding the LDF Reservation is a popular vacation destination and the area swells with tourists and seasonal residents traveling from places like Chicago in the summer. The vacationers are not exposed as consistently as local fulltime resident non-Indians to infor

offici

years

Data

the LI

offici

comm

questi

Direct

partici

intervi

instrum

Ameri

enrolle

tailed d

Reserv

Their a

were e

Departn

of these

information about treaty rights and tribal-state natural resource co-management. Tribal officials from LDF report that many of the confrontations and disagreements in recent years have occurred in the summer with seasonal residents and tourists.

Data Collection

In 2007 and 2008, I interacted regularly with active white-tailed deer hunters from the LDF Reservation. I also interacted with natural resource managers and elected tribal officials. These interactions along with my personal and professional experiences in tribal communities and review of relevant literature helped to formulate the focus and research questions of this chapter.

Key contacts from the tribe, including the Tribal Council President, the Deputy Director of Natural Resources and the Tribal Wildlife Manager, helped identify interview participants. I designed a question-concept matrix (Table 2.1) outlining a series of interview questions plus respective research concepts. I pre-tested this interview instrument with hunters from a politically distinct but culturally related tribe and an American Indian philosophy scholar, making adjustments based on their feedback.

In the summer of 2009, I conducted in-depth semi-structured interviews with 14 enrolled LDF citizens who were highly active hunters and had been involved in white-tailed deer hunting since they were children. All participants were from the LDF Reservation although one had spent a significant number of years living in a nearby city. Their ages ranged from 17 to 72 and included 13 men and one woman. Seven participants were employed by the tribe (including staff from the Natural Resources Department, IT Department, Ojibwe Language Program, Roads Department and Tribal Casino) and two of these seven were also tribal elected official. Three others were self employed including one

part

were

25 –

two

The

main

interv

Interv

incent

Data A

Versio

Geotz

through

respons

referen

softwar

followe

drafts o

Lac du

one as a fishing guide, one was retired, one was a student and one unemployed. Two participants were father and son and lived together in the same household, though they were interviewed separately. The length of these key informant interviews ranged from 25 – 90 minutes and averaged 56 minutes. The wide range in interview length is due to two interview participants fitting our conversations into their particularly tight schedules. The interviews followed the questions established in my question-concept matrix, maintaining the same interview question sequence as best as possible. I recorded all interviews using a portable digital audio recorder and later transcribed the audio files. Interviewees were given a $50 gas card as a token of appreciation and participation incentive.

Data Analysis

I coded interview transcriptions using NVivo qualitative data analysis software Version 8 (QSR International 2008) using an iterative coding procedure (LeCompte and Geotz 1983, Miles and Hubermann 1994), refining my hierarchical coding structure through three rounds of coding. Themes emerged out of similar and interrelated responses within the interview dataset. I confirmed recurrent themes by enumerating the references to each coded concept or idea within the interview transcripts using the NVivo software package. I then reviewed the specific interview responses more thoroughly that followed recurrent themes, providing insights into my research questions. I submitted drafts of the case study for review to a research participants and cultural leader from the Lac du Flambeau Tribe as a form of "member checking" (Lincoln and Guba 1985).

Resu

Hun

first c

age, a

plot th

walkin

hunter

deer.)

species

Severa

muskie

hare, m

that ver

bought

cleanly

was a tr

and eati

intervie

because

families

family t

Results

Hunting Practices

The hunters I spoke with all started hunting at a young age. They had shot their first deer between ages seven and 13. Most had been involved with hunting at an earlier age, as early as five years old, observing the butchering of deer meat, listening to hunters plot their day's hunting strategies, scouting hunting locations and deer movements and walking with older hunters during deer drives (a common technique where a group of hunters walks through the woods pushing deer to "standers" waiting to shoot passing deer.) All of the people I interviewed stated that white-tailed deer was the primary species they hunted, but most also harvested other animals including fur-bearers and fish. Several interviewees were active in spring spearing for walleye and winter spearing for muskie and pike. Other harvests included partridge (ruffed grouse), ducks, snowshoe hare, muskrat, beaver and porcupine.

The primary motivation for hunting was for food. The hunters appreciated the fact that venison is a healthier alternative to commercially available meats. Unlike store bought meats, they knew exactly where their venison came from, that it was processed cleanly and that the deer ate a natural diet free of hormones and other chemicals. Venison was a traditional food source dating back thousands of years in their community; hunting and eating venison therefore helped to maintain an important cultural tradition. Several interview participants stated that at some point in their lives, venison was a survival food because they had limited finances for providing basic needs such as food for their families. Other reasons people hunted included camaraderie and time with family/friends, family tradition and enjoyment of the outdoors.

ow

oth

the

not

indi

hous

was

total

in hig

traditi

emerg

indicat

later, w

whenev

have ar

more tr

keep en

for thei

beginni

The deer meat these hunters harvested was not just for consumption within their own households. Each of the hunters mentioned that they also hunt to provide meat to other people in their extended families, typically giving away as much as they kept for themselves or far more. They shared deer meat with their elders, with households that did not hunt and with single mothers. The number of deer harvested and consumed within the individual households of the hunters ranged from 5-12 per year and the average household size was five people. However, the number of deer harvested by the hunters was often far greater because they were providing meat for several households. Average total harvests ranged from 12 to 30 deer with some hunters harvesting more than 50 deer in high years.

For those individuals interviewed, hunting typically occurred in the fall. Local traditions dictated that it was permissible/acceptable to begin hunting once fireflies emerge in mid-summer. Several participants noted that they respect this traditional indication of the start of hunting season but that they do not actually start hunting until later, whenever last year's venison stock runs out. One hunter stated, "[I start hunting] whenever the deer meat runs out. I don't look at my deer rifle until my freezer doesn't have any more deer meat in it. It's a good supply of meat for me and my nephews…"

Not all LDF hunters own freezers for storing meat. Some LDF families follow a more traditional practice of immediately using a deer after it has been harvested. They keep enough meat for a few meals in their household and give the rest away to relatives for their immediate consumption or short term storage.

Most of the hunters I spoke with finished the bulk of their hunting by the beginning or end of the state-administered gun hunting season which runs annually from

November 20-28. Hunters from LDF who stopped hunting by the start of the state gun season cited safety concerns and did not like to hunt around hundreds of non-Indian hunters who occupy the woods during the nine-day state-administered gun hunt. Those who stopped hunting by the end of the state gun season did so because the weather becomes too cold and unpredictable starting in December.

Three individuals mentioned that they occasionally bow hunt. The rest exclusively use high powered rifles. Calibers of choice included 30.06, .308, .300 Winchester Magnum and 30-30.

Interview participants hunted both on and off their reservation with some concentrating their efforts on-reservation and others off-reservation. Those who hunted off-reservation varied in their locations. Some had specific areas they hunted every year, and others spread themselves out more to varying degrees. Two people noted that they had hunted throughout all areas of their tribe's ceded territories (Figure 2.1) at one time or another. Others noted that they tend to stay within about a 30-40 minute drive of their home to limit their fuel expenditures. Several people stated that they hunt primarily off-reservation because they want to preserve on-reservation hunting opportunities for people who have limited funds for gas money or do not own vehicles.

The hunters used a variety of techniques to harvest deer. The most common techniques were drives (pushing deer) and hunting from a vehicle (a.k.a. "road hunting"). Driving deer was a long standing tradition in LDF and was the method most interviewees first learned as young people. The advantages and benefits of this technique are that hunters encounter a lot of deer, they use less fuel than with road hunting and it is a social activity that brings family members from multiple generations together. It also requires

more skill and gets the hunters out in the woods paying attention and learning about their surroundings. Road hunting is a common practice because it is an efficient use of time and relatively easy way to harvest deer. Road hunting occurs during the day and at night via spotlight. Night hunting is only permitted on-reservation. Other techniques used by the interview participants included still hunting from stands or blinds, stalking deer, using dogs to circle deer around to standing hunters and hunting stream and river bottoms by canoe.

Traditional Values

The hunters described a wide range of family-held and community-held traditional values. They also explained how these values influenced their hunting practices, their perspectives about hunting and their perspectives about white-tailed deer. To provide some organizational structure to this list of interrelated traditional values and value-based practices, I describe them roughly in the order that they are first introduced or taught to young hunters by their older family members. This order also follows roughly the sequence of events for hunters in a given hunting season (Figure 2.2). The values and practices described here are not upheld by every single hunter from LDF; however, these are the recurrent themes that emerged in my interviews with 14 of the community's most active hunters.

One of the first hunting-related values imparted to young people in LDF is hunting safety. Young people are taught proper safety techniques through repetition and over the course of several years by spending time going along on hunts and participating in deer drives prior to earning the rights to carry a weapon or harvest a deer. During this training phase, young hunters are also taught to respect the woods by being mindful of other beings (animals, plants, spirits) that live there and conducting themselves in the woods as if they were in someone else's home. Some hunters are taught to give tobacco as a gift to the beings that reside in the woods before they enter to hunt (more discussion on tobacco use below). LDF notions of respect for the woods also involve leaving the woods the way you found it by not littering. Further, young people are instructed to pay close attention to their surroundings when they are hunting. This helps them learn their way around the woods and provides a measure of safety by keeping hunters' attention on the task at hand. One respondent stated, "My [grandfather] raised me, so I came into his generation, (doing) what he used to do. I was always in the woods with him. He showed me everywhere on the reservation what I needed to know or see. He made me go into the woods. He said 'you look around when you're in there; you don't just go rushing through there.'" I also interviewed this respondent's son, who similarly shared that he was instructed to "Just be aware of my surroundings; know where you are at all times, what you're doing, why you are there." The continuity between these quotes and the father's reference to learning from his grandfather showed that this value had been transferred across at least four generations.

Young hunters are then taught ways of showing respect to the deer that they intend on harvesting or have just harvested. For some hunters, this begins with *taagoziwin* ("talks") which are a sort of prayerful conversation a hunter has with deer before or after a hunt. Through *miigwetchitaagoziwin*, a hunter makes a speech of thankfulness to the animal/spirit world, showing appreciation in advance or after a harvest. *Gaagiizotaagoziwin* are speeches of appeasement to an animal and its spirit.. Traditionally *taagoziwin* were spoken prayers using *Ojibwemowin* (the Ojibwe language).

People who do not speak *Ojibwemowin* often go through a similar process using the English language and many do so mentally rather than aloud.

All the hunters also used *Semaa* (tobacco) as a way to show respect for deer. *Semaa* (pronounced 'say-mah') is one of the most important traditional medicines used by Ojibwe and many other American Indian peoples. It is often used as a traditional gift given as a sign of respect to people or harvested animals (Johnston 1976, Benton-Benai 1988, Cornell 1992). *Semaa* is often put on the ground with a prayer before the beginning of a hunt. It is offered to a deer after it is harvested and before it is gutted. During disposal, it is placed on the gut pile or with any unused body parts. Ojibwe people believe strongly in a spiritual realm and that all living things have spirits that exist in this parallel world. Ojibwe are taught that *Semaa* is a wonderful gift to offer spirits and that a small pinch of this medicine is regarded as a large gift in the spirit realm. Hunters who use *Semaa* as an offering are making a gift to the deer on a spiritual level. The use of *Semaa* was noted as one of the most common and consistent ways traditional values enter into hunting practices in LDF and is a practice consistently taught to young hunters.

Hunters from LDF also show respect to deer by hunting sober. Drinking alcohol before, during and after a hunt are accepted and normal practices for many non-Indian hunters. However, for Ojibwe, to drink during or before a hunt or while butchering would be disrespectful to the deer. Hunting is considered a sacred activity and Ojibwe people are taught not to use alcohol or drugs during such times. The other reason people from LDF maintain sobriety during hunting and while processing meat is for safety, which, again, is a primary traditional value for hunters.

Furthermore, youth are taught to respect deer by processing harvested animals and handling meat respectfully. Lac du Flambeau hunters believe they should be mindful of the life that was given by the deer when they are gutting, butchering and disposing of unused parts. This mindfulness reminds hunters that wasting deer meat or other useful parts would be disrespectful to the spirit of the harvested animal. Handling the deer carcass and disposing of unused portions should be done in a way that maintains dignity for the deer's spirit. The gut pile and any other unused portions are placed in the woods out of plain site and covered with leaves or fern fronds plus an offering of *Semaa*.

Techniques for butchering deer meat are passed down inter-generationally within LDF families. Hunters from LDF are skilled with a knife, butcher deer very rapidly and take great care and pride in the cleanliness and efficiency of their butchering (i.e., lack of waste). One interviewee described the uniqueness and importance of skinning and butchering deer at LDF, stating:

> If there's anything to be passed down here in Flambeau it's a specific way to clean deer. Cause if you see a carcass laying by the road you know who did it just by looking... at the deer dump... if you look at it, you know where that cleaning originated from the way the deer was taken care of. It's pretty amazing. In terms of things being passed down, I think a big thing is how to cape that deer out... get the cuts, you know... clean that deer really good. There's three or four different styles that people do around here. And they all stem from four different elders. That's a real amazing thing 'cause they're all wonderful ways. I do it the way my Mother showed me how. Efficiency and quickness, that's what Ojibwes are good at when it came to cleaning these deer up. And that's one of the main things that were passed down.

Early in the hunting season, while does are still weaning their fawns, LDF hunters harvest deer selectively, leaving does and fawns and focusing on yearlings (i.e., year and a half old deer) and bucks. People generally do not shine for deer (i.e., road hunting at night with a spotlight) in the summertime because they do not want to accidentally shoot

a doe and risk orphaning any fawns. Once the fawns are weaned, this selectivity goes away entirely for most of the hunters. In the fall, they harvest whatever deer presents itself first, irrespective of sex or age. None of the hunters were enamored with the idea of harvesting a large trophy buck. Most admitted that seeing and harvesting a large buck is exciting, but they are not focused on finding large bucks with big racks when they hunt; the focus is on harvesting meat as a nutritious food source.

However, not every household has an active hunter, so most hunters in LDF are providing deer meat to multiple nuclear families. One of the primary traditional values held by LDF hunters is the sharing of meat. Every hunter that I spoke with described responsibilities they had to provide meat to other households within their extended family. For some hunters, the primary reason they hunted was to provide deer meat, fish and other harvested foods to those in need within their family and wider community. This is a generous act considering the amount of time and work involved in locating, harvesting and processing deer.

This generosity starts at a young age. When a person from LDF harvests their very first deer, the entire animal is traditionally given away. There is a ceremony that young hunters go through after their first successful hunt called the First Harvest Ceremony. During this ceremony, adults from the youth's family and broader community talk to them, providing important guidance about safety, respect, and other communally held hunting values.

For some hunters in LDF, the tradition of giving away the first deer you harvest is practiced annually. Hunters also have responsibilities for providing meat for ceremonies that come up throughout the year including funerals. They keep meat on hand for these ceremonies and community events and/or they are prepared to harvest deer as needed for these purposes throughout the year.

The generosity of LDF hunters is repaid to them when they get older. When a hunter reaches an age where it becomes difficult to drag, gut and butcher deer, the young hunters who they have trained in turn begin taking responsibilities for these labor intensive tasks. When a hunter reaches an age where they can no longer hunt, it becomes the responsibility of the younger hunters in their family to provide them with deer meat and other gathered foods. To fail to provide meat to an elder who spent time teaching you all the skills and knowledge necessary to be a successful hunter would be disrespectful and unacceptable.

Young hunters are also taught to respect certain communally held taboos, or things they should never do because it may result in serious consequences. The consequences of violating these taboos can include lack of success in future hunts as well as illness, misfortune or death in one's family, depending on the severity and intentionality (i.e., if you knew better) of the violation. Taboos among LDF hunters include that one should never be greedy (i.e., shoot more deer than necessary for food) or wasteful; should try hard never to wound an animal; and should not shoot deer near one's own home. Shooting deer near one's home is frowned upon because LDF Ojibwes believe that when white-tailed deer come by their home, they are actually the spirits of your deceased relatives coming to visit. Within some LDF families, the notion of stocking up enough deer meat in a freezer to last through the year comes close to violating the taboo of harvesting more than is needed, leading them to follow the practice of immediately using their harvests. For others, freezing meat was an acceptable way of ensuring a year's food supply.

Another important taboo is harvesting and/or eating one's clan animal. The Ojibwe, like other North American Indian cultural groups, have a clan system of kinship that dictates traditional roles and responsibilities in a community and historically was an important organizing framework for inter-community marriage (Johnston 1976). Each larger tribal or cultural group has a different set of clans, represented primarily by different species of animals. For Ojibwe people, these include loon, fish, deer, bear, crane, martin and bird clans (Benton-Benai 1988). A person's clan animal is considered very literally to be their brother or next-of-kin, which is why it is not acceptable to harvest or eat an animal from the species representing one's clan. In LDF, most people are bear clan and very few people are deer clan. This means that most people are free to consume deer meat but prevented from hunting or eating bear, a fact that came up repeatedly in my interviews.

Each of the hunters had spent a great deal of time learning about and harvesting deer in their lifetimes. I asked them to describe the relationship they had developed with deer through these years of pursuing and eating deer. Their responses summarized well the traditional values they held related to hunting. All of the hunters described having a great deal of respect for deer. They appreciated the versatile attributes of the deer (e.g., they are fast yet quiet in the woods, resilient, possessing a quite intelligence, have great senses of smell and hearing, hide well and are patient.) They described that the deer was put on Earth to feed people and that it is an amazing source of food. The hunters described their great appreciation for this food source and for the deer that give their lives to feed people. One hunter described this relationship, stating:

> "My relationship with deer meat is… no man could ask for a better one. The deer are a great source of food and they're a great animal and they'll feed me for the rest of my life. Just to eat one is an honor, and for him to give his life to feed me is one of the greatest gifts you can ever receive… I wish I could give my life up to feed one of them but I can't, but who knows, one day when you're pushin' up daisies maybe one'll eat off my grave."

Another hunter stated that when he puts down *Semaa* for a harvested deer, it is the same as when he puts down *Semaa* after a community member dies. In that way, he regarded deer similarly to the people in his community, except that the deer have a different role which is giving their life to feed the people. Another person pointed out that when Ojibwe people talk about hunting, they do not refer to the culmination as "killing" which is too harsh of a word to describe what is happening. In *Ojibwemowin*, a phrase used to describe what happens when a hunter is successful is *Nin gii nisaa a'aw waawaashkeshii*. In English this translates approximately to "I did take that deer's life."

Continuity in LDF Hunting Values

The hunters expressed that a core group of youth in the community was continuing to learn the LDF hunting values system outlined above. Most of the interviewees actively participated in educating younger generations about hunting and associated traditional values. They acknowledged that a small percentage of the LDF youth are hunting in ways that disregard this value system by being wasteful, focusing on trophy bucks and using drugs or alcohol while hunting. They felt that most of these young people were not raised on the reservation, but moved to their tribal homelands after growing up in the city where they had no opportunity to learn LDF hunting values. Others were being raised in families without adult hunters and had not sought out or connected with people who could teach them LDF ways of hunting. In either case, these self-taught hunters are in the minority and respondents felt confident that two or three generations in the future, hunters in LDF will be operating under the same value system. Educational programs are in place in the tribal and public schools to help teach the minority of LDF youth who have no other means of learning these values.

Hunters explained that certain hunting practices had changed in recent decades or were in a transition phase. For example, there were more hunters at the time of our interviews who exclusively road hunt than at any time in the past. There is a difference between hunters who first learn how to hunt through drives and later adopt road hunting as compared to individuals who only know how to road hunt. Hunters who first learn to hunt on foot learn about the woods and learn about deer so that if they later choose to road hunt, they do so given an existing foundation of hunting knowledge. The most recent generation of hunters includes a small but growing number of people who only know how to road hunt and have comparatively little knowledge about deer or forests.

The introduction of satellite television and internet service on the reservation also generated some changes in hunting practices, particularly among the youth. Young people had recently gained access to hunting shows and were picking up on techniques and perspectives about hunting from non-Native hunters on these shows. For example, a few respondents expressed concern over the adoption of remotely triggered trail cameras, because they allow hunters to stay indoors and reduce the amount of time they spend scouting outdoors learning about the woods. One hunter disapprovingly called this technique "window shopping." Other technological innovations that had been adopted earlier in LDF, such as high powered rifles and hanging poles used for processing deer, were of less concern to the hunters. One respondent explained, "We're accepting of change if it allows us to do our things more efficiently. But along the way we also have to maintain our traditional ways, the original ways of doing things..."

A more serious concern was the influence hunting shows could have on people's perceptions of deer. The hunters expressed concern that the hunting shows teach a trophy hunting mentality that is antithetical to LDF values. The trophy hunting shows emphasize the thrill of getting the biggest possible deer; the adventure sports side of hunting where landing a trophy and breaking records is more important than harvesting food. Some of the LDF hunters shared that they do not watch these shows and advise their children not to watch them. Interestingly, the youngest two respondents (approximate ages were 18 and 30) said they watched trophy hunting shows, but did not feel it interferes with their value systems; they just saw it purely as entertainment.

Discussion and Conclusions

My results indicate that a complex traditional value system remains vibrantly intact among the contemporary subsistence hunters of Lac du Flambeau. Hunters from the LDF tribe are committed to training young people about safety, respect, generosity and showing them effective hunting and deer processing techniques. As more LDF citizens progressively move back to the reservation after spending one to several generations in cities such as Milwaukee, educational programs in public and tribal schools and other similar efforts will be crucial to maintaining cultural continuity and LDF-specific hunting values.

Hunters from LDF harvest a lot of deer. However, it is a small segment of the tribal citizenry that hunts and hunters are providing deer meat to large extended families.

Despite occasional reports of wasteful practices and concerns among non-Indians of over-harvesting by tribal citizens, the LDF Ojibwe people remain very committed to wildlife conservation and loath waste. Wasting meat is considered taboo in the community and Ojibwe hunters from LDF believe strongly in the consequences that could result from being wasteful or greedy. The hunters I spoke with used more parts of the deer than is typical of non-Indians. They ate the ribs, neck roasts, shanks, neck bones and back bones (although some temporarily stopped eating neck and back bones when Chronic Wasting Disease first emerged in Wisconsin deer). Some saved the hides, horns, hooves and other parts for community members who use them for traditional regalia and other purposes, but many people discarded these parts. Historically, all parts of the deer had a use, and harvested deer were more thoroughly utilized. Fewer parts are used today in LDF than in past generations; however, the unused portions are typically placed in the woods or in a field, covered with ferns and an offering of *Semaa*, and left for consumption by eagles, wolves, coyotes and other wildlife. Hunters from LDF view this as a form of sharing with these other animals; but the act is construed differently by some non-Indians who see the piles of guts and unused parts and think deer are being wasted or treated disrespectfully. According to one respondent who regularly addressed questions from the general public on behalf of the tribe's environmental department, when the tribe received complaints about this sort of activity, the complaints were typically issued by vacationing families who lived in the northwoods seasonally. Permanent resident non-Natives were apparently more understanding of this practice.

My conversations with LDF hunters helped illuminate some of the important distinctions and commonalities between Indian and non-Indian hunters in north central

Wisconsin. There are many things that Indian and non-Indian hunters hold in common: they both enjoy spending time in the outdoors, spending time with friends and family, eating venison, seeing big bucks and they are both generous and charitable with harvested meat (non-Indians often donate meat to food pantries) among other commonalities. However, the main driving motivation may be different for the typical Indian and non-Indian hunter.

The primary motivation for Indian hunters from LDF is clearly to gather food, and all the other enjoyable attributes of hunting are secondary benefits. Authors working with American Indian hunters in other regions of the U.S. have found the same primary purpose for hunting within other cultural groups (McCorquodale 1997, Guilmet and Whited 2002). However, tribes and first nations across North America exhibit a great deal of social and cultural distinctiveness, and the value systems that form the foundation of hunting practices within different communities can vary considerably from tribe to tribe. Furthermore, American Indian hunters who are raised off-reservation or who are separated from their tribal traditional value systems are likely to engage in different practices, hold different perspectives and stray from the norms and mores of their respective tribal communities to some extent.

Existing publications and reports from hunter surveys indicate that among non-Indian hunters, there is a wide variety of perspectives and motivations for hunting. For example, a 2005-06 survey administered by the Illinois Natural History Survey asked hunters what motivates them to participate in hunting and the statement receiving the highest number of responses was to "be in the outdoors and interact with nature" (n=672); the second highest response was "provide meat for my family" (n=431)

(Lischka et al. 2006). In the same survey, harvesting a deer was listed as a less important factor influencing the quality of a hunting experience than being outdoors and interacting with nature (n=312), seeing deer (n=339) and getting close enough to a deer to shoot, regardless of whether they shoot the deer (n=936). For these respondents, meat was a primary motivator, but not a primary driver of hunting satisfaction. Others have indicated that harvesting deer and provisioning meat are far less important components of the hunting experience than other factors (Good 1997, Dhuey 2008).

Good (Good 1997) reviewed essays in popular hunting magazines and found that having an opportunity to shoot an animal but letting it go was a more important factor than harvesting an animal. He conceded that "For people who do not understand hunting and think of hunters as blood-thirsty killers, this may be surprising…" but that from his perspective as a hunter, "This demonstrates the deep respect and appreciation many hunters have for wildlife." Hunters from LDF and many other American Indian hunters have very different perspectives about passing up harvest opportunities than those expressed by Good. Hunters from LDF believe that when they are hunting and they encounter an animal, under most circumstances that animal is offering its life to provide food for your family. To turn down that offer would be insulting to the deer and could result in consequences including not seeing animals during future hunts. Indian people often object to catch and release fishing for similar reasons. So an action that is a sign of respect and appreciation among some non-Indian hunters has quite the opposite meaning within the Ojibwe worldview.

