INFLUENCE OF POST-SOVIET LAND REFORM ON THE PATTERNS OF LAND USE DYNAMICS IN GAUJA NATIONAL PARK, LATVIA

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ABSTRACT

GREGORY N. TAFF: Influence of Post-Soviet Land Reform on the Patterns of Land Use Dynamics in Gauja National Park, Latvia
(Under the direction of Professor Stephen J. Walsh)

This dissertation analyzes landuse and landcover dynamics in Gauja National Park (GNP), Latvia from the late Soviet period (1985) through 2002. Landcover change in the Park is assessed through analyses of remotely sensed imagery in conjunction with ancillary Geographic Information Systems (GIS) data layers. Changes in landcover composition and patterns are measured using post-classification change analyses of Landsat Thematic Mapper satellite images, and by computing landscape pattern metrics, respectively. These landscape changes are examined with respect to GNP stakeholder group interests, as determined through qualitative interviews with key informants. Statistical regression models are developed to determine effects on the landscape of spatially explicit variables representing social, biophysical, geographic, and political drivers of landcover change in GNP. Finally, a landowner survey conducted by the GNP Administration was geocoded and statistically analyzed using crosstabs with respect to geographically explicit variables to understand important factors affecting landowner attitudes to GNP landuse policies.

Results from the key informant interviews show that community leaders representing GNP residents are interested in broadening landuse rights and compensation for owners of use-restricted lands. Environmental NGOs, Western government organizations, and supra-national organizations promote their interests in preserving

biodiversity in GNP, while Latvian landscape scientists express interest in preserving Latvia's cultural landscape and promoting rural development within the Park.

Landcover change analyses showed an increase in forest cutting immediately after Latvia's independence (in 1991), and, following, a consistent overall growth in forested lands, particularly in the more protected zones of the Park. A decrease in the amount of fields and meadows was evident since Latvian independence, resulting in a deterioration of Latvia's cultural landscape.

Regression analyses showed the most important predictor variables of the type of landcover change, on a per pixel basis, were the management zones of the Park, the distance from large water bodies, the distance to the nearest road, the municipality, and the slope of the land. In addition, crosstab analyses showed that landowners in zones with more landuse restrictions were more likely to be supportive of GNP landuse policies than were landowners in zones with fewer landuse restrictions.

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Chapter 1: Introduction

Background

This research examines the influence of post-Soviet land reform on landuse and landcover (LU/LC) change patterns in Gauja National Park (GNP), Latvia. The focus of this research is to analyze LU/LC changes relevant to Park conservation, the Park's management goals, and interests of GNP stakeholders. This research combines analyses of LU/LC change in GNP via remotely sensed imagery and Geographic Information Systems (GIS) with an analysis of GNP stakeholder interests informed through qualitative and quantitative survey methods.

This research is part of the broader goals of Land Change Science, that focus on understanding how humans change the Earth's landcover; the causes of these changes through space and time; how landuse changes are likely to affect landcover in the future, how human-environment coupled systems function; how changes in climate and biogeochemistry influence and are influenced by landuse and landcover; and how landuse and landcover affect the vulnerability of coupled human-environment systems (Lambin et al. 1999, Lambin 2006). Ramankutty et al. (2006) calls for local, landscape-level LU/LC change analyses that integrate local stakeholders into scientific efforts, so that results can inform decisions of local land managers and policy-makers.

Since the fall of the Soviet Union, LU/LC change in protected areas of the former Soviet Union and Eastern Europe has been of growing interest to the international

environmental community. Reasons for this are that this region has recently become far more accessible for study by global scientific and civil society communities; the region is undergoing massive post-Soviet changes in landuse and landcover; and there is increased global concern over environmental issues relating to landcover change, particularly carbon budget and biodiversity issues (Pavlinek 2000). Latvia, and GNP specifically, are fundamentally affected by their current geopolitical environment, one involving major economic, political, social, and environmental changes over the past two decades. The recent history of land ownership in this region is of particular interest to this study. Between the Second World War and the fall of the Soviet Union in 1991, private land ownership was generally forbidden in lands and territories comprising the Soviet Union. Almost all lands were communalized in the early Soviet era – privately held land titles were vitiated and lands were surrendered to the State. Lands throughout Eastern Europe were also communalized, though Eastern European lands fell under a variety of ownership regimes, including private, collective, and State ownership. Since 1991, decollectivization and other forms of land reform have been instituted throughout the former Soviet Union and (since 1989) Eastern Europe. Post-communist decollectivization in the Former Soviet Union and Eastern Europe represents the most extensive land reform in history.

Since independence, the countries of the former Soviet Union and Eastern Europe have been reconstructing their cultural and national identities within their new geopolitical environments (Kürti & Langman 1997). Swinnen's (1997) work shows that the national identities of countries of this region have shaped and are shaped by the choice of post-Soviet land reform policies. This research examines cultural landscapes as an integral component in defining national identities, and addresses issues regarding national identity and the Latvian

cultural landscape (described below) that drive some current GNP stakeholder interests regarding LU/LC change in the Park.

Furthermore, as the nations of this region develop new geo-political affiliations, many of them with new stronger ties to Western Europe, they contend with new economic pressures on the land and with Western concepts and standards of nature protection. New land ownership policies intersect with environmental concerns and national identities, particularly as these governments attempt to balance private property rights with public uses for land, including nature protection, cultural landscape protection, and traditional landuse practices. Inadequate funding in these countries intensifies difficulties in nature preservation, environmental research, law enforcement, and compensation for restricted landuse in protected areas. The countries of this region are currently looking to Western European and North American countries for financial and technical assistance to help deal with many of these environmental challenges (Aage 1998).

Protected Areas in Eastern Europe and the Former Soviet Union

Although the former Soviet Union and Eastern Europe had an extremely poor environmental record during the Soviet era (Pryde 1991), a record that figured prominently in the collapse of the Soviet Union (Weiner 1999, Tickle 2000), these countries contain a wealth of protected lands, and the amount of land in protected areas in these countries continues to grow. Supranational organizations (e.g., the United Nations Environmental Program, the European Environment Agency, and the European Commission) and environmental NGO's (e.g., the Worldwide Fund for Nature, the World Conservation Union, Fauna & Flora International, and the Europarc Federation) help maintain networks of protected areas with a primary purpose to preserve biodiversity (Schwartz 2001, European

Commission 2007, World Conservation Union 2007). As the world behind the "Iron Curtain" has opened, these supranational organizations and NGO's have gained increased access to the former Soviet-controlled countries, and now can significantly affect policies and civil society on issues regarding protected lands and environmental conservation.

With the EU's recent expansion into Eastern Europe, Europe acquired new 'hotspots' of species biodiversity, habitat diversity, and cultural landscapes that are no longer common in Western Europe (Tickle 2000, Schwartz 2006). In addition to the value the EU places on these newly acquired resources through expansion into Eastern Europe, the new EU states are economically and socially invested in their EU membership. Of particular relevance to this study is their required compliance with EU directives on nature protection, specifically the Birds Directive and the Habitats Directive, both to gain entrance into the EU and to maintain good standing after joining the EU (Tickle 2000). The focus of these directives are to preserve biodiversity and specific species, particularly through the protection of existing important biotopes and habitats, and the re-establishment and subsequent protection of formerly existing important biotopes and habitats (European Commission 1979, European Commission 1992). Local and national stakeholders often have other interests regarding lands protected for biodiversity, including the use of natural resources for economic productivity and the protection of cultural landscapes. While the Habitats Directive recognizes the need, "in certain cases," to "require the maintenance, or indeed the encouragement, of human activities" to maintain biodiversity (European Commission 1992), the intent of the Directive is to maintain biodiversity, whereas the promotion of economic opportunities and the maintenance of cultural landscapes are of secondary importance within the Directive. There are no European Commission Directives that protect cultural

landscapes. Furthermore, much of the European effort to protect biodiversity (and satisfy the Birds and Habitats Directives) has been through the creation of the Natura 2000 Protected Area Network (Natura 2007). Included in this network are "micro-reserves," a key component in some countries. These abundant small areas (usually 20 hectares or less) provide protected status to the habitat of small populations of specific species or sets of species (Ratfelders, personal communication 2002). This approach to protecting species habitats does not address landscape-level management issues that can both help maintain the diverse cultural landscapes of Europe, as well as help maintain the more general landscape matrices where biodiversity has flourished over time (Naveh 1994, Tickle 2000, Bennet et al. 2006). The protection of cultural landscapes, in addition to the protection of biodiversity, is important in many countries of Eastern Europe and the former Soviet Union, particularly because these cultural landscapes are often tied to the reemergence of national and local identities (Tickle 2000, Schwartz 2006).

Schwartz (2001) makes the point that local and national stakeholders throughout Europe and the rest of the globe have interests in landuse policy aside from the protection of biodiversity, such as multiple-use land protection policies to maintain sustainable resource extraction and policies to protect cultural landscapes, that are being subjugated to the singular goal of biodiversity protection due to environmental policies of supranational organizations such as the EU. Conflicts often exist between the goals of protected area managers (generally backed by NGO's and government organizations) throughout the world and the local population living in and around these areas, since the local population generally relies on the resources in and around the protected areas for economic sustainability (Salafsky 2000, Muller & Albers 2004). The need to balance the nature protection goals of

supranational organizations and NGO's with landuse interests of stakeholders at local and national levels is a difficult and challenging goal (Tickle 2000, Schwartz 2001, Melluma 2004).

Tickle (2000) found that the conflict between protected area managers and locals do not always exist. Since Slovenia's independence from the Socialist Federal Republic of Yugoslavia in 1991, which has generally been characterized by quick development and increased association with Europe (joining the EU in 2004), there has been declining economic opportunity in the countryside (Tickle 2000). Due to this declining opportunity and an increase in the number of tourists to the region, rural inhabitants in Slovenia have recently shown less opposition to protected areas and their restrictions, as tourism is seen as a viable alternative to other economic landuses (Tickle 2000). Another interesting point made by Tickle (2000) is that Slovenia supports protected areas as a way to exclude foreigners from owning land in parts of the country. It is an EU requirement that free markets for land exist in member countries, a requirement that is adhered to throughout the EU with a few notable exceptions, and this policy currently allows foreigners to buy land almost anywhere in Eastern Europe and the Baltic States (Estonia, Latvia, and Lithuania). While Slovenia adopted free market land policies, protected areas have become a means to prevent foreigners from buying land in some regions, and to prevent foreigners that formerly owned land in Slovenian territory from applying for land restitution (following the break-up of the former Yugoslavia) in these protected areas (Tickle 2000).

Land Restitution in Latvia

Latvia (Figure 1.1) gained its independence from Russia in 1918, a date that marked the first moment in the history of Latvia as an independent state. Latvia was then

incorporated into the Soviet Union during World War II (briefly in 1940, and then again in 1945), and then achieved its second period of independence in 1991 (The Latvian Institute 2007). Since 1990, major land reform has taken place in Latvia. A land restitution policy was instituted to restore lands to their previous owners (as of 1940) and their descendents. Some countries in the former Soviet Union and Eastern Europe adopted similar land redistribution policies – Lithuania, Estonia, and Slovenia adopted land restitution – while others privatized State and/or cooperative farms by offering shares of the farms to citizens (e.g., Russia and the Ukraine), and Albania redistributed land equally among rural dwellers (De Janvry et al. 2001, Alanen et al. 2001). Some of these countries privatized lands through mixed means, including some outright sales as well (De Janvry et al. 2001). This is part of a larger process in most of Eastern Europe and the former Soviet Union to privatize all types of formerly State-owned property. Land privatization in the region, and specifically land restitution in Latvia, is further discussed in Chapter 2.

