

FROM INGRESSION TO CIRCUMSCRIPTION:
A GEOGRAPHICAL STUDY OF KUDZU
MANAGEMENT POLICIES IN
THE UNITED STATES

By

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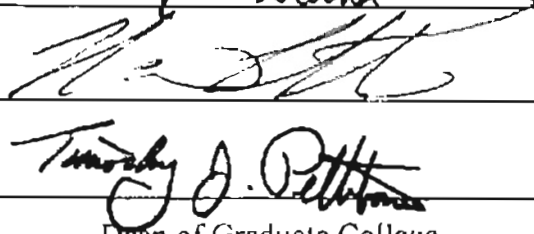
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CHAPTER I

INTRODUCTION

Since its introduction into America from Japan in 1876, kudzu [*Pueraria lobata* (Willd.) Ohwi] has literally taken over the landscape of the southern and eastern United States. Kudzu is a woody, fast-growing, invasive vine of the legume (Fabaceae) family. Boasting blooms ranging from white to purple in late July through August, kudzu is as beautiful as it is devastating. Once kudzu's roots take hold in the soil, it quickly engulfs everything in its path, abandoned houses, barns, telephone poles, and on a more serious note, vegetation (Bell and Wilson, 1989).

As kudzu envelops its living hosts, it deprives them of the vital sunlight they need to survive. In many areas, kudzu has completely replaced the native plant species that once flourished. This is often true when an invasive species, flora or fauna, is introduced into an area without prior knowledge of how it will interact with the native species. And in the case of kudzu, there are no indigenous herbivores in the U.S. to keep its growth in check. While kudzu is found primarily in the southern and eastern regions of the United States (Fig. 1.1), it has been observed as far north as New York, and as far west as Oregon and Washington (Mitich, 2000; Oregon Department of Agriculture, 2001).

This project focuses on the geography of kudzu establishment and control in the United States. The word *ingression* implies that kudzu was given the right or permission to enter, thus, a portion of research focuses on the land use practices and policies that led

to its establishment. *Conscription* reflects the resulting efforts to limit or restrain its spread. This research studies the various kudzu management policies across various spatial and temporal scales.

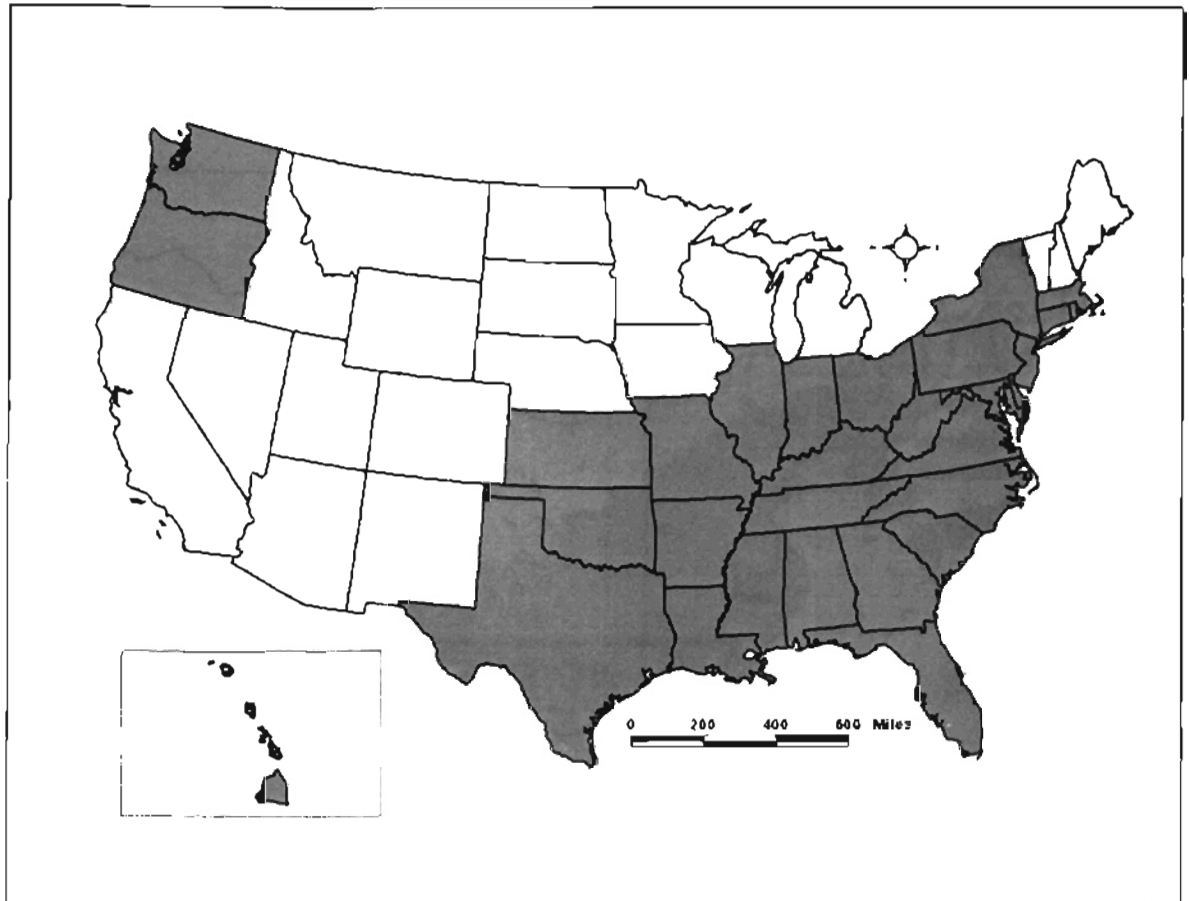


Figure 1.1 States Reporting Kudzu Populations, 2003

Historical Background

There are seventeen known species of kudzu. The species which is the focus of my research, *Pueraria lobata*, (Fig. 1.2), is native to the Asian countries of China, Taiwan, Japan, Korea and India, and associated with temperate broadleaf/mixed forest and subtropical moist broadleaf biomes (Fig. 1.3) (Everest, *et. al.*, 1991).

Historically, kudzu has been prized in these countries for its nutritional and medicinal qualities. Ninth century A.D. Japanese literature reports the leaves of the kudzu plant were being used as vegetables (Mitich, 2000). Japan consumes 1,500 tons of kudzu starch yearly as an ingredient in gourmet foods, beverages and herbal medications (Kellogg, 1990).

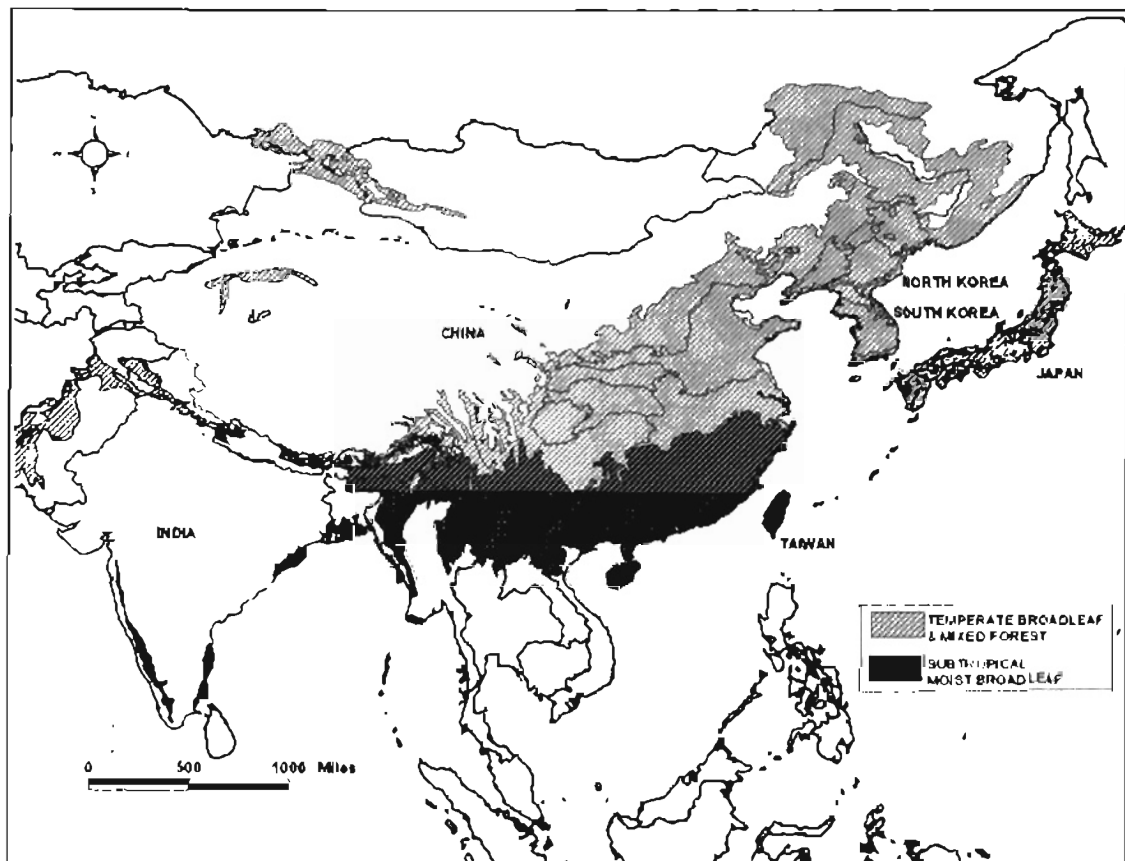


Figure 1.2 Native Origins of Kudzu and Associated Biomes

For centuries, the flower and root of the kudzu plant have been used by the Chinese to curb the consumption of alcoholic beverages. Researchers at Harvard Medical School in Boston are studying the effect of this derivative on golden hamsters. Golden hamsters, given a choice between alcohol and water, prefer alcohol. When given a dose of the

synthetic extract, the hamsters drank half of their usual amount of alcohol (Keung, *et. al.*, 1995).

Adaptable to a variety of climates and topography, kudzu can be grown on rocky hillsides and other places too steep to sustain cultivation or pastureland.