More than one interview participant felt that they had much more in common with non-Indian hunters from rural north central Wisconsin (i.e., their fulltime non-Indian

neighbors) than hunters and vacationers who traveled to the northwoods from the cities. They explained that there is a group of non-Indian hunters in their region who hunt primarily for food and who are committed to eating venison as a main food source, similar to LDF hunters. Individuals raised in rural versus urban environments may have different perspectives and motivations about hunting.

People often refer to all Indian hunters as subsistence hunters and all non-Indians as recreational, sport or trophy hunters. Perhaps it would be more useful to think of a continuum of primary or driving motivations from food-focused on the one end to trophy-focused. Indian and non-Indian hunters may fall anywhere along the continuum depending on their life circumstances, form of hunting education and values system. The vast majority of Ojibwe hunters from Lac du Flambeau appear to be situated far over on the subsistence end of the continuum. The fact that LDF hunters put away their rifles for the year once their freezers are full shows that meat is their main priority. By comparison, trophy hunters may or may not eat deer meat and typically hunt throughout their state-regulated season regardless of whether they have sufficient venison for the year. However, as recent data from Illinois (Lischka et al. 2006) and Wisconsin (Dhuey 2008) have indicated, the majority of non-Indians may have motivations other than harvesting trophy animals and could be described as falling somewhere in the middle of a food-focused to trophy focused continuum.

This exploration of the connections between LDF traditional values and LDF hunting practices provided a unique and somewhat detailed picture of the contemporary Ojibwe hunter. There is a lot more depth to the spiritual side of Ojibwe deer hunting that is beyond the focus of this chapter. However, the chapter provides enough detail to

improve understanding among non-Indians about the hunting practices, perspectives about deer and traditional values of Ojibwe people. The information should be particularly useful for people who have had little or no substantive contact with Indian people but vacation or travel seasonally to places such as Lac du Flambeau where tribal citizens are engaged in treaty harvests.

In this chapter, I also compared the Ojibwe hunting practices and motivations revealed through my interviews with those of non-Indian hunters as reported in recent surveys and research publications. This comparison should help improve cross-cultural understanding needed between Indians and non-Indians who have a shared interest in off-reservation resources such as white-tailed deer.

More generally, the chapter calls attention to the importance of understanding natural resource activities within the context of underlying cultural value systems. Without understanding the cultural contexts of resource users and managers, their actions and priorities can easily be misinterpreted, as described through examples in this chapter. Better understanding of the ethical dimensions of natural resource use and management may improve cross-cultural relations among natural resource users and managers, thereby reducing conflict and creating opportunities for expanded cross-boundary natural resource management.

Table 2.1: Interview questions and associated concepts.

QUESTION	CONCEPT/PURPOSE
1. What animal species do you hunt or trap?	Interview ice breaker
2. How old were you when you started hunting deer?	Community norms
3. Tell me about your hunting practices (e.g., times of year, times of day/night, on-reservation v. off-reservation hunting, who you hunt with.)	Modern hunting practices
4. How many animals of the various species do you harvest on average throughout a given year?	Modern hunting practices, generosity, family networks
5. Why do you hunt? What are all the reasons why you spend time and energy hunting?	Potential common ground w/ non-Indian hunters
6. (Assuming they listed multiple reasons in Q5) Can you separate out the primary driving forces motivating you to hunt? What are the one or two main reasons you invest time, energy and resources hunting?	Distinguishing primary from secondary purposes- primary purposes could be different for Indians and non-Indian hunters
7. Can you tell me about the ways that Ojibwe traditional values factor into your perspectives about deer, perspectives about hunting or your hunting practices? What are the things you teach young people about hunting besides technique?	Hunting-related values
8. Do LDF hunters learn these things from other Ojibwe people exclusively? How else are they learning about hunting? Are outside influences changing the value systems or practices of LDF hunters? Do you feel that in another 2 generations, hunters in LDF will still be operating under the same basic values?	Formation and resilience of values
9. What similarities do you see between Indian and non-Indian hunters? What are the general differences?	Perceptions of similarities and differences
10. Tell me about the current relations between Indians and non-Indians in and around LDF.	Citizen-level relations
11. Do non-Indians hold any common misconceptions about Indian hunters and their practices? What about the other way around?	Stereotyping; cross-cultural understanding
12. How would you characterize your relationship to deer and other large game?	Ojibwe worldview and ecological knowledge

Figure 2.1: Map showing location of Lac du Flambeau Reservation in relation to 1837 and 1842 treaty territories where members of Lac du Flambeau Tribe and five other Ojibwe bands have rights to hunt, fish and gather resources on public lands off their respective reservations.

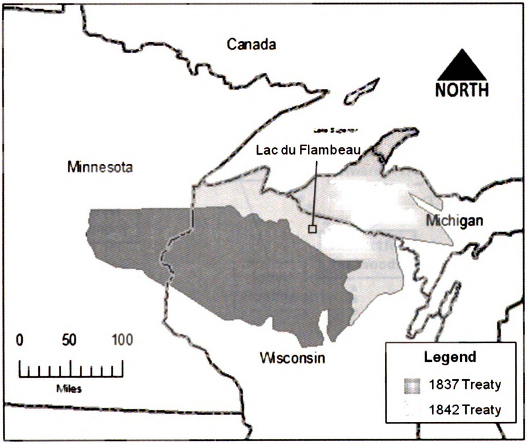


Figure 2.2: Diagram showing primary themes of hunting-related traditional values as expressed in interviews with Lac du Flambeau hunters. The diagram shows A) the various lessons about hunting imparted to young people by their relatives, starting with safety and progressing clockwise through their first harvest ceremony and B) ethical dimensions of hunting that occur throughout an annual hunting cycle, roughly in the order they might occur each year.

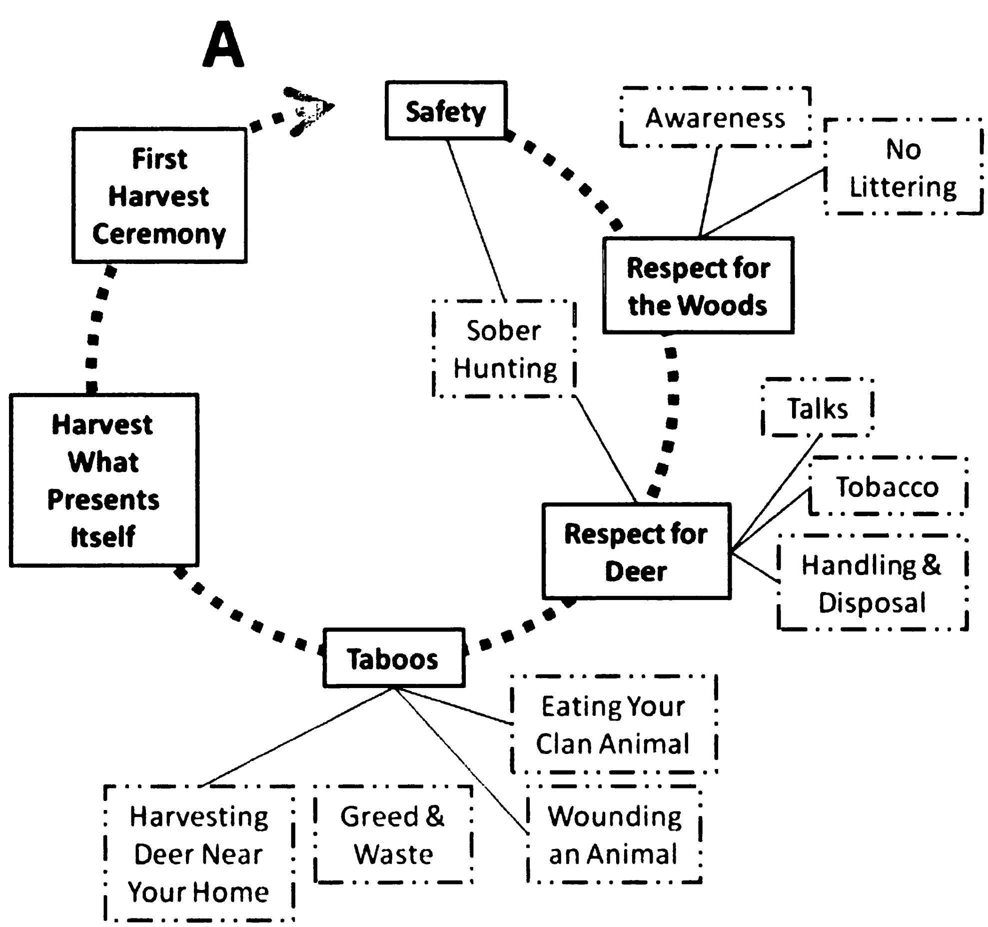
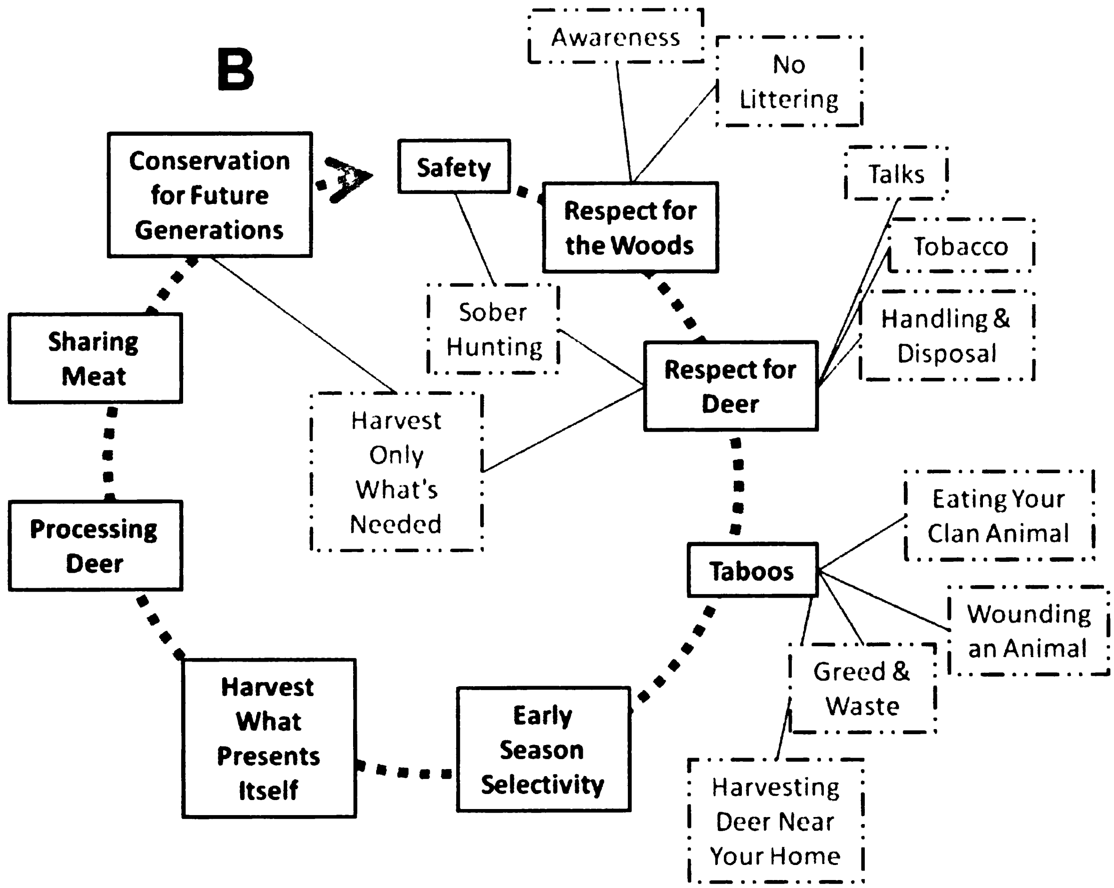


Figure 2.2 Continued:



CHAPTER 3

ECOLOGICAL RESULTS OF A TRIBAL FORESTRY SYSTEM: NORTHERN RED OAK REGENERATION FOLLOWING TIMBER STAND IMPROVEMENT IN LAC DU FLAMBEAU

In collaboration with

Jason Karl

Abstract

Forest managers typically use shelterwood harvest systems to provide adequate light for oak seedling establishment, growth and survival. However, other limiting factors such as understory competition and excessive browsing by high density populations of forest ungulates such as white-tailed deer (*Odocoileus virginianus*) hinder successful oak regeneration. We investigated the effects of hand release treatments on northern red oak (*Quercus rubra* L.) regeneration through an observational study of the timber stand improvement work conducted by the Lac du Flambeau (LDF) Tribe in North Central Wisconsin. Our research was conducted on the LDF Reservation where white-tailed deer densities have been maintained at low levels (2-3 deer/km^2) for at least the last three decades. Tribal timber stand improvement practices showed no effect on northern red oak regeneration, possibly because low deer browse pressure has allowed for widespread oak regeneration throughout the oak forests on the reservation. Residual pockets (clusters of trees <3 ha in area) of northern red oak produced fewer but faster growing seedlings than larger oak stands (>15 ha). For forests supporting higher deer densities than those found in LDF, this result may indicate that pockets provide better oak regeneration environments than larger management units because rapid height growth could help seedlings escape herbivory.

Introduction

Throughout the Northeastern United States (U.S.) and in other regions of the world, forest managers struggle to regenerate species of oak (*Quercus spp.*) desired for wood products, wildlife mast and other ecological, aesthetic and cultural purposes.

Suppression of forest fire and increased densities of forest herbivores such as white-tailed deer (*Odocoileus virginianus*) have contributed to reductions in densities of understory intolerant species such as northern red oak (*Quercus rubrum* L.) and increases in densities of understory tolerant species such as sugar maple (*Acer saccharum* Marshall) (Waller and Alverson 1997).

Shelterwood silvicultural systems are the dominant systems in use on managed oak forests in the U.S. (Isebrands and Dickson 1994). Shelterwood practices significantly thin forest overstories to provide ample light to the forest floor needed by oak and other desired understory intolerant species. However, once "released" into rapid growth following a heavy shelterwood thinning, oak seedlings face other significant challenges that often prevent their successful recruitment into the forest canopy. First, in the absence of fire, mesic understory tolerant species such as sugar maple often occupy a significant portion of the sub-canopy layers, creating additional sources of shade that inhibit oak seedling development and survival. Second, early successional species such as trembling aspen (*Populus tremuloides* Michx) and big-toothed aspen (*Populus grandidenta* Michx), when present, quickly overtop and shade oak seedlings. Third, herbivores such as white-tailed deer, when present in high densities, create browse pressure that reduces survival of oak seedlings.

To combat these limiting factors, foresters have experimented with prescribed burning and the mechanical, chemical and hand removal of understory competition. Each of these treatments has costs associated with them and research results regarding their effectiveness have been mixed. For example, Rathfon et al. (2007) found that removing competing plants from the understory after disking (mechanically mixing acorns into the soil) increased survival of oak seedlings substantially compared with leaving the understory intact. Similarly, Ponder (2003) and Lorimer et al. (1994) found that understory trees were a significant obstacle to oak seedling development and competitor removal was beneficial. However, Dolan and Parker (2004) found that removal of understory competition had no effect on the density of oak seedlings. Motsinger (2010) found only marginal increases in oak seedling growth rates and found marginal *decreases* in oak seedling survival following chemical treatment of understory vegetation. Buckley (1998) suggested that the positive effects on seedling development of competitor removal may be outweighed by the negative effects of increased susceptibility to frost damage and herbivory. Because of such mixed results, forest managers implement understory removal techniques cautiously and require additional evidence regarding effective oak management strategies.

American Indian tribes in the U.S. have treated understory competition in hardwood forests on reservation forests more aggressively in part thanks to funding support from the U.S. Department of Interior, Bureau of Indian Affairs. Limited funding is available to tribes to support their forestry programs as part of federal responsibilities to assist tribes with their land management efforts, including funding for timber stand improvement activities. One such timber stand improvement treatment is hand release, or the cutting of competing vegetation with chainsaws. For more than 25 years, the Lac du Flambeau (LDF) Band of Lake Superior Chippewa Indians' forestry program has used hand release in combination with shelterwood harvests to encourage selected tree species including northern red oak. Their efforts occur within the context of low white-tailed deer densities (average densities of 2.6 deer/km^2 from 1984-2006, internal tribal management document) maintained through active hunting management (see Chapter 4). We investigated the effects the LDF Tribe's timber stand improvement (TSI) efforts have had on northern red oak seedling development. Our objective was to determine whether 25+ years of TSI treatments have lead to significant increases in the density of northern red oak seedlings and small overstory trees on LDF Reservation forests by comparing areas where the tribe has and has not conducted TSI treatments.

Methods

Study Site

Our study site was comprised of the >35,000 hectare (ha) Lac du Flambeau (LDF) Reservation (federally-recognized homeland of the Lac du Flambeau Band of Lake Superior Chippewa Indians) in North Central Wisconsin (Figure 3.1). Climate is characterized by a 121-day growing season, average temperatures range from -6.7 to 35^{o} C and average annual precipitation ranges from 76.2 to 86.4 cm (Albert 1995; internal resource management plan, LDF). Elevation ranges from 442-590m. The most common physiographic systems in the study area are pitted outwash and ice contact-derived landform systems. The study area falls within the "Lac Veaux Desert Outwash Plain" regional ecosystem (Albert 1995). The LDF Reservation has a mix of forest cover types with aspen types as the most abundant followed by red/white pine, northern hardwoods, forested wetlands and northern red oak (internal resource management plan, LDF).

Through conversations with local resource managers plus field and GIS-based reconnaissance we determined that northern red oak grows in a diversity of sites within our study area ranging from dry, nutrient poor outwash plains alongside northern pin oak

(*Quercus ellipsoidalis* E.J. Hill) to mesic sites dominated by sugar maple and eastern hemlock [*Tsuga canadensis* (L.) Carr]. In our study area, northern red oak is more typically a dominant or co-dominant canopy component on intermediate quality sites associated with ice-contact and outwash plain physiographic systems.

Foresters on the LDF reservation manage northern red oak within stands where it is dominant or co-dominant in the forest canopy. They also maintain smaller clusters of northern red oak within stands dominated by other species. For example, it is common for stands of big-tooth aspen to contain small clusters of oak on tops of small hills and ridges within pitted outwash and ice-contact terrain. Tribal and state forest managers intentionally leave these "pockets" of oak intact when big-tooth aspen stands are clearcut to provide a seed source for oak expansion and as important acorn mast for wildlife. Forest managers also protect pockets of oak for similar reasons along margins of lakes, roads and wetlands. These residual pockets of oak may constitute significantly different regeneration environments for oak seedlings. First, because the oak stands have more forest interior and less edge than pockets it is possible that their light environments differ. Second, residual pockets and oak stands may represent different forms of deer habitat and the browse intensity could therefore differ.

Study Design

Our study included two components. First, we investigated the effects of TSI (specifically, manual control of understory competition) on northern red oak regeneration following a somewhat recent regeneration thinning (5-15 years prior to our field work). We refer to this part of the project throughout the rest of the paper as the "recent TSI" component. In the second portion of our study we investigated some of the oldest examples of TSI work on the LDF Reservation to see if controlling oak competition in the forest understory had led to significant differences (from a management perspective) in the overstory composition of tribal forests. We refer to this portion of our study as the "older TSI" component.

In both components of the study, we chose to focus on intermediate quality sites where northern red oak often has a competitive advantage over more mesic species (Lorimer 1992, Buckley et al. 1998) because these sites are becoming the focus of northern red oak management efforts in the region. We determined site quality by using ecological habitat types developed by Kotar et al. (Kotar et al. 2002). All sites were either Pinus-Acer rubrum/Vaccinium-Aralia (PArVAa) or Pinus-Acer rubrum/Vaccinium (PArV) habitat types (Kotar et al. 2002) as determined through field assessment.

RECENT TSI

Our criterion for inclusion of forest stands in the recent TSI portion of our study were that 1) all stands had been harvested in a similar fashion between 1992 and 2002, 2) northern red oak was dominant or co-dominant in the forest canopy and 3) stands were of intermediate site quality within the continuum of sites supporting northern red oak in the region.

In the summers of 2007 and 2008, we identified stands for the recent TSI field sampling based on the ecological and management criteria above with the assistance from tribal foresters and through GIS and field reconnaissance. For the recent TSI component, we used a balanced 2x2 factorial design where half of our plots had been administered hand release TSI treatments within the past 10 years by the Lac du Flambeau Forestry Department and half had undergone no prior TSI work. To explore the influence of

man
and
unit
dor
pri
arc
wei
typ
sta
ma
of l
sta
res
OL

im
foc
abi
im
rec
nor

management unit size on oak regeneration, half of the plots were located in oak stands and half in oak pockets. We defined northern red oak stands as any forest management units 1) that were 15 hectares (ha) or larger in area, 2) where northern red oak was a dominant or co-dominant canopy constituent and 3) where northern red oak was a primary future management goal. We defined "pockets" for the purpose of this study as areas that 1) were less than 3 ha in area, 2) were dominated by oak in the overstory and 3) were an intentional part of forest management strategies, even though they were not typically delineated by local foresters as their own independent management units (i.e., stands). The oak pockets either existed as small clusters of trees within larger management units such as aspen stands or as strips of oak maintained along the margins of lakes, roads, wetlands and clearcuts. We identified five management units (e.g., oak stands and aspen stands containing pockets of oak) per treatment group that met these research criteria.

OLDER TSI

For all forest stands investigated in older TSI, regeneration harvests were implemented between 1972 and 1982, or at least 25 years prior to our field work. We focused on contiguous stands (i.e. not pockets) as defined above because we were not able to identify examples of oak pockets where regeneration harvests had been implemented in the 1972-1982 timeframe. As with the portion of our study investigating recent TSI, all stands in this part of the study were dominated or co-dominated by northern red oak and were of intermediate site quality.

Data Collection

Within all of the sampled stands for both recent and older TSI study components, three random plot locations (Figure 3.2A) were determined in the field, as described by Spies and Barnes (Spies and Barnes 1985). All plots were at least 50 meters from the outer edge of their stand to limit potential edge effects. General plot characteristics were sampled using a 20x20 meter fixed-area plot. We noted all plant species within the plot, classified the ecological habitat type using the system described by Kotar et al. (Kotar et al. 2002), recorded the number and DBH (diameter at breast height, or 137cm) of all overstory (>10.1cm) and understory (2.6-10.0cm) trees by species, and described elements of site physiography including the landform type, slope, position on slope and aspect.

To document northern red oak seedling and sapling densities, we further sub-sampled our stands of interest using five circular plots (5m diameter) in fixed locations within each plot (Figure 3.2B). Within these sub-plots, we counted all northern red oak seedlings in three size classes (0-50cm; 51cm-137cm; and > 137cm). These size classes were chosen because they are easy to implement quickly in the field.

For the portion of the study investigating recent TSI examples, we collected 3 seedlings within each plot to determine northern red oak height growth rates (cm/year). We were careful to select individuals that established in response to the regeneration harvest. When no seedlings/trees were present within a given plot, we sampled individuals from outside the plot, but always within approximately 50 meters.

Investigation of how light availability interacts with deer browse and/or management unit size to influence oak regeneration was beyond the scope of our study.

We chose stands that had ample light for promoting rapid growth of oak seedlings, theoretically marginalizing the effects of light in this study. However, because light is a dominant factor influencing oak seedling growth (Crow 1992, Johnson 1994) and the light environment in our study plots was highly heterogeneous, we documented light availability and included it in our statistical analyses to account for influences light may have on variation in our response variables.

To estimate understory light availability, we recorded canopy openness (i.e., % of full sun) through hemispherical photograph analysis (Canham 1988). We took canopy photos in low light conditions using a Nikon Coolpix5000 digital camera and Nikon UR-E6 180^0 fisheye lens. Canopy photos were processed using Gap Light Analyzer 2.0 software (Frazer et al. 1999).

Statistical Methods

We conducted all statistical analyses in R (software package version 2.10.1, R Development Core Team, 2009) using the *nlme* library for nested, mixed-effects modeling (Pinheiro and Bates 2000).

Because our experiment included both fixed (TSI and stand size) and random effects (stands and plots within stands) in a hierarchical arrangement, we used a nested linear analysis of variance (ANOVA) design with mixed modeling procedures (Zuur et al. 2009). Our treatment groups for the recent TSI component were 1) pockets of oak with TSI, 2) pockets of oak with no TSI, 3) stands of oak with TSI and 4) stands of oak with no TSI. For the older TSI component, our treatment groups were 1) older stands with TSI and 2) older stands with no TSI. In addition to the treatment group effects, we also considered six possible covariates (total species observed, basal area (m^2/ha) of northern red oak in the large overstory (>25cm DBH), total basal area of all northern red oaks in the overstory, total basal area for all species, relative density of northern red oak in the overstory, and number of red oaks in the overstory).

Our ANOVA models were constructed to estimate the significance of observed variation in a series of dependent variables. For recent TSI, these included: height growth rate of northern red oak seedlings (cm/year), density of northern red oak seedlings in three height classes (<50cm, 50-137cm and >137cm), number of northern red oak stems in the understory, total stems (all *spp.*) in the understory and relative density (proportion) of northern red oak in the understory. For the older TSI component, dependent variables included density of northern red oak seedlings in three height classes, number of northern red oak stems in the understory, total stems in the understory, relative density of northern red oak in the understory, as well as relative density and total basal area of northern red oak in small overstory (10.1- 25cm DBH).

Because our dependent variables were correlated (Table 3.1), we could not test for TSI effects on each variable separately for either the recent or older TSI components. We used principal components analysis (Johnson and Wichern 2002) as a data reduction technique and to produce new sets of uncorrelated variables for each component related to northern red oak understory characteristics that could be used to evaluate TSI effects via separate, nested ANOVAs. After transformation, the dependent variables were rescaled to have a mean of zero and standard deviation of one. Principal components analysis was applied, and the percent of total variation accounted for by each principal component was used to determine how many principal components would be retained for further analysis. We kept all principal components that accounted for more than 5% of the total variability in the dependent variables. Interpretation of each of the retained principal components was made by examining the loadings of the original variables on the principal components (Johnson and Wichern 2002).