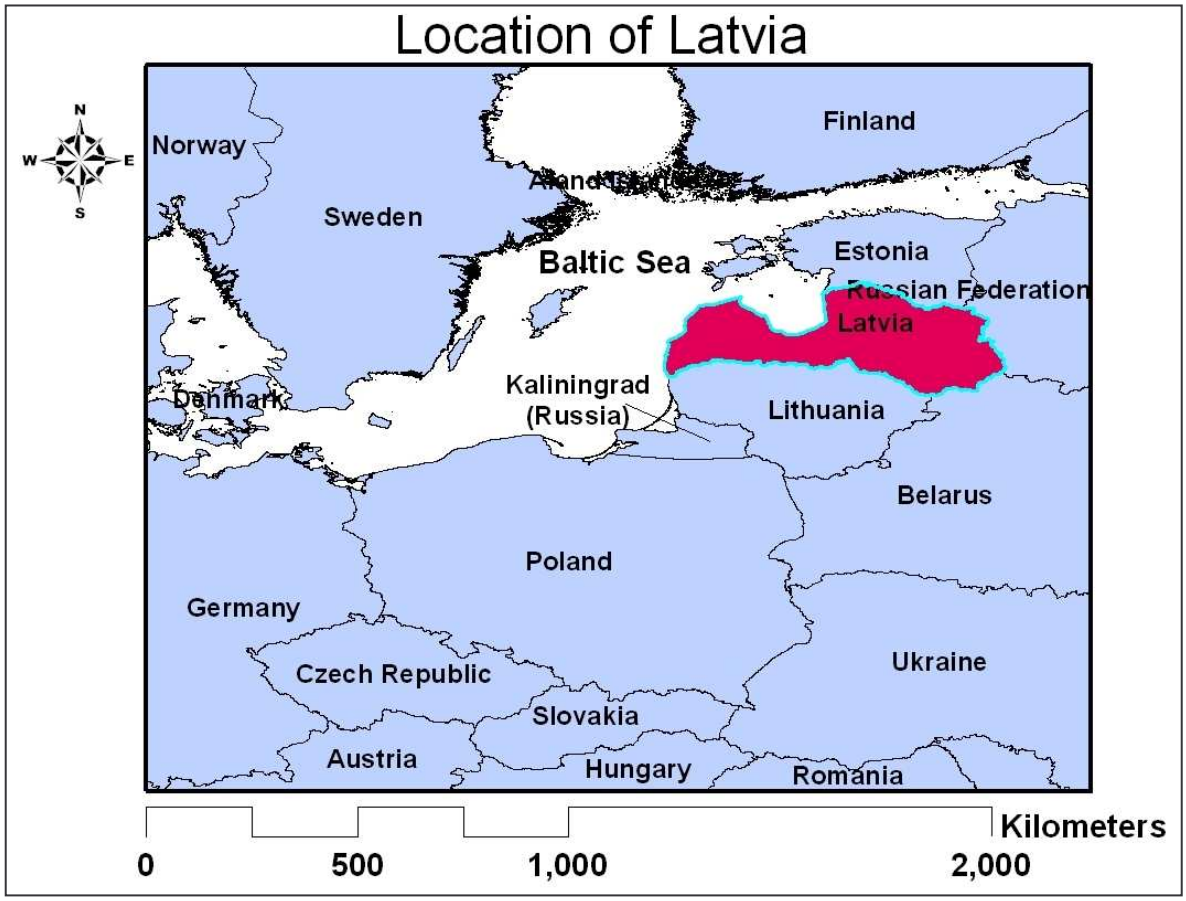


Figure 1.1. Latvia's location within Europe.

The Latvian Cultural Landscape

According to Bunkše (2000), the modern concept of the Latvian cultural landscape has its roots in the late 18th century. However, as with the Estonian cultural landscape, the Latvian cultural landscape emerged as an ideal during the Soviet era in opposition to the Soviet regime and the urban-industrial identity of the Russian-speaking immigrants, who lived mainly in cities (Unwin 1998). The idealized Latvian cultural landscape is one of single family farms, many of which were created from expropriated lands of the Baltic Germans in the late 19th century. According to an interview with Latvian landscape scientist and principal founder of GNP, Aija Melluma (2004), the Latvian cultural landscape varies along with the

biophysical features of the landscape throughout the country, from the remote hills of Latgale in the East to the coastal plains of Kurzeme in the West. Gauja National Park was mandated in part to protect the cultural landscape of Vidzeme in Northern Latvia. This idealized landscape is characterized not by rural villages, but by a dispersed rural settlement pattern of family farmsteads made up of small clusters of distinct buildings (including a main house, barn, stable, sauna, and small granaries), surrounded by a matrix of small, well-maintained forest patches, agricultural fields and meadows, with churches and pubs interspersed throughout the landscape (Melluma 1994, Bunkše 2000). This landscape also contains many "great trees" in isolation and in forests. These trees were labeled as such, given protected status, and considered sacred by citizen groups beginning during the strong nationalist movement in the 1920's (Schwartz 2007). The cultural landscape contains decorative trees planted along roads and elsewhere, and many plants and trees near houses. Forests in the Latvian cultural landscape have very sparse undergrowth, as Latvian forest management practices include "cleaning" the undergrowth away from most forests. This landscape is portrayed in the works of many Latvian writers and poets. For instance, Schwartz (1997, p. 268) translates a 1934 text of the Latvian writer, Birnbaums, where he describes the Latvian landscape:

> "…Houses were built at the forest's edge and around them were planted not only fruit trees, but also lindens, maples, oaks and ashes, as well as other decorative trees and shrubs. These trees were planted not only for exploitation, but more for the sake of love. This love for the forest and trees is inborn in the Latvian nation…"

As is evident from the preceding passage, Latvia's cultural landscape is a construction tied to nationalism (Bunkše 2000, Palang et al. 2003, Schwartz 2007). This landscape is also tied to the concept of political justice, since it dominated rural Latvia during the inter-war years (the years between WWI and WWII), the only former period when Latvia

was not occupied by another ruling force. This landscape is thus representative of Latvia's independence period, and therefore is a source of national pride for many ethnic Latvians (Palang et al. 2003).

Land Restitution in Gauja National Park

Gauja National Park (est. 1973) is Latvia's oldest national park and was the second Soviet national park established; GNP is also Latvia's largest national park (91,745 hectares). Prior to 1940, many Latvian families that owned lands within the current borders of GNP maintained ownership claims to these lands after independence (GNP management 1998). Consequently, Park regulations (GNP management 1998), certified by Latvia's Minister of Environmental Protection and Regional Development, outlined plans to privatize a large portion of the claimed lands within the Park, while maintaining landuse restrictions for the landowners. Notably, 80 percent of Gauja National Park has been privatized since 1990 (Strautnieks, personal communication 2002). Furthermore, the GNP Administration has redefined its vision for the management of both State and private lands within the Park. The new ownership regime and management policies attempt to mediate between the rights of individuals and national responsibilities associated with environmental conservation, tourism, and protection of the Nation's natural and cultural resources. Meanwhile, new policies also reflect Latvia's commitments to international treaties and conventions, as well as European Union (EU) Directives, since Latvia joined the EU in 2004.

According to Muldavin (1996), in China, de-collectivization of land (occurring between 1978 and 1984) forced individuals to focus on short-term gains instead of the long-term sustainability associated with collective farms. For instance, the tree planting programs supported by Chinese collective farms were abandoned at this time (Muldavin 1996). In the

forests of Latvia's Gauja National Park, very little partial cutting and no clear-cutting took place during Soviet times, according to Māris Sestulis, the Cēsis District Head Forester of the State Forest Service (Sestulis, personal communication 20002). It will be shown in subsequent chapters that the amount of forested land in formerly (pre-independence) forested areas decreased due to cutting (legal and illegal cutting on newly private as well as public Park lands). This is primarily the result of individuals in Latvia, as in China, focusing on short-term gains, with timbering being quickly profitable. Individuals may not support sustainable forestry and tree planting programs, a public good, as was supported and enforced by the former State and cooperative farms, or as supported by the current government, yet government law enforcement is currently under-funded and often ineffective. Thus, the forest may be undergoing Hardin's "Tragedy of the Commons," where a public good (maintained forests in Latvia) is exploited by individuals who experience no substantial loss as they harvest a small amount of timber within the forest (Hardin 1968).

Study Site: Gauja National Park, Latvia

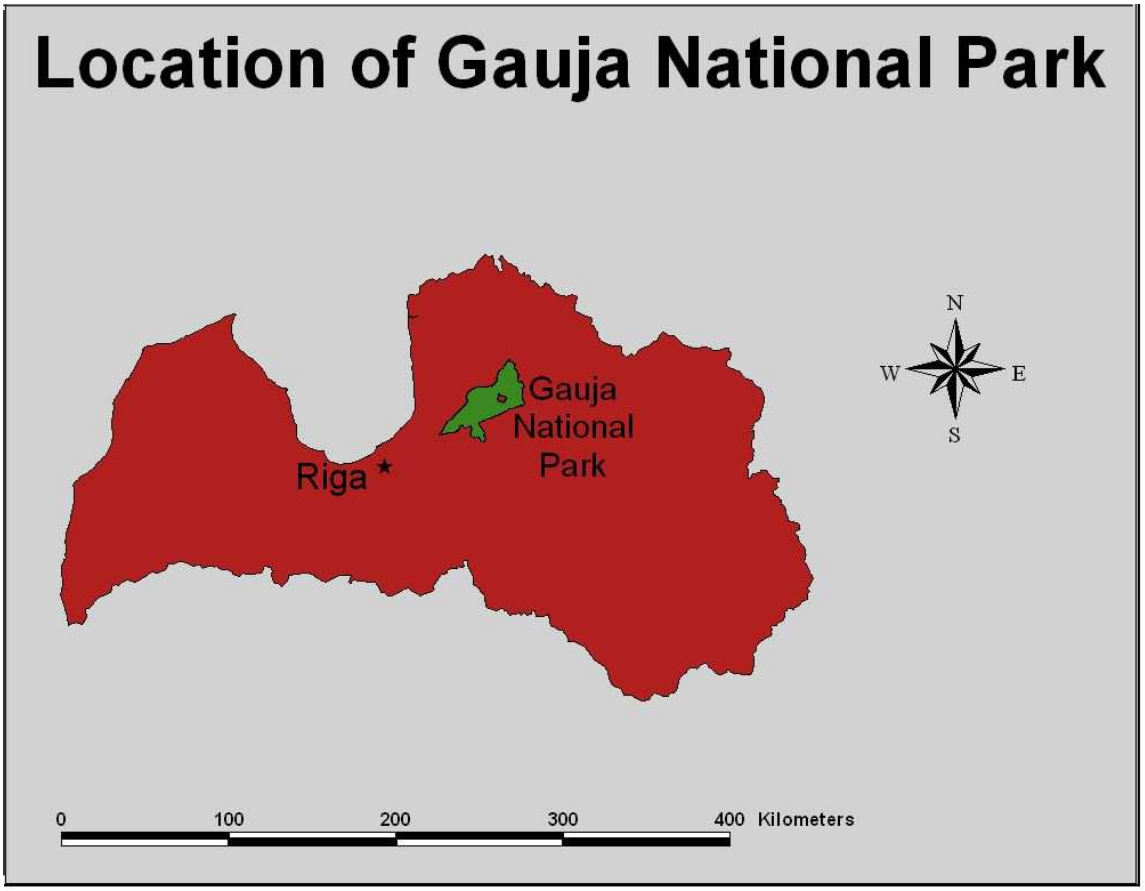


Figure 1.2. The location of Gauja National Park within Latvia.

Gauja National Park, located in Northern Latvia (Figure 1.2) contains forests, agricultural fields, meadows, wetlands, water bodies, cultural-historical sites, villages, and rural homes. The Gauja River and the surrounding valleys and cliffs form the centerpiece of the Park, oriented in a northeast to southwest direction. A total of approximately 900 plant, 149 bird, and 48 mammal species inhabit the Park (GNP website 2007). From extensive in-situ investigation of the Park since 2001, it was determined that conifer forests and mixed (conifer and hardwood) forests, are the most common biotopes in the Park. Limited hardwood forests with few or no conifers can also be found; most of these are mature forests that have been undisturbed for long periods of time, though some are very young forests – generally forest regrowth from recent cuts, or the result of reforestation on abandoned

agricultural lands. Wet hardwood forests also exist in low grounds near bogs and rivers. The most common tree types in the Park are Norway spruce (*Picea abies*), Norwegian pine (*Pinus resinosa*), birch (*Betula pendula*), poplar (*Populus alba*), oak (*Quercus robur*), white alder (*Alnus rhombifolia*), aspen (*Populus tremula*), Norway maple (Acer *platanoides*), ash (*Fraxinus excelsior*), and willow (*Salix alba*). Forest understories are generally sparse: young trees, berries, mushrooms, and peat moss are common. Much forest understory in the Park (and throughout Latvia) is particularly sparse due to the Latvian forestry tradition of "cleaning," a forest management practice common in Latvia, where brush, grasses, and fallen trees are regularly removed from the forest to allow target species to grow (Lagūns, personal communication 2002). There has been substantial human activity in portions of the Park since and prior to its inception in the early 1970's. Partially cut (thinned) conifer stands were found throughout the Park. Fields of short and tall grasses, as well as shrubs also exist throughout the Park. Large and small agricultural fields are widespread – some of the most common crops are oat, wheat, barley, peas, potatoes, and corn. There are a few small villages in the Park, many rural homes (often with nearby household gardens), and historic sites such as manor houses and castles. A map showing basic landcover types (based on a classified Landsat TM image from 2002) and the major towns in and near GNP is shown in Figure 1.3.