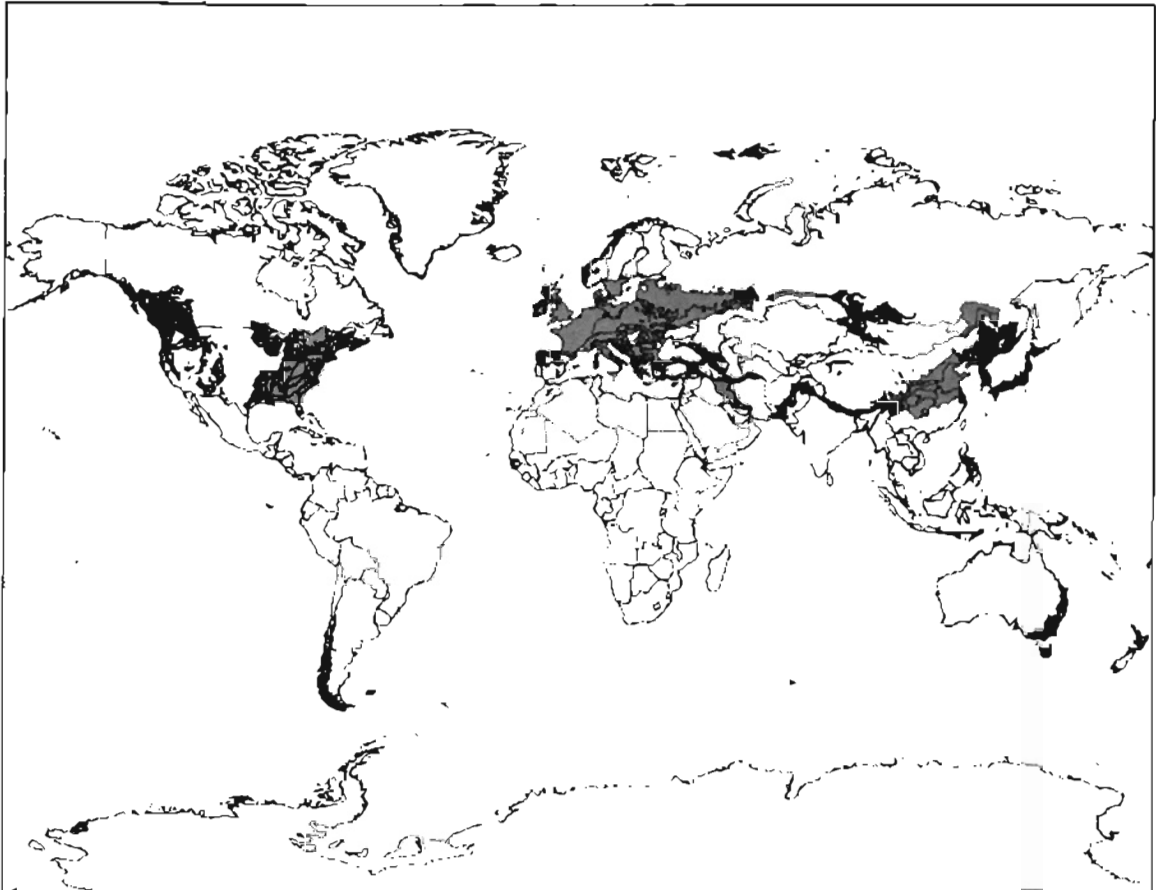


Figure 1.3 Broadleaf/Mixed Forest & Subtropical Moist Broadleaf Biomes

Kudzu is often used for hay in times of famine and farmers have been known to feed it to sick horses, finding that they will choose kudzu over traditional feed in times of illness (Mitich, 2000).

Kudzu was introduced into America during the 1876 Philadelphia Centennial Exposition as an ornamental plant (Alderman, 1998). It instantly became popular as a decorative touch and source of shade on porches of homes throughout the South after its

appearance at the New Orleans Exposition in 1894. During the 1930s, the Soil Conservation Service, originally known as the Soil Erosion Service, distributed approximately 85 million kudzu seedlings to southern landowners to reduce and prevent soil erosion. The Civilian Conservation Corps (CCC) was also employed to plant kudzu along the banks of streams, roadways and railways to prevent erosion (Bell and Wilson, 1989). The federal government further encouraged the spread of kudzu by paying southern farmers \$8 an acre to plant it in their fallow fields (Klinkenberg, 1996). By the late 1940s, approximately 3 million acres of kudzu had been planted on farms across the south (Bell and Wilson, 1989).

In the 1950's, the United States Department of Agriculture (USDA) began to realize that kudzu was out of control and it was summarily removed from the list of permissible ground-cover plants (Bergman, 2000). Kudzu was officially recognized as a weed in 1974 and added to the Federal Noxious Weed List in 1997, which prohibits its importation into the country (Mitich, 2000). Current estimates suggest that nearly 7 million acres of land in the Southeast is plagued by kudzu; 250,000 acres in Alabama alone (Everest, *et. al.*, 1991).

Despite its overall negative connotation, kudzu has become a southern cultural icon. According to Bell and Wilson (1989), "Whatever kudzu's current practical value to the South, it has assumed almost mythic cultural significance." This is evident in the many examples of Southerners embracing kudzu as a popular cultural symbol. A 1998 study revealed that 30 businesses, primarily in the Deep South, use kudzu in their name (Alderman, 1998).

The early popularity of kudzu also spawned countless festivals, pageants and balls, some of them continue until today. Georgia and South Carolina host annual kudzu festivals and Chattanooga, Tennessee, boasts an annual kudzu ball (Ombrello, 2002). “Southerners in general love to party”, says William Ferris, Mississippi chairman of the National Endowment for the Humanities. “We celebrate everything from kudzu to catfish to bluegrass to blues” (Holland, 2002).

The following excerpt from the ‘Kudzu Creed’ adopted by organizers of the Blythewood Kudzu Festival in Blythewood, South Carolina, is an interesting example of the cultural influence of kudzu in the South (Blythewood Kudzu Festival Home Page, 2002):

We are firmly committed to continuing the pursuit of Kudzu recognition
and we believe that any attempt to control nature is contrary to any known
basic self-evident environmental truths...
When we destroy Nature, we destroy our Souls...
Down South here in Blythewood, Kudzu is King and we Honor, Obey, and
Follow wherever He opts to go.

The Kudzu Creed

This creed was posted on the festival’s web page in response to a letter from a reader who thought that it was absurd for any Southerner to promote the spread of kudzu. While it is uncertain whether or not the author penned the creed as an attempt to be humorous, it does raise an important question: Is this just an example of Southern humor, or do such attitudes negatively affect successful control of kudzu? To date, I have found no evidence to suggest that such attitudes exist, other than in a humorous context.

One of the most striking examples of kudzu’s cultural influence is the poem ‘Kudzu’ by James Dickey that recounts the journey of kudzu from Japan to America and the unforeseen consequences of its establishment:

Japan invades. Far Eastern vines
Run from the clay banks they are
Supposed to keep from eroding.
Up telephone poles,
Which rear, half out of leafage
As though they would shriek,
Like things smothered by their own
Green, mindless, unkillable ghosts.
In Georgia, the legend says
That you must close your windows
At night to keep it out of the house....

James Dickey Poems 1957-1967

Justification of Research

According to The National Invasive Species Council, an invasive species is an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. An alien (*syn.* exotic, non-indigenous, non-native) species means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species, that is not native to that ecosystem (National Invasive Species Council, 2001). Unfortunately, these alien species can be devastating to existing natural communities as well as costly in economic terms.

Invasive alien plant species can negatively affect the biodiversity in existing ecosystems by creating dominating monocultures as well as altering the ecological functions of the area (Daehler, 1997). When invasive plants are introduced into a native area they compete with endemic species for nutrients and sunlight. Kudzu has large trailing or climbing vines that can grow up to 60 feet in one season and during early summer, its optimal growth period, can grow up to a foot a day. Kudzu's dense canopy prevents plants from receiving vital sunlight and its weighty vines are particularly

devastating to trees because they can actually fell a mature tree (Tenenbaum, 1996; Miller, 1996; Everest, *et. al.*, 1991).

In economic terms, the impact of invasive species in agriculture and forest loss, as well as money spent in eradication and research, is staggering. In 1993, Congress's former Office of Technology Assessment (OTA) estimated that more than 4,000 harmful exotic species (animals and plants) have been introduced into the United States in this century (Tenenbaum, 1999). It has been estimated that agriculture and environmental damage alone cost the United States over \$138 billion in 1999 (Callaway and Aschenhoug, 2000).

It is clear that invasive plant species pose an ecological and economical threat to the United States. In order to obtain desired management results, one must not only understand the interactions of the biotic and abiotic components of the ecosystem, but also the principles that serve as a basis for sound management decisions. The disparities of management policies across political boundaries only serve to hinder efforts to prevent or control kudzu invasions.

Questions of the Investigation

This research studies kudzu management and control policies across diverse spatial and temporal scales. Questions considered include: (1) Do conflicts exist between federal, state and local governments regarding kudzu management and control? If so do they increase the difficulty of control or prevention of further invasions? Question (2) do management policies differ in states with long histories of kudzu infestation (*e.g.* Mississippi, Georgia and Alabama) and states with relatively short histories of infestation (*e.g.* Illinois, Oregon and Washington)?

Methodology

In the course of my investigation, I have established contacts with various experts in the field of kudzu management, such as Dr. James Miller of the USDA Forest Service Southern Research Station in Auburn, Alabama; Dr. John Byrd, Professor of Weed Science and Extension Specialist, Department of Plant & Soil Sciences at Mississippi State University and Dr. Kerry Britton with the USDA Forest Service Southern Research Station in Athens, Georgia. Dr. Britton offered her insight into past and present kudzu management practices in China, as well as potential biocontrol methods. Dr. Byrd provided information regarding new technologies for detecting kudzu in heavily forested areas as well as provided insight into the attitudes of Mississippi residents toward kudzu in the state. Dr. Miller, in particular, has been most helpful in providing avenues of exploration in the area of federal and state level policy and decision making concerning kudzu management and control. He has also been invaluable in providing additional insight into the prevailing attitudes expressed by the residents of Alabama and how this affects policy at state and federal levels.

Information for research at the federal level was collected from a variety of governmental sources including house bills and senate reports relating to invasive species. The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) Federal Noxious Weed Program offers links to current federal laws, regulations, and policies that affect APHIS' authority with respect to invasive species on their website at <http://www.aphis.usda.gov/ppq/weeds>. Additional information at the federal level was obtained at The National Invasive Species Council website at <http://www.invasivespecies.gov>. Information concerning the efficacy of the

National Invasive Species Council was gleaned from the United States General Accounting Office report entitled *Invasive Species: Clearer Focus and Greater Commitment Needed to Effectively Manage the Problem*.

Much of the information gathered at the state level comes from *Halting the Invasion: State Tools for Invasive Species Management*, a comprehensive guide by the Environmental Law Institute. Other sources include various state Departments of Agriculture as well as state and regional exotic pest plant councils.

Goals of the Investigation

Most research on invasive species is done within the bounds of a specific discipline such as ecology, botany or biology. The discipline of geography possesses the unique ability to bridge the gap between disciplines to offer new and dynamic opportunities to synthesize and compare existing invasive species literature at various spatial and temporal scales. This particular study is an effort to study past and present kudzu management policies in the geographic perspective of time and space.

Thesis Organization

This thesis is organized as follows: chapter 1 is a general outline of this study which includes a brief historical background discussion of kudzu, the justification for research and questions to be addressed. Chapter 2 discusses the history and ecology of kudzu in its native lands while Chapter 3 looks at the environmental, cultural and economic factors that facilitated the establishment of kudzu in the southeastern United States. Chapter 4 highlights current management practices and potential uses of kudzu in the United States. Chapter 5 looks at the interaction between federal, state and local entities in an effort to develop effective management policies and Chapter 6 compares the

policies of states with long histories of kudzu infestation and states with short histories of infestation. Chapter 7 contains conclusions and discusses recommendations for further research.

CHAPTER II

KUDZU: ECOLOGY AND HISTORY IN ASIA

To better understand the impact of alien species invasions on any given ecosystem, it is important to understand how the species functions mechanically and physiologically within its native environment. Similarly, knowledge of how a particular species is managed in its native land can facilitate the implementation of effective control mechanisms and policies.

This chapter offers a brief discussion on the adaptive mechanisms of kudzu as well as management practices in its native lands of Japan and China that serve as human induced constraints on the species.

Ecological Characteristics of Kudzu

Successful adaptability depends on the ability of an organism to adjust morphologically and physiologically to its environment. Kudzu has an extensive root system that can grow from 3 to 8 feet in length, 6 to 12 inches in diameter and weigh up to 400 pounds (Miller and Edwards, 1983). Large storage tissues in the tuberous roots allow for considerable carbohydrate storage, which is essential for the facilitation of regrowth after its foliage dies back in the winter and in times of tissue damage. A Georgia study reported that 52% of total plant biomass was allocated to the root system in the spring and increased to 65% in autumn in preparation for winter storage (Teramura et. al, 1991). The large storage tissues of the root system also allow additional water storage, while the extensiveness of the system allows the roots to tap potential reserve

deep in the soil. These adaptations allow kudzu to survive during times of drought (Mooney and Gartner, 1991).