Both the mixed-effects ANOVA and principal components techniques carry assumptions regarding the distribution of the input variables. Linear mixed-effects modeling assumes a linear relationship between the independent and dependent variables and that the regression residuals are normally distributed (Pinheiro and Bates 2000). Additionally, ANOVA assumes that the dependent variable is normally distributed within treatment groups. While principal components analysis does not require multivariate normality of the input variables, if the variables are not normally distributed, the resulting components may not be truly independent (Johnson and Wichern 2002). To assess whether the variables could be considered as normally distributed, we constructed histograms of each of the six continuous variables and performed transformations as necessary. We used the Shapiro-Wilk normality test (Royston 1982) to assess whether the distribution of each transformed variable approximated a normal distribution.

Three of the input variables to the principal components analysis (relative density of northern red oak in the understory, number of northern red oaks in the small overstory, and basal area of northern red oak in small overstory) and two of the linear model covariates (number and relative density of northern red oak in large overstory) did not approximate normal distributions even after transformation. For the input variables within the principal components analysis, because we were using this technique for data reduction and to achieve a set of variables that were relatively independent, having slightly correlated principal components was acceptable. With regard to the covariates used in the ANOVA, the result of not meeting the normality assumptions may be an F statistic that is too small (Lindman 1974) increasing the possibility of type I error. We elected, however, to keep these variables because they represent oaks in the large overstory and are related to both seed production and understory shade which influence growth of red oaks in the understory.

To test for differences between treatment groups, we used separate, hierarchical ANOVAs for each principal component (PC). The initial ANOVA model for each PC included all five covariates. TSI application (yes or no) and stand size (pockets vs. stands, for the recent TSI component only) were the ANOVA fixed effects. For each response variable, we constructed multiple models with different combinations of the fixed effects, covariates and selected the model with the lowest Akaike Information Criteria (AIC, Burnham and Anderson, 2002). The only two-way interaction considered was between TSI and stand size. In each case, the best model included the main fixed-effects of TSI and stand size (for experiment 1). In the ANOVA results, we not only looked at the TSI and stand size effects, but also interpreted how significant covariates might be influencing the observed patterns.

For the recent TSI component, to test for differences between treatment groups (where each management unit size:TSI combination was considered a treatment group), we used Tukey's Honestly Significant Difference (HSD) test (Tukey 1953). Tukey's HSD compares pairs of treatment group means and tests for pair-wise differences while correcting for the inflation of type I error rate that occurs when multiple comparisons are made (Gotelli and Ellison 2004). We used graphs of the response variables within each of our four treatment groups to help interpret the results of the analyses of variance.

Results

Recent TSI

Using the principal components analysis, we reduced the seven dependent variables in our investigation of recent TSI work to three independent PCs which accounted for 86.70% of the variability observed in the dependent variables (Table 3.2). Loadings of the original variables on the PCs were used to interpret the meaning of each component (Table 3.3). PC1 represents overall density of understory-sized individuals of all species because it loaded highly for northern red oak stems, total stems and relative density of northern red oak in the understory. PC2 represents the density of medium (50-137cm) and tall (137cm+) seedlings in the groundcover layer because it loaded highly for these two seedling height classes. PC3 represents a contrast between seedling growth rate and density of small (< 50cm) groundcover stems because it loaded highly/negatively for density of small seedlings and highly/positively for seedling height growth rate. Results from our ANOVA analyses of recent TSI efforts are reported in Table 3.4 and Figure 3.3. Our ANOVA for understory density (PC1) indicated that canopy openness (P<0.0001; F=22.59) and relative density of northern red oak in the small overstory size class (P=0.02; F=5.45) were significant covariates where more open stands and stands with higher densities of small overstory oaks were associated with higher understory stem density values. Our ANOVA for medium to tall seedlings (PC2) indicated a marginally significant main effect for stand size where residual pockets of oak had higher densities of these medium to tall seedlings as compared to larger stands (P=0.06; F=4.01, Figure 3.3B). Significant covariates included canopy openness (P=0.001; F=12.82) and relative density of large overstory-sized northern red oaks (P=0.07; F=3.49). As with PC2, our

ANOVA contrasting growth rate vs. small seedling density (PC3) also indicated a main effect for stand size (P=0.007; F=9.55, Figure 3.3C) and significant covariates of canopy openness (P=0.002; F=10.35) and relative density of large overstory-sized northern red oak (P=0.04; F=4.38). The main effect for stand size indicates that larger oak stands produced more small seedlings compared to residual pockets but that seedlings grow more slowly in the larger stands than in pockets.

Older TSI

Using the principal components analysis, we were able to reduce the eight dependent variables from our investigation of older TSI work to four independent PCs that accounted for 93.55% of the variability observed in the dependent variables (Table 3.2).

Loadings of the original variables on the PCs were used to interpret the meaning of each component and are reported in Table 3.3. Principal Component 1 represents an axis contrasting density of northern red oak in the groundcover and understory layers (three seedling variables plus one understory variable, all with moderate/positive loadings) with basal area of northern red oak in the small overstory (moderate/negative loading). PC2 loaded positively on all the original variables with highest loadings for northern red oak variables and represents the abundance of northern red oak in the groundcover and sub-canopy layers. PC3 loaded positively for understory variables including total density of stems (all species) in the understory, density of northern red oak stems in the understory and relative density of northern red oak in the understory. It loaded negatively for density of northern red oak seedlings in the three groundcover size classes, with the highest loading for medium height seedlings. This component was interpreted as an axis showing the tradeoffs between sub-canopy density and groundcover density. PC4 loaded highly and positively for total stems in the understory and represented overall density of understory-sized individuals of all species (i.e., "understory density").

Results from our ANOVA analyses of older TSI efforts are reported in Table 3.4 and Figure 3.4. Our ANOVA for seedling and sapling vs. sub-canopy oaks (PC1) showed no significant main effect of TSI but indicated three highly significant covariates, namely total (all species) basal area within the large overstory ($P<0.0001$; $F=193.12$), number of large overstory-sized northern red oaks ($P<0.0001$; $F=66.47$) and total species (woody and herbaceous) encountered in the sampling plots ($P<0.0001$; $F=598.90$). Our ANOVA for abundance of northern red oak in the groundcover and sub-canopy layers (PC2) showed significant relationships for the same three covariates as PC1, though less significant and with far smaller F-values. Our axis contrasting sub-canopy density and groundcover density (PC3) had non-significant results for all variables. For understory density (PC4), total basal area (all species) within the large overstory was a significant covariate ($P<0.001$; $F=68.15$) as was the number of northern red oak in the large overstory ($P=0.06$; $F=4.79$).

Discusssion

Our goal in this study was to determine whether 25+ years of TSI treatments have led to significant increases in the density of northern red oak seedlings and small overstory trees on LDF Reservation forests. We were unable to detect a TSI effect in any of the ANOVAs of our principal components. We also ran ANOVAs on each of the original response variables as an additional way of exploring and analyzing our data, and again found no TSI effect.

There are a few possible explanations for why we did not detect a TSI effect in any of our analyses. First, northern red oak could be regenerating well everywhere on the LDF Reservation where densities of white-tailed deer are consistently maintained at low levels, limiting the potential for TSI treatment effects. This explanation is compelling considering the results from our work comparing oak development on tribal and state forests reported in Chapter 4. In this related study reported in Chapter 4, we found northern red oak was regenerating very well on LDF stands where no TSI treatments had ever been implemented. Seedling survival was nearly threefold greater in tribal stands than state stands and more than eightfold greater in tribal pockets than state pockets.

A second possible explanation is that TSI treatments in LDF could have limited or no benefits for northern red oak because bigtooth and trembling aspen were sprouting back quickly after each TSI treatment and overtopping oak seedlings. A third possibility is that TSI work could be making a significant difference for northern red oak development and growth in the groundcover and sub-canopy of LDF forests, but our methods and/or sample size precluded us from detecting a TSI effect.

Recent TSI

Our analysis of recent TSI treatments indicated that stand size mattered for northern red oak seedlings. There were lower densities of small seedlings and higher densities of medium-tall seedlings growing in residual pockets vs. larger oak stands. Seedling height growth rates were also higher in pockets than stands. These results are explained by the fact that the oak pockets had more light penetrating into their understories than stands (F=13.45, P=0.0019 based on a separate ANOVA of canopy openness not reported in results section). The importance of light in this study is also evident in the fact that canopy openness was an important covariate in ANOVAs for all three PCs. These results reinforce the importance of light for northern red oak seedling development and survival reported by several other authors (e.g., McGee 1968, Sander 1990, Pacala et al. 1994, Finzi and Canham 2000).

Older TSI

Total number of species (woody and herbaceous) encountered in our sampling plots was an important covariate in our analysis of seedling and sapling vs. sub-canopy oaks (PC1) and abundance of northern red oak in the groundcover and sub-canopy layers (PC2). This result may be a reflection of site differences (e.g., soil fertility, soil moisture availability and drainage, microclimate and physiography) across the stands we sampled. The forest ecosystems in our study area are very heterogeneous, and although we attempted to limit our investigation to intermediate quality sites, there were still potentially significant site differences across the various forest units we sampled. These site differences could influence species richness (Barnes et al. 1998), making the total number of species encountered an important covariate.

Management Recommendations

Forest managers have struggled to regenerate northern red oak and other economically and ecologically important hardwood species for decades. More research is

needed on the effects of manual understory competition control (i.e., hardwood hand release) on northern red oak regeneration as well as the regeneration of other hardwoods before managers invest or de-invest in this technique. Nevertheless, on the LDF Reservation, where white-tailed deer herbivory does not appear to be a significant limiting factor for northern red oak seedlings (see Chapter 4), our results did not show a significant TSI (hardwood hand release) effect. Although it is possible that our sample size and study design may have caused us to miss a significant TSI effect, based on results from our study reported in Chapter 4, there appear to be plenty of large red oak seedlings in the reservations' forests (also see raw data averages, Table 3.6). Therefore, the LDF Tribe might consider directing more of its TSI efforts into recovering other species that are part of their TSI program. The tribe also uses TSI treatments to recover Eastern white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) on their reservation forest. Some positive effects of understory competition control have been reported for these pine species; however treatments may require careful timing to promote pine regeneration (Pitt et al. 2009).

Furthermore, the use of prescribed burning could provide a productive alternative to hand release. Besides favoring oak and controlling competition by species of aspen and understory-tolerant hardwoods (Abrams 1996, 2005), controlled burns could also stimulate growth of understory forbs (Cook et al. 2008, Phillips and Waldrop 2008) that have ecological values as well as cultural values to the LDF Tribe. A combination of thinning and prescribed burning could also provide significant benefits in central hardwood forest (Albrecht and McCarthy 2006) and is a recommended management alternative.

In our study, residual pockets of northern red oak produced fewer but faster growing seedlings than larger oak stands. Differences in growth rates were likely attributable to greater amounts of understory light found in the residual pockets. For forests supporting higher deer densities than those found in LDF, this result may indicate an oak regeneration advantage in oak pockets versus larger oak management units. Rapid height growth could help seedlings escape herbivory in areas where forest herbivores are a key limiting factor. Additional research is needed exploring the effects of understory competitor removal along deer density or herbivory intensity gradients.

Table 3.1: Correlation matrix for dependant variables in recent Timber Stand Improvement (TSI) portion of study and older TSI portion. All seedling densities and height growth rates are for northern red oak only. Abbreviations: RO = northern red oak; US = understory; BA = basal area (m^2/ha); GR = height growth rate; small OS is small overstory (10.1-25cm DBH).

Recent TSI matrix	seedling GR	seedling density <50cm	seedling density 50-137cm	seedling density >137cm	RO stems in the US	total stems in US
seedling GR (cm/yr)	1.000					
seedling density <50cm (stems/ha)	-0.1953	1.000				
seedling density 50-137cm (stems/ha)	0.0629	0.2220	1.000			
seedling density >137cm (stems/ha)	0.1634	-0.1685	0.6211	1.000		
RO stems in US(stems/ha)	0.0102	-0.1850	-0.0632	0.1853	1.000	
total stems in US all spp. (stems/ha)	-0.1903	-0.0419	0.0268	0.1512	0.4386	1.000

2

Table 3.1 Continued:

Older TSI matrix	seedling density <50cm	seedling density 50-137cm	seedling density >137cm	relative density of RO in US	RO in small OS	relative density RO in small OS	RO BA in small OS
seedling density <50cm	1.000						
seedling density 50-137cm	0.7734	1.000					
seedling density >137cm	0.7615	0.9039	1.000				
relative density of RO in US	0.4398	0.3352	0.4189	1.000			
RO in small OS (stems/ha)	-0.0001	-0.1960	-0.2232	-0.0782	1.000		
relative density of RO in small OS	-0.0363	-0.0047	-0.0378	-0.3580	0.7511	1.000	
RO BA in small OS	-0.4080	-0.4794	-0.4955	-0.3728	0.8642	0.6803	1.000

Table 3.2: Importance of principal components within recent TSI and older TSI components of the study. Only principal components accounting for more than 5% of the total variance are shown.

Recent TSI	PC 1	PC 2	PC 3	
Percent of Variance	32.31%	23.65%	18.76%	
Cumulative Variance	32.21%	55.85%	74.62%	
Standard Deviation	1.4824	1.2702	1.1315	
Older TSI	**PC 1**	**PC 2**	**PC 3**	**PC 4**
Percent of Variance	40.49%	24.46%	20.69%	8.32%
Cumulative Proportion	40.49%	64.95%	85.64%	93.96%
Standard Deviation	1.8519	1.4396	1.3239	0.8395

Table 3.3: Principal component (PC) loadings for response variables in recent TSI and older TSI components of the study. Growth rates are height (cm) growth per year. Seedling variables represent densities (number of stems/ha). Abbreviations: RO = northern red oak; US = understory; numROlt25 = number of RO in small understory (10.1-25cm DBH); RdensROlt25 = relative density of RO in small overstory; ROBAlt25 = basal area (m^2/ha) of RO in small overstory.

Recent TSI	**PC 1**	**PC 2**	**PC 3**	
growth rate		0.188	0.656	
0-50cm seedlings	-0.232		-0.630	
50-137cm seedlings		0.701	-0.225	
>137cm seedlings	0.199	0.677		
RO stems in US	0.628		0.252	
total US stems	3.740		-0.342	
RO relative density in US	0.607		0.388	
Older TSI	**PC 1**	**PC 2**	**PC 3**	**PC 4**
0-50cm seedlings	0.383	0.306	-0.190	0.104
50-137cm seedlings	0.403	0.204	-0.385	
>137cm seedlings	0.418	0.228	-0.242	0.321
RO stems in US	0.200	0.346	0.525	-0.251
total US stems		0.170	0.477	0.807
RO relative density in US	0.357	0.224	0.402	-0.331
numROlt25	-0.286	0.536		-0.173
RdensROlt25	-0.282	0.449	-0.291	0.130
ROBAlt25	-0.426	0.353		-0.124

Table 3.4: ANOVA results for recent TSI component of the study. Numbers are F values with p-value in parentheses. Variable abbreviations are ROBAgt25 = northern red oak basal area in large overstory (>25cm DBH), ROBAlt25 = northern red oak basal area in small overstory (10.1-25cm DBH), RdensROlt25 = relative density (proportion) of northern red oak in small overstory, RdensROgt25 = relative density of northern red oak in large overstory, totalBA = total stand basal area (m^2/ha).

	PC 1	**PC 2**	**PC 3**
Intercept	0.0682 (0.7955)	0.0180 (0.8942)	0.1728 (0.6801)
TSI	1.9043 (0.1866)	0.7311 (0.4044)	0.1617 (0.6926)
Stand size	0.4982 (0.4904)	4.0119 (0.0614)	9.5510 (0.0066)
Stand size * TSI	3.4535 (0.0816)		
Canopy Openness	22.5890 (<0.0001)	12.8211 (0.0011)	10.3522 (0.0027)
ROBAgt25	2.6984 (0.1094)		0.0001 (0.9986)
ROBAlt25	0.1952 (0.6614)	2.7423 (0.1069)	
RdensROlt25	5.4466 (0.0255)	1.7607 (0.1934)	
RdensROgt25		3.4964 (0.0701)	4.3762 (0.0436)
TotalBA		2.3757 (0.1325)	

Table 3.5: ANOVA results for older TSI component of the study. Numbers are F-values with p-values in parentheses. Principal component 3 was not significant for TSI or any covariate and is not reported here. Variable abbreviations are: totalBAgt25 = total (all spp.) basal area (m^2/ha) in large overstory (10.1-25cm DBH), numROgt25 = number of northern red oak stems in large overstory, Total Spp = total number of species encountered/plot, RdensROgt25 = relative density (proportion) of northern red oak in large overstory, ROBAgt25 = basal area of northern red oak in large overstory.

	PC 1	**PC 2**	**PC 4**
Intercept	0.0018 (0.9668)	0.0722 (0.7950)	0.1805 (0.6821)
TSI	0.2882 (0.6199)	1.7721 (0.2539)	0.1580 (0.7113)
TotalBAgt25	193.1328 (<0.0001)	6.3421 (0.0359)	68.1490 (<0.0001)
numROgt25	66.4748 (<0.0001)		4.7878 (0.0601)
Total spp.	598.9001 (<0.0001)	11.0223 (0.0105)	
RdensROgt25		14.0817 (0.0056)	
ROBAgt25			3.5128 (0.0978)

Table 3.6: Median values (and ranges) for untransformed response variables.

Recent	Pockets w/ TSI	Stands w/ TSI	Pockets No TSI	Stands No TSI
% Canopy Openness	22.2 (14.0 - 31.3)	15.45 (11.22-21.13)	25.1 (14.6 - 45.5)	13.7 (10.3 - 19.1)
Height Growth Rate (cm/year)	30.4 (7.6 - 57.7)	15.74 (7.21 - 49.11)	31.2 (6.2 - 82.3)	14.7 (5.9 - 52.4)
A density (stems/ha)	3,158 (1324 - 10188)	4,381 (2038-14162)	3,362 (1223 - 8253)	5,298 (2955-15486)
B density (stems/ha)	1,834 (917 - 4177)	1,426 (0 - 2852)	1,324 (917 - 2343)	1,223 (0 - 2140)
C density (stems/ha)	815 (102 - 1732)	509 (0 - 1732)	713 (0 - 1732)	204 (0 - 2547)
Older		TSI		No TSI
A density (stems/ha)		6,215 (2038-14162)		3,770 (0 - 16403)
B density		1,426 (0 - 2853)		204 (0 - 7234)
C density		306 (0 - 713)		102 (0 - 1936)

Figure 3.1: Map of Lac du Flambeau Reservation and surrounding region.

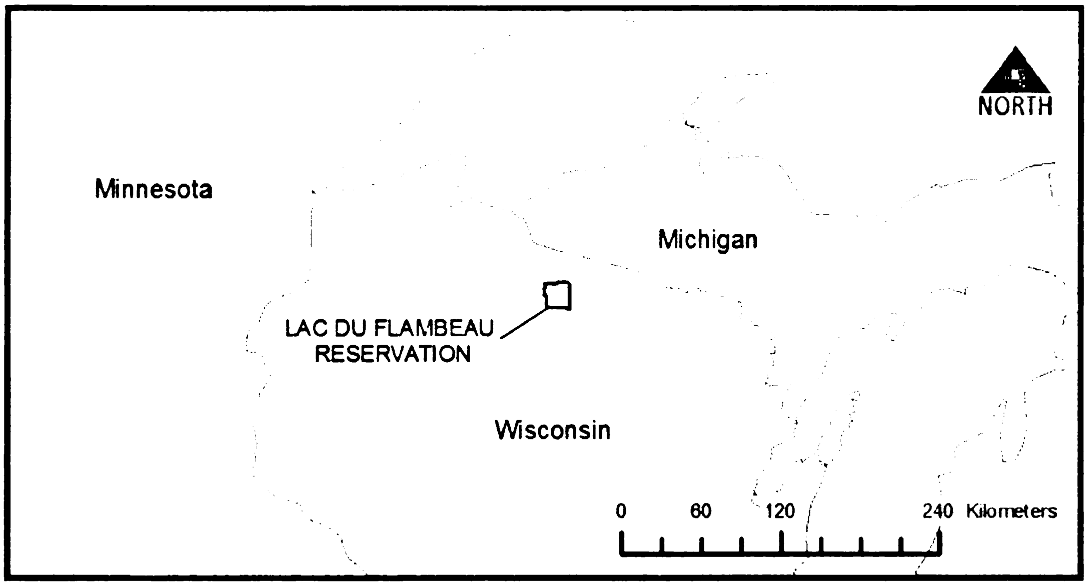


Figure 3.2: Diagram showing A) experimental design for younger Timber Stand Improvement study component and B) vegetation sampling design.

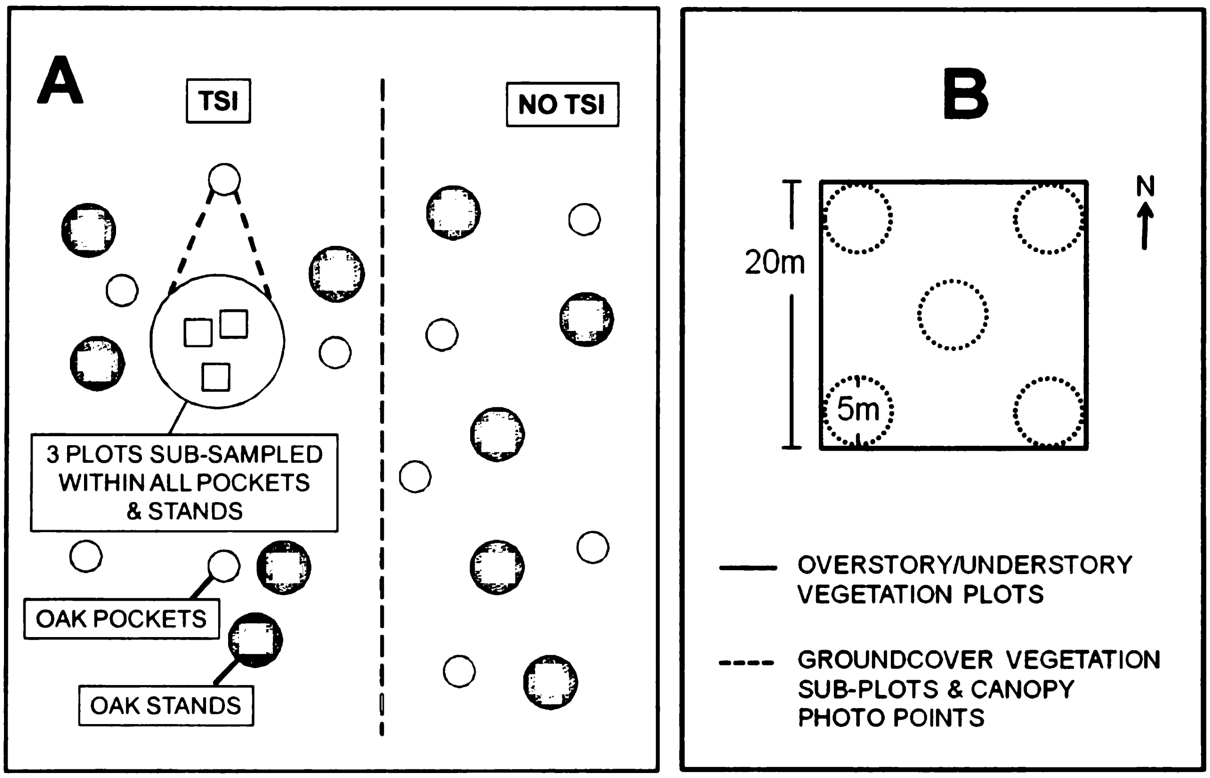


Figure 3.3: Mean values for the following principal components from recent TSI portion of study: A) PC1, overall density of understory-sized individuals of all species; B) PC2, density of medium (50-137cm) and tall (137cm+) seedlings in the groundcover layer; C) PC3, representing a contrast between seedling growth rate and density of small (< 50cm) groundcover stems. For associated factor loadings, see Table 3.3. Error bars represent +/- one standard error.