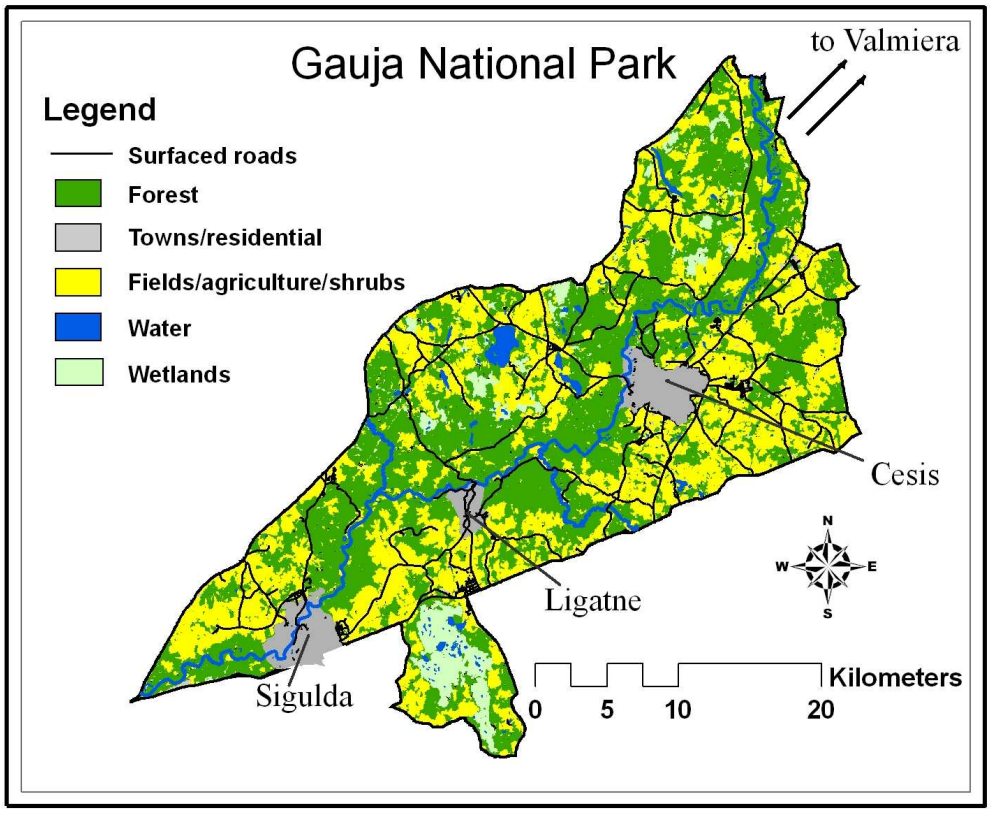


Figure 1.3. Gauja National Park map.

Much of the land is flat, but slopes are common up to 30 degrees, and sometimes up to 50 degrees. Elevation ranges from approximately 10 meters to 300 meters above mean sea level. The majority of the steeper slopes, and the most topographic variability in Latvia, are found close to the Gauja River Valley.

North central Latvia, where GNP is located, has a temperate high latitude maritime climate. The average temperature in July is around 17 °C (63 °F), while highs in the middle of summer often range from 13 °C (55 °F) to 32 °C (90 °F). The average temperature in January is about –5 °C (23 °F), while winter highs commonly range from –15 °C (5 °F) to 0 °C (32 °F). The leaf-on period begins in April and leaf-off is in early October (Kabucis 2001, GNP website 2001). Lying north of 57 degrees North Latitude, GNP experiences no

complete darkness during its long summer days with only a few hours of partial darkness, while the winter days are short and have low light. The average annual precipitation in the Park is about 60 cm/year (Central Statistical Bureau of Latvia 2003).

In 2004, the human population living inside the Park was approximately 21,000 (Pilāts, personal communication 2004). There is no existing data on the population and socioeconomic characteristics of Gauja National Park residents, specifically. In the absence of such data, information is provided about the composition of the human population in and around GNP primarily from: 1) a summary of a 1999 survey of GNP landowners, created by the Gauja National Park management (GNP management 1999), and 2) the 2002 and 2003 Latvian Statistical Yearbooks (Central Statistical Bureau of Latvia 2002, 2003).

The 1999 survey of GNP landowners was administered by the Gauja National Park Administration. A total of 1,500 questionnaires were sent out by mail or delivered by Park rangers to landowners in GNP in 1999 (GNP management 1999). The survey was administered with the goal to understand landowner attitudes towards GNP and identify the key problems that concern the GNP residents. Participation in the survey was voluntary and there were 575 valid respondents. Although such a sample is subject to potentially severe selection bias, it still offers general information regarding the land owning population of GNP. The distribution of property size and the amount of forest on the land of respondents (Table 1.1) is taken from a survey summary (GNP Management 1999).

Table 1.1. Size of property and of forested portion (% of respondents).

Size of land property		%	Size of forest property		%
1.	1 – 10 ha	28,6	1.	No forest on land	7,3
2.	11 – 20 ha	28,3	2.	1 - 5 ha	35,1
3.	21 – 30 ha	15,1	3.	6 -10 ha	21,1
4.	31 – 50 ha	15,5	4.	11 – 20 ha	20,7
5.	51 – 280 ha	12,5	5.	21 – 40 ha	11,8
			6.	41 – 200 ha	4,0

The survey respondents ranged in age from 19 to 89 with a mean age of 56.6 (GNP Management 1999). In a country with a life expectancy of 71.3 years and a median age of 39.4 years (calculated for 2006), the respondents comprise a relatively old population (CIA 2007). This may signify a relatively old population in GNP; however, only adults answered the questionnaire, so the mean age of Park residents may be substantially younger. With a consistent net out-migration in Latvia between 1991 and 2002, and an increase in the urban workforce, an aging rural population in areas such as GNP would not be surprising (Central Statistical Bureau of Latvia 2003). According to the survey summary, the average household size of survey respondents was 3.6, and 10 percent of respondents lived alone, 26 percent had two-person families, 15 percent had three person families, 18 percent had four person families, 18 percent had five person families, and 13 percent had more than five person families (GNP Management 1999). Furthermore, 46 percent of families had no children under 18, 18 percent had one child under 18, 21 percent had two children under 18, 11 percent had three children under 18, and 4 percent had more than three children under 18 (GNP Management 1999). A question on the Landowner Survey (GNP management 1999) asks for the respondent's "main sources of income," though the question does not make a distinction between the main income source(s) of the respondent herself/himself alone, and

for all members of the household. The following list shows the options that were offered, and the response rate for each (more than one response was allowed):

Paid employment	49%
Agricultural production	52%
Timber harvesting	22%
Other economic activities	11%
Pension	61%
Welfare support	18%

The high rate of pension support reflects the relatively old age structure of the respondents. This could mean that the age structure of GNP landowners is quite old, or that pensioners are more likely to respond to such a survey. It is interesting that only about one-half of the survey respondents identified paid employment as a main source of income. This may reflect a dearth of employment opportunities in GNP, which is primarily a rural area. The lack of paid employment and the high percentage of respondents indicating agriculture and timber harvesting as main income sources indicates an incentive for landowners to be concerned with Park landuse laws.

The territory of GNP is located within three administrative districts in Latvia: the Districts of Riga, Cēsis, and Valmiera. Data for the District of Cēsis is summarized from the 2003 Latvian Statistical Yearbook and provides information on population characteristics of those living in and around GNP. The District of Cēsis data is summarized because it comprises the majority (71%) of the geographic area of GNP, and approximately 20% of the geographic area of the District of Cēsis is comprised by GNP (Cēsis District website 2007). The town of Cēsis is also located within the district of Cēsis, and the town is also wholly

enclosed within GNP, though it lies officially outside of the GNP borders (Figure 1.3). The town of Cēsis is the largest town within the district of Cēsis, with a 2003 population of 18,480. The 2003 population of the full District of Cēsis was 59,599. Though no data can be found regarding the exact number of GNP residents within the District of Cēsis, the district houses more GNP residents than do the other two districts. Since approximately one third of the population of the Cēsis district live in the town of Cēsis, the population of the district is more urban than that of GNP. Although residents of the town of Cēsis do not live in GNP, they have substantial interest in landuse and the management of GNP for local recreation, tourism, extraction of non-timber goods from public access forests, and maintaining the landscape of their surroundings. There is a substantial population within the Cēsis district that does not live in the Cēsis town, nor GNP, but is near to the Park. As such, population characteristics are likely to be similar as those within GNP. Data on the population of Cēsis was compiled by the Central Statistical Bureau of Latvia from civil registries, local government institutions, medical certificates for births and deaths, and other sources (Central Statistical Bureau of Latvia 2003). The 2003 Latvian Statistical Yearbook summarizes data as of January 1, 2003, and thus corresponds well with the final year of satellite imagery of GNP that was obtained for this study (2002).

The Cēsis district follows the trend of Latvia as a whole, in that it has consistently lost population since independence in 1991 (through 2003), though the loss is not as drastic as that of the rest of Latvia. The Cēsis district had a 2003 population of 59,599, which is 93.4 percent of its 1991 population of 63,802, whereas the whole of Latvia's 2003 population was 2,331,480, or 87.7 percent of its 1991 population of 2,658,161 (Central Statistical Bureau of Latvia 2002, Central Statistical Bureau of Latvia 2003). This population reduction

in Latvia is due both to migration patterns (there has been a net out-migration from Latvia each year since 1991) and a low fertility rate: Latvia has one of the lowest fertility rates in the world – it has been below 1.3 between 1995 and 2006 (Central Statistical Bureau of Latvia 2003, Central Intelligence Agency 2007). While there was a net out-migration from the Cēsis district each year between 2000 and 2002, there was a net in-migration to the Cēsis district in the year 1995. The age structure of Cēsis district residents is typical of that of the rest of rural Latvia, with 60.4 percent of working age (15 – 61 years for men, and 15 – 58 years for women). While this is typical for rural Latvia, urban areas have a higher percent of working age population, and 62.4 percent of the population in Latvia is of working age.

The slower population reduction since independence in the Cēsis district, as compared with the rest of Latvia, may be in part due to economic activity in the district. In 2000, the Cēsis district had an unemployment rate of 6.8 percent, the 4th lowest of the 26 districts in Latvia (the overall unemployment rate in Latvia in 2000 was 7.8 percent) (Central Statistical Bureau of Latvia 2003). In 2002, the Cēsis district had an unemployment rate of 7.6 percent, the 7th lowest of the 26 districts (the overall unemployment rate in Latvia in 2002 was 8.5 percent) (Central Statistical Bureau of Latvia 2003). Thus, the Cēsis district has more employment opportunities per capita than most other places in the country. Of the 842 businesses registered in the Cēsis district in 2002, 386 (46 percent) were in the business of wholesale and retail trade or repair of motor vehicles and personal and household goods (compared with 42 percent in all of Latvia); 121 (14 percent) were in industry (compared with 13 percent in all of Latvia); 115 (14 percent) were in construction (compared with 6 percent in all of Latvia); 51 (6 percent) were in agriculture, hunting, forestry, and fishing (compared with 3 percent in all of Latvia); and 40 (5 percent) were in hotels and restaurants

(compared with 5 percent in all of Latvia) (Central Statistical Bureau of Latvia 2003). According to these statistics, the Cēsis district is substantially more economically active than other parts of Latvia in construction, agriculture, forestry, and fishing.

There is wide geographic variation in the ethnic distribution of Latvia. Only 58.5 percent of the2003 resident population of Latvia is considered ethnically Latvian. A full 29.0 percent of the population is considered ethnically Russian, 3.9 percent ethnically Belarusian, 2.6 percent ethnically Ukrainian, 2.5 percent ethnically Polish, 1.4 percent ethnically Lithuanian, and 2.1 percent of other ethnicities (Central Statistical Bureau of Latvia 2003). The Cēsis district has one of the highest district percentages of ethnic Latvians, at 85.5 percent, and only 9.4 percent of the district's population is ethnically Russian, 1.6 percent ethnically Belarusian, 0.9 percent ethnically Ukrainian, 1.0 percent ethnically Polish, 0.5 percent ethnically Lithuanian, and 1.1 percent of other ethnicities (Central Statistical Bureau of Latvia 2003).