Kudzu has large trailing or climbing vines capable of growing up to 60 feet in one season and during early summer, its optimal growth period, up to a foot a day. While the vines do produce a few viable seeds, reproduction is primarily vegetative via prolific stem elongation and the establishment of adventitious root systems at the nodes. Root nodulation capable of high levels of nitrogen fixation allows kudzu to flourish even on nonproductive, eroded soils (Lynd and Ansman, 1990; Shurtleff and Aoyagi, 1985).

Climbing vines combine a variety of form and structure, which enable them to place their foliage at the most advantageous positions for best possible growth and geographic distribution. The primary climbing mechanism of kudzu is twining. Twining is achieved by the growth of shoot tips in circular, elliptical or unidirectional patterns, which allow the vine to interact with a variety of upright supporting natural and man made structures (Hegarty, 1991; Teramura et. al, 1991).

Because kudzu often uses other structures for primary support, more energy is allocated to production of leaf biomass that allows for the formation of dense canopies of foliage. A study conducted in 1983 measured the total shoot dry mass in leaf biomass for mature kudzu at 21-28% compared to 1-2% leaf biomass for mature deciduous trees located in temperate zones. Similarly, greater investment in photosynthetic surface vs. support tissue allows higher growth rates in vines compared to trees in the same community, thus allowing a competitive advantage (Teramura et. al, 1991).

Kudzu's large, tri-foliate leaves have adaptive mechanisms that allow the plant to control the amount of sunlight it receives, thus further adding to its competitiveness.

Reversible leaf movement allows for maximizing carbon gain, reduces heat load and decreases chances of cell and tissue death due to extreme light intensity. This mechanism also allows kudzu to survive in shady environments by repositioning the leaf to receive the maximum amount of sunlight possible (Castellanos, 1991).

As discussed earlier, how successfully an exotic species adapts to its new environment depends on its ability to acclimate morphologically and physiologically to its environment. It is clear that kudzu has managed to do just that.

Native Climate, Topography and Land Use

Although kudzu is native to many Asian countries, China and Japan in particular share various common environmental characteristics with the southeastern United States. For example, they each lie within the temperate broadleaf/mixed forest biome that extends from the Great Lakes to the Gulf of Mexico in the United States and includes a majority of China and Japan and the subtropical moist broadleaf forest biome (Fig. 1.3) located in the southernmost regions of China (McKnight, 1996; Melosi, 1989).

Ultisols and Alfisols are the dominant soils in these biomes where broadleaf trees are abundant. Both soil orders are moderately to strongly leached, low to moderate acidic forest soils. Alfisols are relatively fertile and productive for both agriculture and silviculture. Ultisols are poorly suited for continuous agriculture without the extensive use of fertilizer and lime, but nonetheless capable of supporting productive forests. The biome contains a small percentage of Andisols which developed from volcanic ash and are found primarily in the Pacific Northwest regions of the United States and in Japan (Quandt, *et. al.*, 1998).

The climate in the temperate broadleaf forest biome is generally humid subtropical with hot rainy summers and mild winters. Temperatures range from 4°C to 30°C and precipitation rates range from 40 to 60 inches annually (McKnight, 1996). Likewise, the climate in the subtropical moist broadleaf forest biome is mild characterized by low variability in annual temperature and high annual rainfall, often over 78 inches (World Wildlife Fund, 2003).

Native Management Practices

Kudzu has been part of the Chinese and Japanese cultures for over 2000 years. Fabric making was among the many historic uses of kudzu in China. Although the use of kudzu for fabric is not as widespread as it once was, lightweight *ko-pu* (kudzu cloth) and *kung-pu* (offeratory cloth) is still valued for summertime use (Shurtleff and Aoyagi, 1985).

Today it is more common to see kudzu used as rope “straight off the plant seems to work fine” (Britton, personal communication, 2003). The roots are dug and fed to pigs, and it is commonly used for livestock forage. Livestock graze along the roadsides in China, eating the leaves and “it seems to be the young boys' job to take the cow for a walk and dinner” (Britton, personal communication, 2003).

Kudzu is rarely used for food other than in medicinal compounds. *Ko-ken*, diced dried kudzu root, is the primary ingredient in kudzu root tea to treat influenza, fever and dysentery. Kudzu powder, *ko-fen*, is used in medicine and as an ingredient in Chinese cuisine. Most of the extracted starch is sold to foreign markets (Britton, 1999, 2003; Shurtleff and Aoyagi, 1985).

The introduction of kudzu into Japan from China was first mentioned in Japanese manuscripts around 600 A.D. In ancient times the Nara Prefecture, located south of Kyoto in what today is the Kinki district, was the most famous for producing kudzu powder. So much so that the Japanese still call the kudzu powder produced in the region surrounding Mount Yoshino, 'Yoshino Kudzu'. *Kuzu-ko*, kudzu powder, is a product of the root and used to enhance Japanese cuisine. As in China, the root is diced, dried and used as an ingredient in medicinal teas. Comparable to clover and alfalfa in nutrient content, the leaves, roots and vines of the plant are used for animal fodder. Fiber from the roots and vines is used for making cloth, paper and some basic household items such as wallpaper, window coverings and placemats. Chlorophyll from the leaves is used in herbal supplements (Shurtleff and Aoyagi, 1985).

Although kudzu is kept in check primarily by human induced constraints, there are a few natural enemies that cause minor damage to kudzu in Japan. Black leg fungus, rust fungus and the mosaic viral disease are the most common plant diseases to attack kudzu in Japan. Nematodes cause 'root-rot' which weakens the root system, but does not kill the plant (Shurtleff and Aoyagi, 1985).

There are certain insects that feed on kudzu, but they seem to cause only slight damage to the plant. Shurtleff and Aoyagi mention a red fruit bug that feeds on the leaves, inflorescence and seeds of the plant rendering it infertile (1985). Other insects associated with kudzu in Japan include *Chauliops fullax* Scott of Lygaeidae, *Megacopta punctissimum* Montandon of Plataspidae and *Homoeocerus unipunctatus* Thunberg of Coreidae (Tayutivutikul and Yano, 1989).

One characteristic both countries share is a limited amount of arable land available for agriculture. Each country is heavily populated and requires intensive agricultural production to feed their growing populations. In some mountainous areas agriculture is limited to the basin and coastal areas where barley, soybeans and rapeseed are regularly intercropped with rice (Noh and Kimura, 1989).

In addition to the presence of naturally occurring pests and pathogens that serve to limit the spread of kudzu, intensive land use practices combined with commercial and domestic uses of kudzu prove to be the key to successful control of the plant in its native lands.

CHAPTER III

KUDZU IN THE SOUTHERN UNITED STATES

An important addition to this study is the investigation of the environmental and cultural factors that facilitated the establishment of kudzu in the southeastern United States. It has been said that the South holds the distinction for the most severely degraded land in the United States (Melosi, 1989). The Fairfield County, South Carolina Soil Survey of 1911 stated that 90,000 acres of cultivated land had to be re-classified as rough gullied land due to inappropriate land use practices. Streams full of eroded material lost their original channel properties and as a result an additional 46,000 acres of rich bottom land was re-classified as swampy meadow land (Bennett, 1939).

What happened to the landscape that once offered a seemingly endless abundance of wealth? This is a complex issue. According to Douglas Helms (1989), the condition of the southern environment in the 1800s was a combination of physical, climatic, economic and cultural events.

Physical Characteristics of the Southern United States Landscape

The soil in the South is inherently susceptible to degradation without human intervention. The South missed the last glaciation so it lacks many minerals normally left by grinding ice. This region has the highest precipitation rate of any region in the continental United States, ranging from 30 to 80 inches and spread evenly across the

seasons. Over time, heavy rains have leached the soil of nutrients leaving behind large deposits of clay. Most of the soil in the southern United States is of medium to low grade texture, thus more prone to erode on hilly or mountainous terrain. In many areas of South Carolina, Georgia, Alabama and Mississippi the deep substratum is made up of loose sandy material, which when incised by gullies, creates deep ravines.

The topography of the southern United States is quite variable, ranging from elevations below 100 feet above sea level in the coastal plains to over 6,000 feet above sea level in the Blue Ridge Mountains, with any combination of hills, rolling plains and vertical cliffs found in between (Bennett, 1939; Hilliard, 1984).

Southern Economy and Culture

Elevation, weathering, plant occupation, erosion, transportation and deposition are all part of the normal geologic cycle that has created the features of the landscape over time. In certain areas humans have accelerated this process causing great damage to the environment. Hugh Hammond Bennett in his landmark book, *Soil Conservation*, states that “lack of foresight and restraint...has created in the country a land problem of tremendous implications” (Bennett, 1939, pg. 8).

For the first 100 years, settlement was generally restricted to the Eastern Seaboard because of the dense belt of forested land extending from the Atlantic to the prairie. The ever-expanding population and desire for new territory stimulated westward settlement. The ‘myth of inexhaustibility’ prevailed as settlers consistently depleted the natural resources of the land. Protective forests were cut from sloping hillsides and watersheds to provide housing and fuel. Grasslands were plowed under for cultivation and minerals were extracted from the earth at an increasing rate. Rapid development of agriculture,

industry, commerce, trade, transportation and communications all led to further expansion into the wilderness and degradation of the landscape.

When the colonists settled the Eastern Seaboard, they brought with them methods of cultivation adapted to climates of gentle rain and flat, smooth topography. Shallow disc plowing failed to incorporate nutrients into the topsoil; thus crops quickly rendered the soil infertile and fields were abandoned. Row cropping “straight up and down” the rolling landscape” created watercourses for frequent and heavy rains (Cowdrey, 1996, p.79).

Prior to 1789, tobacco was the staple economic crop in the colonies. Intensive tobacco farming depleted the soil of nutrients and the land was abandoned in search of new lands. The tobacco culture spread throughout the tidewater region until trade routes to the West Indies were closed due to the effects of the Revolutionary War. Eventually corn and wheat replaced tobacco as staple crops (Cowdrey, 1996).

Historically, the South produced a variety of crops. Oats, rye, barley and Irish potatoes were grown primarily in the northern regions of the South while sweet potatoes, peas and beans dominated the southern regions. Tobacco was produced in small quantities all over the south; however commercial production was limited to a few counties in Kentucky and Virginia. Rice was concentrated along the coastal areas of South Carolina and Georgia (Cowdrey, 1996).

Cotton by far was the crop that most defined the South. According to Sam Bowers Hilliard the census first recorded cotton production in 1840, although there are some reports of cotton being grown prior to that date. A majority of cotton production was in eastern Georgia and west central South Carolina. It soon spread northeastward into North

Carolina and Virginia. By 1820, cotton was being produced in the Alabama Black Belt, the Tennessee River valley of Alabama and central Tennessee as well as in Louisiana and Mississippi. By 1830 production had spread to southwestern Georgia and western Tennessee. During the next 20 years, production areas continued to spread and soon merged producing what is commonly referred to as the Cotton Belt (Cowdrey, 1996).

The Civil War inflicted heavy casualties not only on the population, but agriculture and the economy as well. The Confederate currency no longer had any value. Owners of large tracts of property, who were forced from their lands, found their estates in ruins when they returned. In an effort to recoup losses, many of the landowners partitioned their lands, sold what they could, and rented the rest to tenant farmers (Cowdrey, 1996).