A)

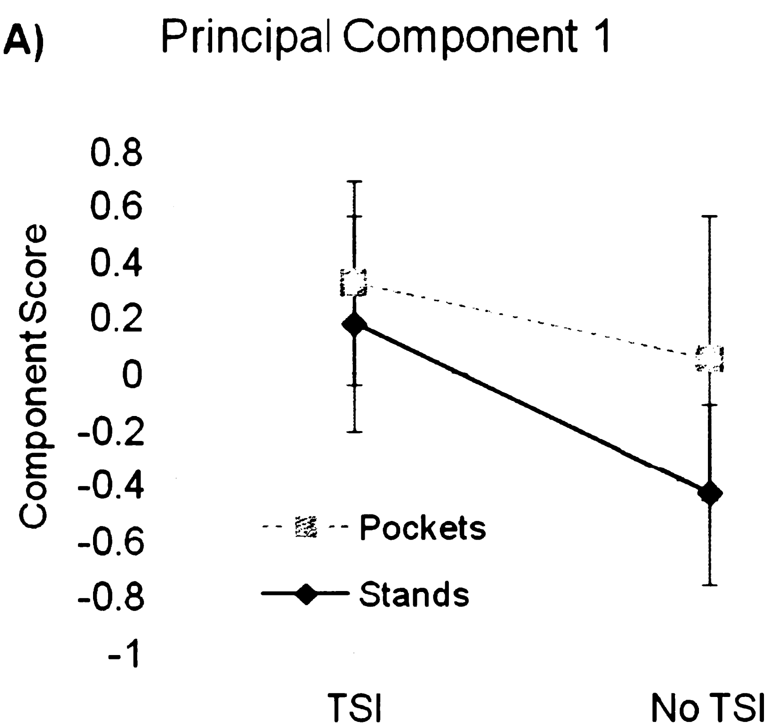
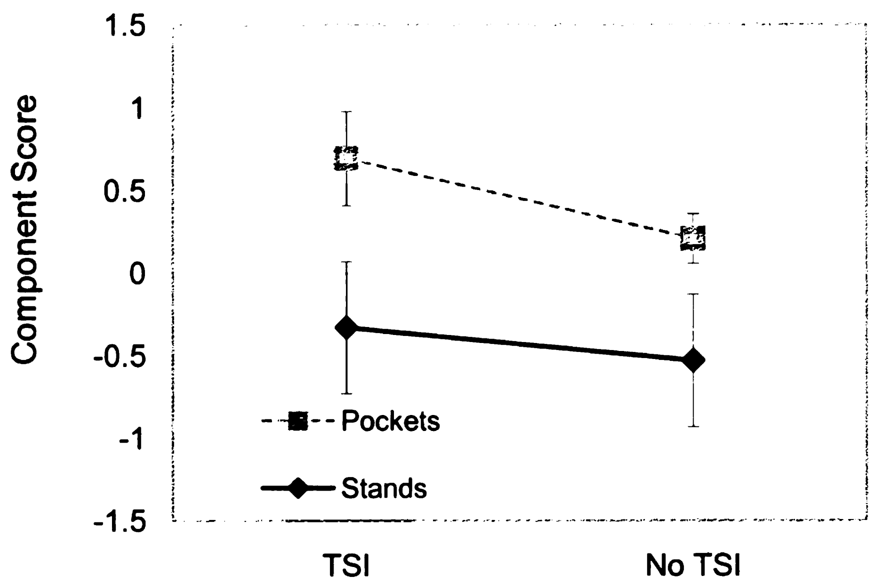


Figure 3.3 Continued:

B) Principal Component 2



C) Principal Component 3

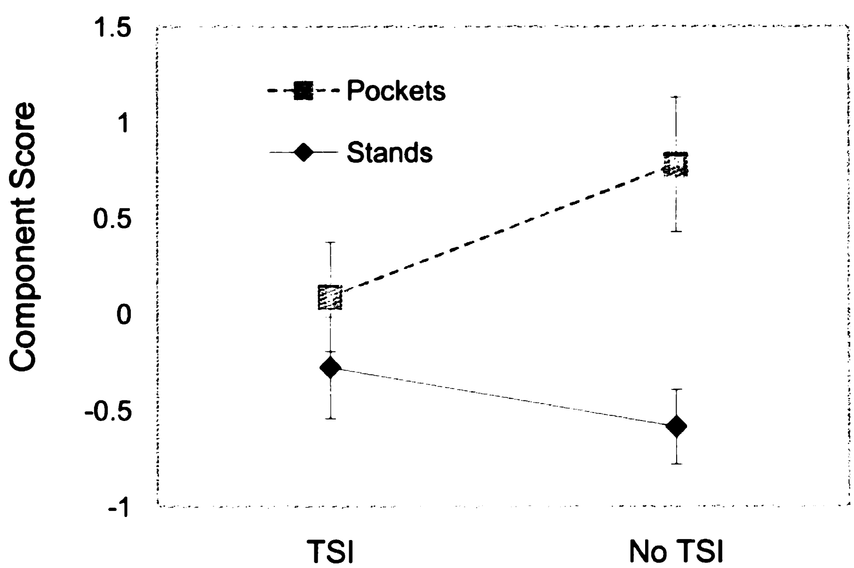
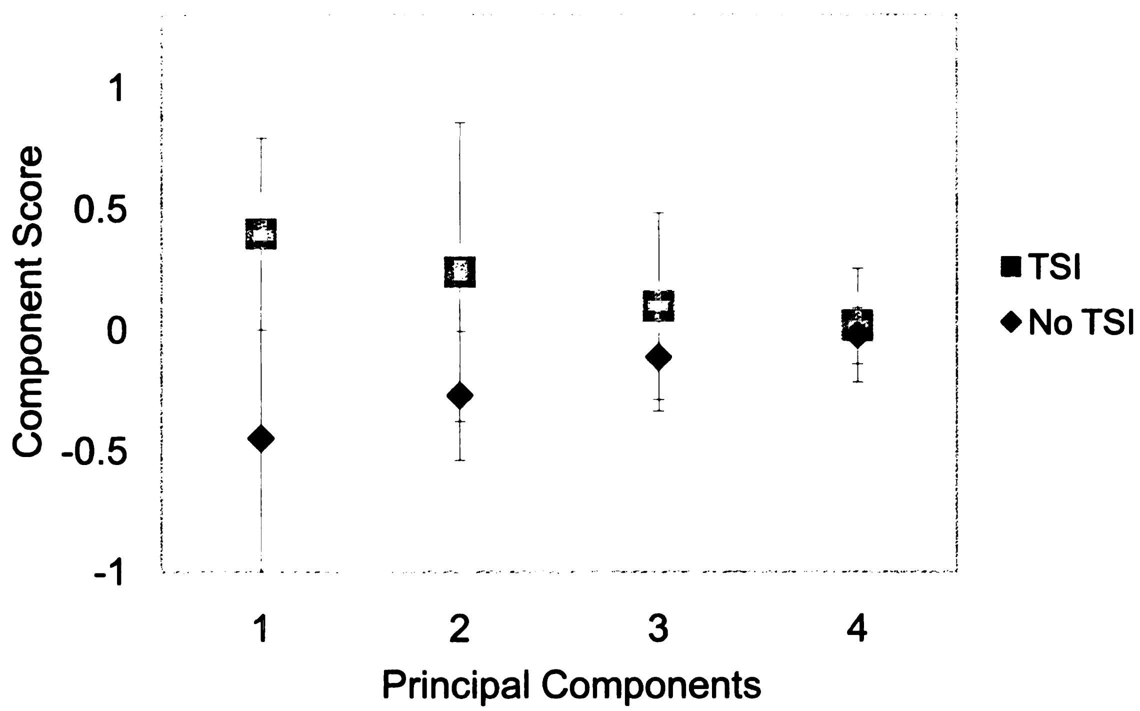


Figure 3.4: Mean values and standard errors for the older TSI portion of this study. Error bars represent +/- one standard error.



CHAPTER 4

A CROSS-BOUNDARY COMPARISON OF FOREST REGENERATION FOLLOWING TRIBAL AND STATE ECOSYSTEM MANAGEMENT

In collaboration with

Jason Karl

Abstract

Wild ungulates such as white-tailed deer (*Odocoileus virginianus*) are highly valued wildlife assets that provide subsistence, economic and cultural benefits to hunters and rural communities. Yet, high density populations of these herbivores can contribute significantly to regeneration failures in a wide range of forest types. Pre-European settlement white-tailed deer densities were estimated to have been approximately 2-4 deer/km^2, and similar densities have been recommended to balance contemporary forest regeneration and wildlife objectives.

We studied northern red oak (*Quercus rubra* L.) regeneration on neighboring tribal and state forests where socio-cultural differences have led to distinct hunting management practices and subsequent differences in wildlife-plant interactions. Tribes such as the Lac du Flambeau Chippewa have kept deer populations relatively low on reservation lands through active hunting practices. We used an observational study approach to compare in situ ungulate herbivory under low (2-3 deer/km^2) and high (>10 deer/km^2) population densities. We measured northern red oak regeneration on tribal and state forests in two management unit types: contiguous stands of oak >15 ha in area and small residual "pockets" of oak < 3 ha left by foresters as a source of seed and wildlife mast. Herbivory levels were significantly higher on state forests than tribal forests and were closely correlated with the density of taller seedlings, particularly in oak pockets. If herbivory levels are too high, even with adequate light, our results suggest that seedlings may not survive in densities sufficient to maintain northern red oak as a co-dominant species in mixed forests. However, when deer densities are kept at 2-4 deer/km^2, our

results suggest that northern red oak seedlings can survive beyond browseable heights in sufficient numbers for maintaining oak. Tribal lands can provide contemporary examples of longstanding low to intermediate deer densities and sustainable deer-forest relationships.

Introduction

Protecting the world's forests is becoming progressively challenging. Forests not immediately in danger of deforestation face a long list of threats to their functional integrity including elevated levels of herbivory by high density populations of ungulates and other herbivores. Forest impacts attributable to excessive herbivory include biotic impoverishment and homogenization (Rooney et al. 2004) and regeneration failures in ecologically and economically important tree species.

Oak species (*Quercus* spp.) are highly valued for timber products and as a major food source for wildlife (McShea and Healy 2003). They also have aesthetic, cultural and ecological significance throughout the Eastern United States (US) and other temperate regions of the world (Isebrands and Dickson 1994). Although oaks remain a common canopy component within a variety of mixed forest types, understory oak seedlings for the last several decades have been failing to survive and transition to the overstory canopy at sufficient rates to maintain their dominant and co-dominant status (Lorimer 1992, Palmer et al. 2004). A long list of potentially interacting factors including fire suppression, excessive herbivory, damage by forest insects and pathogens, understory competition and inadequate light resources have been linked to the decline of oak forests (Abrams 2003, Lorimer 2003), but clear understanding of these underlying issues and proven strategies for oak forest management remain elusive (Crow 1988, 1992, Lorimer 2003).

White-tailed deer (*Odocoileus virginianus*) and other large ungulates have been implicated for regeneration failures in oaks and other tree species (Gill 1992, Cote et al. 2004, Wisdom et al. 2006). When deer populations reach high densities, their herbivory has been shown to severely affect forest regeneration (Frelich and Lorimer 1985, Gill 1992, Rooney and Waller 2003) and alter the structure and composition of forests (Augustine and McNaughton 1998, Rooney and Waller 2003, Tremblay et al. 2007). Yet, white-tailed deer are highly regarded for their subsistence, recreational, and cultural values, and spending associated with recreational hunting contributes significantly to rural economies. For example, in 2006, approximately $4.6 billion was spent on trip-related expenditures (e.g., lodging, food, guide fees, etc.) by big game hunters in the U.S. (U.S. Fish and Wildlife Service 2006). Forest and wildlife managers must therefore balance the trade-offs between a significant wildlife asset and possible ecological and economic threats posed by high deer densities.

Wildlife managers choose their management strategies based in part on the hunting culture and other cultural contexts of their constituent societies. As McCorquodale (1997) stated, "cultural contexts are extremely important aspects of hunting management; they mandate objectives and constraints within which wildlife managers must operate." On American Indian reservations where hunting is primarily a subsistence activity and per capita consumption of wild game by tribal citizens is very high, hunting is used as a primary tool for controlling game populations. By contrast, on public forestlands in the U.S., where the majority of hunters are pursuing recreation more than harvesting meat, the use of hunting to control wildlife populations such as white-tailed deer is declining (Brown et al. 2000).

Because American Indian hunters are meat-focused and readily harvest both antlered and antlerless deer, hunting pressure tends to be higher and deer populations lower on Indian reservations. This trend has been documented, for example, in the State of Wisconsin (DeBoer 1947, Alverson et al. 1988, Rooney et al. 2000). Considering the aforementioned linkages between deer herbivory and forest development, deer density differences across tribal and public lands could lead to important differences for forest ecosystems. To date, we know of no research that has explicitly compared forest development in light of differential deer densities following long term tribal and public resource management systems.

In the present study, we investigated the effects of management-induced differences in deer densities on northern red oak (*Quercus rubra* L.) seedling growth and survival. Our study was implemented on adjacent tribal and state forestlands in North Central Wisconsin where differing approaches to white-tailed deer management have led to distinctly different deer population densities for the last half century or longer (DeBoer 1947, Alverson et al. 1988, Rooney et al. 2000). Deer move back and forth across this management boundary, but due to greater hunting pressure, average deer densities are significantly lower on tribal lands. Our specific research objective was to determine the influence management regime (i.e., tribal vs. state natural resource management approaches), management unit size and/or interactions between these two factors have on the growth and survival of northern red oak seedlings.

Methods

Study Site

Forest Ecosystems

Our study site was comprised of the >35,000 hectare (ha) Lac du Flambeau (LDF) Reservation (federally-recognized homeland of the Lac du Flambeau Band of Lake Superior Chippewa Indians) and the >95,000 ha Northern Highland - American Legion State Forest (NH-AL) in North Central Wisconsin (Figure 4.1). Forest ecosystems on the LDF Reservation and NH-AL have similar bio-physical conditions. Climate in both areas is characterized by a 121-day growing season, average temperatures range from -6.7 to 35° C and average annual precipitation ranges from 76.2 to 86.4 cm (Albert 1995). Elevation ranges from 442-590m. The most common physiographic systems in both sections of the study area are pitted outwash and ice contact-derived landform systems. The study area falls within one regional ecosystem called the "Lac Veaux Desert Outwash Plain" (Albert 1995). The NH-AL and LDF Reservation have a similar mix of forest cover types with aspen types as the most abundant followed by red/white pine followed by northern hardwoods, forested wetlands and northern red oak (WDNR 2005).

Through conversations with local resource managers plus field and GIS-based reconnaissance we determined that northern red oak grows in a diversity of sites within our study area ranging from dry, nutrient poor outwash plains alongside northern pin oak (*Quercus ellipsoidalis* E.J. Hill) to mesic sites dominated by sugar maple (*Acer saccharum* Marshall) and eastern hemlock [*Tsuga canadensis* (L.) Carr]. In our study area, northern red oak is more typically a dominant or co-dominant canopy component on intermediate quality sites associated with ice-contact and outwash plain physiographic systems.

Forest and Wildlife Management

There are noteworthy differences and similarities between natural resource management priorities on the LDF Reservation and the NH-AL; differences that are rooted in socio-cultural distinctions between state forest constituents and tribal citizens. Both land areas are managed to maintain ecosystem health and conserve biological diversity. However, on the NH-AL, managers also prioritize providing recreation opportunities for Wisconsin citizens, whereas on the LDF Reservation, subsistence hunting and gathering, preservation of culturally important plant and animal species and protection of culturally-significant sites are important management priorities. The state forest serves as a public resource for all the people of the State of Wisconsin, whereas forests on the LDF Reservation are managed to meet the needs of the LDF Tribe and its approximately 3,100 enrolled citizens. The tribe has to balance forest preservation with community development needs that accompany their rapidly growing reservation population, but on the NH-AL, forestland development is strictly limited.

Northern red oak is managed for similar purposes and using similar silvicultural techniques on tribal and state forests. Oak is managed as a natural component of mixed deciduous forests in the region and acorn mast is a valued food for bear, deer, wild turkey and other wildlife. Oak also serves as an important timber species and harvests provide critical revenue for tribal and state programs. Shelterwood-style harvests, where a large proportion of the overstory is removed in multiple stages, are the most common technique used by local foresters to regenerate northern red oak.

In our study area, foresters manage northern red oak within forest stands where it is dominant or co-dominant in the forest canopy. They also maintain smaller clusters of northern red oak within stands dominated by other species. For example, it is common for stands of big-tooth aspen (*Populus grandidentata* Michx) to contain small clusters of oak on tops of small hills and ridges within pitted outwash and ice-contact terrain. Tribal and state forest managers intentionally leave these "pockets" of oak intact when big-tooth aspen stands are clearcut to provide a seed source for oak expansion and as important acorn mast for wildlife. Forest managers also protect pockets of oak for similar reasons along margins of lakes, roads and wetlands. These residual pockets of oak may constitute significantly different regeneration environments for oak seedlings. First, because the oak stands have more forest interior and less edge than pockets it is possible that their light environments differ. Second, residual pockets and oak stands may represent different forms of deer habitat and the browse intensity could therefore differ.

Hunting Management

White-tailed deer hunting is a popular recreational activity on the NH-AL, drawing hunters from around the state during relatively short hunting seasons in the fall and winter. For LDF tribal citizens, white-tailed deer is perhaps the most important subsistence resource (Reo, unpublished data) and they consume deer meat extensively. Lac du Flambeau tribal citizens can hunt deer year-round on the reservation, creating extensive hunting pressure on white-tailed deer. As a result, average deer densities on the reservation are consistently and significantly lower than on the NH-AL. Based on annual pellet count surveys, tribal wildlife managers have determined that white-tailed deer densities on the LDF Reservation averaged 2.6 deer/km^2 from 1984 through 2006 (LDF

integrated resource management plan, internal document). Over the same time period, based on data derived from Sex-Age-Kill methodologies, deer densities averaged 10.3 deer/km^2 in deer management units encompassing the NH-AL (unpublished data, WDNR).

Field Methods

In the summers of 2007 and 2008, with the assistance of tribal and state foresters, we identified stands for field sampling if they met the following criteria: 1) northern red oak was dominant or co-dominant in the forest canopy; 2) a regeneration harvest (i.e., thinned sufficiently to stimulate rapid seedling growth or "release") had been implemented in the last 5-15 years; 3) they were of intermediate site quality within the continuum of sites supporting northern red oak in the region. The first two criteria were established to limit our inquiry to sites where the potential for regeneration was not limited by either seed source or light availability. We chose to focus on intermediate quality sites where northern red oak often has a competitive advantage over more mesic species (Lorimer 1992, Buckley et al. 1998) because these sites are becoming the focus of northern red oak management efforts in the region. We determined site quality by using ecological habitat types developed by Kotar et al. (Kotar et al. 2002). All sites were either *Pinus-Acer rubrum/Vaccinium-Aralia* (PArVAa) or *Pinus-Acer rubrum/Vaccinium* (PArV) habitat types (Kotar et al. 2002) as determined through field assessment.

We used a balanced 2x2 factorial design with half of our plots on state and half on tribal forests. Within each management regime (i.e., tribal and state), half of the plots were located in oak stands and half in oak pockets. We defined northern red oak stands as any forest stand 1) that was 15 hectares (ha) or larger in area, 2) where northern red oak was a dominant or co-dominant canopy constituent and 3) where northern red oak was a primary future management goal. We defined "pockets" for the purpose of this study as areas that 1) were less than 3 ha in area, 2) were dominated by oak in the overstory and 3) were an intentional part of forest management strategies, even though they were not typically delineated by local foresters as their own independent management units (i.e., stands). The oak pockets either existed as small clusters of trees within larger management units such as aspen stands or as strips of oak maintained along the margins of lakes, roads, wetlands and clearcuts. We identified five management units (e.g., oak stands and aspen stands containing pockets of oak) per treatment group that met these research criteria.

Within selected forest stands, three random plot locations were determined in the field, as described by Spies and Barnes (Spies and Barnes 1985). All plots were at least 50 meters from the outer edge of their stand to limit potential edge effects. When sampling oak pockets, for stands that contained multiple pockets of oak, we dispersed our plots among three different pockets. When sampling small elongated strips of oak along margins of lakes, roads, wetlands and clearcuts, we distributed our three plots such that they were never closer than 50 meters from one another. General plot characteristics were sampled using a 20x20 meter fixed-area plot. We noted all plant species within the plot, classified the ecological habitat type using the system described by Kotar et al. (Kotar et al. 2002), recorded the number and DBH (diameter at breast height, or 137cm) of all overstory (>10.1cm) and understory (2.6-10.0cm) trees by species, and described elements of site physiography including the landform type, slope, position on slope and aspect.

To document northern red oak seedling and sapling densities, we further sub-sampled our stands of interest using five circular plots (5m diameter) in fixed locations within each plot (for plot arrangements and other details of sampling design, see Figure 4.5). Within these sub-plots, we counted all northern red oak seedlings in three height classes: 0-50cm; 51cm-137 cm; and >137 cm. These size classes were chosen because they are easy to implement quickly in the field. We also harvested 3 seedlings within each plot to determine northern red oak growth rates (i.e., height growth per year). We were careful to select individuals that established in response to the most recent regeneration harvest or heavy thinning. When no seedlings were present within a given plot, we collected individuals from outside the plot, but always within approximately 50 meters.

To estimate deer browse pressure, we modified the sugar-maple-browse-index method of Frelich and Lorimer (Frelich and Lorimer 1985) for use with northern red oak. The sugar maple browse index quantifies browse intensity by establishing a ratio of seedlings browsed to total number of seedlings counted where only seedlings 30-200cm in height with current growing season terminal shoot herbivory are tallied as "browsed." Seedlings below 30cm in height are ignored to exclude small mammal herbivory from the analyses. We modified this index by limiting our counts to a slightly different size range to maintain consistency with our vegetation sampling size classes (i.e., we counted browse on seedlings in the 51-137cm and >137cm height classes). Also, we counted seedlings with deer browse on terminal shoots and lateral shots/branches rather than just terminal shoots because of differences in how maples and oaks respond to herbivory. We recorded the proportion of northern red oak seedlings that were browsed vs. un-browsed along a 240m x 1.5m transect in a pattern that concentrated our sampling near plot locations. The deer component of our study was conducted without using fenced enclosures or exclosures because we were interested in comparing in situ deer herbivory on tribal and state forests.

Investigation of how light availability interacts with deer browse and/or management unit size to influence oak regeneration was beyond the scope of our study. We chose stands that had ample light for promoting rapid growth of oak seedlings, theoretically marginalizing the effects of light in this study. However, because light is a dominant factor influencing oak seedling growth (Crow 1992, Johnson 1994) and the light environment in our study plots was highly heterogeneous, we documented light availability and included it in our statistical analyses to account for influences light may have on variation in our response variables.

To estimate understory light availability, we recorded canopy openness (i.e., % of full sun) through hemispherical photograph analysis (Canham 1988). We took canopy photos in low light conditions using a Nikon Coolpix5000 digital camera and Nikon UR-E6 180^0 fisheye lens. Canopy photos were processed using Gap Light Analyzer 2.0 software (Frazer et al. 1999).

Quantitative Analyses

To examine differences in northern red oak seedling development and stand structure due to management regime and stand size, we used linear discriminant analysis (Johnson and Wichern 2002) and linear mixed-effects analysis of variance (Zuur et al. 2009). Both of these techniques carry assumptions regarding the distribution of the input variables. Linear discriminant analysis assumes that the input variables can be described by a multivariate normal distribution (Johnson and Wichern 2002). Linear mixed-effects modeling assumes a linear relationship between the independent and dependent variables and that the regression residuals are normally distributed (Pinheiro and Bates 2000). Additionally, ANOVA assumes that the dependent variable is normally distributed within treatment groups. To assess whether the variables could be considered as normally distributed, we constructed histograms of each of the six continuous variables and performed transformations as necessary (Table 4.5). We used the Shapiro-Wilk normality test (Royston 1982) to assess whether the distribution of each transformed variable approximated a normal distribution. Density of >137cm oak seedlings was the only variable that did not approach a normal distribution even after transformation due to the abundance of plots with zero seedlings >137cm in height. The effect of violating the ANOVA normality assumption in this case may be an F statistic that is too small (Lindman 1974) and increasing the possibility of type I error. We elected, however, to keep this variable because of its relationship to deer density and forest management in the study area despite the fact that it might make it more difficult to detect significant differences between the treatment groups.

We examined differences in stand structure related to management regime (state vs. tribal) and size of management unit (stands vs. pockets) using a linear discriminant analysis (LDA). Linear discriminant analysis finds the linear combination of input variables that best separates categories to which different observations belong (Johnson and Wichern 2002). The independent variables used for the LDA were canopy openness, percent deer browse, total basal area, and basal area of northern red oak >25cm DBH. Basal area of northern red oak >25cm DBH was included as a variable because trees of this size class are expected to provide the most abundant seed source in northern red oak stands (Sander 1990). For the LDA, these variables were rescaled to a mean of zero and a standard deviation of 1. Each plot was assigned a code for the LDA corresponding to its *management regime:management unit size* (hereafter "regime:size") combination. The linear discriminant axes were interpreted using their weighting coefficients, and the plots were graphed on the first two axes to evaluate separability by the four variables. To assess the reliability of the LDA at discriminating stands, we performed a leave-one-out cross-validation where each observation, sequentially, was left out, the LDA ran, and the regime:size combination of the missing observation predicted. The predicted and actual regime:size values for each plot were collected and used to construct an error matrix for the LDA.

To test for differences between management regime (state vs. tribal) and management unit size (stands vs. pockets) we used a 2-way ANOVA for northern red oak growth rate and density in the three size classes. We used linear mixed-effects modeling to account for the hierarchical nature of this study design (i.e., plots nested within stands) and to capture within-stand variability. Plots nested within stands were considered random effects.

Standard ANOVA requires the assumption of independence of treatment groups and equal variance of the response variable between treatment groups. The nested nature of our study design violated this first assumption, and the variances between treatment groups were not equal (as determined by an F test for equal variances) for any of the response variables. A mixed-effects ANOVA, however, provides for dependence

between the random effects (i.e., stands and plots) and also for variance to be different between treatment groups (Pinheiro and Bates 2000).

To test for differences in our response variables (oak seedling growth rate and oak seedling densities in three size classes), we used separate, hierarchical two-way ANOVAs for each response variable including the following as covariates: canopy openness, percent deer browse, total plot basal area (i.e., area occupied by the cross-section of tree trunks at a height of 137cm), and basal area of northern red oak >25cm. Regime (tribal vs. state) and size (pockets vs. stands) were the ANOVA fixed effects. For each response variable, we constructed multiple models with different combinations of the fixed effects, covariates, and their two-way interactions and selected the model with the lowest Akaike Information Criteria (Burnham and Anderson 2002). In each case, the best model included the main fixed-effects of regime (state vs. tribal) and size (pockets vs. stands), a two-way interaction between regime and size, with canopy openness and basal area of northern red oak >25cm DBH as a covariates. Percent browse, total basal area and total northern red oak basal area were not significant variables in any of the models, and so were not included in the final model structure.