The Management of Gauja National Park

Since independence, the Latvian government has been reworking its environmental legal system. New environmental laws and policies, as well as the organization of the institutional structures in charge of overseeing environmental legislation and enforcement, have been in a state of flux. A succession of four government institutions oversaw the management of Gauja National Park within a period of five years, beginning in 1988. Between 1993 and 2000, GNP fell under the jurisdiction of the State Forest Service, which is a part of the Ministry of Agriculture. Then beginning on August 1, 2000, the Ministry of Environmental Protection and Regional Development has supervised GNP (Ābolinja, personal communication 2002; GNP website 2003). Furthermore, specific legislation

relating to the Park has been far from stable. Soviet environmental legislation was phased out throughout the 1990's and was mostly obsolete by January 1, 2000. To replace these phased-out Soviet laws, sometimes temporary and often incomplete legislation was set in place (Michanek 1998). In addition to the environmental urgency of quickly instituting satisfactory new laws, during the period leading up to Latvia's accession to the EU in 2004, all Latvian government organizations instituted policies to comply with European Union directives. EU accession was very important to Latvia, and, therefore, being in compliance with EU Directives was a high priority for all government institutions in the country. Of particular relevance to this GNP policies are the nature protection Directives, specifically the Birds and Habitats Directives (European Council Directive 1979, 1992). A joint research project of the Swedish Environmental Protection Agency and Latvia's Ministry of Environmental Protection and Regional Development in the late 1990's found considerable overlap in functional duties of multiple government organizations in relation to environmental protection in Latvia (Michanek 1998). The plethora of legislation throughout the period since independence has caused confusion for government organizations as well as businesses and citizens, and has led to inefficiency in the overall system (GNP management 1998, Michanek 1998).

Since its inception in 1973, Gauja National Park (currently 91,745 hectares) has been divided into several management zones. The original zones, upon creation of the park, were (Grundule 1977):

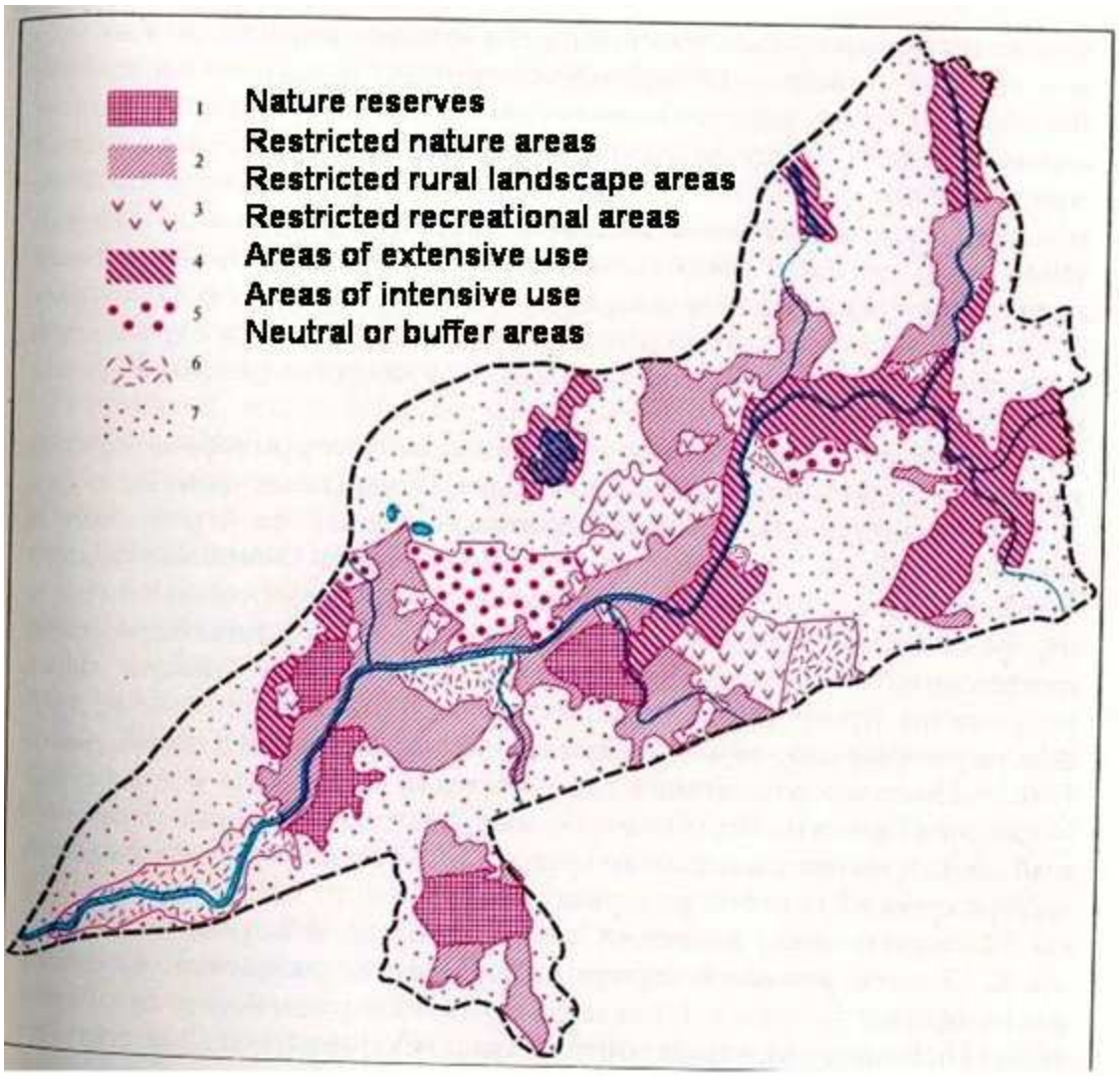


Figure 1.4. The management zone boundaries inside Gauja National Park, as of 1994.

1) Restricted Reserves – 4,500 hectares (most restricted area – tourists are not even allowed to enter),
2) Restricted Areas of Natural Landscapes – 14,700 hectares (2nd most restricted area, mostly located in the Gauja River valley),
3) Restricted Areas of Cultural Landscapes – 5,300 hectares,
4) Restricted Areas of Recreation Landscapes – 11,700 hectares,
5) Extensive Recreation zone – 3,800 hectares,
6) Intensive Recreation zone – 4,800 hectares, and

7) Neutral zone – 47,200 hectares (least restricted area where most commercial activity is allowed).

In 1994 the borders of these management zones were altered in minor ways, but the zones remained the same. These zones are shown in Figure 1.4. Then in 2000, these seven management zones were reduced to five management zones, and the zone borders were again altered in relatively minor ways, now totaling 91,745 hectares. The five new zones of GNP (Figure 1.5), whose boundaries are now digitally recorded, are (State Forest Service 1998):

1) Nature Reserve (strict regime) zone – 3,668 hectares: designated for nature protection: only Park rangers and scientists allowed inside.
2) Nature Conservancy zone – 32,655 hectares: designated for nature protection and nature recreation.
3) Cultural Historic zone – 3,501 hectares: designated to preserve cultural and historic objects in the Park.
4) Landscape Protection zone – 40,303 hectares: designated to preserve the Latvian cultural landscape.
5) Neutral zone – 11,618 hectares: designated to promote rural development.

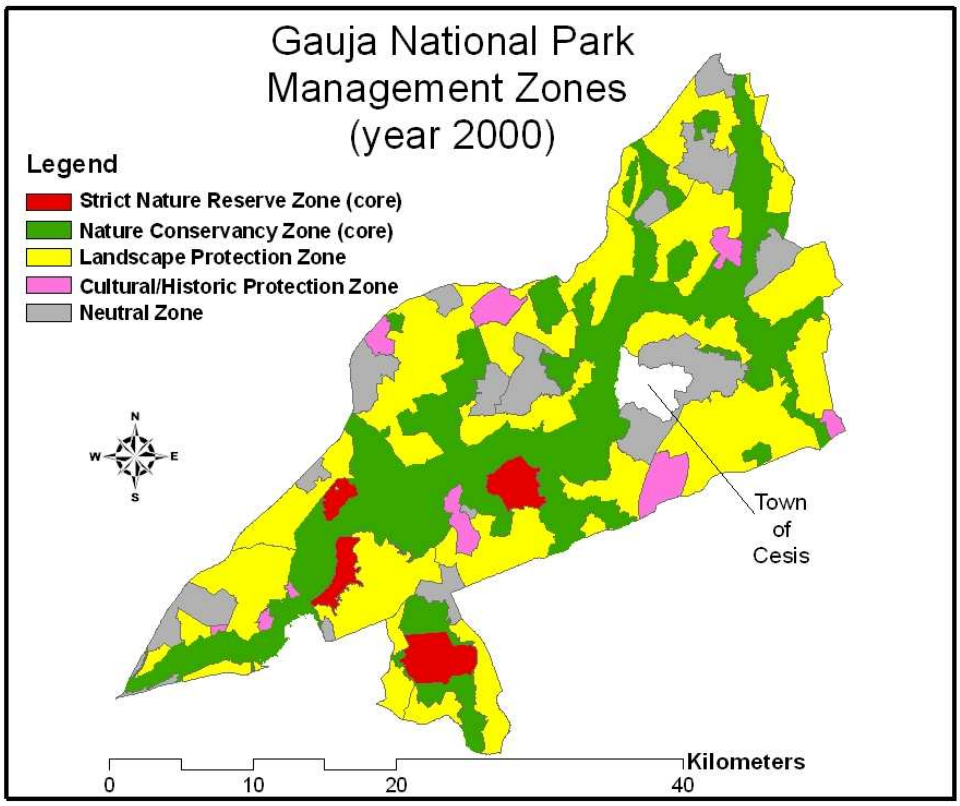


Figure 1.5. Management zones of Gauja National Park, as of 2000.

In the former and current sets of zones, the more restrictive the landuse regime, the lower the number of the zone.

The results of the aforementioned joint Swedish/Latvian research project also suggested a clear and strong statement be added to the Latvian Constitution stating the need for rights as well as obligations to be inherent in the privilege of owning land (Michanek 1998). According to the study, the Latvian Constitution currently requires "appropriate compensation" to owners of expropriated land, and a law on "Particularly Protected Nature Territories" states that a landowner or user has a right to demand compensation from the local government for financial losses resulting from legal restrictions concerning the use of

private land. However, there is no constitutional backing for this and there are no clear principles regarding how to determine the amount of compensation, nor the form of compensation (Michanek 1998). The study also cites severely limited financial resources rendering such compensation thus far inefficacious. Finally, although laws are in place governing the need for compensation when the government limits the economic capacity of land, these laws do not specify rules about compensation to be given to people who are receiving restricted-use lands for the first time (since the interwar independence period, through land restitution), as in the case of Gauja National Park. To address this issue, the GNP administration has, in conjunction with the Danish Ministry of Food, Agriculture and Fisheries – Division for Land Consolidation, developed and tested a Land Exchange Project within the Park. The project's intent was twofold: (1) offer owners of highly restricted land in the Park a parcel of land that can be used more productively by the landowner, and (2) allow the State (via the Gauja National Park Administration) complete ownership and control over lands in the most restrictive landuse zones of the Park for conservation purposes (Land Exchange Project Reports 2000; Østergaard and Apenītis, personal communication 2002). Although this pilot project was successful, it raised questions and complaints in the community, according to Cēsis Region Head Forester, Māris Sēstulis, regarding which landowners would be eligible for such land exchange, as well as which State lands within GNP were given to these landowners in exchange for their original parcels (Sēstulis, personal communication 2002). Sēstulis's complaints were particularly about the fact that many of these compensation lands were severely deforested soon after their receipt by the landowners (Sēstulis, personal communication 2002).

NATO, the European Union, international conventions and treaties, and well-funded Western NGO's have exerted influence on the environment of Latvia and other Eastern European countries since the fall of the Soviet Union (Staddon & Cellarius 2002). The primary means by which these larger powers from the West have affected GNP's landscape is by economically motivating compliance with Western values. According to Schwartz (2001), this has affected a major shift in the focus of GNP's goals, placing emphasis on the Western value of biodiversity over preserving a cultural and historic Latvian landscape in GNP.