The development of the one-crop credit system created an environment of dependency in the South. Many farmers, who once relied on subsistence farming, were forced to turn to commercial farming of cotton and tobacco. Between 1865 and 1925, farmers were forced to pay inflated prices for farming supplies and charged high interest rates on crop liens. As a result, landowners became increasingly dependent on local merchants to finance even the most basic farming supplies. Subsequently, local merchants became financially dependent on regional wholesalers' to sustain their businesses. The regional wholesalers' were in turn subsidized by Northern and English bankers. In order to make a profit, the bankers required the tenant farmers to meet a quota. What was once viewed as a way to save the South became an endless, vicious cycle of dependency (Cowdrey, 1996).

The crop-lien system was as devastating to the landscape as it was the economy of the South. The practice of monoculture was once notorious for rapidly depleting the soil of vital nutrients. Owners of large estates who rented their land were often far removed from the reality of the condition of the land. Additionally, most tenant farmers were uninformed of proper land use practices and were mainly concerned with short term productivity rather than long term management applications. By 1933, most of the South was an ecological disaster (Bennett, 1939; Hilliard, 1984).

The Establishment of Kudzu in the Southern United States

Although agriculture reform began in the late 1800s with the advent of agricultural societies, farming journals and the development of agricultural science by Sir Humphrey Davys, it was not until May 11th, 1934, that the seriousness of the situation drew national attention. On that date, displaced topsoil from Texas, Oklahoma, Kansas and Colorado darkened the skies over the eastern United States. From 1931-1941 there were over 300 dust storms on the southern plains. Looking back, this climatic event and others like it during the dust bowl years led author and historian Donald Worster to believe "The ultimate meaning of the dust storms of the 1930s was that America as a whole, not just the plains, was badly out of balance with its natural environment" (Worster, 1979, p. 43).

Franklin D. Roosevelt established the Soil Erosion Service (SES) in 1933 in an effort to educate farmers in basic soil conservation methods. In April of 1935, just two weeks after one of the largest dust storms of the Dust Bowl, the SES was transferred over to the United States Department Agriculture and became the Soil Conservation Service (SCS). Directed by Hugh Hammond Bennett, the SCS was devoted to three broad

objectives; (1) to educate the farmer and public in sound land use practices, (2) encourage integration of local, state and federal government in conservation policies and (3) the relief of economic and social pressures that prevent proper soil conservation (Bennett, 1939; Cowdrey, 1996).

To be fair, farmers in the South were not ignorant as to the plight of the soil. Many of them cared for the state of the land, and cared deeply. In *Front Porch Farmer*, Georgia farmer Channing Cope states "Soil erosion is not merely topsoil being moved off the land. It is school erosion, church erosion, and family erosion. Everyone is affected." (Cope, 1949, p. xv). In the late 1890s a local farmer named C.E. Pleas noticed that his cattle would graze on kudzu from time to time. He began experimenting with kudzu as a source for forage and by 1902 began growing kudzu as a field crop. Around 1910 Pleas and his wife began selling kudzu cuttings through the mail and published a pamphlet entitled *Kudzu: Coming Forage of the South* in 1925.

Channing Cope agricultural writer for the *Atlanta Journal Constitution*, host of a daily radio program and farmer, was one of kudzu's biggest supporters. In the late 1930s he began planting his 700 acre Yellow River Farm with kudzu and various other forages in an effort to stop erosion. In 1943 he started the Kudzu Club eventually boasting 20,000 members, and in 1949 he published a book entitled *Front Porch Farming*. In fact, Cope was so enamored with kudzu he stated that "if the Chinese had protected their kudzu...there would be no Gobi desert in central Asia" (Cope, 1949, 27). It is no wonder Cope was considered by many to be the 'father of kudzu' (Bell and Wilson, 1989; Stewart, 1997).

In the early 1930s, agriculture experts began to advocate kudzu as the plant to save the South. As forage, it was found to have crude protein content of 15-18% and total digestible nutrient value of greater than 60%. As ground cover, it could be grown cheaply, replenish nitrogen poor soil and was good for continuous grazing. Despite farmers' early suspicions, by 1934, over 10,000 acres had been planted in the South (Everest *et. al.*, 1991; Stewart, 1997).

The Soil Conservation Service took over the production of kudzu in 1935. Seed preparation and experts in nurseries located at Agricultural Experiment Stations supervised the preparation of seeds and growth of the seedlings. After the seedlings became dormant in the fall, Civilian Conservation Corps (CCC) workers removed the vines on the surface for easier access to the root systems. The roots were then cut in pieces and seedlings lifted by hand. The seedlings were sorted, tied in bundles of 25 and placed on a truck for distribution. Millions of seedlings were distributed in this manner to farmers who were paid \$8 an acre to plant kudzu in their fallow fields. The CCC was employed to plant seedlings along roadways, gullies and riverbanks. Between 1935 and 1946 over one-half million acres of kudzu were planted across the South (Everest *et. al.*, 1991; Stewart, 1997).

Disenchantment with Kudzu

In the late 1940s, fears that the plant would get out of hand became a reality. The SCS received complaints from power companies that kudzu planted along the roadways was climbing up power lines and causing power outages. Similarly, railroad engineers complained that the vine growing across the tracks often caused trains to lose traction and skid to a stop. Highway engineers had to constantly cut back vines growing across

roadways. Some of the biggest complaints came from the forestry industry as kudzu invaded forests destroying trees. In 1953, the SCS ceased seedling production in its nurseries, and in 1955 stopped planting kudzu altogether. Kudzu was officially listed as a weed in 1970 and added to the Federal Noxious Weed List which was enacted in 1997 as part of the Plant Protection Act (Mitich 2000; Stewart, 1997; U.S. Senate, 105th Congress, 1997).



Figure 3.1 Kudzu Covered House, Kerry Britton, USDA Forest Service, at <http://www.invasive.org>

What happened to change the publics' perception of the 'miracle vine'? The Law of Unintended Consequences states that every action has an equal and unexpected reaction. This is particularly true when humans initiate such action. However, these were desperate times and desperate times often call for desperate measures. What researchers did not know was that many alien species have a lag phase of 10-20 years before they

experience exponential growth. They also did not realize that in an effort to reclaim the eroded lands, they actually created a condition that in the future would require reclamation of the lands from kudzu.

CHAPTER IV

CURRENT MANAGEMENT PRACTICES AND POTENTIAL USES OF KUDZU

Sociologists Kathleen Lowney and Joel Best (1998) describe the early period of kudzu's presence in the United States as the 'enthusiastic period' (1917-1953), in which the plant was touted by agronomists as the agricultural solution to the erosion problem in the South. The subsequent shift from management efforts to eradication attempts *i.e.*, the 'period of disenchantment' (1954-1984) reflected a drastic change in societal and governmental attitudes towards kudzu. This chapter discusses what Lowney and Best (1998) would describe as the 'period of tempered enthusiasm' (1985-present) in which researchers and entrepreneurs actively search for new ways to manage and utilize kudzu.

Years of experience have proven that one control method alone is ineffective in eradicating or controlling kudzu. Many researchers and policymakers believe that an Integrated Weed Management System (IWMS) that utilizes all proven methods based on scientific facts, current technology and economic considerations is the best hope for the control of kudzu and other noxious weeds (Weed Science Society of America, 2001). IWMS combines preventive measures, traditional chemical and mechanical control, prescribed burning with biological control agents and developed commercial uses for kudzu (Miller, 1997).

Current kudzu control methods are costly, time consuming and potentially harmful to the environment. The most effective way to control kudzu is by eradicating the plant; however eradication methods frequently involve multi-year treatments with a

combination of mechanical and chemical means. Additionally to prevent reestablishment, the area must be continuously monitored and follow up treatments applied as necessary. Older infestations and those near sensitive habitats such as water bodies are virtually impossible to eradicate (Miller, 1997).

Over the years, agronomists and foresters alike have experimented with many different herbicides for kudzu control. Of the 12 herbicides registered for kudzu control products containing picloram have proven to be the most cost-effective. These herbicides are labeled as restricted use herbicides and require permits from county or state regulatory agencies. Picloram is highly water soluble and can leach through sandy soils contaminating groundwater and nearby desirable vegetation. Additionally, picloram products tend to remain active in the soil for extended periods delaying the subsequent introduction of desirable plants into the area (Miller, 1996).

Biocontrol

According to the *Weed Science Society of America Position Statement on Biological Control of Weeds*, biological control of weeds is the use of “an agent, a complex of agents, or biological processes to bring about weed suppression” (WSSA, 2001). If the weed in question is a non-native weed, this involves returning to the homeland of the weed, carefully selecting several natural enemies that do not feed on other plants then introducing and releasing them to establish and feed on the target weed. While this does not eradicate the weed, it does reduce its aggressiveness and abundance to economically and ecologically feasible levels (Atlanta Kudzu Conference, 1998).

Like traditional chemical treatments, biological control of kudzu can be time consuming and expensive. Dr. David Orr, an entomologist at North Carolina State

University in Raleigh states in an interview with the *Washington Post*, that in the early stages of his research, he has spent approximately 400,000 dollars of state and federal money. He estimates it will take at least another 5 -10 years of work and an additional 1.5 million dollars to create a successful biocontrol agent for kudzu (Pressley, 1998). The primary advantage to biocontrol is that once established, it can provide permanent control over the weed with very little additional expenditure for management (Atlanta Kudzu Conference, 1998).

It is understandable that land managers dealing with kudzu would be hesitant to use biocontrol methods; after all, kudzu was once used as a biocontrol agent to halt erosion. Many lessons have been learned since kudzu was introduced into the U.S., subsequently the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) and the Environmental Protection Agency have enacted strict guidelines to review petitions for the biological control of weeds.

Many studies are currently underway to discover a suitable biocontrol agent for kudzu control. Researchers from the U.S. Forest Service have been working closely with scientists in China to conduct surveys for potential biocontrol agents. Insect feeding, mating and egg laying behavior of 25 insect species were observed as well as rates of defoliation and damage to main vines and branches. To date, 7 of the 25 species known to feed on plants other than kudzu have been dropped from consideration. Researchers have also identified 6 fungal pathogens that may prove to be useful in kudzu biocontrol (Britton *et. al.*, 2000).

Japanese entomologists are also studying the biology of insects associated with kudzu. A preliminary study in conducted in Yamaguchi City in 1984 found many species

known to feed, breed or live on the plant. Three herbivorous insects dominant in the Yamaguchi area: *Chauliops fallax* Scott of Lygaeidae, *Megacopta punctissimum* Montandon of Plataspidae and *Homoeocerus unipunctatus* Thunberg of Coreidae (Tayutivutikul and Yano, 1989).

Most biological control research focuses on the insects of kudzu's native environment while almost nothing is known of its ecology and interactions with insects in the United States. Dr. David Orr and colleagues are studying of the biology of three insects native to the United States including the soybean looper, *Pseudoplasia includens* Walker. The soybean looper actively feeds on kudzu and is in turn preyed upon by a common native parasite, the *Copidosoma truncatellum* Dalman, a stingless wasp, which would keep the population in check. This would allow for a large number of insects to be released into field plots without the fear of non-target impacts on surrounding vegetation. It is hoped the information collected in this study will help to use the soybean looper as a model foliar feeding insect for comparisons between kudzu populations from the U.S. and China (Kidd and Orr, 2001).