To test for differences between treatment groups (where each regime:size combination was considered a treatment group), we used Tukey's Honestly Significant Difference (HSD) test (Tukey 1953). Tukey's HSD compares pairs of treatment group means and tests for pair-wise differences while correcting for the inflation of type I error rate that occurs when multiple comparisons are made (Gotelli and Ellison 2004). We used graphs of the response variables within each of our four treatment groups to help interpret the results of the analyses of variance.

Results

The LDA for discriminating regime:size combinations showed separability between management regimes, but little separation of management unit size within the management regimes (Figure 4.2). The first two linear discriminant axes accounted for 90.7% of the variability in the data (66.3% and 24.7% for the first and second axes, respectively). The first linear discriminant axis loaded positively on canopy openness and red oak basal area and negatively on percent deer browse. We interpreted this axis as: high values for the axis had high canopy openness and red oak basal area and low percent deer browse; whereas low values on the axis had high percent browse and low canopy openness and red oak basal area (Table 4.1, Figure 4.2). The second axis weighted heavily on all four variables, but only accounted for 24.7% of the variability in the data. Using the cross-validation procedure to predict management regime and management unit size from the original data, 66.7% of the stands were correctly classified (Table 4.2). Percent of observations correctly classified (i.e., producer's accuracy) ranged from 53.33% for state pockets to 73.33% for tribal and state stands (Table 4.2). Percent of predicted classes correctly assigned (i.e., user's accuracy) ranged from 57.14% for state pockets to 83.33% for tribal pockets.

Based on the role of canopy openness, percent deer browse and basal area of northern red oak >25cm DBH in both linear discriminate axes, we conducted separate ANOVA's for each of these variables to examine their relationships to management regime and management unit size. Canopy openness was similar for oak pockets and oak stands on state lands, but significantly greater ($p<0.0001$) between oak pockets and oak stands on tribal lands (Figure 4.3A). Conversely, percent browse showed a significant difference with regard to management regime with a higher proportion of oak seedlings browsed on state forests than on tribal forests (Figure 4.3B). Deer browse was similar across management unit size (i.e., between oak pockets and oak stands) in both state and tribal forests. Basal area of northern red oak >25cm DBH was significantly greater in pockets than stands (p=0.0013) with a marginally significant difference across management regime (p=0.0883) (Figure 4.3E).

The ANOVA of northern red oak sapling growth rate suggested a significant interaction between management regime and management unit size (p=0.009, Table 4.3, Figure 4.4A). Pairwise comparisons between all treatment group combinations in the growth rate ANOVA indicated that tribal pockets had significantly higher growth rates than tribal stands (i.e., partial size effect, p=0.021) and state stands had significantly higher growth rates than tribal stands (i.e., partial management regime effect, p=0.005) at the α=0.05 level (Table 4.4). For growth rate, the random effects of plots nested within management units accounted for 47.45% of the observed variability.

The ANOVA for density of 0-50cm northern red oak seedlings indicated a significant regime:size interaction (p<0.001, Table 4.3, Figure 4.4B). Although each of the pairwise group comparisons showed statistically significant results (Table 4.4) at the α=0.05 level, the most significant differences were in the greater number of seedlings in pockets vs. stands on state forests (p<0.001) and significantly fewer seedlings in state stands vs. tribal stands (p=0.001). The random effects of plots nested within management units accounted for less than 0.01% of the total variance in the 0-50cm height class density observations.

There were no detectable differences in 51-137cm seedling densities due to management regime or management unit size (Table 4.3). All pairwise comparisons were non-significant at the $\alpha=0.05$ level and are not reported. The random effects of plots nested within management units accounted for less than 0.01% of the observed variability in 51-137cm seedling density.

The ANOVA for density of >137cm oak seedlings showed significantly greater seedling densities on tribal vs. state forests (Figure 4.4D, $p<0.001$). Closer examination of the significant management regime difference through pairwise comparisons indicated that the management regime effect was driven by the higher density of >137cm oaks in tribal vs. state pockets ($p<0.001$, Table 4.4). Our results also suggested a higher number of >137cm oaks on tribal stands compared with state stands, but this difference was not significantly different (Table 4.4, Figure 4.4D) at the $\alpha=0.05$ level. Random effects of plots nested within stands accounted for 1.94% of the observed variation in >137cm seedling density.

Discussion

This research project provides a unique contribution because we compared deer-forest relationships in the context of high deer densities, similar to those found throughout much of the range of white-tailed deer, and low deer densities that match population goals suggested by many ecologists and ecosystem managers. On tribal lands, where average deer densities are maintained at 2-3/km^2, northern red oak seedlings are regenerating successfully. Our >137cm seedling density results provide convincing evidence regarding regeneration success or failure because these seedlings are tall enough that they are no longer browsed by white-tailed deer and therefore provide a measure of deer herbivory survival. In our study area, oak seedlings survived into this taller height class in significantly greater densities on tribal than state forests, regardless of management unit size. Our ANOVA results indicated a negative correlation between percent browse and >137cm seedling densities (r=-0.3527, figures 4.3B and 4.4D). These results indicate that when deer densities are kept at 2-3/km^2, and given sufficient understory light, resource managers can successfully regenerate northern red oak. This result is noteworthy given the widespread hardwood regeneration failures reported elsewhere.

Seedlings <50cm in height are buried by snow in the winter when white-tailed deer do most of their woody plant browsing (Healy 1997). We therefore expected that 0-50cm seedling densities were driven more by light availability and seed source than deer herbivory. Our results for 0-50cm seedling densities showed a significant regime:size interaction with highest densities in tribal stands and state pockets. Our ANOVA results suggest that 0-50cm seedling densities are related to light given the similar trends across our treatment groups for canopy openness and 0-50cm seedling densities (figures 4.3A and 4.4B). Because we did not make a detailed accounting of acorn production, our best approximation of seed source is basal area of northern red oak >25cm DBH. In pockets (but not in stands), these acorn production-sized oaks showed concurrent trends to 0-50cm seedling densities (i.e., greater basal area and greater density of seedlings in state vs. tribal pockets) (figures 4.3E and 4.4B).

Light availability is likely the most important abiotic factor influencing northern red oak seedlings growth and survival (McGee 1968, Sander 1990, Pacala et al. 1994, Finzi and Canham 2000). Given Finzi and Canham's (2000) and Pacala et al.'s (1994) findings that northern red oak seedlings not only grow more rapidly with increasing light levels but cannot tolerate the slow growth that accompanies deep shade, adequate understory light can be thought of as a "pre-requisite" to oak seedling survival. In our study, we looked at sites that had ample light to support seedling growth and survival. Even given sufficient light, few seedlings survived beyond the browseline (i.e., low densities of seedlings >137cm) on state forests where deer densities are high.

Management Implications

In our study area, tribal natural resource management is resulting in northern red oak seedlings densities that approach silvicultural recommendations for "full stocking" (Sander et al. 1984, WDNR 1990). The densities of tall (>137cm) seedlings we observed on tribal lands would be more than satisfactory to most resource managers, particularly considering the struggles managers have had regenerating oak in recent decades. Seedling survival was nearly threefold greater in tribal stands than state stands and more than eightfold greater in tribal pockets than state pockets. Our results from state lands suggest that even when the prerequisite of adequate light is met, if herbivory levels are too high, seedlings may not survive in densities sufficient to maintain northern red oak as an important component of future forests. However, when deer densities are kept at 2-4/km^2, northern red oak seedlings may survive in sufficient numbers for maintaining oak.

Because tribal citizens continue to use large game as a primary subsistence resource, tribal resource managers are able to use hunting as a means of achieving relatively low deer densities. For example, the deer densities maintained on the Lac du Flambeau Reservation are similar to estimated pre-European settlement densities and match contemporary recommendations for managers trying to promote hardwood regeneration and biotic diversity in their forest units. The Lac du Flambeau Reservation provides a contemporary example of longstanding low to intermediate deer densities and sustainable deer-forest relationships. Managers of public lands, such as the Wisconsin DNR, are not able to replicate tribal hunting management programs because their work is situated in significantly different socio-cultural and political contexts. However, to sustain wildlife and forest assets, managers of public lands will need to find their own context-appropriate mechanisms for reducing deer densities.

Table 4.1: Coefficients of the first two linear discriminant axes for examining class separation of management regime:size groups by canopy openness, percent deer browse, total basal area, and red oak basal area. The first linear discriminate axis was heavily influenced by canopy openness and percent deer browse. The second axis weighted more evenly across all the variables.

Variable	Linear Discriminant Axis 1	Linear Discriminant Axis 2
Canopy Openness	0.7397	0.7562
Percent Deer Browse	-1.1294	0.9152
Total Basal Area	0.1265	0.6315
Red Oak Basal Area	0.6762	-1.5103

Table 4.2: Error matrix from cross-validation of the discriminant function analysis.

			Observed Group				% of Predicted Correctly Classified
			Pockets		Stands		
			State	Tribal	State	Tribal	
Predicted Group	Pockets	State	8	2	3	1	57.14%
		Tribal	1	10	0	1	83.33%
	Stands	State	3	2	11	2	61.11%
		Tribal	3	1	1	11	68.75%
% of Observed Correctly Classified			53.33%	66.67%	73.33%	73.33%	Total % Correct 66.67%

Table 4.3: Results of Analysis of Variance for growth rate and density of three size classes of northern red oak seedlings by management regime (state vs. tribal) and management unit size (stands vs. pockets). Canopy openness and basal area of northern red oaks >25cm DBH were used as covariates. Degrees of freedom were 1 and 40 for each F-test.

	F-Value	**P-value**
Growth Rate		
Mgmt Unit Size	2.659	0.111
Mgmt Regime	4.100	0.050
Canopy Openness	0.254	0.617
Red Oak >25cm Basal Area	0.001	0.975
Regime*Size	7.671	0.009
0-50cm Oak Seedling Density		
Mgmt Unit Size	0.037	0.845
Mgmt Regime	0.837	0.366
Canopy Openness	0.079	0.379
Red Oak >25cm Basal Area	3.082	0.087
Regime*Size	26.242	<0.001
51-137cm Oak Seedling Density		
Mgmt Unit Size	0.003	0.961
Mgmt Regime	1.366	0.245
Canopy Openness	7.984	0.007
Red Oak >25cm Basal Area	0.539	0.467
Regime*Size	0.091	0.764
>137cm Oak Seedling Density		
Mgmt Unit Size	0.050	0.825
Mgmt Regime	35.917	<0.001
Canopy Openness	1.751	0.193
Red Oak >25cm Basal Area	4.658	0.037
Regime*Size	2.234	0.143

Table 4.4: Results Tukey's HSD test of pairwise comparisons between treatment groups for growth rate and density of 0-50cm and >137cm sized northern red oak seedlings. Est. Diff. is the estimated difference between the treatment group means.

Comparison	Est. Diff.	Std. Error	z-value	p-value
Growth Rate				
State:Pockets to Tribal:Pockets	0.277	0.224	1.236	0.583
State:Pockets to State:Stands	0.029	0.099	0.289	0.991
Tribal:Pockets to Tribal:Stands	-0.728	0.257	-2.831	0.021
State:Stands to Tribal:Stands	-0.480	0.146	-3.269	0.005
0-50cm Oak Seedling Density				
State:Pockets to Tribal:Pockets	-0.686	0.240	-2.854	0.022
State:Pockets to State:Stands	-1.141	0.295	-3.872	<0.001
Tribal:Pockets to Tribal:Stands	0.755	0.233	3.242	0.006
State:Stands to Tribal:Stands	1.210	0.265	4.565	0.001
>137cm Oak Seedling Density				
State:Pockets to Tribal:Pockets	32.701	6.247	5.235	<0.001
State:Pockets to State:Stands	6.715	7.479	0.898	0.799
Tribal:Pockets to Tribal:Stands	-13.094	11.156	-1.174	0.634
State:Stands to Tribal:Stands	12.892	11.191	1.152	0.647

Table 4.5: Description of variables used in this study. The transformations that were applied to each variable so that its distribution approximated a normal distribution and the Shapiro-Wilk test for normality (null hypothesis was that the data were normally distributed).

Variable	Description	Transformation	Shapiro-Wilk Score	p-value
CanOpen	Covariate measuring the percent openness of forest canopy (inverse of canopy closure)	Inverse	0.9765	0.2989
% Browse	Covariate measuring percentage of oak seedlings browsed by white-tailed deer	None	0.9696	0.1388
Total Basal	Total basal area of all trees	None	0.9771	0.3170
RO_Basal	Proportion of the total basal area made up by red oaks	$(RO\_Basal)^{0.69}$	0.9753	0.2623
GrwRate	Response variable measuring average height accrued per year ($cm\ yr^{-1}$) in oak seedlings	Log	0.9879	0.8188
<50Dens	Response variable measuring number of seedlings 0-50cm in height per hectare (extrapolated from plot data)	Log	0.9795	0.4078
50-137Dens	Response variable measuring number of seedlings 50cm-137 cm in height per hectare (extrapolated from plot data)	$(50\text{-}137Dens)^{0.66}$	0.9715	0.1727
>137Dens	Response variable measuring number of seedlings >137cm per hectare (extrapolated from plot data)	Box-Cox(>137Dens,λ=0.5)	0.8868	<0.0001

Table 4.5 Continued:

Variable	Description	Transformation	Shapiro-Wilk Score	p-value
Mgmt Regime	Fixed-effect variable with levels: state and tribal	N/A	N/A	N/A
Mgmt Unit Size	Fixed-effect variable with levels: oak stand and oak pockets	N/A	N/A	N/A
Mgmt Unit	Random-effect variable. Management units within each treatment group numbered consecutively from one to five.	N/A	N/A	N/A
Plot	Random-effect variable. Plots within each management unit (i.e., oak stands and oak pockets) numbered from one to three	N/A	N/A	N/A

Figure 4.1: Map of study area and surrounding region.

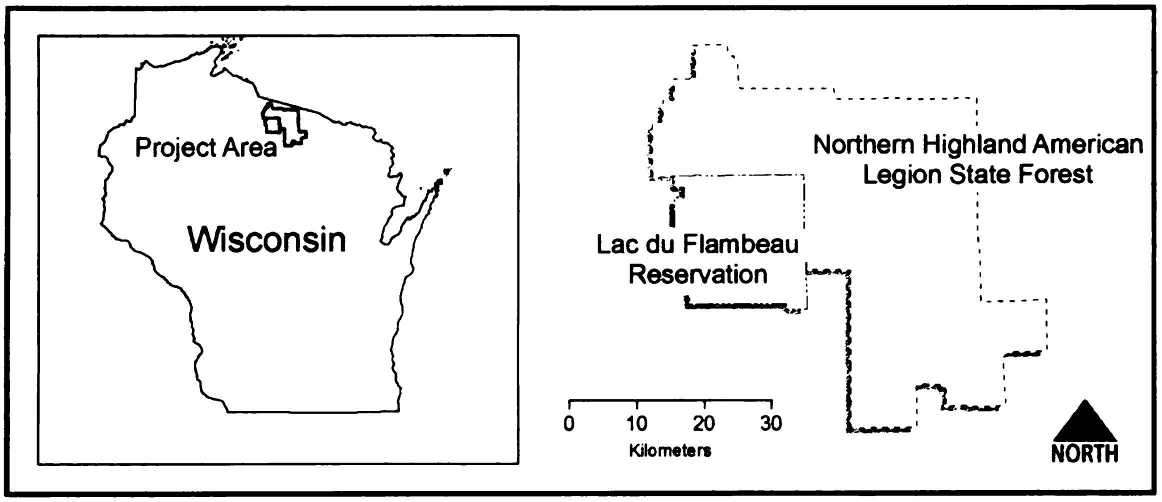


Figure 4.2: Plot of management regime and management unit size by the first two linear discriminant function axes. State pockets (gray circles) and stands (black diamonds) were very similar to each other, but were distinct from tribal pockets (gray squares) and stands (gray triangles).

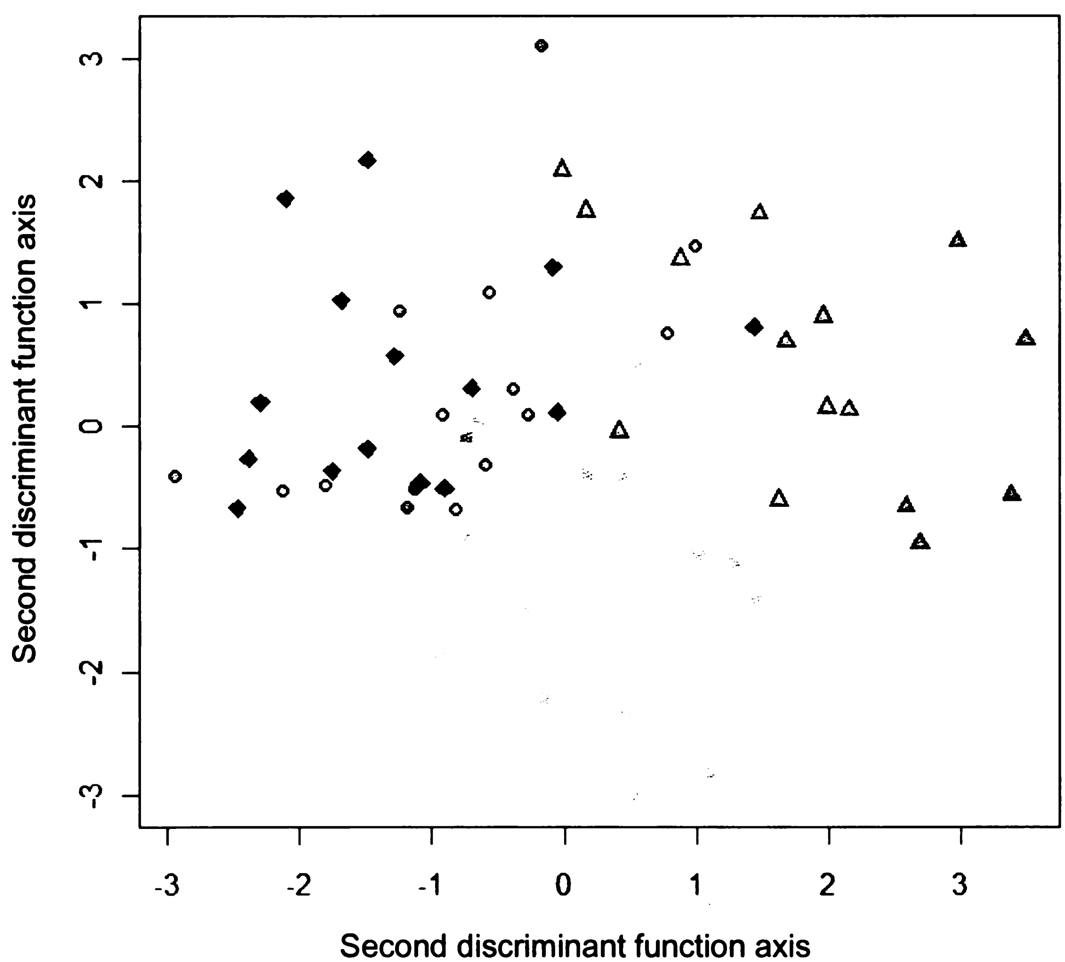


Figure 4.3: Mean values for the covariates by management regime (state vs. tribal) and size (pockets vs. stands) for: A) canopy openness, B) percent of 51-137 and >137cm sized oak seedlings browsed by deer, C) total tree basal area, D) red oak basal area, and E) basal area of northern red oaks with >25cm Diameter at Breast Height. Variables were transformed as per Table 4.5. Error bars represent standard error.

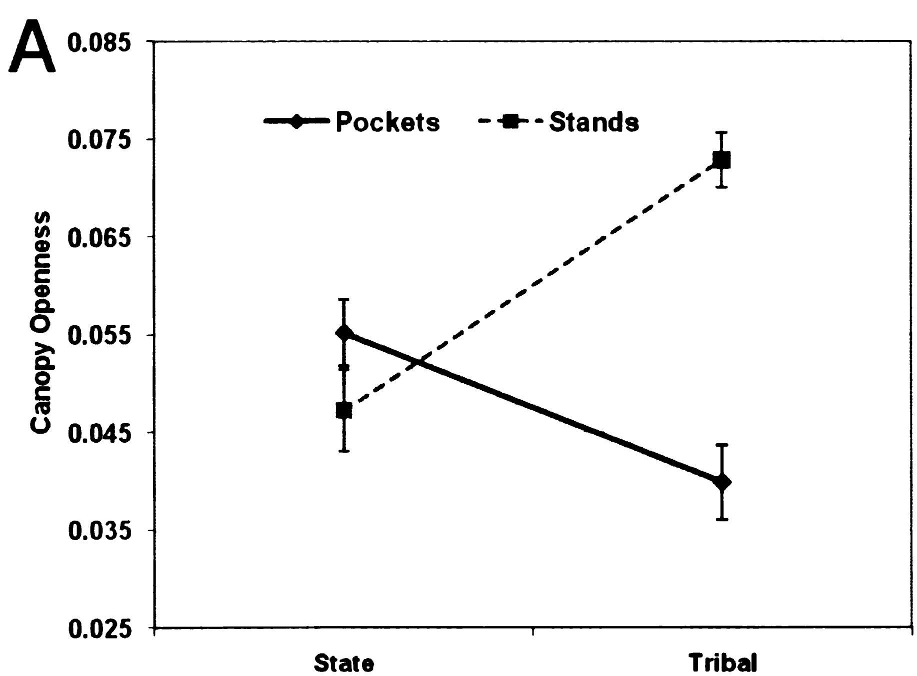


Figure 4.3 Continued:

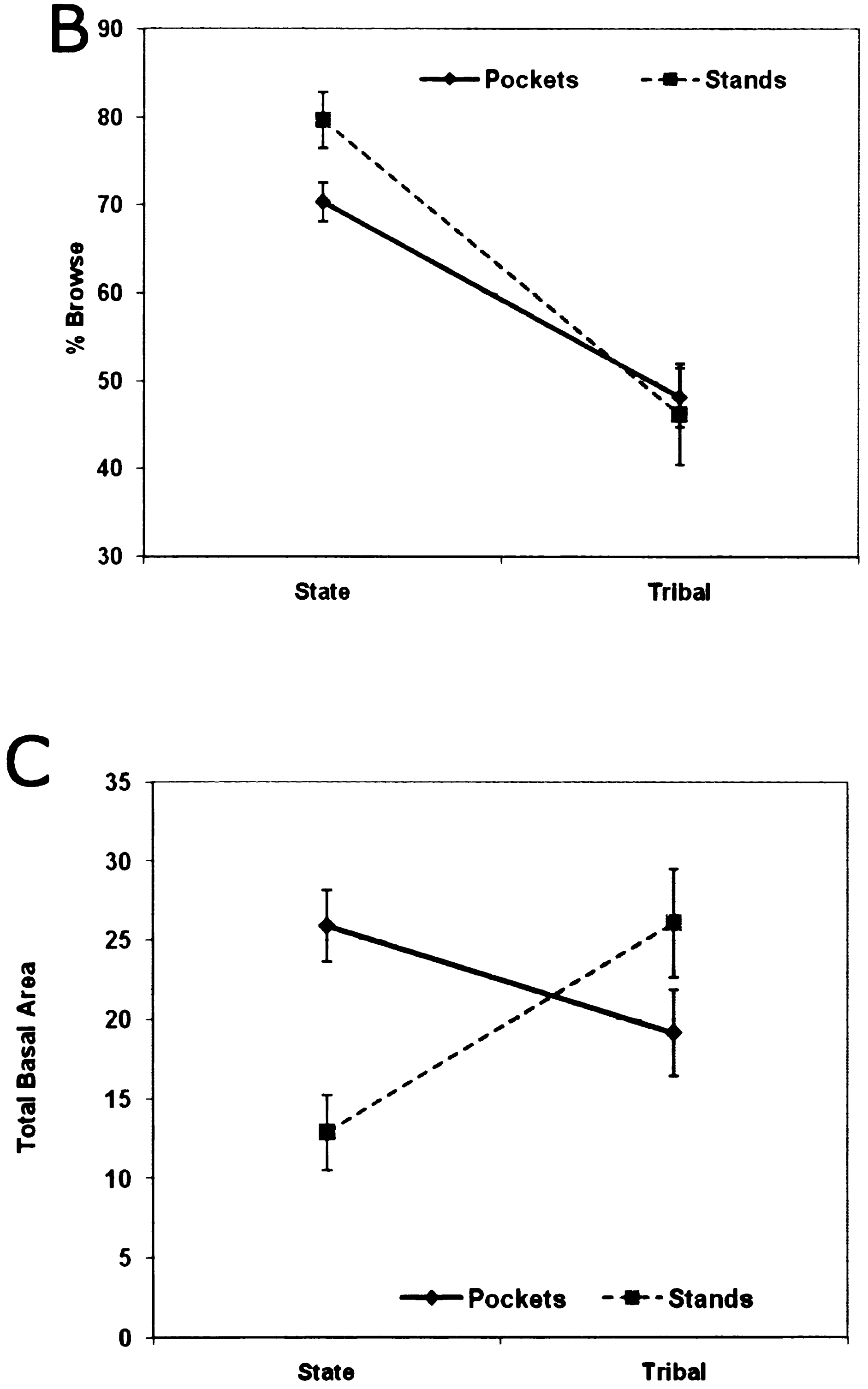


Figure 4.3 Continued:

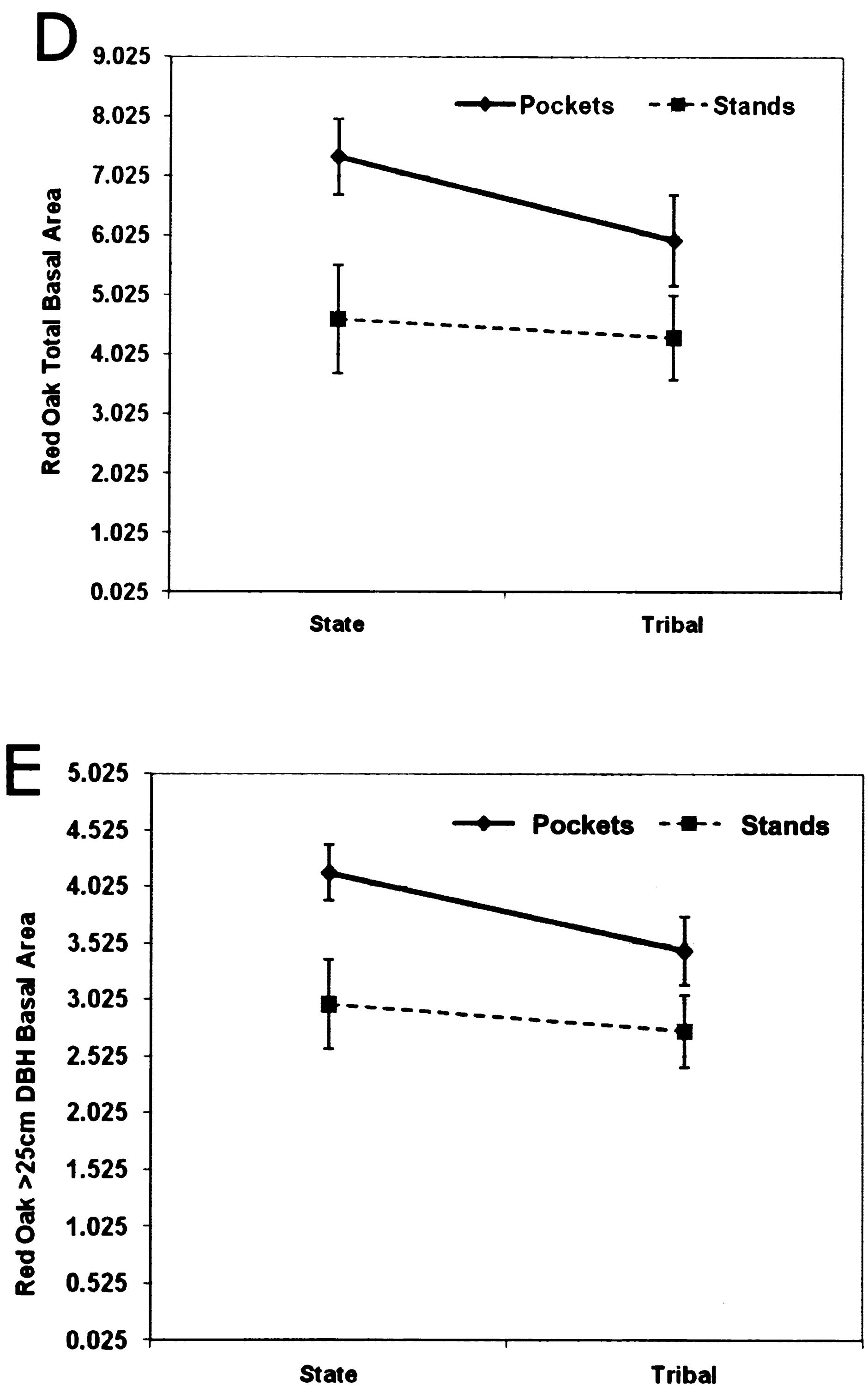


Figure 4.4: Graphs of mean values for each of the four response variables (transformed as per Table 4.5) by management regime (state vs. tribal) and size (pockets vs. stands) for: A) growth rate of northern red oak seedlings, B) density (# seedlings per ha) of 0-50cm northern red oak seedlings, C) density (# seedlings per ha) of 51-137cm northern red oak seedlings, and D) density (# seedlings per ha) of >137cm northern red oak seedlings. Error bars represent standard error.

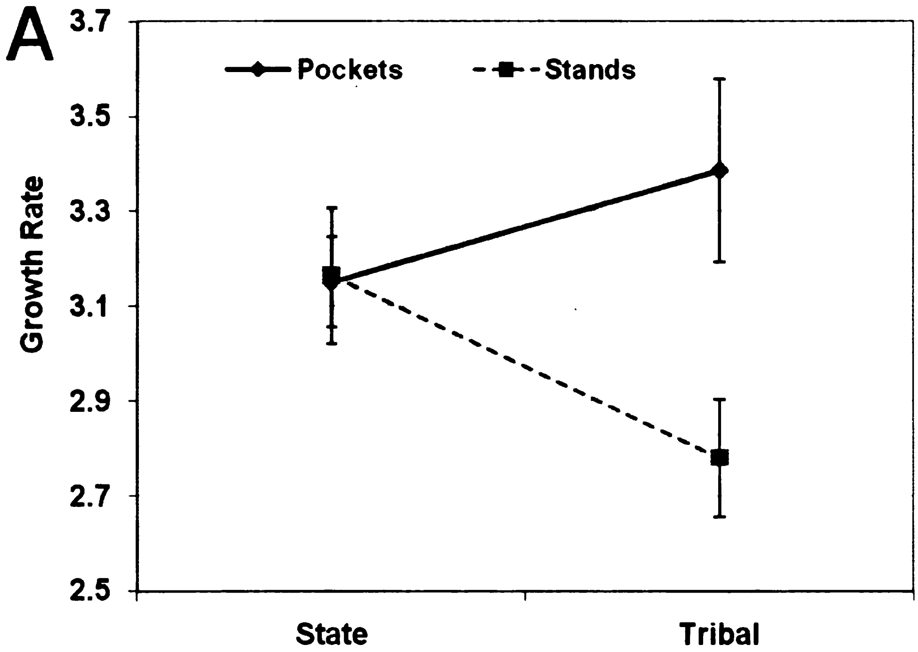
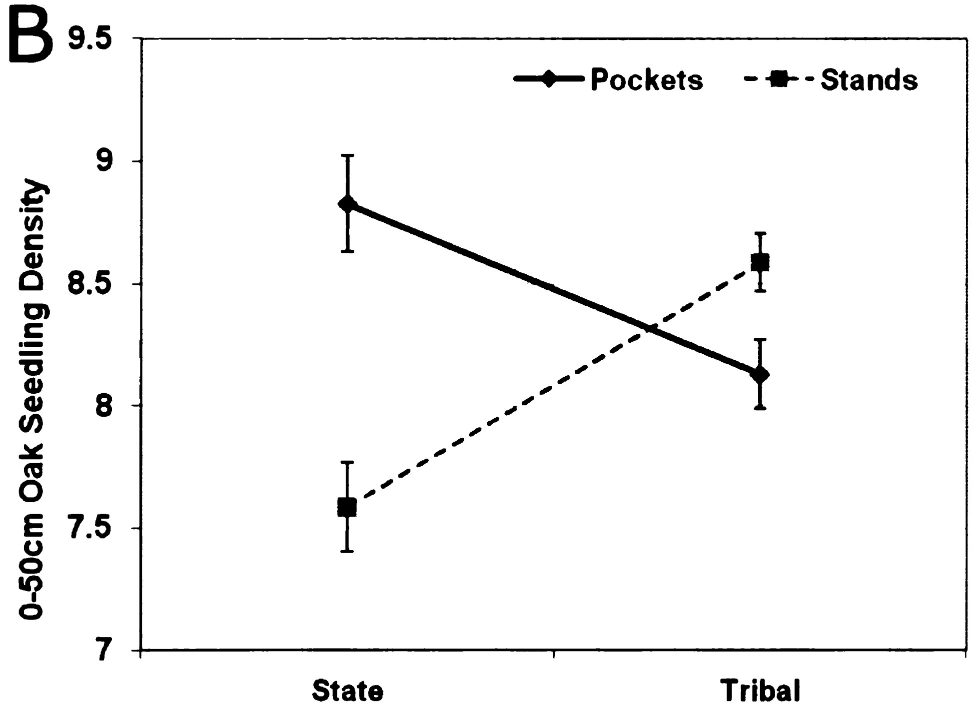


Figure 4.4 Continued:



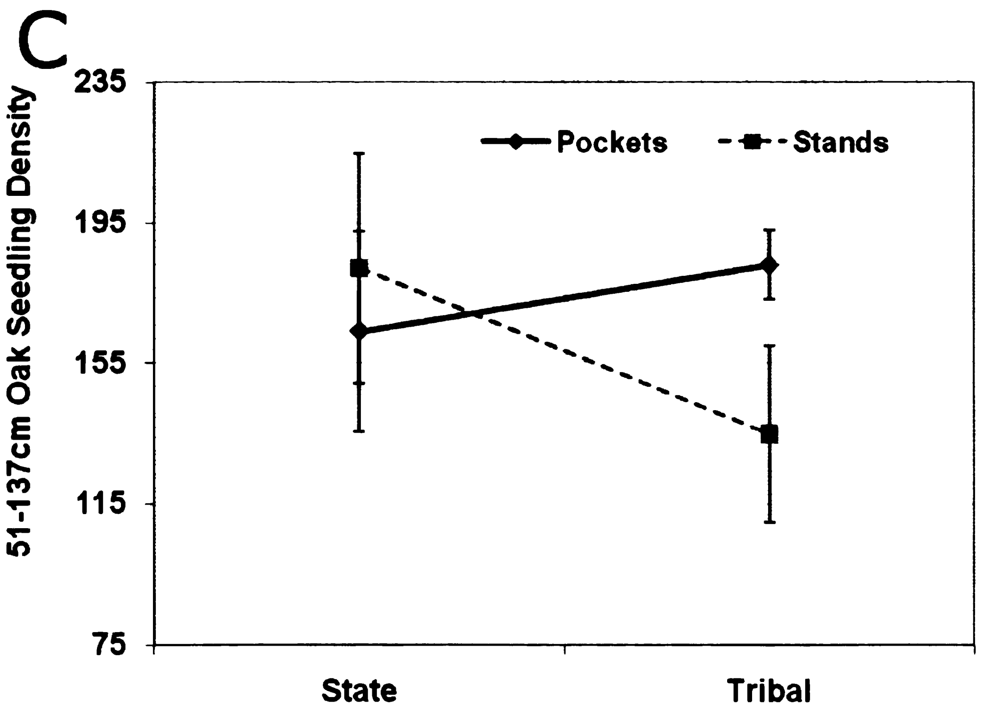


Figure 4.4 Continued:

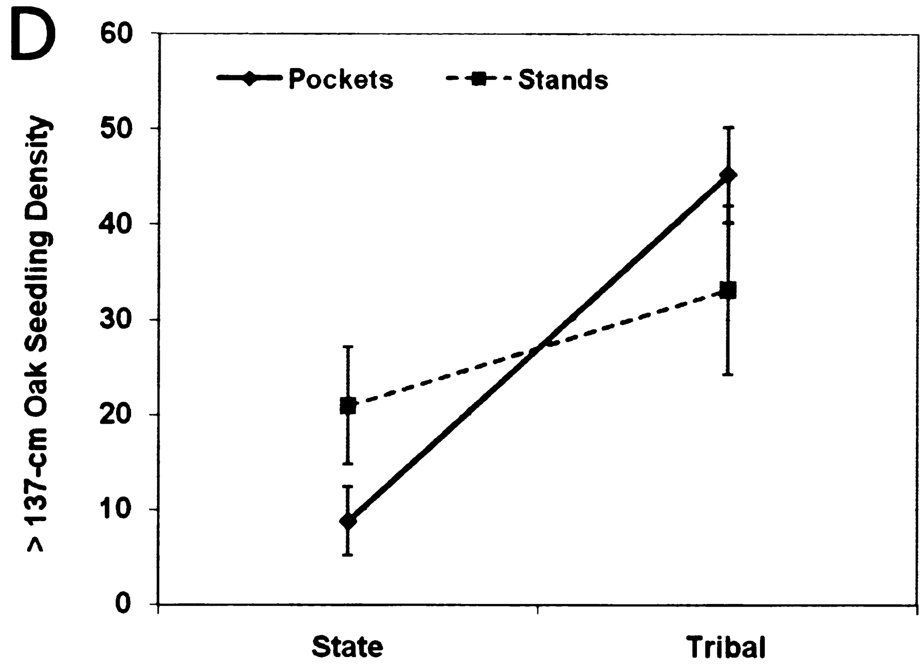


Figure 4.5: Diagram showing A) experimental design and B) sampling design of vegetation plots and deer browse transects.

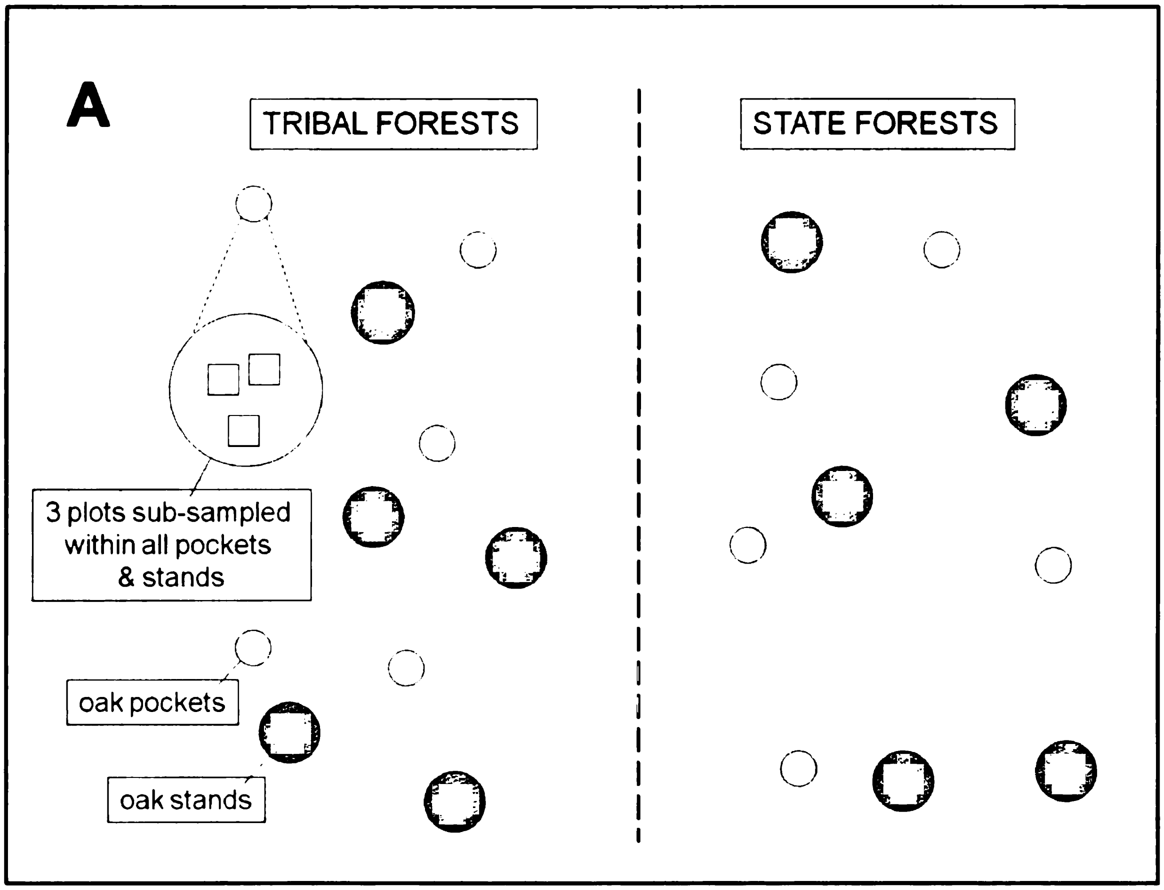
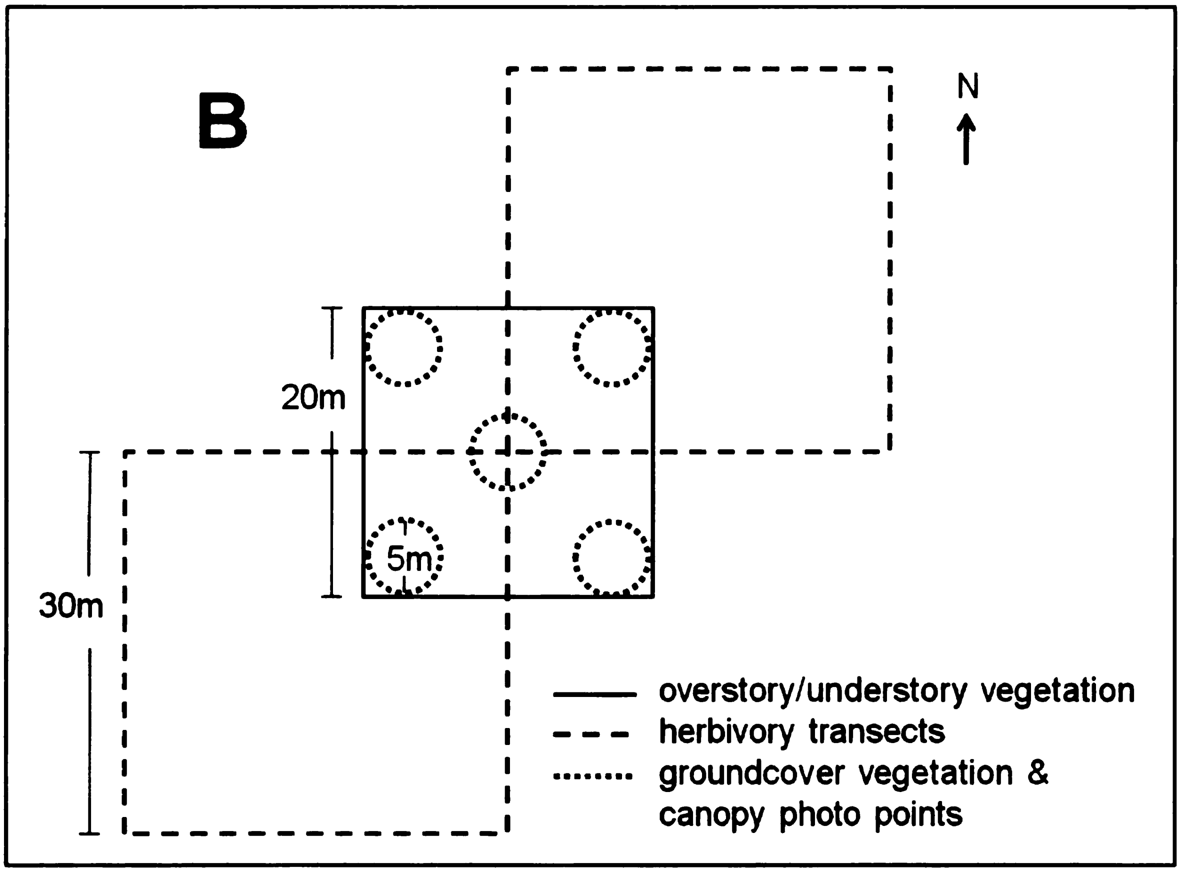


Figure 4.5 Continued:



CHAPTER 5

FROM CONFLICT TO COOPERATION:

EVOLUTION OF A SUCCESSFUL TRIBAL-STATE

RESOURCE MANAGEMENT COOPERATION

Abstract

Solving complex natural resource and conservation problems within mixed-ownership landscapes requires resource management cooperation across jurisdictional boundaries; yet such cooperation is challenging and few successful cases exist. In portions of the United States, state and tribal officials are forging co-management and cooperative agreements to protect off-reservation treaty rights of tribes, monitor harvest allocations and facilitate regional ecosystem management. These arrangements have the potential to provide models of cross-boundary cooperative management; however, few success stories have been documented to date. This study explores the more than 25 year history of natural resource management cooperation between the Lac du Flambeau Tribe and the Wisconsin Department of Natural Resources, focusing on tribal and state officials' navigation of contentious natural resource conflict and arrival at a highly cooperative status. Results emphasize the importance of personal relationships and open communication among local field staff. Bridging organizations were important catalysts for communication and relationship building. Key communication strategies included maintaining regular, informal interactions. Lessons from this case study will help resource managers overcome conflict and improve cross-boundary management of regional natural resources and ecosystems.

Introduction

Regional landscapes around the world are composed of land tenure mosaics that include private, industrial and public land ownership. Because ecological processes and environmental issues do not respect land ownership boundaries (Forman 1995, Knight and Landres 1998), resource practitioners, scientists and policy makers have called for cross-boundary, regional approaches to ecosystem management (Yaffee 1999, Liu and Taylor 2002, Rickenbach and Reed 2002, Bergmann and Bliss 2004, Schulte et al. 2008, Levin 2009). However, effective cross-boundary resource management cooperation is difficult to achieve and relatively few successful natural resource examples exist (Wondolleck and Yaffee 2000).

Examples of successful resource cooperation between states and North American Indian tribes are particularly rare. In the United States, state and tribal officials are forging co-management and cooperative agreements that provide venues for cross-boundary natural resource management. These agreements are designed to protect off-reservation treaty rights of tribes, monitor harvest allocations and facilitate regional ecosystem management. However, the relationships between tribes and states are often contentious because they involve high-stakes natural resource and jurisdictional issues (Bays and Fouberg 2002, Jones Jarding 2004). Although a few co-management and cross-boundary cases involving tribes (and first nations) have been studied (Nadasdy 2003, Ebbin 2004, Natcher et al. 2005, Ebbin 2009) examples of cooperative relationships are lacking.

To help address this knowledge gap, the present case study explores natural resource management cooperation between the Lac du Flambeau Band of Lake Superior Chippewa Indians ("LDF Tribe") and the Wisconsin Department of Natural Resources (WDNR) in North Central Wisconsin. The LDF tribal landbase, known as the LDF Reservation, is directly adjacent to the Northern Highland and American Legion state forests (Figure 5.1) managed by the WDNR. These state and tribal lands are primarily undeveloped and dominated by forest, water (i.e., inland lake) and wetland cover types. The area is rich in natural resources and a popular tourist destination. Tribal citizens have rights to fish, hunt and gather on public lands across a large portion of Northern Wisconsin, including in the neighboring state forests. A strong relationship between the LDF Tribe and the WDNR is necessary because the state forests are important for tribal subsistence harvests and because the tribe and the state recognize the ecological benefits of cross-boundary natural resource management cooperation.

The case provides an example of a highly cooperative state-tribal relationship that includes open communication, information sharing and shared natural resource management decision-making. According to tribal and state officials, the cooperation has fostered ecosystem-based management strategies and improved natural resource protection. The objective of this project was to understand how tribal and state officials navigated contentious natural resource conflicts of the 1980's and built a high functioning, cooperative relationship. Three research questions are central to this study.

1. What were the main motivations for resource management cooperation?
2. What were the main obstacles to cooperation?
3. What actions and/or behaviors helped tribal and state officials rise above natural resource conflicts enabling cross-boundary resource management cooperation?

Methods

Study Area Background

Throughout the first half of the 19th Century, the United States negotiated land cession treaties with various Indian nations that ceded lands and enabled the creation of Wisconsin Territory in 1836 and the establishment of the State of Wisconsin in 1848. The

1837 Treaty of St. Peters and 1842 Treaty of La Pointe negotiated between the U.S. and various Lake Superior Chippewa bands (including the Lac du Flambeau band) provided access to copper and timber resources for non-Indian businessmen and ceded large land areas to the United States in what is now northern Wisconsin. From the 1830's through the first half of the 1850's, the U.S. worked to access additional land and resources in the region and proposed removing Indians to areas west of the Mississippi River. Simultaneously, Chippewa leaders worked diligently to maintain permanent residence in their Great Lakes homelands. A compromise was negotiated through the 1854 Treaty of La Pointe which ceded additional resource-rich lands to the U.S. and established several permanent Indian reservations, including the 70,000 acre Lac du Flambeau Reservation (Figure 5.1) (Satz 1991, Silvern 2008).

In 1887, thirty-three years after the establishment of the LDF Reservation, an influential piece of federal legislation called the General Allotment Act was enacted as a way to separate individual Indians from their communal landbase so that they might become "productive" agriculturalists. The Act divided reservations into individual allotments and opened so called "surplus" lands to white settlement. Through this Act, the Lac du Flambeau Reservation transitioned from 70,000 communally-held acres to 30,542 tribal acres, 14,382 acres allotted to individual Indians and the remainder in non-Indian ownership (as of 1989) (Satz 1991). Besides this measurable loss of land, the General Allotment Act also significantly affected jurisdiction over reservation resources and tribal autonomy by bringing a large number of non-Indian landowners onto tribal land. The General Allotment Act had similar effects across the United States. Tribal lands in the U.S. went from 138 million acres in 1887 to 47 million acres by 1934 (Debo 1970)

and opened a jurisdictional "Pandora's box" regarding land use, environmental, civil, criminal and other issues (Sutton 2001).

Pre-existing rights to hunt, fish and gather resources in these ceded territories were never relinquished by the Chippewa through their treaties with the U.S. However, from the time of the 1854 Treaty of La Pointe through most of the 1900's, Wisconsin officials and Wisconsin citizens progressively encroached on Chippewa hunting, fishing and gathering rights. Throughout the 20th Century, state officials contested tribal rights by enforcing state laws upon Chippewa harvesters within ceded territories and on reservation lands (Satz 1991, Silvern 2008). These game and fish violations were unsuccessfully challenged in the courts by Chippewa harvesters on several occasions from the late 1800's through mid-1900's. In 1974, two Chippewa from Lac Courte Oreilles were arrested for spearing fish off their reservation. The convictions were upheld in federal district court; however, when the cases were taken to the U.S. Court of Appeals, the rulings were overturned. In 1983, the Voigt Decision legally affirmed Chippewa treaty rights in Wisconsin for the first time in over a century.