Since independence, Gauja National Park has annually received only partial funding from the State budget (called the Latvian State Fund). For instance, in 2001, Gauja National Park received only 36.4 percent of its budget (515,492 Ls, or approximately USD 885,725) from the Latvian State Fund, and produced 63.6 percent of its income in other ways. Of this 63.6 percent, GNP earned a full 83.4 percent (751,179 Ls, or approximately USD 1,290,685) through public auction of GNP lands, primarily for logging use (GNP Yearbook 2001). The auctioned lands had been State land in the Landscape Protection and Neutral zones (Østergaard, Sēstulis, and Apenītis, personal communication 2002). According to interviews conducted for this study, the intended use for lands in general from these zones is contested and currently under debate among the GNP Administration, local governments, the State Forest Service, and Latvian landscape scientists (Sēstulis, Strautnieks, personal communication 2002, Nikodēmus, personal communication 2003, Melluma, personal communication 2004). Furthermore, it may be considered a conflict of interest for the GNP Administration to make decisions about which forest areas in the Park should undergo cutting to fund its own budget (Sēstulis, Strautnieks, personal communication 2002). The

forests in GNP that are being cut mostly lie in the Neutral zone or the Landscape Protection zone, and the GNP Administration regards these lands partly as income sources to fund its budget. According to GNP Director Strautnieks, none of the forests that are cut are primary forest, and the forests are cut with strict adherence to sustainable forestry standards (Strautnieks, personal communication 2002). Cēsis Region Head Forester, Sēstulis, claims that some of the lands in the Neutral and Landscape Protection zones are quite similar to lands in the Nature Conservancy zone, and that their categorization is rather arbitrary. Sēstulis is lobbying to keep the GNP forests in the Neutral and Landscape Protection zones near Cēsis intact for the Cēsis residents to enjoy (Sēstulis, personal communication 2002). It is hypothesized that GNP decisions to deforest contested valuable lands are partially founded on motivations to cater to foreign conservation interests. These foreign interests are most concerned with strict biodiversity conservation in highly protected natural reserve areas, as opposed to conserving forests and the landscape throughout the full Park (Schwartz 2001, Østergaard, personal communication 2002, Melluma, personal communication 2004).

Research Goals

As the goals of this dissertation are to examine the influence of the various GNP stakeholders and post-Soviet land reform processes on the Park's landscape changes relevant to Park conservation and the Park's management goals, three basic research goals are addressed:

1) Understand the interests of GNP stakeholder groups and analyze how landuse policy changes in GNP are shaped by these stakeholder groups' interests and values (Chapter 2);

2) Understand how the post-Soviet changes in composition and pattern of the GNP landscape have affected key Park resources of stakeholder interest – these resources, identified in Chapter 2, are biodiversity and the natural and cultural landscapes (Chapter 3);

3) Determine the important drivers of landuse/landcover change in GNP, examine how they have changed over time, and assess how these factors are associated with landowner opinions regarding management of the Park (Chapter 4).

Methods

This landuse/landcover change research integrates quantitative GIS, remote sensing, and statistical analyses with a qualitative assessment of GNP stakeholder values, interests, and conflicts. This integration of multiple research methods provides for a broader perspective of the drivers and consequences of landuse and landcover change than either method would provide in isolation. Detailed discussions of methods for each research objective are given in their respective chapters. A brief overview of the methods for the entire project is outlined here.

Most actions of the multiple stakeholder groups in GNP, and their influences on LU/LC change in the Park, cannot be wholly understood in isolation. The interconnectedness among stakeholder groups, the transformations in some of these groups, and the conflicts between them must be understood to comprehend their direct and indirect effects on changes in GNP's LU/LC. To provide the local contextual framework and to understand the interactions of these important factors, a qualitative study was undertaken in GNP, which helped direct the quantitative LU/LC change research. To identify GNP

stakeholders and assess their values, interests, and conflicts, open-ended interviews were conducted with key informants. These interviews were directed to understand the policies and processes affecting landuse change in the Park, to understand the stakeholder groups' interests regarding landuse in the Park, and to understand important interactions between the stakeholder groups. A detailed discussion of the methods for this portion of the research is presented with the rest of this research in Chapter 2.

Chapter 3 evaluates how the post-Soviet changes in composition and pattern of the GNP landscape have affected biodiversity and the natural and cultural landscapes. The primary data used for these analyses were a time series of Landsat Thematic Mapper (TM) images with a temporal coverage from the late Soviet era through today. The obtained images, with dates from leaf-on periods of the summers of 1985, 1994, 1999, and 2002, were preprocessed and classified in preparation for landcover change analyses. Landsat TM was chosen due to its sufficient temporal coverage, and its spatial and spectral resolution, designed for determining general landcover at the landscape scale. Ground control data for purposes of image georectification and to aid in classification labeling were obtained via in-situ field work in the Park utilizing Global Positioning Systems (GPS) data. The changes in landscape composition and patterns (through the computation of ecological pattern metrics) were analyzed over time with respect to landscape characteristics associated with biodiversity and the cultural and natural landscapes of the Park. These changes are discussed in relation to the landscape processes and stakeholder interests and conflicts identified in Chapter 2.

In Chapter 4, research was conducted to identify influential drivers of LU/LC change in GNP, understand the effects of these drivers on landcover change, and determine how the

influence of certain drivers changed over time. Classification tree analyses and multinomial logistic regression models were developed for each pair of consecutive Landsat TM image dates, and for the 1985 – 2002 image pair (that represents the first and last images in the time-series). The dependent variable in these models was landcover change, and the independent variables represented geographic, biophysical, and political forces and factors, spatially represented in the landscape. The statistical models were used to assess the effects of these independent variables on landcover change. The spatially referenced independent variables and the Landsat TM images were integrated through the use of Geographic Information Systems (GIS). The statistical analyses were conducted at the pixel level.

Finally, responses to a GNP landowner survey conducted by the Gauja National Park Administration (GNP Management 1999) were geocoded in 2004 through address matching between the original survey responses and a GIS data layer of addresses for each building in GNP, assembled by the GNP Administration. Bivariate associations were analyzed in Chapter 4 between each of the geographically referenced drivers of landcover change (as determined by the statistical models) and the opinions of GNP landowners (whose homes were geocoded from the landowner survey) towards the Park's protection and development policies. Only bivariate statistical analyses were performed because of the small sample size of valid, geocoded landowner survey responses.

Contributions

The globalization of environmental politics is changing the focus of nature protection in many places throughout the world – from promoting traditional environmental customs and values to globally-recognized values such as biodiversity and carbon sequestration. The focus in Latvia on maintaining biodiversity is a recent development. Before independence,

Latvian nature protection was focused on preserving both natural areas and cultural and historic landscapes. This shift in focus of Latvian nature protection is explored. Of particular interest to the whole region, this dissertation addresses the conflicts of interest between new Western influences on nature conservation (i.e., NGO's, Western European governments, the European Union, NATO) and national and local multiple-use traditions for protected lands.

This research has implications throughout the former Soviet Union and Eastern Europe regarding the intersection of nature protection policies and post-Soviet land ownership reform. The research investigates the influence of political, economic, and social processes at multiple spatial and temporal scales on landuse in GNP, and analyzes the resulting effects on the Park's ecological and cultural landscapes.

This research specifically addresses the impacts of LU/LC change and land fragmentation on species habitat availability and cultural landscape evolution using a landscape ecology framework with data from a times-series of Landsat TM satellite images. The maintenance of biodiversity in GNP and other parks throughout the world is considered to be of major importance, not only to the managers of those parks, but to the global scientific and nature protection communities.

The primary methodologies used in this LU/LC change research are remote sensing, GIS analyses, and statistical modeling, however, this research also integrates qualitative interviews and a synthesis of information from other sources, such as State statistical publications, government legal and policy documents, and official documentation from NGO's and supranational organizations. These two very different approaches inform each other in this research and give unique and broad perspective regarding the drivers of LU/LC

change in a protected landscape. This integrative methodological approach may serve as a model for other landscape level LU/LC change research in Eastern Europe and beyond.

Chapter 2: Competing Stakeholder Interests in Latvia's Gauja National Park

INTRODUCTION

This chapter analyzes the competing interests of stakeholder groups in Latvia's Gauja National Park (GNP), and how landuse policy changes in GNP are shaped by a debate between stakeholders. In the current international environmental context, nations must contend with global influences on local environmental policy in addition to multiple internal demands. This research has found that the various GNP stakeholder groups primarily value biodiversity, Latvia's cultural landscape, economic use of the forest and agricultural lands, and recreation and tourism within the Park. It will be shown that the value of preserving biodiversity is backed by international NGO's, Western government organizations, and the European Union, and that preserving biodiversity has been at the forefront of the GNP Administration's agenda. The value, espoused by Latvian academics, of preserving/restoring the Latvian national identity through the preservation/restoration of an idealized Latvian cultural landscape is a part of a larger post-Soviet policy of political justice, reinstating Latvians in positions of power within Latvia, and helping a Latvian national identity to reemerge since Latvian independence. The value of economically sustainable landuses among local inhabitants also figures heavily into the discourse among stakeholders regarding land ownership and landuse in GNP. Since the Latvian cultural landscape, as defined by Latvian landscape scientists, developed between the late 1700's and the beginning of the

Soviet period (1940) through historical economic utilization of the land, the preservation of the Latvian cultural landscape is closely tied to sustainable economic uses of the land.

This chapter investigates how the post-Soviet GNP landscape has been altered through two mechanisms: land restitution and changes in the GNP Administration's goals. Although land restitution in Latvia reflects the multitude of values around which multiple post-Soviet land privatization methods were based throughout the region, it will be shown that Latvian land restitution reflects foremost a commitment to the political justice of preserving national identity and restoring power primarily to ethnic Latvians from pre-Soviet times. Schwartz (2001) makes the argument that changes in the GNP Administration's goals throughout the 1990's reflect the global value of preserving biodiversity at the expense of protecting some of Latvia's cultural landscapes. The research in this chapter supports this argument, and examines the local backing for biodiversity protection and for the protection of the cultural and productive landscapes in the Park. This chapter analyzes the values and interests of key GNP stakeholders. It will elucidate the values that inspired the GNP Administration's goal changes and those that inspired land restitution, how these values conflict, and how they manifested themselves in the landscape and landuse policy of GNP.

METHODS

A questionnaire was designed by the author for the purpose of interviewing a large number of GNP residents (see Appendix I). The questionnaire functioned as a guide for the interviewers during the interview process, though the respondents did not read the questionnaire. The responses from these questionnaires were to be used to understand the population and socioeconomic characteristics of the Park, the residents' income sources, the progression of household ownership from the Soviet era through modern times, the ways in

which the residents were using the land in GNP, the residents' knowledge about the Park's landuse laws, and information about land sales in the Park. A beta-test, or "test run", of these interviews was conducted in the field in July of 2002. Seven interviewees were chosen (six were chosen arbitrarily and one was a personal contact – the translator's grandfather) in different regions of the Park, and the interviewers (Gregory N. Taff and translator, Sandra Tece) drove to houses and asked for a resident who would be willing to answer questions. If no one was available for interview, a convenient nearby house was chosen. Although initial results were useful and interesting, it was determined that much of the information that would be gathered from interviewing a large number of GNP residents was obtainable through other sources, including the Latvian Central Statistical Bureau, and a landowner survey already administered by the GNP Administration in 1999. In addition, to understand the breadth of post-Soviet influences on landuse change in GNP and the conflicts between stakeholders, it was determined that a broader set of stakeholders should be interviewed, and a more effective method to study these issues was through open-ended interviews of key informants. The interviews obtained through the beta-test served as useful anecdotal evidence, though no statistical inferences can be drawn from them due to the small sample size.

Open-ended interviews of key informants were conducted in the field in the autumn of 2002, the winter of 2003, and the winter and spring of 2004 to identify GNP stakeholder groups, to ascertain the various stakeholder values and interests regarding the landscape in GNP, to understand how these stakeholder groups interact, and to gather information about how the GNP landscape and landuse policy are changing. Topics discussed in the interviews were often based on issues identified as important by the interviewee and by previously

interviewed key informants. Most interviews lasted between one and three hours, and some required the assistance of a translator, Sandra Tece, to translate between English and Latvian. Interviews were recorded with permission of the interviewee. During the evening after each interview, the author and the translator, Sandra Tece, typed up the important points of the interview, often with the help of the audio tape. These interviews were conducted with members of multiple government institutions at local and national levels, the GNP Administration, representatives from domestic and international NGO's, academics, and a local journalist. The set of stakeholders interviewed is similar to the set interviewed in related case studies conducted by Tickle (2000) on the relationships between nature protection and landscape conservation, and the post-socialist socioeconomic and political transitions. Tickle conducted research "primarily through questionnaires and semi-structured interviews with key individuals including relevant government or state officials, protected area managers, local government representatives and interested citizen groups (often environmental non-government organizations or NGOs), combined with field visits to the countries" (p. 212).

Interviewees were identified using a snowball approach, beginning with contacts made at the GNP Administration and those listed in Schwartz's research (2001). The set of GNP stakeholder groups was determined through these interviews using an iterative process (key informants from GNP stakeholder groups were interviewed, and they identified other members of the same stakeholder group or members of another stakeholder group, who were subsequently interviewed, and who subsequently identified others, etc., until the author determined each stakeholder group to be sufficiently represented.) This method was chosen because when the research began, the important stakeholder groups were not specifically known. The snowball method allowed the identification of these groups via those intimately

involved with GNP. Interviewees were recruited until the major stakeholder groups were well represented. Thirty-seven interviews were conducted with 35 interviewees (two key informants were interviewed twice). The set of GNP stakeholder groups, as determined from these interviews, is presented in Figure 2.1. A shortcoming of the snowball approach is that the individuals identified by interviewees may be from limited social/professional circles, and they may be a subset of the full population of interest, and therefore, some key stakeholders may have been unknowingly overlooked. In addition, the particular individuals within each stakeholder group may tend to hold similar views as those from other stakeholder groups, since the members of the stakeholder groups were identified by members of another group to be interviewed. Key members from all groups represented in Figure 2.1 were interviewed.