Fungal pathogens are also being considered as biocontrol agents for kudzu. Initial studies have shown the fungus *Myrothecium verrucaria* to be highly virulent against kudzu in a controlled greenhouse environment. Similar results were observed in a naturally occurring patch within 14 days of inoculation. To date, no harmful effects were noted when the fungus was tested on economically important hardwood and softwood trees. Care must be taken however when applied near soybeans and must be applied with proper timing and application techniques to avoid damage (Boyette *et. al.*, 2002).

In February of 2000 *The Daily Oklahoman* reported the discovery of another fungus that shows potential for kudzu biocontrol. Jeremy Farris, a Georgia high school student, while working on a science fair project, identified *Colletotrichum*, a stress pathogen that attacks plants already subject to stress by drought or other circumstance. *Colletotrichum* causes kudzu to develop lesions on the leaves and stems. Unfortunately, this fungus also attacks pecan, apple and peach trees (Nesmith, 2000).

The Japanese and Chinese have used kudzu to feed grazing cattle, sheep and goats for centuries. U.S. farmers, during the 'enthusiastic period' also used kudzu as forage for their livestock. Recently, researchers have renewed their interest in kudzu as a feed for ruminants. Nutritional comparisons show the leaves, stems and roots of kudzu are comparable to other forages commonly fed to ruminants. Preliminary results show no difference in color or flavor of milk in dairy cattle. Further study is needed to test its support of animal performance, milk composition and yield, growth and reproduction and to determine if anti-nutritional factors are present (Corley *et. al.*, 1997).

Studies are also underway to determine if goats may be an effective biological agent for the control of kudzu and other noxious weeds. An experiment conducted at North Carolina State University in Raleigh was designed to determine if brush goats could thrive while in turn controlling kudzu. Results indicate goats may offer an economical alternative to traditional methods of control (Luginbuhl *et. al.*, 1996). Similar studies at the Tuskegee Institute in Alabama show that Angora goats can be successfully grazed using kudzu as their primary forage (Rhoden *et. al.*, 1991).

Commercial and Industrial Use

According to Shurtleff and Aoyagi (1985), the key to successful control of kudzu in the west is to utilize similar management strategies employed by China and Japan.



Figure 4.2 Kudzu along roadside in North Carolina. Photo courtesy of Dr. James Lowry, Stephen F. Austin State University

This includes utilizing all of the by-products of the plant for commercial and industrial use. China and Japan regularly use kudzu for commercial uses such as paper and textile production. In the United States, the Pynyon Press of Atlanta, Georgia has been attempting to duplicate the oriental process for papermaking. The company successfully produced a paper from kudzu for artists that proved to be mold resistant, non-fading and slow to brittle (Tanner, *et. al.*, 1979).

The Georgia Institute of Technology pulp and paper program has been researching ways to manufacture kudzu paper. Preliminary results produced rough sheets of paper unsuitable for commercial use. Dr. Jeffrey Hsieh, director of the project, states that technology needs to be refined before it can compete with paper made from wood fiber. He also cited the need for increased funding to aid in the development of commercial uses for natural products including kudzu (Anonymous, 1994).

The USDA National Research Initiative Competitive Grants Program (NRICGP) awarded a \$150,000 grant in 1997 to the Textile, Retail and Consumer Sciences Department at the University of Tennessee to determine the feasibility for commercializing kudzu paper products. The purpose of this study was to determine if kudzu can be made into paper using industrial paper machines. It also investigated various chemical and mechanical methods of pulping kudzu and ways to improve its strength. The study hopes to identify specific end use applications and potential markets for kudzu paper products (USDA National Research Initiative Competitive Grants Program, 1997).

A recent study at the Department of Materials Science and Engineering at the University of Tennessee investigates the feasibility of using kudzu fiber as reinforcing material in polymer composites. Chemically treated kudzu fibers extracted from the interior part of the plant can be converted into long staple fibers and used as marine lumber for floating and stationary docks, outdoor maintenance-free decks, and automobile parts to reduce weight and decrease fuel consumption, and increase recyclability (Luo *et. al.*, 2002).

The search for alternative sources for fossil fuels began in earnest in the early 1970's. Research conducted at Vanderbilt University in 1979 studied the feasibility of using the vines of the kudzu plant in combination with coal for the production of steam in electric power plants. While kudzu only has half the heating value of coal, the low-sulfur, fast growing renewable resource could serve as a partial local solution to environmental pollution. By blending kudzu biomass with high sulfur coal, the total sulfur content can be reduced to meet air pollution regulations (Tanner *et. al.*, 1979).

More recently, much research has focused on using renewable natural resources for alternative fuel sources or biofuels. Studies suggest that ethanol produced from cellulosic biomass could be a viable alternative to ethanol produced from corn. Cellulosic biomass includes anything that grows or has grown, such as agricultural and forest residues, prairie grass, kudzu, waste wood, used paper products and much of urban wastes. In 1998, 95% of the ethanol produced came from corn. Utilizing the above sources of biomass with no additional land use could supply over 15 billion gallons of ethanol a year, 10 times more than corn (Lugar and Woolsey, 1999).

Biotechnology allows plants to become more efficient providers of food, fiber, and medicine. It also allows plants to be used in unique ways to better the environment. Phytoremediation is the use of plants to remove pollutants from the environment or to render them harmless. Potential threats associated with accumulation of heavy metals in the environment include reduction of ecosystem diversity, plant and animal death and reduced rates of reproduction in affected organisms (Gleba *et. al.*, 1999).

Heavy metals are often discarded into lakes and streams or washed into water bodies during rain. There they bioaccumulate in the food chain, posing a threat to public

health and wildlife. Mining and manufacturing are the primary cause of heavy metal accumulation, however urban and agricultural runoff can contribute significant amounts of certain metals. This research examines the use of kudzu as a medium for the capture of copper, cadmium and zinc from low concentration aqueous solutions. The same characteristics that made kudzu desirable for erosion control can be useful as forming a living biomass filter through which runoff must pass before intersecting a waterway. Kudzu already present on a hillside could be demonstrated as a low cost best management practice to control erosion and provide a medium for the capture of pollutants present in agriculture runoff (Brown *et. al.*, 2001).

Industrial dyes produce environmental hazards when colored agents interfere with the transmission of light through water and hinder photosynthesis, resulting in ecological imbalance. It is estimated that out of the 10 million kg per year of current world production of dye, between 1 and 2 million kg of active dye enter the biosphere, either dissolved or suspended in water. The removal of such colored agents from flowing water is of significant environmental and commercial importance (Allen *et. al.*, 2003).

Studies are underway to assess the use of dried kudzu as an adsorbent medium for the removal of two basic dyes, Basic Yellow 21 and Basic Red 22, from aqueous solutions. Initial results of the study showed that kudzu's capacity for color removal was not as high as an activated carbon, but it proved to be a potential alternative to activated carbon when carbon cost is excessive (Allen *et. al.*, 2003).

Medicine and Nutrition

During the last decade more attention was focused on the production of new and alternative crops for pharmaceutical and nutritional use. For example, the chemical

daidzin, found in kudzu is thought to be a cancer preventive. Researchers from Monash University's Institute of Reproduction and Development in Melbourne, Australia discovered that isoflavone metabolites found in legumes such as soybeans and kudzu appear to affect malignant tumors in one of two ways; by causing cancer cells to alter their structure or die (Johnstone, 1999).

Some of the most promising research is the use of kudzu as an antidipsotropic (anti-alcohol abuse) agent. Researchers at the Center for Biochemical and Biophysical Sciences and Medicine, Harvard Medical School in Boston, have demonstrated that an extract from kudzu root suppresses alcohol cravings when administered to golden Syrian hamsters. Similar investigations have confirmed these findings in rats that were either trained or genetically bred to prefer and consume large amounts of ethanol (Keung and Vallee, 1998).

Considering the extent and degree of kudzu establishment in the southeastern United States, it is not surprising that Dr. James Miller of the United States Forest Service states the "general attitude of resignation at all levels of public and private sectors in the Southeastern Regions has hindered support for integrated control and containment" (Miller, 1997). On the other hand, intensive establishment has led to some impressive research in the areas of alternative fuel resources, phytoremediation and medicinal uses for kudzu that may not have been adequately explored in the United States.

Future Directions of Research

This chapter and discussions in previous chapters have shown that most research on kudzu focuses on its ecology, traditional management practices and potential uses. While these are essential in aiding resource managers and decision-makers in developing

effective policy regarding kudzu and other invasive alien plant species, there is little current research focused on the policies themselves. The final chapters of this project focus on policies in place at federal, state and local levels that affect kudzu management and control in the United States.

CHAPTER V

MANAGEMENT PRACTICES ACROSS POLITICAL BOUNDARIES

The natural landscape places limits on what types of management practices are practical in a particular area. It is quite possible that the political landscape places as many restrictions on management as the physical landscape. This chapter discusses how federal state and local entities interact in an effort to develop and implement invasive species management policies.

The federal government acts as an umbrella organization in cooperation with various regional, state and local officials, including non-profit and for-profit organizations to battle invasive species (National Invasive Species Council, 2001). Currently, information on invasive plants is divided between 20 federal agencies and numerous state and local agencies with a majority of the responsibility falling to two agencies, the United States Department of Agriculture (USDA) and the Department of Interior (U.S. General Accounting Office, 2002).

The USDA has by far the greatest impact on invasive species prevention, detection, control/management, monitoring, restoration, research and development. They also provide the public with information on management of invasive species through education and outreach programs. Likewise, the USDA actively engages in cooperative partnerships and activities with various landowners to help them achieve noxious weed control. There are several agencies under the auspices of the USDA that are charged

with specific concerns relating to invasive species (GAO, 2002; NISC, 2001). The following is a short summary of agencies that take a leading role in invasive species management.

The Animal and Plant Health Inspection Service (APHIS) is the agency responsible for preventing invasive species from entering the country. APHIS garners its authority from various laws such as the Plant Protection Act, which incorporates the Plant Quarantine Act, Federal Plant Pest Act and the Federal Noxious Weed Act. These acts enable APHIS to restrict or prohibit the importation or interstate movement of any plant, plant product, biological control organism or noxious weed that the Secretary of Agriculture deems necessary to prevent the introduction into or the dissemination of within the U.S. When a state is unwilling or unable to take necessary action to prevent the diffusion of a plant pest or noxious weed, under the provisions of the Plant Protection Act, the Secretary of Agriculture has the authority to declare an extraordinary emergency and take the necessary steps to prevent the propagation of the species within the borders of the state (GAO, 2002; NISC, 2001).

The Agricultural Research Service (ARS) is responsible for providing scientific and technical support for federal agencies whose main focus is detection of invasive species at ports of entry into the U.S. as well as the rapid identification of species that might become invasive when introduced into the U.S. Additionally, the ARS provides support for pesticide and herbicide application technology, aids in the development of biologically based controls and helps monitor target pests of Integrated Pest Management Programs (GAO, 2002; NISC, 2001).

The Forest Service (FS) has the jurisdiction for the management of invasive species in its 192 million acre national forest and grasslands system. The FS has authority to prevent the spread of invasive species onto National Forest System (NFS) lands and may assist other Federal, State and non-governmental entities in preventing the spread onto non-federal lands under its cooperative authorities, such as the Landowners Assistance Program which provides private landowners assistance in protecting, restoring and sustaining forests (National Forest Service Landowners Assistance Program, 2003).

The Forest Service can implement projects across state boundaries by combining resources from the NFS and State and Private Forestry Deputy Areas. In locations where a national forest is contiguous to private land, and invasive species have invaded an area, the Forest Service can allocate funding to that particular area in a coordinated effort to eradicate or control the invader (Tenny, 2002).