The Voigt Decision directed the district court to work with the tribes and the state to define the extent of tribal harvesting rights and state regulatory authority over such activities (Silvern 2008). For nearly a decade following this decision, the State of Wisconsin and the Wisconsin Chippewa tribes negotiated over 40 interim harvest agreements (GLIFWC 2007). In 1991, a final agreement was signed by the state and the tribes that outlined the current system of co-management and tribal self-enforcement.

Between the issuance of the Voigt Decision and the final co-management agreement, anti-Indian groups such as *Protect Americans' Rights and Resources* and *Stop*

Treaty Abuse emerged and initiated a violent response to the Voigt Decision and subsequent negotiations. Boat landings used by tribal harvesters during spring spearing seasons became central locations of violent "protest" activities that included death threats, assault and battery against tribal harvesters and their families, use of Indian effigies, verbal abuse, rock throwing, use of sling shots and pipe bombs. Shouting and signage at boat landings included such abusive phrases as "timber nigger," "wagon burners," "save a walleye, spear a squaw" (derogatory term for Indian woman), "spear a pregnant squaw, save two walleye" and "you're a conquered nation- go home to your reservation" (GLIFWC 2007). Large numbers of law enforcement officials, including WDNR conservation officers, were deployed to the boat landings to protect tribal harvesters.

In 1991, along with the final co-management agreement, a federal court ruling fined and placed an injunction on *Stop Treaty Abuse* and its members, significantly reducing the severity and frequency of conflicts over tribal harvests. The co-management agreement dictated that the tribes and the state must work together to manage regional natural resources. However, it was left up to the WDNR and the tribes to develop the skills and relationships necessary to work cooperatively across political and cultural boundaries. This study describes how, given this history of regional natural resource conflict, resource managers and leaders from the LDF Tribe and WDNR transitioned into the current cooperative regime.

Data Collection

From 2007 through 2010, I interacted with natural resource professionals and decision makers from the LDF Tribe and WDNR. All but one of these individuals had lived and worked in the region during the natural resource conflicts of the 1980's and 1990's. Ongoing interactions with these key informants, along with a review of existing literature, helped to frame my general understanding of the recent history of regional natural resource conflict and cooperation between tribes and states, particularly in Wisconsin.

I designed a question-concept matrix (Table 5.1) outlining a series of interview questions plus respective research concepts and empirical foundations underlying each question. I pre-tested this interview instrument with tribal natural resource managers from Michigan as well as ecosystem management and sociology scholars, making adjustments based on their feedback. Wisconsin DNR and LDF tribal officials provided me with an initial list of interview contacts. Interview participants suggested additional interviewees, subsequently expanding the list of participants through snowball sampling (Patton 1990).

In the summer of 2008, I conducted in-depth semi-structured interviews with 11 natural resource managers and decision makers who were closely involved in cooperation between the LDF Tribe and WDNR. I interviewed five current or former WDNR employees, five LDF staff and one representative from an inter-tribal organization (who was also an LDF citizen). Of the LDF staff, four out of the five participants were LDF citizens and two out of the five were elected tribal officials. All interviews except for one were conducted with individual participants; two LDF representatives had to be interviewed together due to scheduling difficulties. The length of these key informant interviews ranged from approximately 1-2 hours and averaged 90 minutes. The wide range in length of interviews reflects the semi-structured, conversational design of the interviews and the fact that respondents varied in the amount of time they could invest in their respective interview. The interviews followed the questions established in my question-concept matrix. Within each interview, we discussed the written questions and maintained the same interview question sequence as best as possible.

I took hand written notes during the interviews and documented my post-interview reflections within 24 hours. I chose not to use a digital audio recorder because I was concerned the presence of a recorder would stifle responses due to the highly politicized nature of our discussion topics and cultural norms of LDF tribal citizens.

Data Analysis

I coded interview transcriptions using NVivo qualitative data analysis software Version 8 (QSR International 2008). I used an iterative coding procedure (LeCompte and Geotz 1983, Miles and Hubermann 1994), refining my hierarchical coding structure through four rounds of coding. For the one interview that included two LDF participants, I tallied their responses as one source because I was unable to attribute their responses separately in my interview notes. Therefore, the source interviews for my analysis were four from LDF tribal representatives, five from WDNR and one from an intertribal organization. Themes emerged out of similar and interrelated responses within the interview dataset. I confirmed recurrent themes by enumerating the references to each coded concept or idea within the interview transcripts using the NVivo software package. I then reviewed the specific interview responses more thoroughly that followed recurrent themes, providing insights into my three research questions. I submitted drafts of the case study for review to selected research participants as a form of "member checking" (Lincoln and Guba 1985).

Results & Discussion

Motivations for Cooperation

The motivations for cooperation cited by the greatest number of interview respondents were common interests, policy mandates and the tribe/state being an important neighbor (Table 5.2). Common interests cited by interviewees related primarily to conservation of natural resources (e.g., protecting aquatic resources, combating invasive species and promoting wild rice beds.) Respondents also discussed their common interest in conservation enforcement, communication with public resource users and promoting recreation tourism. Others have noted that building from common ground can foster cooperative behaviors (Wondolleck and Yaffee 2000, Axelrod 2006). Ebbin (2009) refers to issues that create common ground as "cross-cutting cleavages" in her exploration of co-management involving tribes. For the LDF Tribe and the WDNR, building from common interests played an important role in their cooperative successes.

Policy mandates were also mentioned as a primary motivation for cooperating across political boundaries. The main policies referenced were the Voigt Decision and subsequent co-management agreement. Previous research by Adelzadeh (2006) indicates that co-management agreements negotiated out of court between tribes and public land managers may be more successful than those emerging from court battles. In this case, however, the court battle was not perceived as an obstacle to success. Both LDF and WDNR representatives referenced the Voigt Decision with a matter-of-fact tone. One WDNR leader stated plainly, "The tribe is our partner. They are entitled to 50% of the harvest. It is a no brainer." The LDF-WDNR partnership emerged from a court battle; however, the Voigt Decision did not dictate the nature of the co-management agreement, but rather insisted that an agreement be negotiated by both parties. The final agreement took years of negotiation, and over that time, the notion of co-managing resources may have grown palatable to both tribal and state representatives.

A third commonly cited rationale for cooperation was the fact that the tribe and state are one another's biggest neighbors and it is important to work together to improve long term resource stewardship. The notion of cooperating because the tribe/state is an important neighbor was mentioned more by tribal representatives (3 out of 4 source interviews) than WDNR representatives (2 out of 5). This rationale may have been more poignant for LDF because their reservation is surrounded on two sides by state lands (Figure 5.1) and the state forests are critical harvest areas for tribal citizens. Both WDNR and tribal representatives referenced the need to work together using similar language. One WDNR manager noted "LDF is one of our biggest neighbors. We need to be good neighbors and it works both ways." Tribal representatives similarly stated, "The state is a big neighbor" and "We are neighbors and we are here for the next seven generation ahead. We need to leave it better than today."

Obstacles

The main obstacles to cooperation cited by interview participants were personalities/attitudes and jurisdictional issues (Table 5.3). Personality traits or attitudes that interfered with cooperation included being overly confrontational, embattled and disrespectful. All five state representatives and two tribal representatives felt that personalities and attitudes were key obstacles to cooperation. These observations are consistent with Fisher and Ury's analysis (1991) that people problems can often be greater obstacles to finding agreement than substantive problems.

Wisconsin DNR officials indicated that the attitudes of tribal elected and appointed officials in the past were highly confrontational, making cooperation difficult and unpleasant. Changes in tribal leadership eventually brought in representatives with which the WDNR found it far easier to work. This idea was clarified further by more than one state official, who expressed that confrontational tribal leadership was needed for a time to move treaty rights forward. When cooperative leadership styles were needed for co-management, appropriate leaders were elected or appointed by the tribe who could facilitate cooperation.

Jurisdictional issues that interfered with cooperation included those related to aquatic resources on the LDF Reservation. Wisconsin DNR representatives expressed that they were motivated to participate in aquatic resource management (e.g., conducting lake assessments) on the reservation and wanted to work more regularly with tribal officials. The WDNR was motivated in this regard because it had jurisdiction over waters on the reservation. Also, the reservation holds many high quality lakes and important fisheries. But WDNR officials have had difficulties cooperating with LDF on water-related issues.

The WDNR managers struggled to find tribal cooperators for on-reservation lake management because on-reservation water jurisdiction is a particularly contentious issue. Tribal representatives felt they should have full jurisdiction over the waters on their reservation and that gaining tribal jurisdiction would help them protect and manage natural resources. Furthermore, in 1997/98 the State of Wisconsin sued the U.S. Environmental Protection Agency over its granting LDF so called "Treatment-as-State" status. Treatment-as-State status would give the LDF Tribe partial jurisdiction over reservation waters by allowing them to establish their own water quality standards under Section 303(c) of the Clean Water Act and issue water quality certifications under Section 401 of the Clean Water Act. Although local and regional-level WDNR managers did not initiate the litigation, their ability to partner on lake management was negatively impacted.

The Treatment-as-State issue is also an example of state-level politics interfering with local cooperation. Local personnel who are professionally and personally invested in cross-boundary cooperation found their efforts hampered due to state-level activities. One LDF representative noted the influence state politics can have on communication, stating "politics beyond local and regional levels often interfere with local relationships and locals can't even talk about what's happening." A WDNR representative noted that cooperation is also negatively influenced by the fact that there are no tribal members on the state natural resource policy-making board, implying that the state lacks the political will to appoint a tribal representative into one of these influential positions.

Interview participants also highlighted that communication was a barrier to improved cooperation. Despite the fact that communication was highlighted as one of the key factors *enabling* cooperation in this case (see below), it was repeatedly expressed that communication could improve further. Tribal representatives stated that they should be kept apprised better of the permitting and development activities that the state manages on non-Indian owned lakeshore properties on the reservation. Both WDNR and tribal representatives suggested that better information sharing between their organizations would enhance resource management and benefit natural resources.

Cooperation-Enhancing Characteristics

Besides communication, the characteristics that interview participants said helped them overcome obstacles and enhanced cooperation included key individuals, personal relationships, trust, effective leadership, informality of relationships and bridging organizations (Table 5.4). Within the context of co-management, bridging organizations help build social capital and relationships among parties by fostering networking, trust-building and resolving conflicts (Hahn et al. 2006, Berkes 2009). In this case, the primary bridging organization was an event called Gathering of the Guides. Gathering of the Guides is an annual fishing tournament involving WDNR and LDF officials plus Indian and non-Indian fishing guides. Invited participants are placed strategically onto teams and boats so that they have the opportunity to get to know one another. They spend the day fishing for walleye, eating dinner and socializing. The social atmosphere lends itself to personal conversations, puts participants on a first name basis and opens the door to future interactions. In seven out of ten interviews, Gathering of the Guides was referenced as important to initiating communication and building personal relationships across political and cultural boundaries. Other bridging organizations cited by the interview participants were the Great Lakes Indian Fish and Wildlife Commission (organizations established to monitor off-reservation harvests and resources), the Biological Working Group (cooperative management group comprised of tribal and state biologists) and the Voigt Intertribal Taskforce (intertribal working group established to coordinate harvest and management activities associated with Voigt Decision).

Open communication was viewed as a critical method of overcoming obstacles and enhancing cooperation. Key informants noted that communication began with getting

on a first name basis (e.g., during a Gathering of the Guides event), then gradually expanded through low risk-low stakes issues followed by higher stakes issues. As one interview participant stated, “We’re not afraid to call each other up on the phone and raise issues. You practice with smaller issues which opens the door for cooperative response to bigger issues.” Eventually the parties reached the point where they felt, "If the problem is big, we know we can talk." The fact that open communication was cited as one of the most important strengths and one of the biggest obstacles/areas for improvement indicates just how important it is to successful cooperation in this case.

Specific communication strategies included maintaining regular and informal interactions. One WDNR representative stated, “Keep it as low-key as you can. This is a key element. Meet regularly with the basic purpose of keeping each other tuned in on the neighboring forest. No agendas. No sitting around with attorneys." This sentiment was expressed variously by several interview participants. Tribal and WDNR staff made a point to meet regularly for coffee and give each other informal updates on activities and issues within their respective forests.

These regular, informal interactions helped build trust, a crucial element of building and sustaining cooperative relationships (Wondolleck and Yaffee 2000) and co-management (Berkes 2009). Noting the importance of trust and personal relationships, one LDF manager commented, “You can learn to trust each other when you get to know each other. When it comes to the tough issues or disagreements you can agree to disagree easier. You are both just representatives of your office or government.” Stability in leadership and field staff also helped build trust by allowing time for people to get to know one another and gain cross-boundary work experiences. Trust was also built by

following through on commitments. Resource managers made sure that when key counterparts made requests or asked for assistance, that they followed through providing information or help, regardless of how busy they were or whether the activity was part of their job description.

Certain key individuals played sizable roles in fostering cooperation by serving as "ambassadors" for cooperation. They kept cooperation at the forefront in their work and spoke openly about the importance of co-management. Some redefined their professional roles to contribute more thoroughly to co-management efforts. Effective leaders displayed many of the aforementioned characteristics, modeling cooperation within their organization and insisting that other team members work cooperatively with their counterparts. They communicated effectively across organizational, political and cultural boundaries. Effective leaders attended regular meetings and built personal and trusting cross-boundary relationships. A WDNR conservation officer described a particularly effective tribal leader stating that, "He looks at things as "us" rather than "we vs. them." Having individuals that hold a broader, more unified view appeared to play an important role in cultivating a lasting cooperative relationship between LDF and WDNR resource managers.

Conclusions and Recommendations

This study focused on three questions: what motivated the parties to cooperate? What obstacles interfered with their cooperation? What characteristics helped them overcome obstacles and enhanced cooperation? Although initially this partnership was court-mandated, both LDF and WDNR representatives believed over time that regional natural resources and ecosystems could be managed more effectively and would benefit from cross-boundary cooperation. Despite the litigious beginnings, the co-management system came to be viewed as an important way to protect the natural resources, protect treaty rights and ensure long term access to natural resources for both tribal and non-tribal citizens.

Personalities were a significant obstacle. The "time heals" adage applies in this case considering that some personality issues resolved themselves over time through attrition. More intentional means were also employed such as LDF citizens electing the right personalities at the right times and tribal representatives working with administrators from the state to keep stubborn and less cooperative WDNR personalities on the periphery.

Communication was an important aspect of the successful cooperation in this case and was also noted as an area for improvement. Those working on similar collaborations should focus on open and regular communication. Regular, informal interactions also are important. Such interactions build personal-level relationships and trust. Board room-style interactions with legal representation may be important in formal negotiations, but they do not necessarily lead to the trusting relationships that are important to effective co-management and cooperation. Regular, agenda-free conversations over coffee are better suited for relationship building. Such interactions may not emerge organically, and bridging organizations or institutions such as the Gathering of the Guides model can serve as a catalyst for relationship building.

The importance of building interpersonal relationships should apply to any cross-boundary natural resource management scenario, not just those involving tribes. This

lesson may be most pointedly relevant in situations where parties are required to work across their political, organizational and cultural boundaries by court mandates or legally binding agreements, such as in the example studied in this chapter.

Table 5.1: Interview questions and underlying concepts associated with each question. Responses/results were interpreted within the context of the results reported in the references listed next to each question/concept.

QUESTION	CONCEPT/ PURPOSE	REFERENCES
1. How would you rate the level of cooperation between LDF and WDNR on a scale of 1-5 (1 being the least and 5 being the highest level of cooperation)?	Ice Breaker, Contextualization, Perception of cooperation	(Silvern 1999, Wilkins 2002, Silvern 2008)
2. Compared to the relationships other tribes in the Upper Great Lakes have with state natural resource programs, how would you rate LDF-WDNR cooperation on a scale from 1-5?	Ice Breaker, Contextualization, Perception of cooperation	(Silvern 1999, Wilkins 2002, Silvern 2008)
3. How long have LDF & WDNR been working cooperatively together?	Ice Breaker, Contextualization	
4. Why do you and your DNR cooperate with the neighboring DNR?	Motivations behind cooperation	(Wondolleck and Yaffee 2000)
5. What are some of the more long standing examples of cooperation between LDF and WDNR?	Contextualization, Perception of value of cooperation	
6. Can you tell me about broad, big picture factors that have enhanced cooperation between LDF and WDNR	Enhancing characteristics	(Ostrom 1990, Wondolleck and Yaffee 2000, Ebbin 2002, 2004, Adelzadeh 2006, Axelrod 2006, Ostrom et al. 2007, Berkes 2009)
7. Can you identify specific conditions, behaviors or factors that have enhanced cooperation between LDF and WDNR	Enhancing characteristics	(Ostrom 1990, Wondolleck and Yaffee 2000, Ebbin 2002, 2004, Adelzadeh 2006, Axelrod 2006, Ostrom et al. 2007, Berkes 2009)
8. Are personal relationships important to the cooperative nature of your management initiatives? If so how?	Importance of personal relationships among field staff, leaders, administrators	(Yaffee 1996, Wondolleck and Yaffee 2000, Axelrod 2006)

Table 5.1 Continued:

QUESTION	CONCEPT/ PURPOSE	REFERENCES
9. Do you have any suggestions on how to improve cooperation between LDF and WDNR? Can you envision a set of conditions that might lead to improved cooperation between LDF and WDNR?	Obstacles to success/opportunities for future	(Ostrom 1990, Wondolleck and Yaffee 2000, Ebbin 2002, 2004, Adelzadeh 2006, Axelrod 2006, Ostrom et al. 2007, Berkes 2009)
10. In what ways would increased cooperation enhance or hinder your forest/wildlife management efforts?	" "	
11. Are there any consequences to not cooperating with your neighboring managers?	" "	

Table 5.2: Number of sources (respondents) who referenced various rationales for cooperating across their political boundary and the total number of times each rationale was referenced; differences in total sources and total references reflects the fact that some respondents referenced a rationale more than once. One representative of an intertribal organization was interviewed and their responses are not included to help protect confidentiality.

Rationale	# Sources	LDF Sources	WDNR Sources	Total # References
common interests	6	2	3	14
policy mandate	5	2	3	9
Neighbor	5	3	2	6
protecting treaty rights	4	2	1	9
stewardship	4	2	1	7
co-management	4	1	2	6
long term perspective	4	2	1	5
avoidance of conflict	2	1	1	2
efficient use of financial resources	1	1	-	1

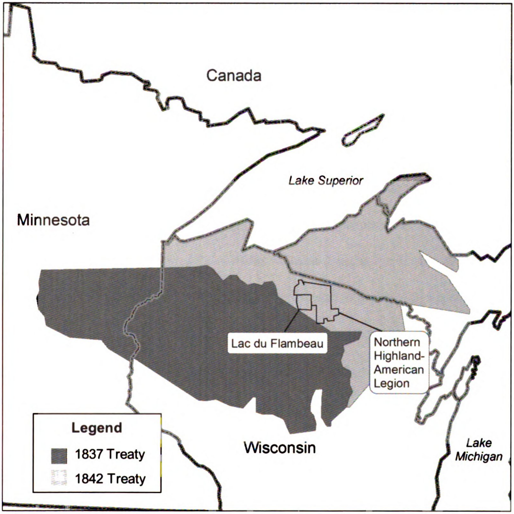
Table 5.3: Number of respondents (sources) who referenced various obstacles to cooperating across their political boundary and the total number of times each obstacle was referenced; differences in total sources and total references reflects the fact that some respondents referenced an obstacle more than once. One representative of an intertribal organization was interviewed and their responses are not included to help protect confidentiality.

Obstacles	# Sources	LDF Sources	WDNR Sources	Total # References
personalities and attitudes	7	2	5	12
jurisdiction	5	3	2	7
lack of communication	5	2	3	6
state-level politics	3	2	1	3
misconceptions	3	2	1	3
lack of fairness	2	2	-	3
lack of transparency and information sharing	2	-	1	2
lack of integration	2	-	2	2
lack of trust	1	-	-	2
turf battles	1	1	-	1
required top-down progression	1	-	1	1
individuals needing to conform to group image or norm	1	-	1	1
time limitations	1	-	1	1
lack of understanding	1	1	-	1
pride	1	-	1	1

Table 5.4: Number of respondents (sources) who referenced various characteristics that enhanced cooperation across their political boundary and the total number of times each characteristic was referenced; differences in total sources and total references reflects the fact that some respondents referenced a characteristic more than once. One representative of an intertribal organization was interviewed and their responses are not included to help protect confidentiality.

Characteristic	# Sources	LDF Sources	WDNR Sources	Total # References
bridging institutions:	(10)	(3)	(6)	(13)
Gathering of the Guides	7	3	4	10
GLIFWC	2	-	1	2
Biological Issues Group	1	-	1	1
communication	9	4	5	19
personal-level relationships	7	3	4	12
trust	7	3	3	10
effective leadership	6	2	4	15
key individuals	6	2	4	9
informality	6	2	4	7
regular interactions	5	1	4	9
change in leadership	5	-	5	9
LDF as proactive tribe	4	2	1	5
transparency	4	3	1	4
acceptance	3	2	1	5
changes in staff	3	-	3	4
time heals	3	-	3	4
integration	2	-	1	3
open-mindedness	2	1	1	5
understanding your neighbor	2	1	1	2
compromise	1	1	-	2
follow-through	1	-	1	1
checks and balances	1	1	-	1
size & capacity of tribal programs	1	1	-	1

Figure 5.1: Map showing location of Lac du Flambeau Reservation and Northern Highland-American Legion State Forests in context of 1837 and 1842 treaty areas and surrounding region.



CHAPTER 6

SUMMARY AND CONCLUSIONS

Summary

This dissertation was an interdisciplinary exploration of ecological and human dimensions of neighboring tribal and state natural resource management systems. The goal of the dissertation was to provide insights of value within the local study area that also improved general understanding of tribal-state relations, contemporary subsistence hunting, cross-boundary natural resource management and interrelated management of oak forests and deer.

The results regarding contemporary hunting by Lac du Flambeau (LDF) citizens (Chapter 2) have potential for positively impacting local citizen relations by documenting tribal hunting practices and explaining the thoughtful purposes and perspectives behind tribal member harvests. It provides similar value to a wider audience, including on a global scale, by providing an in-depth description and explanation of ethical dimensions of subsistence hunting by indigenous practitioners. Through interviews with active LDF Ojibwe hunters, I determined that hunters from this community have a vibrant and extensive set of hunting-related values. I summarized their values system through a cyclical framework that approximates the order in which youth are taught lessons about hunting, and also coincides with the seasonal pattern of hunting activities and practices (Chapter 2, Figure 2.2).

Amid increasing multi-cultural interactions and recent access to the internet and satellite television, LDF youth continue to learn LDF and Ojibwe-specific hunting values and value-based practices. My evaluation of the continuity of traditional hunting values within the LDF Tribe can be replicated to ascertain the relative resilience and vulnerability of subsistence value systems in other communities. After comparing the perspectives of Indian and non-Indian hunters, I determined a list of commonalities and explained important differences in new ways. These results can help build cross-cultural understanding and respect among neighboring Indian and non-Indian people in and beyond the study area.

My investigation of forest regeneration following tribal and state resource management efforts (chapters 3 and 4) provides new insights about influences on northern red oak regeneration. On the LDF Reservation, deer hunting management has limited deer densities to 2-3 deer/km^2 compared to deer management units encompassing the adjacent Wisconsin Department of Natural Resources (WDNR)-managed state forests where deer densities have averaged >10/km^2. I found that tribal stands >15 ha in area produced 3 times as many tall (>137cm) oak seedlings as was produced on comparable state stands. In smaller forest management units <3 ha in area, oak pockets within tribal forests produced eight times as many tall seedlings as comparable state pockets of oak. Stand size had other effects on regeneration as well. Within tribal forests, residual oak pockets <3 ha in area produced more medium height and tall oak seedlings and had greater height growth rates than larger oak stands.

I did not find evidence suggesting that hand release timber stand improvement (TSI) efforts had improved red oak regeneration on tribal forests. My primary explanation for not finding a TSI effect is that with limited deer herbivory on the reservation, northern red oak seedlings are establishing and surviving at high rates, mitigating the need and potential for a TSI effect. More research is needed on the effects of TSI treatments on northern red oak and other species before responding with either a de-investment (i.e., by the LDF Tribe or another manager currently using these

techniques) or investment (i.e., by the WDNR or other managers contemplating hand release) in this type practice. Importantly, both the WDNR and the LDF Tribe invested time and energy into supporting this project and are interested in learning from the results of both tribal and state practices.

One reason why they are willing to learn from each other is that they have spent more than 20 years working together and learning to cooperate across their political boundary. The WDNR and LDF Tribe moved beyond regional conflicts over natural resource use and treaty rights to the point where they collaborate on a wide range of regional issues including those related to wildlife and habitat, wild rice resources, transportation, recreation and public education/outreach. I studied the evolution of their cross-boundary cooperation (Chapter 5) and found that building cross-boundary personal relationships among field staff, administrators and elected officials facilitated their successful cooperation. These relationships were built best through regular, informal interactions without agendas or attorneys present in the majority of their meetings. The annual Gathering of the Guides event convened tribal, federal and state resource managers, elected officials and Indian and non-Indian fishing guides in an informal, social environment. These events help tremendously in initiating personal relationships between key individuals throughout the 1837 and 1854 ceded territories.

Lac du Flambeau and WDNR officials' engagement in my dissertation research exemplified their tribal-state working relations and interest in cross-boundary cooperation. I met with representatives from the WDNR and LDF regularly and they helped devise research topics that would have relevance to both the tribe and the state.

WDNR representatives introduced me to tribal representatives and vice versa, often complementing one another, providing evidence of their close working relationships.