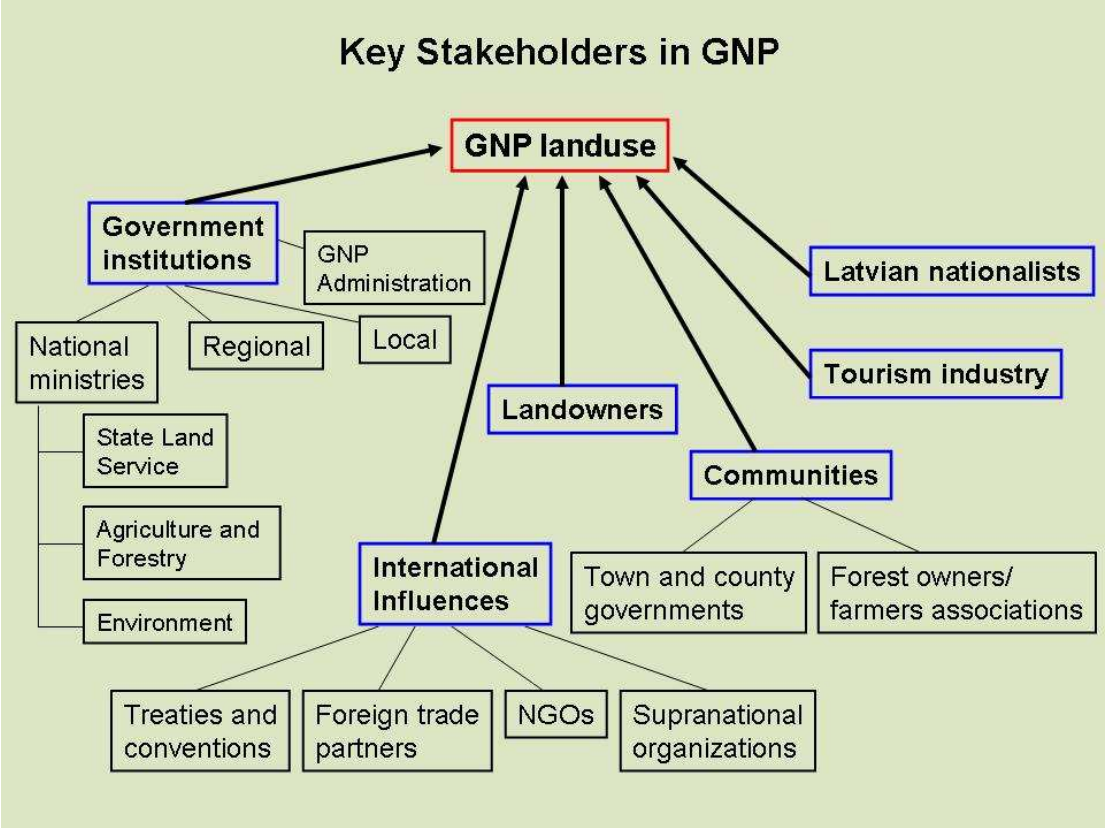


Figure 2.1. Key Gauja National Park stakeholders groups.

Open-ended questions were asked in the interviews regarding the history of GNP, the structure of institutions overseeing GNP, the changing ecology of the Park, the interests of the various stakeholder groups, and the conflicts between stakeholder groups, particularly as these topics relate to landuse and landcover change in the Park. 'Stories' were generated by interviewing stakeholders with conflicting views or interests on the same topic, and an attempt was made through the interviews to understand the motivations for the various stakeholder interests and actions. To analyze the interviews, text from similar topics discussed by multiple interviewees were grouped together, and topics were categorized into general categories (e.g., the Latvian cultural landscape, the Park's management zones, the ecology of the Park, tourism in the Park, Park landuse restrictions, illegal forest cutting, and economic production on the land). These topics were then analyzed one at a time, while considering each interviewee response related to that topic. The results of these interviews were supplemented with information gleaned from relevant GNP policy and planning documents, press articles, and academic literature on Latvia and GNP.

LAND RESTITUTION

Land restitution, as a method for privatizing State-owned land in Latvia, was implemented as a form of political justice, to reestablish national identity and to restore power primarily to ethnic Latvians from pre-Soviet times. Mathijs & Swinnen wrote that Latvia's "active [land restitution] policy was inspired by nationalistic motivations" (p. 18, 1996). In this section, land restitution in Latvia, and in GNP specifically, is compared with methods of land privatization in other parts of Eastern Europe and the former Soviet Union, and it is shown that the service of political justice figures more heavily into Latvia's land restitution than do the primary values that motivated other means of land privatization in

many countries of the region. At the same time, it is shown that land restitution in Latvia has had some unanticipated consequences that have partially prevented it from serving the political justice for which it was intended.

Land restitution, through several mechanisms described below, helped to renew and preserve the Latvian national identity in post-Soviet Latvia. Latvia's decision to privatize the majority of the land even inside the National Park is, in part, a reflection of the level of Latvia's original commitment to preserve its national identity upon independence, even favoring this commitment over the protection of some of the Park's resources. In Latvia during Soviet times, many rural households owned their living quarters and up to 0.6 ha of nearby land for private farming (Tarvel & Kahk 2004). Essentially all other land in the country was owned by the State. Since independence, Latvia, along with most countries of the former Soviet Union, privatized the major portion of its land. On July 10, 1992, Latvia's Supreme Council passed a law "On Privatization of Land in Rural Areas" stating that former owners who owned land on July 21, 1940 should have their land returned, or else they should receive compensation for their land (Jemeljanovs 1996). By the year 2000, Latvia had privatized 62 percent of its total territory in land (Vilcins & Grine 2003). This law on land restitution was part of a political justice policy framework that helped both to preserve/restore a sense of Latvian national identity and to restore power primarily to ethnic Latvians from pre-Soviet times. In addition to this law on land restitution, a law was passed in 1989 that officially reinstated the Latvian language as the official language and it limited the use of the Russian language in public life. Another law was passed in 1991, granting Latvian citizenship only to those who were citizens, or descendants of citizens, in 1940.

Latvia's choice to privatize land through land restitution as a form of political justice was in contrast to some countries of the former Soviet Union and Eastern Europe. These countries employed multiple systems to privatize land, based on different value systems. Albania, for instance, divided land equally among its rural dwellers, demonstrating its emphasis on the value of equal opportunity for its citizens (De Janvry 2001). In addition to some direct land sales, Russia and the Ukraine privatized shares of cooperative and State farms (allowing these large farms to continue to function), indicating their value emphasis on efficiency in the economic transition from communism to a free market system (De Janvry et al. 2001), making use of the infrastructure put in place during Soviet times and allowing farm workers to maintain an essentially uninterrupted income. Moreover, as land in the Ukraine and Russia had not been privately owned since 1918, the tradition and memory of owning private land in these countries was farther from the national consciousness than it was in most East European countries (Swinnen 1997). Therefore, after the fall of the Soviet Union there was less demand in these countries for privatization of land than in many Eastern European countries (where land often remained legally privately owned throughout the Communist regime) and in the Baltic States (where land was privately owned just prior to World War II) (Swinnen 1997). The Baltic States, in addition to the Czech Republic, Slovakia, and Bulgaria, chose to privatize land through land restitution, returning land ownership to its previous owners (or their descendents) from pre-Soviet times. This decision was based upon the value of political justice, instead of, for instance, equity in the Albanian case, or efficient economic growth in the Russian and Ukrainian cases (De Janvry et al. 2001).

For some Latvians, regaining a family plot of land through restitution, or the ability to purchase land restituted to others, has provided them with a way to reconnect with Latvia's pre-Soviet agrarian lifestyle, one of small, productive family farms. This pre-Soviet agrarian lifestyle is directly associated with the current Latvian national identity, as discussed in more depth below. Schwartz (2007) writes that prominent Latvian poets identified tending the landscape as *the* defining Latvian act. The regaining of family plots of land has facilitated a reconnection with this lifestyle for GNP resident interviewee #4, for instance, who received her grandfather's land in GNP in 1993 through restitution. The land was part of a State Farm during the Soviet era, and in 1998 she built a new house on the land and moved there from Riga to start a small farm. GNP resident interviewee #6 bought his land in 1989 from a returning Siberian exile (according to him, Siberian exiles began receiving land through restitution as early as 1988). This land was also part of a State Farm during the Soviet era and the interviewee was a member of this State Farm. Since independence, this man has been farming his purchased land on an individual level. Also, GNP resident interviewee #7 bought land in GNP in 1992 and moved there from a nearby municipality to begin a family farm. However, Vanadzinš, a local reporter, claims that many who received land in GNP live in Riga (personal communication 2002). Furthermore, he claims that many who live in Riga don't tend to their land, and many sell their forested lands to timber companies. GNP resident interviewees #1, 4, and 7 all reported that they knew of others buying land in GNP exclusively for timber production. So while land restitution has led to a revival of the pre-Soviet agrarian lifestyle for some, others have not used this opportunity to return to an agrarian lifestyle. Furthermore, in some cases, the restitution of land has led to poor land

stewardship, which has, in turn, hindered the restoration of Latvia's cultural landscape, a landscape that is shown below to figure heavily into Latvia's national identity.

The political justice of land restitution in Latvia was achieved (albeit with some unintended consequent landscape changes such as extensive timbering) at the expense of the equal opportunity that Albania strived for. Unlike in the Albanian case, where land was divided equally among rural dwellers, land restitution in Latvia has recreated an inequality among its population in land holdings. It may be argued that the value of equality played a role in Latvian land restitution policy, because although land ownership in Latvia in 1940 was not equally distributed, it was relatively equally distributed compared to, for example, Czechoslovakia, Hungary, Romania, or Lithuania in the same period (Swinnen 1997). In 1935, 68.4 percent of private land in Latvia belonged to land holders owning less than 20 ha, while only 6.5 percent belonged to land holders owning over 50 ha (Melluma 1994). However, some citizens owned no land. Interestingly, 48 percent of Latvia's population in 1989 was not ethnically Latvian. This mostly Russian speaking population, the majority of which moved to (or was born in) Latvia from other parts of the former Soviet Union during Soviet times, was ineligible to receive land through land restitution since this population did not own land in Latvia at the time of the Soviet takeover in 1940. Latvia's land restitution policy may be seen as a means of alienating Latvia's Russian-speaking minority populations and serving the interests of the ethnic Latvians, and can be seen in the same discriminatory light as Latvia's strict citizenship policy, which leaves over 450,000 mostly Russian-speaking residents (approximately 20% of Latvia's total population) still without any citizenship as of 2005 (BBC 2005), and has been directly denounced by Russia as discriminatory (cnn.com 1998).

Latvia's land restitution policy created economic opportunity for a portion of its citizens. However, the role of land restitution in the creation of economic opportunity was not as successful as land restitution was in the service of political justice. The privatization of land through land restitution has created economic opportunity for many Latvians in post-Soviet Latvia through farming, forestry, and tourism. The creation of this economic opportunity has helped many Latvians during the extended post-Soviet economic depression. Although land restitution has enhanced Latvia's economy, it was not instituted as the most efficient means to "jumpstart" the economy. Russia and the Ukraine focused more on these economic consequences of land privatization by offering State and cooperative farm workers shares of the farms (De Janvry et al. 2001), which continued to function after the collapse of the Soviet Union. Latvia's rural economy may be suffering more than that of some other post-Soviet countries due to the fact that the value of economic development was subjugated to the service of political justice.