The Cooperative State Research, Education and Extension Service (CSREES) in conjunction with the land grant university system, works primarily at state and local levels to fund research, extension and education initiatives to manage infestations and promote restoration. These efforts include participation by and cooperation with scientists and educators at non-land grant institutions and from private sector organizations. CSREES provides the general public with information on cost-effective management, and environmentally safe control of invasive species using biological, chemical, cultural, and mechanical practices (GAO, 2002; NISC, 2001).

One of the concerns expressed by the U.S. General Accounting Office is the lack of analysis that has been done to examine the potential of a new species to invade new locations and to estimate their economic impact on that area. The Economic Research

Service (ERS) Program of Research on the Economics of Invasive Species Management (PREISM) was developed to conduct specific research about potential economic consequences of invasive species, as well as provide cost-benefit analysis for proposed management programs. PREISM supports research through competitively funded grants and cooperative agreements that focus on economic research, evaluation, modeling and decision support systems relating to invasive species issues (Economic Research Service, 2003; GAO, 2002).

The Farm Service Agency (FSA) is charged with stabilizing farm income, helping farmers conserve land and water resources, providing credit to new or disadvantaged farmers and ranchers and helping farm operations recover from the effects of disaster. One of the requirements for program participation is that participants employ a comprehensive noxious weed control program on their lands (Farm Service Agency, 2003).

The Natural Resource Conservation Service (NRCS) works primarily with private landowners to aid in prevention and mitigation of invasive species infestations. Additionally, the NRCS is allied together with local, state and other federal agencies and non-governmental organizations, through state technical committees and county level local working groups in each of the 3000 Soil and Water Conservation Districts to disseminate information and technical advice regarding invasive species control. An extensive online database on the PLANTS website (<http://plants.usda.gov>) is maintained by the NRCS and allows the general public and professionals alike to access information on specific invasive species issues (GAO, 2002; NISC, 2001).

Kudzu is found on disturbed land throughout Florida, from the northern panhandle regions extending through central and southern Florida. To the dismay of environmentalists, it has most recently been discovered growing in the Everglades (Florida Department of Environmental Protection, 2000). The Department of Commerce is involved with all aspects of invasive species issues particularly in the area of invasive aquatic species. Although kudzu is not an aquatic invasive species, it has the potential to cause extensive damage to sensitive wetland areas thus, the National Oceanic and Atmospheric Administration (NOAA), under the guidance of the DOC, has regulatory authority to prevent the introduction of and monitor the control of invasive species that may affect marine sanctuaries such as the Everglades (GAO, 2002; NISC, 2001).

The Department of Defense (DOD) is actively involved in the management and control of invasive species by preventing the entry of invasive species in the U.S. as well as controlling invasive species on Defense installations. A recent article in the *Washington Times* states that kudzu covers 128 acres of Fort Picket, Virginia, a training post used by the National Guard, Army, Marines, Navy SEALs, and the anti-terrorist unit Delta Force. There are also extensive populations at Fort Bragg, North Carolina, Redstone Arsenal in Alabama and Fort Jackson, South Carolina (Baskervill, 2002).

The Environmental Protection Agency (EPA) has regulatory authority over certification of compounds included in pesticides/herbicides listed under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and is authorized to place limits on the conditions under which they may be used. For example, before a company can sell an herbicide in the U.S. the EPA under the guidance of the National Environmental Protection Act (NEPA), must review studies to determine it will not pose unreasonable

risks to humans or the environment. In addition, the EPA is obligated under the Clean Air Act to review and make public its comments on Environmental Impact Statements (EIS) of major federal actions (Environmental Protection Agency, 2003; NISC, 2001).

The Department of Interior (DOI) oversees 507 million acres of surface land, or about one-fifth of the land in the United States, including lands managed by the Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), United States Geological Survey (USGS) and the National Park Service (NPS). Each of these agencies is responsible for invasive species management in their respective jurisdictions (EPA, 2003; NISC, 2001).

The Bureau of Land Management (BLM) actively manages invasive species on approximately 260 million acres in the western states and Alaska. It has implemented a plan called Partners Against Weeds to fund cooperative efforts with landowners to prevent and control the spread of invasive weeds on private lands. This funding also includes provisions for cooperative outreach and education projects with schools and local governments (EPA, 2003; NISC, 2001).

The Fish and Wildlife Service (FWS) is responsible for controlling invasive plants and animals in the 93 million acre National Wildlife Refuge System (NWRS). It works with private landowners to implement projects that eradicate and control invasive species on lands adjacent to NWRS. Additionally the NWRS has invasive species teams such as the Lower Tennessee-Cumberland Ecosystem Team to develop and implement plans to control invasive species and protect affected trust resources (U.S. Fish and Wildlife Service, 1995).

The United States Geological Survey (USGS) through the implementation of the

Biological Resources Division (BRD) and National Biological Information Infrastructure (NBII) supports resource managers in their efforts to obtain reliable information on invasive species, develop methods and tools to prevent and control invasions and reduce their impacts on ecosystems. The Biological Monitoring and Research Program of the USGS focuses research on areas managed by the Department of Interior and regions notably threatened by invasive species, such as the western rangelands, various wetlands and Hawaii. The program incorporates the use of remote sensing, Global Positioning Systems (GPS) and Geographical Information Systems (GIS) technologies to detect and monitor invasions (EPA, 2003; NISC, 2001).

The National Park Service (NPS) incorporates an Integrated Pest Management Systems (IPMS) approach to the control of invasive species within its jurisdictional boundaries. Since National Parks often encompass many states, it is imperative that the NPS work cooperatively with local, state and federal organizations to manage invasive species. The Natural Resource Challenge was created to facilitate this cooperation. This management strategy established Exotic Plant Management Teams (EMPT) to form partnerships with local and regional entities involved in invasive species management. For example, the Florida EMPT formed partnerships with the Florida Department of Environmental Protection and over 100 other groups to control invasive plants. Together they fund the removal of exotic species in 11 units of the NPS in Florida (U.S. House, 107th Congress, 2001). Similarly, the NPS has assisted with the establishment of several Exotic Pest Plant Councils to represent dozens of agencies dealing with invasive plant issues at the federal, state and private levels (National Park Service, 2003).

It is reasonable to assume that since so many federal, state and local agencies are

charged with invasive species activities there would be conflicts in the implementation of effective management policies. Although federal laws establish national policy, it is not feasible for these laws to encompass all manner of invasive species. Likewise, each federal agency has its own list of priorities based on differing agendas. For example, although kudzu does occur in limited areas under the authority of the BLM, it is not considered a serious threat to western lands; therefore the BLM promotes management activities only when it deems necessary. On the other hand, kudzu has garnered a place of high priority among the NPS and FS particularly in the southern and eastern regions of the U.S. where the plant is highly prevalent.

Often federal laws are either so broadly constructed or so narrowly focused it is not clear what agency has the authority or jurisdiction to deal with specific invasive species threats. A report issued by the National Plant Board in 1999 stated that laws giving APHIS its authority are passed in response to specific plant threats and the various overlaps and gaps in this process often leave the agency unsure of which authority to apply in any given case (NISC, 2001).

The enactment of comprehensive state laws help to fill in gaps left by federal laws, however there are at times conflicts between federal and state agencies. For example, states cannot legislate in direct conflict with federal law. Similarly they cannot implement invasive species policies on federal lands with a cooperative agreement. This can hinder state based control efforts when kudzu is located on federal lands (Office of Technology Assessment, 1993).

Like federal agencies, states often experience conflicts with neighboring state because of differing economic, ecological and political agendas. When this is the case,

regional approaches such as the involvement of regional pest plant councils provide states with the opportunity to resolve disputes and influence neighboring states. These organizations are often highly effective, yet they do have limits. Since they are non-profit organizations based on voluntary membership, they have no legal authority to implement policy (OTA, 1993).

In an effort to rectify these issues, The National Invasive Species Council (NISC), established by Executive Order 13112, was created to provide national leadership and oversight on invasive species issues and facilitate the coordination of federal, state and local invasive species activities (NISC, 2001).

The NISC is co-chaired by the secretaries of Agriculture, Commerce, Interior, as well as the secretaries of State, Treasury, Defense, Transportation and the Administration of the EPA. Additionally, there are federal entities in place that provide for the sharing of information among the numerous agencies regarding invasive species. For example, the Federal Interagency Committee on the Management of Noxious and Exotic Weeds (FICNMEW) shares scientific and technical information and enhances collaborative efforts among federal agencies by sponsoring technical and educational conferences and workshops (NISC, 2001). Technical liaisons from the DOI, USDA and DOC also strive to facilitate the flow of information between various federal agencies and council members. In addition, the Council draws on existing state and local invasive species authorities to augment and coordinate research, funding and implementation of active invasive species management plans (NISC, 2001).

This chapter has offered a brief overview of issues and concerns in relation to invasive species management policies across political boundaries. It is evident that much

progress has been made, yet it is also evident that there is much more to be addressed.

The enactment of Executive Order 13112 and subsequent creation of the National Invasive Species Council is a positive step toward a more unified public invasive species policy. It must be understood, however that the problem of invasive alien species is not a new one and that what current policies are in place have evolved over a period of many years.

CHAPTER VI

COMPARISON OF MANAGEMENT POLICIES ON A TEMPORAL SCALE

As discussed in the previous chapter, invasive species policies are often developed in response to a specific threat and given priority depending on present ecological, economic or political situations. Policies are also implemented on the basis of past experience or in the light of historical evidence.

This chapter compares management policies of states with long histories of kudzu infestation (*e.g.* Mississippi, Georgia and Alabama) and states with relatively short histories of infestation (*e.g.* Oregon, Washington and Illinois). Mississippi, Georgia and Alabama were chosen for this study because they reflect how current kudzu management policies are influenced by past experience. Oregon, Washington and Illinois represent states whose kudzu policies are influenced by knowledge gleaned from others past mistakes.

Mississippi, Georgia and Alabama

Despite years of intensive research and control efforts, kudzu has continued to retain its hold on the South. When discussing kudzu management policies in these states it is important to keep in mind the long history of kudzu in the South. The initial enthusiasm and subsequent disenchantment with kudzu as well as the degree of infestation plays a vital role in how attitudes toward kudzu are formed, which in turn affects policy toward its management.

The state of Mississippi does not have a comprehensive plan for addressing all categories of invasive species, *i.e.*, insects or fauna, but it has established a council that specifically addresses invasive plant species. The Mississippi Exotic Pest Plant Council (MEPPC), formed in 2001, has over 30 members from state and federal agencies, universities and private non-profit and for-profit organizations (ELI, 2002).

According to Dr. John Byrd, the prevailing attitude toward kudzu varies by landowner. A majority of people still actively fighting kudzu are private landowners who derive income from their land. On the other hand, absentee and corporate landowners, *i.e.* John Hancock and timber companies are not overly concerned with kudzu. The general public thinks "what a weed, but isn't it pretty forming that massive topiary!" (Byrd, personal communication, 2003).

Dr. Byrd states that Mississippi has turned its attention toward other invasive species in the state such as cogongrass. Cogongrass was accidentally introduced into the United States from Asia via shipping crates that contained the plant as packing material. It was also intentionally introduced as an ornamental plant and like kudzu was promoted by the USDA as a forage grass and for soil erosion. In addition to displacing many native plant species used by native animals, it also can alter the normal fire regime of an ecosystem by causing more frequent and intense fires (Johnson and Shilling, 1998). Currently there are more program dollars available for cogongrass and it is not as widely distributed across the state as kudzu, making it more economically feasible to control. He also commented that for the past three years the state legislature has defeated an amendment to the State Plant Pest Act to include noxious weeds as pest plants. Additionally, kudzu was not included on the final list of weeds submitted to the

Mississippi Department of Agriculture for inclusion on the state noxious weeds list (Byrd, personal communication, 2003).