Conclusions

This dissertation provides a rare example of successful cross-boundary resource management cooperation between a tribe and a state. In the U.S., such examples are needed to foster regional approaches to natural resource management at the interface of public and tribal lands. With 562 distinct tribal nations and over 100 million acres of land controlled by tribes and Alaskan Native communities, the potential for cross-boundary management involving tribes is vast. The cross-boundary lessons from this dissertation are also applicable within regions that are home to indigenous communities outside of the U.S. The lessons about cooperation and cross-boundary/cross-cultural relationship building are also relevant in scenarios that do not involve Native peoples. For example, the importance of using regular, informal interactions to build personal relationships at multiple levels from field staff to elected officials applies to other scenarios such as transboundary (i.e., across international borders) and state-local government relations.

Results from the dissertation provides insights into the values system of the Ojibwe people, who comprise a large North American Indian cultural group spanning from the eastern Great Lakes west to the Dakotas and north into northern Manitoba. More generally, the study helped dispel misconceptions about contemporary American Indian hunters. Reframing the term "traditional" within the context of value systems rather than technology opens the door for deeper cross-cultural understanding and appreciation between Indian and non-Indian people. This dissertation also provides an example of how

t
n
n
a
a

m
re
Th
gi
de
de
no

as
pre
Ind
Dhu
into
non
and
for s
and

the traditional and cultural values of a community inform its natural resource use and management. Exploration of the ethical dimensions of natural resource use and management, such as the dimensions studied here, can help reduce citizen-level conflict and improve institutional-level cooperation by improving cross-cultural understanding among resource practitioners and resource management staff.

The sections of this dissertation focused on hunting management, forest management and forest ecology contribute to general understanding about oak regeneration and management which have frustrated scientists and managers for decades. The primary contribution is a quantified example of the potential for oak regeneration given low densities of large forest ungulates. The LDF Tribe's combined white-tailed deer hunting management and forest management provides an example of sustainable deer-human-forest relationships that include widespread regeneration and recruitment of northern red oak.

This dissertation leads to some interesting questions left for future research, such as "How can wildlife managers reduce deer densities on public lands given political pressures from sport hunting groups and the fact that hunting satisfaction among non-Indians is often tied closely with seeing deer during every hunt (Lischka et al. 2006, Dhuey 2008)?", "How do top predators such as the grey wolf and mountain lion factor into the sustainability of deer and forests?", "How have the perspectives of Indian and non-Indian hunters (and non-hunters) about top predators evolved in the last 100+ years and how could improved knowledge of these perspectives help us identify mechanisms for sustained co-existence of predators, deer, forests and people?" and "How do tribes and states or tribes and federal partners who work well together expand their collaborative network to include other governments, citizen groups, non-profit organizations and private/commercial landowners who also have a stake in regional socio-ecological issues and whose lands are an important part of regional landscapes?"

REFERENCES

Abrams, M. D. 1996. Distribution, historical development and ecophysiological attributes of oak species in the eastern United States. Pages 487-512.

Abrams, M. D. 2003. Where has all the white oak gone? Bioscience **53**:927-939.

Abrams, M. D. 2005. Prescribing fire in eastern oak forests: Is time running out? Northern Journal of Applied Forestry **22**:190-196.

Adelzadeh, M. 2006. Empowerment in an era of self-determination: the case of the Washoe Tribe and U.S. Forest Service co-management agreement. University of Michigan, Ann Arbor.

Agrawal, D. P. 1997. Traditional knowledge systems and western science. Current Science **73**:731-733.

Albert, D. A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: a working map and classification. Gen. Tech. Rep. NC-178. U.S. Department of Agriculture, Forest Service. North Central Forest Experiment Station, St. Paul, MN.

Albrecht, M. A. and B. C. McCarthy. 2006. Effects of prescribed fire and thinning on tree recruitment patterns in central hardwood forests. Forest Ecology and Management **226**:88-103.

Alverson, W. S., D. M. Waller, and S. L. Solheim. 1988. Forests too deer - edge effects in northern Wisconsin. Conservation Biology **2**:348-358.

Augustine, D. J. and S. J. McNaughton. 1998. Ungulate effects on the functional species composition of plant communities: Herbivore selectivity and plant tolerance. Journal of Wildlife Management **62**:1165-1183.

Axelrod, R. 2006. The Evolution of Cooperation. 2nd edition. Basic Books, New York.

Barnes, B. V., D. R. Zak, S. R. Denton, and S. H. Spurr. 1998. Forest Ecology. 4th edition. John Wiley and Sons, New York.

B

Be

Be

Bl

Bri
U

Bays, B. A. and E. H. Fouberg, editors. 2002. The Tribes and the States: geographies of intergovernmental interaction. Rowman and Littlefield, Lanham.

Becker, C. D. and K. Ghimire. 2003. Synergy between traditional ecological knowledge and conservation science supports forest preservation in Ecuador. Conservation Ecology **8**.

Benton-Benai, E. 1988. The Mishomis Book: the voice of the Ojibway Indian Country Communications, Hayward.

Bergmann, S. A. and J. C. Bliss. 2004. Foundations of cross-boundary cooperation: Resource management at the public-private interface. Society & Natural Resources **17**:377-393.

Berkes, F. 1998. Indigenous knowledge and resource management systems in the Canadian subarctic. Pages 98-128 *in* F. Berkes and C. Folke, editors. Linking Social and Ecological Systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge, UK.

Berkes, F. 1999. Sacred Ecology: traditional ecological knowledge and resource management. Taylor & Francis, Philadelphia.

Berkes, F. 2009. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. Journal of Environmental Management **90**:1692-1702.

Berkes, F., C. Folke, and M. Gadgil. 1994. Traditional ecological knowledge, biodiversity, resilience and sustainability. Pages 269-287 *in* C. A. Perrings, K.-G. Maler, C. Folke, C. S. Holling, and B.-O. Jansson, editors. Biodiversity Conservation: problems and policies. Kluwer Academic Publishers, Dordrecht.

Berkes, F., M. Kislalioglu, C. Folke, and M. Gadgil. 1998. Exploring the basic ecological unit: Ecosystem-like concepts in traditional societies. Ecosystems **1**:409-415.

BIA. 2010. Bureau of Indian Affairs Frequently Asked Questions Site. www.bia.gov/FAQs/index.htm. Last Accessed March 22, 2010.

Brightman, R. A. 1993. Grateful Prey:Rock Cree Animal-Human Relationships. University of California Press, Berkeley.

Brody, H. 1997. Maps and Dreams: Indians and the British Columbia Frontier. Waveland Press.

Brown, T. L., D. J. Decker, S. J. Riley, J. W. Enck, T. B. Lauber, P. D. Curtis, and G. F. Mattfeld. 2000. The future of hunting as a mechanism to control white-tailed deer populations. Wildlife Society Bulletin **28**:797-807.

Buckley, D. S., T. L. Sharik, and J. G. Isebrands. 1998. Regeneration of northern red oak: Positive and negative effects of competitor removal. Ecology **79**:65-78.

Burnham, K. P. and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd edition. Springer Science, New York.

Canham, C. D. 1988. An index for understory light levels in and around canopy gaps. Ecology **69**:1634-1638.

Cook, J. E., N. Jensen, and B. Galbraith. 2008. Compositional, cover, and diversity changes after prescribed fire in a mature eastern white pine forest. Botany-Botanique **86**:1427-1439.

Cornell, G. L. 1992. Environmental philosophy and perceptions of the environment.*in* Human Values and the Environment. Wisconsin Acadamy of Sciences, Arts and Letters, Madison, WI.

Cote, S. D., T. P. Rooney, J. P. Tremblay, C. Dussault, and D. M. Waller. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology Evolution and Systematics **35**:113-147.

Crow, T. R. 1988. Reproductive mode and mechanisms for self-replacement of northern red oak (*Quercus-rubra*) - a review. Forest Science **34**:19-40.

Crow, T. R. 1992. Population-dynamics and growth-patterns for a cohort of northern red oak (*Quercus rubra*) seedlings. Oecologia **91**:192-200.

Debo, A. 1970. A History of the Indians of the United States. University of Oklahoma, Norman.

DeBoer, S. G. 1947. The deer damage to forest reproduction survey

Wisconsin Conservation Bulletin **12**:1-21.

Deloria Jr., V. 1999. Reflection and revelation: knowing land, places and ourselves. Pages 250-260 For This Land: writings on religion in America. Routledge, New York, NY.

Deloria, S. 2006. New paradigm: Indian tribes in the land of unintended consequences. Natural Resources Journal **46**:301-315.

Dhuey, B. 2008. Gun deer hunting questionnaire 2008. Wisconsin Department of Natural Resources.

Dolan, B. J. and G. R. Parker. 2004. Understory response to disturbance: an investigation of prescribed burning and understory thinning treatments. In Spetich, Martin A., ed. Upland oak ecology symposium: history, current conditions, and sustainability. Gen. Tech. Rep. SRS-73. U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Ebbin, S. A. 2002. Enhanced fit through institutional interplay in the Pacific Northwest Salmon co-management regime. Marine Policy **26**:253-259.

Ebbin, S. A. 2004. The anatomy of conflict and the politics of identity in two cooperative salmon management regimes. Policy Sciences **37**:71-87.

Ebbin, S. A. 2009. Institutional and ethical dimensions of resilience in fishing systems: Perspectives from co-managed fisheries in the Pacific Northwest. Marine Policy **33**:264-270.

Fagergren, F. J. 1998. Big Cypress National Preserve: The Great Compromise. Pages 199-215 *in* R. L. Knight and P. B. Landres, editors. Stewardship Across Boundaries. Island Press, Washington DC.

Fienup-Riordan, A. 2000. Hunting Tradition in a Changing World: Yup'ik Lives in Alaska Today. Rutgers University Press, New Brunswick.

Finzi, A. C. and C. D. Canham. 2000. Sapling growth in response to light and nitrogen availability in a southern New England forest. Forest Ecology and Management **131**:153-165.

Fisher, R. and W. Ury. 1991. Getting to Yes: negotiated agreement without giving in. 2nd edition. Penguin Books, New York.

Fixico, D. L. 2003. The American Indian mind in a linear world: American Indian studies and traditional knowledge. Routledge, New York, NY.

Folke, C., F. Berkes, and J. Colding. 1998. Ecological practices and social mechanisms for building resilience and sustainability. Pages 414-436 *in* F. Berkes and C. Folke, editors. Linking Social and Ecological Systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge, UK.

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

Forman, R. T. T. 1995. Land Mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge, UK.

Frazer, G. W., C. D. Canham, and K. P. Lertzman. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Copyright © 1999: Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York.

Frelich, L. E. and C. G. Lorimer. 1985. Current and predicted long-term effects of deer browsing in hemlock forests in Michigan, USA. Biological Conservation **34**:99-120.

Gill, R. M. A. 1992. A review of damage by mammals in north temperate forests. 3: Impact on trees and forests. Forestry **65**:363-388.

GLIFWC. 2007. A guide to understanding Ojibwe treaty rights. Great Lakes Indian Fish and Wildlife Commission, Odanah, WI.

Good, S. P. 1997. Wilderness and the hunting experience: what it means to be a hunter. Wildlife Society Bulletin **25**:563-567.

Gotelli, N. J. and A. M. Ellison. 2004. A primer of ecological statistics. Sinauer Associates, Inc, Sunderland, MA.

Guilmet, G. M. and D. L. Whited. 2002. American Indian and Non-Indian Philosophies of Technology and Their Differential Impact on the Environment of the Southern Puget Sound. American Indian Culture and Research Journal **26**:33-66.

Gunderson, L. H. and C. S. Holling, editors. 2002. Panarchy: understanding transformations in human and natural systems. Island Press, Washington DC.

Hahn, T., P. Olsson, C. Folke, and K. Johansson. 2006. Trust-building, knowledge generation and organizational innovations: The role of a bridging organization for adaptive comanagement of a wetland landscape around Kristianstad, Sweden. Human Ecology **34**:573-592.

Healy, W. M. 1997. Influence of deer on the structure and composition of oak forests in central Massachusetts. In W.J. McShea, H.B. Underwood and J.H. Rappole (eds.) The science of overabundance: deer ecology and population management. Smithsonian Institute Press, Washington.

Henson, E. C., J. P. Kalt, S. Cornell, K. W. Grant, J. B. Taylor, M. R. Jorgensen, C. E. A. Curtis, A. J. Lee, and H. Nelson. 2008. The state of the native nations: conditions under U.S. policies of self-determination. Oxford University Press, Oxford, UK.

Isebrands, J. G. and R. E. Dickson. 1994. Biology and silviculture of northern red oak in the north central region: a synopsis. Gen. Tech. Rep. NC-173. U.S. Department of Agriculture, Forest Service. North Central Forest Experiment Station, St. Paul, MN.

Johnson, P. S. 1994. The silviculture of northern red oak. In Isebrands, J.G. and Dickson (eds.) Biology and silviculture of northern red oak in the north central region: a synopsis. Gen. Tech. Rep. NC-173. U.S. Department of Agriculture, Forest Service. North Central Forest Experiment Station, St. Paul, MN.

Johnson, R. A. and D. W. Wichern. 2002. Applied multivariate statistical analysis. 5th edition. Prentice Hall, Upper Saddle River, New Jersey.

Johnston, B. 1976. Ojibway Heritage. Columbia University Press, New York.

Jones Jarding, L. 2004. Tribal-state relations involving land and resources in the self-determination era. Political Research Quarterly **57**:295-303.

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

Knight, R. L. and P. Landres. 1998. Stewardship Across Boundaries. Island Press, Wsahington, DC.

Kotar, J., J. A. Kovach, and T. L. Burger. 2002. Field guide to forest habitat types of northern Wisconsin. Dept of Forest Ecology and Management, University of Wisconsin-Madison.

LeCompte, M. D. and J. P. Geotz. 1983. with ideas: analysis of qualitative data. Meeting of the American Educational Research Association.

Levin, S. A. 2009. Sustainability, Discounting and Cooperation: The Need for New Institutions. Rachel Carson Distinguished Lecture, Michigan State University, East Lansing. December 10, 2009.

Lincoln, Y. S. and E. G. Guba. 1985. Naturalistic Inquiry. Sage Publications, Thousand Oaks, CA.

Lindman, H. R. 1974. Analysis of variance in complex experimental designs. W.H. Freeman & Co, San Francisco, CA.

Lischka, S. A., W. L. Anderson, and L. K. Campbell. 2006. Results of the 2005-2006 Illinois Deer Hunter Survey. Illinois Natural History Survey, Champaign, IL.

Liu, J. and W. W. Taylor, editors. 2002. Integrating Landscape Ecology into Natural Resource Management. Cambridge University Press, Cambridge.

Loew, P. In Review. Ojibwe treaty rights: after the storm. American Indian Quarterly.

Lorimer, C. G. 1992. Causes of the oak regeneration problem. In D. L. Loftis & C. E. McGee (Eds.), Oak regeneration: Serious problems, practical recommendations. Gen. Tech. Rep. SE-84. U.S. Department of Agriculture, Forest Service. Southeastern Forest Experiment Station, Asheville, NC.

Lorimer, C. G. 2003. The decline of oak forests. Bioscience **53**:915-915.

Lorimer, C. G., J. W. Chapman, and W. D. Lambert. 1994. Tall understory vegetation as a factor in the poor development of oak seedlings beneath mature stands. Journal of Ecology **82**:227-237.

McCorquodale, S. M. 1997. Cultural contexts of recreational hunting and native subsistence and ceremonial hunting: their significance for wildlife management. Pages 568-573.

McCorquodale, S. M. 1999. Historical and contemporary policies regarding off-reservation hunting by Native Americans. Wildlife Society Bulletin **27**:446-455.

McGee, C. E. 1968. Northern red oak seedlings growth varies by light intensity and seed source. Research Note SE-90. U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville, NC.

McShea, W. J. and W. M. Healy. 2003. Oak Forest Ecosystems: Ecology and Management for Wildlife. The Johns Hopkins University Press, Baltimore, MD.

Miles, M. B. and A. M. Hubermann. 1994. Qualitative data analysis : an expanded sourcebook 2nd edition. Sage Publications, Thousand Oaks, CA.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington DC.

Motsinger, J. R., J. M. Kabrick, D. C. Dey, D. E. Henderson, and E. K. Zenner. 2010. Effect of midstory and understory removal on the establishment and development of natural and artificial pin oak advance reproduction in bottomland forests. New Forests **39**:195-213.

Nadasdy, P. 2003. Reevaluating the co-management success story. Arctic **56**:367-380.

Natcher, D. C., S. Davis, and C. G. Hickey. 2005. Co-management: Managing relationships, not resources. Human Organization **64**:240-250.

Nesper, L. 2002. The Walleye War: the struggle for Ojibwe spearfishing and treaty rights. University of Nebraska Press, Lincoln.

Nie, M. 2009. The Use of Co-Management and Protected Land-Use Designations to Protect Tribal Cultural Resources and Reserved Treaty Rights on Federal Lands. Natural Resources Journal **48**:585-647.

Ostrom, E. 1990. Governing the Commons: the evolution of institutions for collective action. Cambridge University Press, New York.

Ostrom, E. 2004. Panarchy: understanding transformations in human and natural systems. Ecological Economics **49**:488-491.

Ostrom, E., M. A. Janssen, and J. M. Anderies. 2007. Going beyond panaceas. Proceedings of the National Academy of Sciences of the United States of America **104**:15176-15178.

Pacala, S. W., C. D. Canham, J. A. Silander, and R. K. Kobe. 1994. Sapling growth as a function of resources in a north temperate forest. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere **24**:2172-2183.

Palmer, S. C. F., R. J. Mitchell, A. M. Truscott, and D. Welch. 2004. Regeneration failure in Atlantic oakwoods: the roles of ungulate grazing and invertebrates. Forest Ecology and Management **192**:251-265.

Patton, M. Q. 1990. Qualitative Evaluation and Research Methods. 2nd edition. Sage, Newbury Park, California.

Phillips, R. J. and T. A. Waldrop. 2008. Changes in vegetation structure and composition in response to fuel reduction treatments in the South Carolina Piedmont. Forest Ecology and Management **255**:3107-3116.

Pinheiro, J. C. and D. M. Bates. 2000. Mixed-effects models in S and S-Plus Springer Verlag, New York.

Pinkerton, E. 1998. Integrating management of a temperate montane forest ecosystem through wholistic forestry: a British Columbia example. Pages 369-389 *in* F. Berkes and C. Folke, editors. Linking Social and Ecological Systems: management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge, UK.

Pitt, D. G., A. Morneault, W. C. Parker, A. Stinson, and L. Lanteigne. 2009. The effects of herbaceous and woody competition on planted white pine in a clearcut site. Forest Ecology and Management **257**:1281-1291.

Ponder, F. 2003. Effect of site treatments on soil temperature and moisture and oak and pine growth and nutrient concentration. In Van Sambeek, J.W.; Dawson, J.O.; Ponder, F., Jr.; Loewenstein, E.F.; Fralish, J.S., eds. 2003. Proceedings, 13th Central Hardwood Forest conference; 2002 April 1-3; Urbana, IL. Gen. Tech. Rep. NC-234. U.S. Department of Agriculture, Forest Service. North Central Research Station, St. Paul, MN.

Propst, L., W. F. Paleck, and L. Rosan. 1998. Partnerships Across Park Boundaries: The Rincon Institute and Saguaro National Park. Pages 257-278 *in* R. L. Knight and P. B. Landres, editors. Stewardship Across Boundaries. Island Press, Washington DC.

QSR International. 2008. NVivo qualitative data analysis software. QSR International Pty Ltd.

Rathfon, R. A., N. I. Lichti, and R. K. Swihart. 2007. Disking and mid- and understory removal following an above average acorn crop in three mature oak forests in southern Indiana. In Jacobs, D.F., Michler, C.H., eds. April 8-9, 2008. Proceedings, 16th central hardwood forest conference. Gen. Tech. Rep. NRS-P-24. U.S. Department of Agriculture, Forest Service. Northern Research Station, Newtown Square, PA.

Rickenbach, M. G. and A. S. Reed. 2002. Cross-boundary cooperation in a watershed context: The sentiments of private forest landowners. Environmental Management **30**:584-594.

Riemer, J. W. 2004. Chippewa spearfishing, lake property owner/anglers, and tourism - A case study of environmental social conflict. Sociological Spectrum **24**:43-70.

Rooney, T. P., R. J. McCormick, S. L. Solheim, and D. M. Waller. 2000. Regional variation in recruitment of hemlock seedlings and saplings in the upper Great Lakes, USA. Ecological Applications **10**:1119-1132.

Rooney, T. P. and D. M. Waller. 2003. Direct and indirect effects of white-tailed deer in forest ecosystems. Forest Ecology and Management **181**:165-176.

Rooney, T. P., S. M. Wiegmann, D. A. Rogers, and D. M. Waller. 2004. Biotic impoverishment and homogenization in unfragmented forest understory communities. Conservation Biology **18**:787-798.

Royston, J. P. 1982. An extension of Shapiro and Wilk-w test for normality to large samples. Applied Statistics-Journal of the Royal Statistical Society Series C **31**:115-124.

Salmon, E. 2000. Kincentric ecology: Indigenous perceptions of the human-nature relationship. Ecological Applications **10**:1327-1332.

Sander, I. L. 1990. Northern red oak. In: Silvics of North America, Volume 2: Hardwoods. Burns, R.M., Honkala, B.H. (Tech. Coords.). Agriculture Handbook 654, U.S. Dept. of Agriculture, Forest Service, Washington D.C. Available online at http://www.na.fs.fed.us/pubs/silvics_manual/Volume_1/pinus/lambertiana.htm. Last accessed on October 12, 2009.

Sander, I. L., P. S. Johnson, and R. Rogers. 1984. Evaluating oak advanced reproduction in the Missouri Ozarks. Research Paper NC-251. U.S. Department of Agriculture, Forest Service. North Central Forest Experiment Station, St. Paul, MN

Satz, R. N. 1991. Chippewa Treaty Rights: the reserved rights of Wisconsin's Chippewa Indians in historical perspective. Wisconsin Academy of Sciences, Arts and Letters, Madison, WI.

Schulte, L. A., M. Rickenbach, and L. C. Merrick. 2008. Ecological and economic benefits of cross-boundary coordination among private forest landowners. Landscape Ecology **23**:481-496.

Silvern, S. E. 1999. Scales of justice: law, American Indian treaty rights and the political construction of scale. Political Geography **18**:639-668.

Silvern, S. E. 2008. Negotiating Ojibwe Treaty Rights: Toward a Critical Geopolitics of State-Tribal Relations. American Indian Culture and Research Journal **32**:153-176.

Spies, T. A. and B. Barnes. 1985. Ecological species groups of upland northern hardwood hemlock forest ecosystems of the Sylvania recreation area, Upper Peninsula, Michigan. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere **15**:961-972.

Sutton, I. 2001. Tribes and States: a political geography of Indian environmental jurisdiction. Pages 239-263 *in* R. L. Clow and I. Sutton, editors. Trusteeship in Change: toward tribal autonomy in resource management. University Press of Colorado, Boulder, Colorado.

Tremblay, J. P., J. Huot, and F. Potvin. 2007. Density-related effects of deer browsing on the regeneration dynamics of boreal forests. Journal of Applied Ecology **44**:552-562.

Trosper, R. L. 2002. Northwest coast indigenous institutions that supported resilience and sustainability. Ecological Economics **41**:329-344.

Tukey, J. W. 1953. The problem of multiple comparisons. Unpublished manuscript. Princeton University.

Turner, N. J., M. B. Ignace, and R. Ignace. 2000. Traditional Ecological Knowledge and Wisdom of aboriginal peoples in British Columbia. Ecological Applications **10**:1275-1287.

U.S. Department of Interior Fish and Wildlife Service and U.S. Department of Commerce Census Bureau. 2006. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Waller, D. M. and W. S. Alverson. 1997. The white-tailed deer: a keystone herbivore. Wildlife Society Bulletin **25**:217-226.

WDNR. 1990. Wisconsin DNR Silviculture and Forest Aesthetics Handbook 2431.5. Available online at: http://dnr.wi.gov/forestry/Publications/Handbooks/24315/. Last accessed on October 12, 2009.

WDNR. 2005. Northern Highland - American Legion State Forest master plan. Available online at: http://dnr.wi.gov/master_planning/nhal/. Last accessed on October 27, 2009.

Wilkins, D. E. 2002. Tribal-State Affairs: American States as "Disclaiming" Sovereigns.*in* B. A. Bays and E. H. Fouberg, editors. The Tribes and the States: geographies of intergovernmental interaction. Rowman and Littlefield, Lanham.

Wisdom, M. J., M. Vavra, J. M. Boyd, M. A. Hemstrom, A. A. Ager, and B. K. Johnson. 2006. Understanding ungulate herbivory-episodic disturbance effects on vegetation dynamics: Knowledge gaps and management needs. Wildlife Society Bulletin **34**:283-292.

Wondolleck, J. M. and S. L. Yaffee. 2000. Making Collaboration Work: lessons from innovation in natural resource management. Island Press, Washington D.C.

Xu, J. C., E. T. Ma, D. Tashi, Y. S. Fu, Z. Lu, and D. Melick. 2005. Integrating sacred knowledge for conservation: Cultures and landscapes in southwest China. Ecology and Society **10**.

Yaffee, S. L. 1996. Ecosystem management in practice: The importance of human institutions. Ecological Applications **6**:724-727.

Yaffee, S. L. 1999. Three faces of ecosystem management. Conservation Biology **13**:713-725.

Zuur, A. F., E. N. Ieno, S. Walker, A.A., and G. M. Smith. 2009. Mixed effects models and extensions in ecology with R. Springer New York.