In the case of land restitution inside Gauja National Park, the values of economic development and equality are further subjugated to the global value of preserving biodiversity. Legal landuse restrictions accompanied land restitution for lands inside GNP to support the protection of nature and biodiversity. Limited finances inhibit local and national governments from compensating landowners for landuse restrictions (Michanek 1998, Vēveris 2002, Strautnieks, personal communication 2002). According to Vilnis Burcevs (personal communication 2002), Mayor and Head Deputy of Kocenis (Kocenis is a rural county with 30 percent of its land territory inside Gauja National Park), many Park landowners feel that the placement of the Park borders is quite arbitrary. He claims that those with land just inside the borders of the Park are not able to make as much economic use of

their lands as are their neighbors with land just outside the borders, even though these lands are quite similar. For instance, those with land inside the Park borders are prohibited from building fences around agriculture to keep wild mammals away from their crops; they are prohibited from using pesticides and chemical fertilizer; forests on private land inside the Park are required to be older than forests outside the Park before cutting is permitted; it is often difficult to get a construction permit for developing a business inside the Park; and there are hunting prohibitions within the Park. According to Burcevs (personal communication 2002), many Park landowners feel that these landuse restrictions are unjust because they restrict their livelihood, and further, they are not treated equally with respect to their landuse rights, as compared with landowners outside the Park. In addition, Krimulda Mayor Jūris Salminš stated in an interview (personal communication 2002) that landuse restrictions throughout much of the Park are too strict for many of his constituents in the Park.

As previously mentioned, land restitution has allowed some Latvians to reconnect with Latvia's pre-Soviet agrarian lifestyle through land ownership. Land restitution in Latvia has led to renewed private land ownership on a large scale: by 2002 there were 867,200 registered private land parcels in Latvia (State Land Service of the Republic of Latvia 2002). However, according to Grinfelde & Mathijs (2004), family farms in Latvia have low profitability, which, in conjunction with several other factors, has inspired many Latvian families to abandon their farms. This may in part be due to a lack of economies of scale in the agricultural sector in Latvia, and the fact that Latvia has eliminated trade restrictions with Western Europe. The lack of economies of scale in Latvia's agricultural sector stems from the land restitution process: the large farms of the Soviet era were divided into the small

family farm plots that predominated during the inter-war years (as opposed to Russia and the Ukraine, for instance, where the large Soviet farms were privatized but continued to operate as large farms). In addition, the elimination of trade restrictions with the rest of Europe was necessary for Latvia's accession into the European Union in May of 2004. Although labor, land, and material inputs for agriculture are relatively cheap in Latvia, many Western European agricultural products are often sold cheaper than Latvian products (even in Latvia) partially because of agricultural subsidies in Western Europe. As these economic realities dissuade many Latvians from becoming farmers, the effect is to limit the number of Latvians that can reconnect with their traditional agrarian culture. According to Grinfelde & Mathijs (2004), the unused portion of the total agricultural land in Latvia increased from 16% in 1997 to 21.2% in 2002. Unwin (1998) reports a similar decline in Estonian agriculture due to Western European farming subsidies.

Another important form of political justice offered by land restitution is the restoration of the Latvian cultural landscape, as described in Chapter 1, and its association with Latvia's national identity. Latvia has a rich folk tradition steeped in values of an agrarian lifestyle and a deep connection with forests and nature. Bunkše (2000) claims the restoration of this landscape helps to revive the Latvian national identity. Schwartz (2001) claims that within Latvia, and Unwin (1998) claims that within Estonia, two competing visions exist regarding national identity, one vision based upon these countries' rural past, and one based upon their role as a trading crossroads between East and West and a democratic state, well-connected to the modern technological world. Bunkše (2000), however, claims that the rural past is more fundamental to Latvian culture. He writes that the "foundation of Latvian national identity… is rural folk culture, rural landscapes, [and] natural

and geographic features…" (Bunkše, 2000, p. 124). The Latvian identity is memorialized in the extensive collection of Latvian folk poetry, called the *dainas*. With the poetry's frequent references to the traditional rural landscape, "[t]he *dainas* epitomize Latvian ties to the rural countryside and to nature" (Bunkše, 1992, p. 206). The Latvian cultural landscape, as discussed here, was described in Chapter 1. The termination of Soviet-style cooperative farming and the consequent partial re-emergence of family-owned individual farms have allowed this traditional landscape to begin to flourish once more. The 40,303-hectare Landscape Protection Zone of GNP was designated to protect Latvia's cultural landscape, and land restitution within this zone of the Park has allowed a partial reconstruction of this landscape inside of the Park.

There are, however, also processes hampering the return of this traditional landscape. Recent farm purchase and consolidation has led to an increase in recent years in the number of large fields, both inside and outside the Park. More alarmingly, local reporter, Andris Vanadzinš, claimed in an interview (2002) that many new owners of forest lands are not managing their lands sustainably, and the elected mayor of the Krimulda Municipality (which contains 9,000 hectares of GNP), Jūris Salminš, stated in an interview (2002) that some illegal forest cutting is taking place in GNP. Latvia has a strong tradition of sustainable forestry, yet according an interview with Cēsis Region Head Forester, Māris Sēstulis (personal communication 2002), forest-owning families that were once knowledgeable in these methods often failed to pass on their knowledge through generations during the five-decade Soviet period, a period when they did not own land and family members often worked on State or cooperative farms, in industrial jobs, or were victims of massive Soviet deportations. Moreover, many new (post-Soviet) landowners remained city dwellers after

independence and do not feel connected to their land, nor even the town where their land is located. Some of these landowners do not tend their restituted land as well as local inhabitants tend theirs (Sēstulis, personal communication 2002). Some landowners have clear-cut their land for a quick profit, when sustainable thinning methods are often preferable for long-term economic gain, for environmental reasons, as well as to preserve the traditional Latvian rural landscape (Sēstulis, Lagūns, personal communication 2002). This is likely due, in part, to a lack of funding for land management programs, landuse law enforcement since independence, and the near absence of compensation for landuse restrictions in GNP (Strautnieks, Burcevs, personal communication 2002).

CHANGES IN GOALS OF THE GNP ADMINISTRATION

Schwartz (2001) argues that since independence, the GNP Administration has focused its goals more on the global value of preserving biodiversity rather than the local value of preserving the cultural landscape. According to these new priorities, Schwartz claims that "biology trumps ethnography, and the [Gauja] national park is internationalized by eliminating its national content" (Schwartz 2001, p. 303). Here, she refers to eliminating the Latvian cultural landscape, and asserts that the focus on preserving biology [biodiversity] diminishes the unique local content of the Park and caters to the international community. Furthermore, subjugating the goal of protecting the Latvian cultural landscape to that of protecting biodiversity is a departure from the broader policy framework set up in Latvia in the early 1990's (including policy on citizenship, the use of the Latvian language, and land restitution), policies to promote the political justice of preserving/restoring the Latvian national identity and restoring power primarily to ethnic Latvians from pre-Soviet times.

This section discusses the changes in the stated goals of the GNP Administration, and supports Schwartz's findings. This shift in priorities towards preserving biodiversity sacrifices long-held values of some local Park stakeholders, such as landscape scientist Olģerts Nikodēmus, who said in an interview (2003) that the landscapes (which he states are defined in Latvia as the landscapes structures, and the historical causes of these structures) in GNP's Landscape Protection Zone should be protected. In addition, GNP's principal founder and landscape scientist, Aija Melluma, stated in an interview (2004) that the goals of national parks in Latvia have multiple functions, including protecting cultural landscapes as well as promoting development. Melluma stated that some of her current research works on conceptualizing the Latvian cultural landscape, and drawing Latvia's attention to preserving its cultural landscapes. It is shown below that the GNP Administration is following a new policy direction focused on the preservation of biodiversity over that of the cultural landscape, and that this is in line with, and influenced by, Western guidelines for protected areas.

GNP, established in 1973, was the second Soviet national park, established at the beginning of a wave of Soviet parks established throughout the 1970's. National parks were a divergence from the existing *Zapovedniki* (Nature Reserves) in the Soviet Union. The purpose of the *Zapovedniki*, first established in 1919 for scientific research, was to preserve typical and unique ecosystems and conduct baseline research in ecology (Ostergren 2001). The only anthropogenic activities allowed in these reserves were for the purposes of scientific investigation – no land or wildlife management, and no tourism activities were permitted (Ostergren 2001). Soviet national parks, on the other hand, were modeled after America's Yellowstone National Park, with limited human use being a key function of the

parks (Melluma, personal communication 2004). The original goals of GNP were clearly laid out when the Park was formed in 1973. According to the principal founder of GNP, Aija Melluma, the original goals of the Park were to:

- promote education;
- promote scientific research;
- protect nature;
- protect the landscape;
- promote development; and
- promote recreation (Melluma, personal communication 2004).

She says that protecting the landscape meant protecting Latvia's cultural landscape, and that rural development would help maintain Latvia's cultural landscape – via tending forests, maintaining pastures, and growing crops, in addition to maintaining tourist facilities in the countryside. The maintenance of pastures and croplands has been particularly lacking in post-independence Latvia, which has experienced extensive farm abandonment as a consequence of the breakup of Cooperative and State farms. Petek (2001) also found that in post-Soviet Gorenjsko, Slovenia, the abandonment of crop production, and farmland overgrowth, are partially destroying the region's cultural landscape. The current goals of GNP, as outlined by the GNP Administration, are to:

- promote education;
- promote scientific research;
- protect nature;
- promote tourism development;
- promote recreation; and

- raise funds to support the GNP Administration's budget (Gauja National Park 2004).

According to these two sets of goals, the key changes between the original goals and the current goals of the Park Administration are:

A. the elimination of the stated goal to protect the landscape,
B. the implementation of internal fund raising to support the GNP Administration's budget, and
C. the Park Administration's support of tourism development, without support of the original broader development goals.

With the Sovietization of the Latvian nation, the Latvian cultural landscape of the inter-war years was disappearing during Soviet times. It was disappearing due to farm consolidation into large communal farms, which led to a de-fragmentation of the landscape, leaving ubiquitous large single-purpose agricultural plots. Soviet Bloc housing was built in towns and villages throughout the countryside, while approximately one-half of the single-family farmsteads were bulldozed, and many more fell into ruin (Melluma 1994). According to Melluma (personal communication 2004), the creation of GNP occurred during the Soviet period, and was considered a triumph by many Latvians in their assertion of national identity under an oppressive regime. It was important to the Latvians that the word "national" be used in naming the "national park". According to Melluma, the Soviet government resisted the use of this term, as the Soviet policy was to repress nationalism among its member states, but an obscure document was found where Lenin suggested that the Soviet Union develop national parks, and this reference was used by those establishing the Park to convince the Soviet government that the term "national" should be used in "national park". When Gauja "National" Park was formed, it was celebrated in many Latvian newspapers (Melluma,

personal communication 2004). In this way, the formation of GNP was connected to the Latvian national identity. However, now that Latvia is again independent, the need for Latvians to assert their national identity is diminishing, and the Latvian concept of national identity is changing as well. In Bunkše's review of 1993 interviews with key Latvian literary figures regarding the Latvian identity, Bunkše concludes that the "grand story of 'Latvianness' is… coming into question as to its exact meaning and relevance in the Latvia of today" (Bunkše 2000). Similarly, instead of a focus on protecting the Latvian cultural landscape (and thus the Latvian national identity), other goals are gaining priority within the GNP Administration.

Since Latvian independence, the preservation of biodiversity within the Park has become the focus of the nature protection goal for the current GNP Administration. Multiple stakeholders cater to the focus on biodiversity, including NGO's, some academicians, and national government bodies in Latvia, (Pakālne, Ratfelders, Auninš, personal communication 2002). Schwartz (2001) and Melluma (personal communication 2004) claim that this new focus on the protection of biodiversity in GNP stems from global influences, primarily recent Western influences. Cellarius (2004) discusses the same phenomenon as related to Bulgaria, writing that Western concern for the East European environment has been accompanied by financial and technical assistance for environmental projects, and thus the global concern about biodiversity has been imported into Bulgaria in the form of Western-supported projects.

Latvia joined the European Union in May of 2004. In addition to many other EU requirements, Latvia needed to show compliance with EU nature protection standards to become a member. These standards reflect Western European values. The primary value

dictating these standards is the value of maintaining biodiversity in protected areas. These standards are defined by the European Union through the Birds and Habitats Directives (EC Directive 79/409/EEC, EC Directive 92/43/EEC). Further, Western government institutions and NGOs, such as Finland's Ministry of Environment, the United States Environmental Protection Agency, the Swedish Environmental Protection Agency, the Danish Ministry of Environment and Energy, the Netherlands Ministry of Housing and Physical Planning, and the Worldwide Fund for Nature, are aiding Latvia in environmental protection through funding, research, consulting, training, and cleanup programs. Along with these benefits, the organizations have influenced the direction of Latvia's and GNP's environmental protection away from landscape protection towards a focus on the preservation of biodiversity. Evidence of this within the GNP landscape is found via satellite image monitoring of landscape change during the period 1985 – 2002 in Chapters 3 and 4. Similarly, Cellarius (2004, p. 68) writes that most Bulgarian NGO's "rely largely on project funding, so that donor priorities may influence the activities undertaken."