Georgia, on the other hand, is still actively fighting to control kudzu. For example, the First Annual Georgia Exotic Pest Plant Symposium held in 1999 in Athens, Georgia highlighted an Integrated Pest Management approach (IPM) specifically for kudzu control (University of Georgia Center for Continuing Education, 1999). In 1999, the Georgia Exotic Pest Plant Council (GA-EPPC), a state affiliate of the SE-EPPC was established to address invasive plant species and adheres to the goals set forth by the SE-EPPC. The GA-EPPC is a non-profit organization that funds activities of the Council by seeking voluntary contributions, in-kind services, grants, or donations to supplement membership fees in order to pay for the activities and functions of the Council (Georgia Exotic Pest Plant Council, 2002).

According to the Environmental Law Institute, how a state chooses to define a particular species will determine the scope of the state's statutes, regulations, programs and authorities toward that species (ELI, 2002). When establishing its Top Ten Exotic Pest Plant List, the GA-EPPC categorized Rank 1 Species according to this definition: exotic plant species which possess characteristics of invasive species spread easily into native plant communities and displace native vegetation. Similarly, the Council defined an exotic pest plant species as an introduced (not native to the United States) plant that has the potential to disrupt or change the plant or animal species composition of a native plant ecosystem. Kudzu is currently ranked as the number one exotic pest plant species in Georgia, therefore any viable project that addresses kudzu management and control

receives priority consideration for funding according to the by-laws established by the SE-EPPC (GA-EPPC, 2002; SE-EPPC, 2002).

To date, Alabama has no statewide plan to address invasive species and is not yet a member of the SE-EPPC. Alabama, like Mississippi, does have a general list of noxious weeds, but kudzu is not included on it (ELI, 2002; Miller and Chambliss, 2002). This shows that resignation is the prevailing attitude toward kudzu management in Alabama. At the state and local level, attitudes play a large part in whether the state receives adequate funding for invasive species control. When the public becomes complacent about kudzu control, it directly affects lobbying for new funding and management programs in the state legislature.

Despite the amount of program dollars available today for management of invasive weeds on Conservation Reserve Program (CRP) and timber lands, few in Alabama choose to pursue these funds (Miller, personal communication, 2003). One reason for this hesitancy could be that because kudzu control/eradication is so time and labor intensive that landowners are easily discouraged. In addition, it often takes up to 2 years for a landowner to receive reimbursement in cost share programs, understandably adding to already mounting frustrations (Byrd, personal communication, 2003).

Illinois, Oregon and Washington

Unlike states that have experienced a long history of kudzu infestation, Illinois and Oregon and Washington tend to take a pro-active rather than reactive view of kudzu management and control. It is interesting to note that much of the success these states enjoy in invasive weed control comes from the fact that they have had the opportunity to view mistakes already made in the southern states. Additionally, by listing kudzu as a

state noxious weed, these states have the backing of their respective state legislatures which enables them the legal authority to prohibit inter/intra state import, sale or distribution of kudzu without a permit (ELI, 2002; Oregon Department of Agriculture, 1999).

A three-year survey conducted by the Illinois Department of Natural Resources (IDNR) found fewer than 100 populations of kudzu covering less than 400 acres, spread across 22 counties (Fig. 6.1). Although Illinois does not have an interorganizational council or statewide plan to address all invasive species, the IDNR in conjunction with the U. S. Fish and Wildlife Service, Natural Resources Conservation Service, Illinois Department of Transportation, Shawnee National Forest, Southern Illinois University and Eastern Illinois University, have been working to assess the kudzu populations in Illinois and to develop plans to begin an eradication program (McClain, 2000). According to Brent Manning of the IDNR, kudzu may be the only invasive species in the state that can be totally eradicated (Speaker, 2001; Illinois Department of Natural Resources, 2001).

According to the Environmental Law Institute (2002, p. 8) "an effective state program affirmatively declares that all non-native invasive species are subject to regulation". Oregon is one of the few states with an interagency comprehensive invasive species council established by the state legislature. The Oregon Invasive Species Council (OISC) is charged with developing a statewide management plan for all categories of invasive species. Oregon also has a State Weed Board that works in conjunction with the State Department of Agriculture to develop a statewide noxious weed strategic plan. In addition, 15 of 36 Oregon counties have active weed control programs (ELI, 2002). The OISC is also authorized to provide grants or loans through the Invasive Species

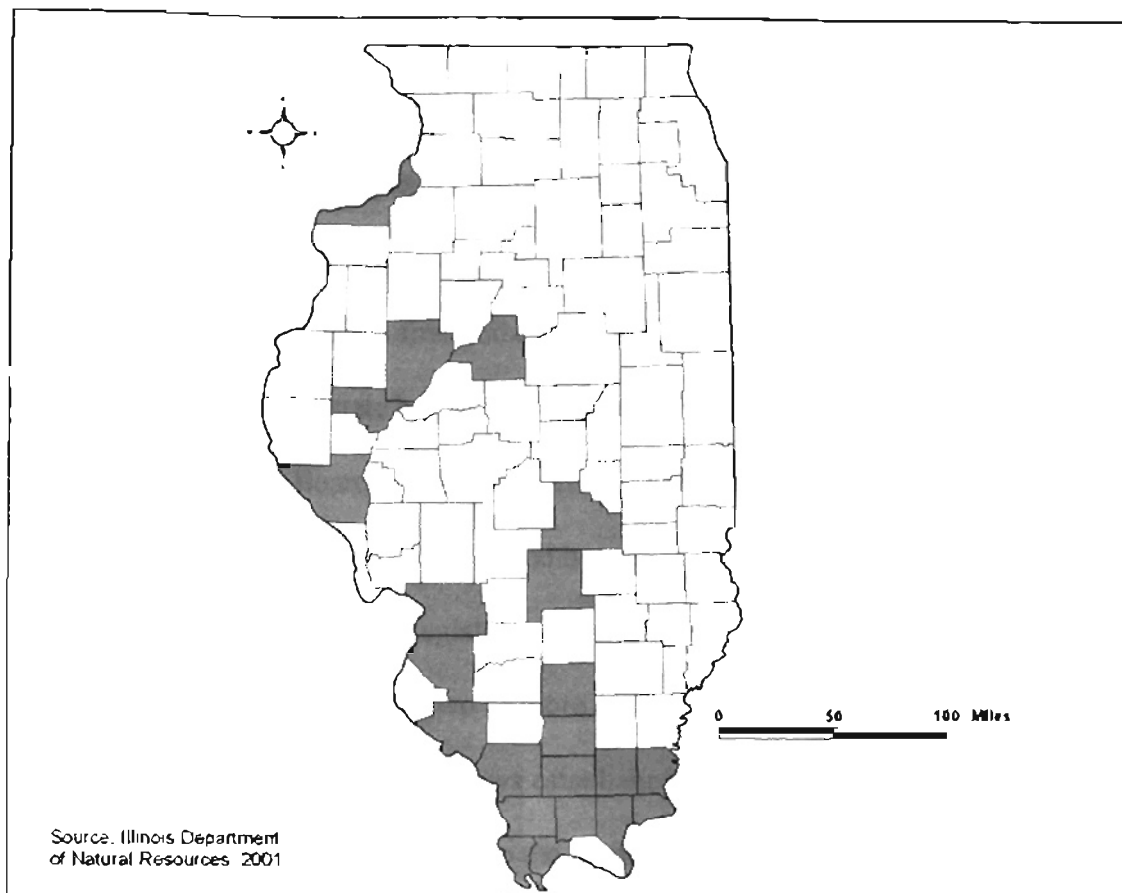


Figure 6.1 Counties Reporting Kudzu Populations in Illinois, 2003

Council Account established in the general fund of the state treasury to agencies, organizations or individuals for eradicating new invasions. According to state law, the Council must create websites, toll free phone numbers or other means of communication necessary for use in reporting sightings of invasive species in Oregon. The Oregon State Weed Board serves an advisory role to the State Noxious Weed Program (ELI, 2002).

Two populations of kudzu were reported in Clackamas County, Oregon, in 2001 (Fig. 6.2). Kudzu is designated as a high priority class 'A' noxious weed in the state of Oregon. A class 'A' designated weed is one of known economic importance (one that can potentially pose a positive or negative economic change in an area) which occurs in the state in small enough infestations to make eradication or containment possible. A class

'A' weed is also one in which does not occur in the state, but its presence in neighboring states make future occurrence in Oregon seem imminent. The Oregon Department of Agriculture (ODA) has subsequently initiated an intensive eradication program that entails a combination of mechanical and chemical methods (ODA, 2001).

Washington reported its first kudzu vine in Clark County, near Vancouver in the fall of 2002. Although the state has no invasive species council, it does have a State Noxious Weed Control Board established by State Law RCW 17.10. This law also has provisions for the activation of county weed boards as deemed necessary by a vote of the people in the respective county. Legislation has also provided for the creation of an Inter County Weed District made up of two or more counties as an additional effort to combat the threat of invasive species. Weed laws established by RCW 17.10 assign primary responsibility of noxious weed control to the landowner, regardless of whether it is private, state or county lands. The purpose of state and county weed boards is to ensure that weed control measures meet the minimum standards set forth by the legislature (Washington State Noxious Weed Control Board, 2003). State Law WAC 16-750 also provides for a State Noxious Weeds List to be updated annually by the State Noxious Weeds Board. As of 2003, kudzu is listed as a class 'A' weed, a non-native species with a limited distribution in the state of Washington. As in Oregon, preventing new infestations and eradicating existing ones is highest priority (WSNWCB, 2003).

States possess a wide variety of tools to address invasive species issues. For states that face an imminent infestation of kudzu or any noxious weed, prevention is the best strategy. This includes the identification and mitigation of future threats, early detection and timely response to invasions; establishing policies that address the importation,

introduction and release of invasive species, the use of quarantines, and above all, public education (ELI, 2002).

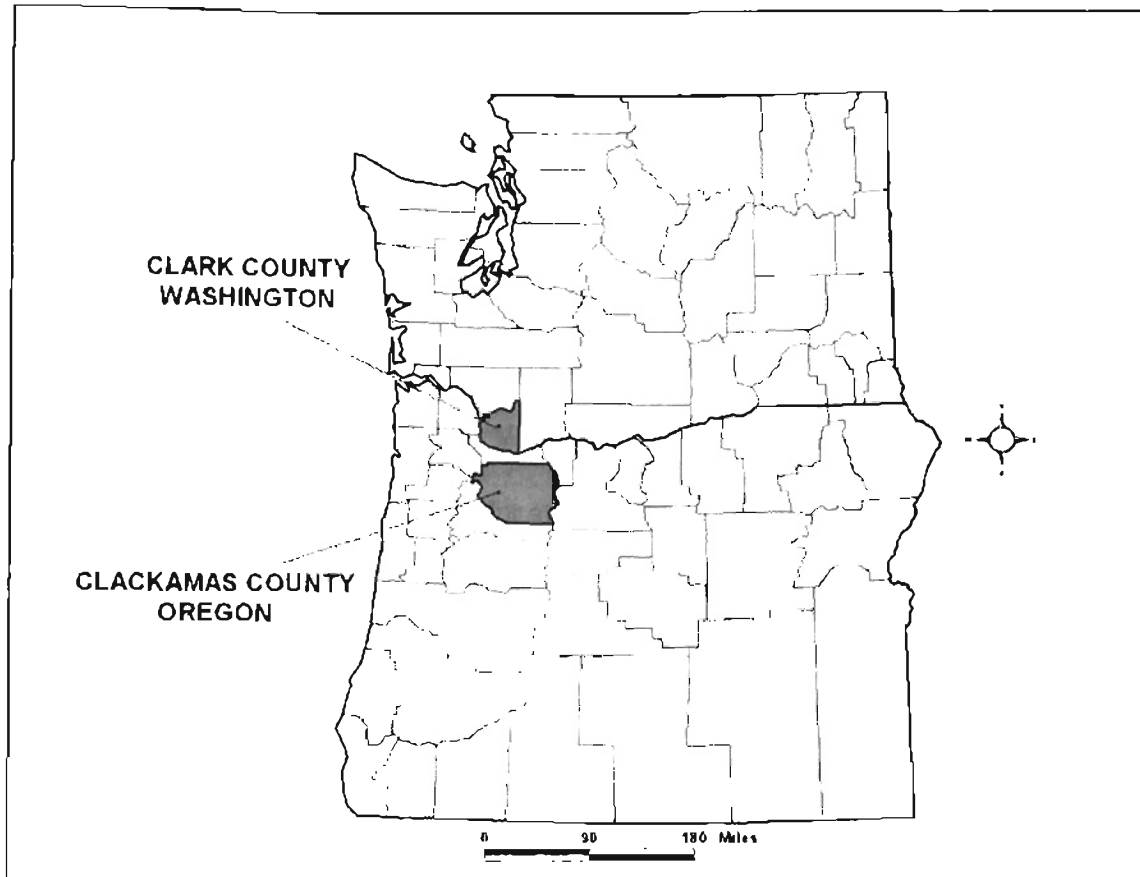


Figure 6.2 Counties Reporting Kudzu Populations in Washington and Oregon, 2003

It is hoped that this chapter has provided the reader with some insight into how the passage of time can influence public perception, attitude and policy toward invasive species issues. States that experienced long and intense histories of kudzu invasions have vastly different priorities in relation to policy and decision-making. States with relatively short histories and fairly well contained populations of kudzu tend to give management of the plant a higher priority in an effort to avoid the mistakes of the past.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

Of the hundreds of non-indigenous plants introduced into the United States, kudzu has perhaps the most controversial history. Within a span of less than a century, it has been loved and hated, praised and ridiculed and has irreversibly embedded itself into the Southern culture of the United States. When traveling through the South, one cannot help but become struck with awe and wonder at the sight of kudzu blanketing trees and fields. It is no wonder there are a host of myths and legends surrounding this incredible plant from the Orient.

A majority of past research on invasive species has focused on their biological and ecological characteristics as well as the susceptibility of ecosystems to these invaders. Likewise, millions of dollars have been directed toward effective control of invasive species once they have become established. While some invasive plant species are capable of invading healthy, intact ecosystems, most prefer disturbed areas such as agricultural lands, roadways and human settlements. Humans are the primary cause of movement and establishment of invasive species, and kudzu is a prime example of this.

Conclusions

Over the years, there have been many attempts by federal and state governments to prevent the introduction and control the spread of invasive species and for the most part such efforts have been described as “piecemeal, *ad hoc* and reactive” (Tibbetts, 1997, p. 594). Historically, federal and state governments have had no unified policy for

combating kudzu or any other invasive species (Miller, J., 1997). These actions are aimed at invasive species that cause harm to agricultural and economic endeavors, while ignoring the potential harm to the natural environment (Miller, 2000).

Invasive species control is most effective at the state level, yet legal authority over this issue varies greatly by state. Several states such as Illinois, Oregon and Washington have substantial legal structures in place; others like Alabama, Mississippi and Georgia have relatively incomplete legal structures in place to deal with invasive species.

For the most part, states retain the power to do whatever they want with state lands within certain limitations, *i.e.*, federal lands within state boundaries and private lands where private property rights prevail (Miller, 2000). Federal land management policies that do not coincide with state and local management policies can create delays, increase costs, and limit the choice of effective treatment control options (Oregon Invasive Species Council, 2002).

On a local level, conflicts between forest users and landowners and urban and rural populations can hinder organizing aggressive programs to control or eradicate kudzu. For kudzu eradication or control to be effective, all landowners must treat their properties simultaneously. Likewise, private landowners adjacent to infested federal lands have difficulty especially if they lack funds to treat their land (OISC, 2002; Miller, J., 1996).

Recommendations

Kudzu has become so entrenched in the South that no one entity or control method can hope to contain its spread. Integrated Weed Management (IWM) offers the

best hope for these areas. IWM is a system that utilizes all proven methods based on the best available scientific facts, current technology and economic considerations. These systems combine preventive measures with biocontrol agents, herbicides, prescribed burning, mechanical and manual treatments. IWMs also encourage the development of commercial uses for the plant (Miller, 1997).

Even as resource managers, land managers and conservationists fight to restrain the spread of kudzu in the South, the public in general tends to see it as a natural part of the ecosystem (Blaustein, 2001). The scope of the problem is defined by people; thus the response to the invasion is defined by people. This is why it is so important to properly define the legal status of an invasive species. If kudzu is designated by federal and state law as a noxious weed, there will be increased efforts on the part of all players to continue with eradication and control measures. Political support is needed to implement effective policies, laws and regulations regarding kudzu control. This depends on the support of the public, which is directly related to the quality of information provided on the seriousness of invasive species control (McNeely, 2001).

Although there are multiple federal laws and programs in place to address the invasive species problem, state and local governments are the ones on the front lines of battle. Even though kudzu and many other invasive plants are not covered by federal mandates, some states such as Oregon, Washington have passed comprehensive laws to address these issues.

According to the Environmental Law Institute, states have a wide variety tools available to them to create strong, pro-active policies for addressing invasive species concerns. The first and possibly most important tool is prevention. This includes (1) the

identification and mitigation of future threats by invasive species; (2) early detection and response to new invasions; (3) import, introduction and release requirements aimed at individuals or entities who consider bringing an invasive species into the state; (4) quarantines enacted to intercept intentional and/or unintentional introductions by trade associations and (5) establishing strong education programs that stress the importance of invasive species prevention and control (ELI, 2002).

Secondly, mechanisms should be in place that allows state authorities to regulate the transportation, release, possession and use of invasive species. These mechanisms may include the (1) issuance of permits and licenses; (2) transportation and shipping requirements; (2) post-release monitoring to assure the species causes no unforeseen damage to the ecosystem; (3) and the issuance of bonds and insurance to ensure those who are responsible for the release of an invasive species are held liable (ELI, 2002).

When prevention fails, as it sometimes does, proper control and management measures need to be in place to assure rapid response to the early detection of an invasive species. The state may choose to authorize a designated agency(s) to act as a first-responder to new invasions. Policies may also be enacted that allow the designated agency access to public and private lands to ensure necessary control measures are in place. Similarly, states may authorize emergency powers to respond to outbreaks that threaten to become permanently established or feared to cause widespread damage. While APHIS and the EPA are the primary federal agencies that regulate the use of biocontrol agents, states should also enact complimentary measures designed to augment federal efforts. Finally, states should implement restoration projects in areas where eradication of

an invasive plant is possible. The restoration process would help protect the area from future invaders (ELI, 2002).

Effectiveness of laws and regulations rely on adequate implementation and enforcement of these policies. Enforcement authorities need to be in place to ensure proper compliance with invasive species laws. States need to have in place (1) broad enforcement policies relating to all categories of invasive species; (2) strict penalties to deter policy violations; and (3) policies to encourage and reward compliance with invasive species regulations (ELI, 2002).

As in the example of Oregon and Washington, the establishment of statewide invasive species councils is often quite effective in developing statewide invasive species plans which in turn facilitate the coordination between various federal, state and local agencies. These councils and plans draw knowledge from a consortium of stakeholders who have a vested interest in kudzu management and control. Additionally, the establishment of regional invasive species councils like the Southeastern Exotic Pest Plant Council is essential in educating the general public and refocusing efforts towards kudzu control.

A Geographic Perspective

The invasive species problem is a dynamic one that spans many social, political and economic boundaries. Likewise, the study of invasive species crosses many academic disciplines. Hence, it is reasonable to suggest no effective study of the invasive species problem can occur within the vacuum of any one entity or discipline. There must be an integrated effort among all involved to achieve success in invasive species control.

The key concepts of geography that give the discipline its distinct identity and unique contribution to the study of invasive species are its ability to study phenomena in relation to space, holism and human-environment relationships over time (Hunter, 1971). Understanding the spatial distribution and interaction of a particular species within its environment as well as its changing spatial pattern through time is essential in assisting resource managers in developing models to predict its potential to spread and invade surrounding ecosystems.

Holism emphasizes the totality of the environment, *i.e.*, the physical, biological and human elements that play a role in the success or failure of an invasive species to establish or spread. Historically, the study of invasive species has focused specifically on physical, biological or ecological aspects of the species itself. More recent attention has turned to human actions that serve to expedite the success of invasive species. *The Great Reshuffling: Human Dimensions of Invasive Alien Species* published by the World Conservation Union is a compilation of articles focused on the human side of the invasive species problem. Articles such as *The Rise and Decline of the "Miracle vine": Kudzu in the Southern Landscape* by geographers John Winberry and David Jones (1973), and *The Changing South: A Vine for Postmodern Times, an Update on Kudzu at the Close of the Twentieth Century* by Dr. Derek Alderman (1989) offer insight into the mindset and society of the South that has made kudzu the cultural icon it is today.

The discipline of geography offers the innate ability to bridge the gap between social, political and economic boundaries as well as various disciplines to assist in the development of successful invasive species management and control.

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GLOSSARY

Alfisols: Moderately leached forest soils that have relatively high native fertility. These soils are well developed and contain a subsurface horizon in which clays have accumulated. Alfisols are mostly found in temperate humid and sub-humid regions of the world.

Alien Species: With respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species, that is not native to that ecosystem. *Synonyms:* 'Exotic' 'Non-Indigenous' 'Non-Native'.

Alluvial plain: Flat area built up of alluvium.

Alluvial soil: General term for soils developed on a fairly recent alluvium.

Alluvium: Sediment deposited by streams and varying widely in particle size. The stone stones and boulders when present are round or sub-rounded. Some of the most fertile soils are derived from alluvium of medium or fine texture.

Andisols: Soils that have formed in volcanic ash or other volcanic ejecta. These soils differ from those of other orders in that they typically are dominated by glass and poorly crystalline colloidal materials. As a result, Andisols possess many unique chemical and physical properties that include high water-holding capacity and the ability to 'fix' (and make unavailable to plants) large quantities of phosphorus.

Control: As appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.

Introduction: The intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.

Invasive Plant: An exotic plant that produces significant change in composition, structure or ecosystem processes.

Invasive Species: An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Native Species: With respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

Noxious Weed: Any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health or the environment.

Ultisols: Strongly leached, acid forest soils with relatively low native fertility. They are found in humid temperate and tropical areas of the world, typically on older, stable landscapes. Ultisols have a subsurface horizon in which clays have accumulated, often with strong yellowish or reddish color due to the presence of iron oxides, such as in the 'red clay' soils of the southeastern United States.

Weed: Any plant that poses a major threat to agriculture and/or natural ecosystems in the United States.

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