There are concrete actions the GNP Administration has taken to focus protection efforts on biodiversity over the cultural landscape. A motivation for this agenda, as Strautnieks stated in a 1999 interview with Dr. Katrina Schwartz (when Latvia was not yet a member of the EU), is "to keep up with the times, to anticipate where Europe is heading – if we want to join it politically" (Schwartz 2001). Maintaining good standing in the EU is vital for Latvia, and therefore complying with European environmental standards and goals is essential. Thus, in addition to considering the preservation of biodiversity an important value in its own right, Strautnieks backs it in support of Latvia's political and economic aspirations. The Park Administration's actions to promote the protection of biodiversity over the cultural

landscape are discussed below in sections A, B, and C, referring to the above stated key changes from the original goals to the current goals of the Park. To understand some of these actions, it is helpful to recall the five Park management zones, created in 2000 (Figure 1.3):

1. Nature Reserve Zone – 3,668 ha;
2. Nature Conservancy Zone – 32,655 ha;
3. Cultural Historic Zone – 3,501 ha;
4. Landscape Protection Zone – 40,303 ha;
5. Neutral Zone – 11,618 ha.

Note that the "white" space inside the Park, as seen in Figure 1.3, which represents the city of Cēsis, although enclosed in the Park, is not actually a part of GNP.

In the Nature Reserve Zone, no economic activity or land altering activities are allowed, and tourists are also not allowed to visit this zone. No development or agriculture is allowed in the Nature Conservancy Zone, and in this zone the only allowable logging is that which is needed to maintain forest paths, to maintain views of the Gauja River, and for "sanitary" cuts. Note that sanitary cutting is a standard Latvian forestry practice in managed forests that removes dead wood and trees that are "damaged" or "sick" due to storms, disease, or insects (Lagūns, personal communication 2002). The Cultural Historic Zone and Landscape Protection Zone allow for restricted agriculture, limited forestry, and limited development. Agriculture, forestry, and development are allowed in the Neutral Zone with only minor restrictions (Latvian Cabinet of Ministers 2001).

Latvian landscape scientist and Professor of Geography Olģerts Nikodēmus, who has worked closely for many years with principal GNP founder Aija Melluma and has published

extensively on Latvian landscapes, described in an interview (2003) the original goals designated for the five management zones of GNP:

- the Nature Reserve Zone was intended to protect natural landscapes and biodiversity;
- the Nature Conservancy Zone was intended to preserve natural landscapes and biodiversity, however, this zone was also intended for tourist recreation, and, therefore, the landscape was to be managed with some forest cuts in order to maintain trails and views of the Gauja River;
- the Cultural Historic Zone was intended to preserve cultural and historic objects in the Park;
- the Landscape Protection Zone was intended to protect typical and historic landscapes of Latvia; and
- the Neutral Zone's intended goals and uses were not clearly defined by either Nikodēmus or Melluma. Melluma, however, stated in an interview (2004) that the Neutral Zone was intended to be those areas within the borders of the Park that were not directly useful for one of the stated values for the Park (education, scientific research, nature protection, landscape protection, development, and recreation).

A. The Elimination of the Stated Goal to Protect the Landscape

The stated goal of landscape protection in GNP is being replaced by a more international standard of environmental protection, one that focuses on the protection of biodiversity. GNP Director Jānis Strautnieks refers to the Nature Reserve and Nature Conservancy Zones as the core zones of the Park, viewing the others (the Cultural Historic, Landscape Protection, and Neutral Zones) more as buffer zones (Strautnieks, personal communication 2002). This terminology mirrors the international framework of a Biosphere

Reserve, and has been introduced in regards to GNP after Latvia's independence (Salafsky 2000). The core area of the Park (the land in the core zones, considered separately from the buffer zones) qualifies as a category II park under the World Conservation Union (IUCN) standards. GNP Director Strautnieks stated in an interview (2002) that the GNP Administration is considering the implementation of a plan in which the spatial extent of GNP would be reduced to this core areas (the Nature Reserve and Nature Conservancy Zones), divesting itself of the three buffer zones. In addition to making the Park more manageable given the Administration's financial constraints, this would result in GNP becoming an IUCN category II park, held in high esteem in the international community. For instance, IUCN category II is stated as a valued status for the EuroParc Federation, an umbrella organization of Europe's protected areas, of which GNP is a member.

But Melluma (personal communication 2004) believes that this reduction of GNP to its core area "would not be Gauja National Park"; it would totally disregard the cultural aspect of the Park. Melluma (personal communication 2004) explains that this would be trying to emulate the concept of a biotope, a nature protection concept that came from the preservation of Scandinavian nature, and it would be a mistake to mimic the Scandinavian model in Latvia. She explains that other goals are more important in Latvia: GNP's river valleys are unique, as is the cultural history, and the landscape matrix, the preservation of which is also essential for certain species to survive. Melluma (personal communication 2004) also makes the point that *Zapovedniki* throughout the former Soviet Union are large areas reserved for strict nature protection and scientific study, and that the distinction between *Zapovedniki* and national parks should not be overlooked. National parks have other functions, including development, landscape protection, recreation, education, and protecting

culture and history in the landscape. She asserts that Latvia must adapt concepts from abroad in a way that is sensitive to the local environment (Melluma, personal communication 2004).

GNP Director Strautnieks said in an interview (2002) that he is discussing plans for the nearby municipalities to expand to parts of the Park where they currently have no jurisdiction. Although this is a separate project from the potential plan to reduce the size of the Park to its core area, it may be seen as moving in the same direction. Strautnieks stated that in the near future the Landscape Protection Zone may be fully managed by the municipalities instead of the Park Administration (Strautnieks, personal communication 2002). Melluma (2004) said in an interview that she believes that the town councils of the municipalities in the Park already have too much control over the land. She believes that GNP should have jurisdiction over land use laws within its borders so that the land can be managed with the broader values of the Park instead of the interests of each municipality (Melluma, personal communication 2004). In particular, the traditional Latvian landscape may not be well protected within the Landscape Protection Zone if the Park had no jurisdiction over land use in this zone. Furthermore, Rolands Bebris, the Director of the Environmental Protection Department in Latvia's Ministry of Environmental Protection and Regional Development, also stated simply that the landscape is an important feature of GNP and that it should be preserved (Bebris, personal communication 2002).

As mentioned, the GNP Administration has taken concrete actions that reflect its growing commitment to protecting biodiversity rather than the traditional Latvian landscape. The GNP Administration has focused efforts to protect the core zones much more than the buffer zones of the Park. Strict limitations in development and tourist activities were passed into law in 2001 for the core zones of the Park (GNP 2001). The Park is currently funding a

project to inventory the core zones of its wetlands, peat, steep slopes, and river valleys in order to be better prepared to protect these resources (Strautnieks, personal communication 2002). Strautnieks' vision for GNP will annex some forest areas currently in buffer zones into the core zones of the Park, in order to increase the size of these zones and step up protection of these forest areas.

The GNP Administration undertook a land exchange project along with the Danish Ministry of Food, Agriculture and Fisheries (Division for Land Consolidation), funded by the Danish Ministry. This project, completed in 2002, was successful in offering individuals State forest lands in exchange for private forest lands – State forest lands in the Landscape Protection and Neutral Zones were given to individuals in exchange for their lands in the Nature Reserve and Nature Conservancy Zones (which they had received through land restitution or subsequent purchase of restituted land) (Danish Ministry of Food, Agriculture, and Fisheries 2002). The reasoning for this exchange was that the Park Administration preferred that the State own the forest lands in the core zones of the Park, so it could better manage these lands, and so that private individuals would be less likely to disturb the land in these core zones (Østergaard, Apenītis, personal communication 2002). However, laws regarding use of private forest lands in the core zones are quite strict, including a prohibition on clear-cuts, so there is little landuse change that these landowners were allowed to impose on their lands in the core zones. Many of the private landowners that exchanged their lands through this project cut portions of the forests they received (including some clear-cuts) in the Landscape Protection and Neutral Zones of the Park soon after receiving their new lands (Sēstulis, personal communication 2002). Thus, the land exchange project resulted in some forest cuts in GNP that would not have taken place had the project not been instituted. The

Park Administration's compromise of forest land in buffer zones in order to secure protection of comparable forest land in core zones reflects the Administration's priority of protecting the Park's core zones more than the Landscape Protection and Neutral Zones.

B. The Implementation of GNP Administration Internal Fund Raising

The current reality of limited financial resources is forcing the GNP Administration to reprioritize its goals. While limited funds are directed towards increased protection of the core areas of the Park, it has been at the expense of landscape protection in the buffer areas. A lack of full funding for GNP from Latvia's State budget has forced the GNP Administration to raise approximately 60 percent of its own funding annually (Strautnieks, personal communication 2002). The Administration's primary fund raising activity is logging (and selling logging rights) on State lands inside the Park, acquiring 83 percent of its internal funding in 2001 through logging activity (GNP 2001). Logging of these State lands occurs in planted forests (not old growth forests), primarily in the Landscape Protection and Neutral Zones, although limited cutting for this purpose also occurs in the Cultural Historic and Nature Conservancy Zones (Latvia's Cabinet of Ministers 2001, Strautnieks, personal communication 2002). According to an interview with Melluma (2004), GNP was established after these forests were planted, and the Park was originally mandated to protect these planted forests in addition to the old growth forests of the Park. Some of the Administration's fund raising activities include clear-cutting of forest sites up to two hectares in State and private forests in the Neutral Zone, and in private forests in the Landscape Protection Zone (Latvia's Cabinet of Ministers 2001). It is necessary to note that although clear cuts of up to two hectares approximate natural fire disturbances and is considered by foresters to be an environmentally sound practice in pine forests (Rozītis, personal

communication 2002), clear-cutting was not practiced in the Park throughout the Soviet period, although sanitary logging was practiced (Sēstulis, personal communication 2002; Nikodēmus, personal communication 2003). Latvian landscape scientist Nikodēmus said in an interview (2003) that he believes that the existing landscapes should be preserved in the Park's Landscape Protection Zone. According to Nikodēmus, selective cuts preserve the landscape, but clear-cuts do not. Nikodēmus believes that further clear-cutting should be prevented in the Landscape Protection Zone.

GNP Director Strautnieks explained in an interview (2002) that the State is trying to reach a high level of nature preservation with legal acts alone. He contends the State does not fund GNP well enough to do so, and it offers no tools to cooperate with municipalities and local inhabitants, such as financial compensation for restricted landuse laws in the Park. Some residents in the Park have resorted to illegal land uses for income, including the illegal use of chemical fertilizers and illegal logging of Park lands, most often on private lands in the Landscape Protection and Neutral Zones (Salminš, Bebris personal communication 2002). Thus the lack of funding for the Park has had adverse affects on the Landscape Protection and Neutral Zones more than on the core zones of the Park, and this reinforces the current trend in GNP toward a focus on the protection of biodiversity over that of the Latvian cultural landscape.

C. The Park Administration support of tourism development, without support of the original broader development goals

The promotion of development has been dropped from the GNP Administration's list of goals. In its place, the promotion of tourism development has been added. Conforming to the international trend, the tourism industry is intended to replace other industry in the Park

that is hampered by Park land use restrictions. The United Nations Environmental Programme - Production and Consumption Branch promotes tourism in protected areas to "raise awareness of environmental values and… serve as a tool to finance protection of natural areas and increase their economic importance" (UNEP 2004). The GNP Administration currently supports tourism development in several ways. Although GNP is already visited by over 1 million tourists each year, the Administration is aiming to increase the number of visitors, especially overnight tourists, in the coming years. GNP Director Strautnieks said in an interview (2002) that he believes there are large untapped tourist markets in Russia and in Europe (especially since Latvia has joined the EU). To increase the number of annual GNP visitors, the Administration is building a more extensive tourism infrastructure in the Park, through its own works and through encouraging private tourism enterprise. As of 2002, GNP has begun creating the first new forest trails since the Soviet era (Strautnieks, personal communication 2002). The Administration has built a website to promote tourism, and continues to produce new literature about the nature and available tourist activities in GNP. The Administration promotes and works closely with businesspeople that open and run restaurants, hotels, and Bed and Breakfast enterprises in and near GNP (Strautnieks, personal communication 2002, GNP website 2007). The GNP Administration is working with the European Union and multiple international NGO's to gain funding and assistance to be used for Park infrastructure and tourism activities (Strautnieks, personal communication 2002). Such cooperation is common throughout East and Central Europe, as protected areas in the region are experiencing growing numbers of tourists, and Turnock (2001) reports that some national parks and reserves in this region are unprepared for this increase in tourism.

While tourism development is supported by the international community (often through direct funding, as in the EU case just mentioned) to complement nature and biodiversity protection, well-managed broader development goals in GNP would lead to the additional protection of Latvia's cultural and historic landscape throughout the Park. With approximately 21,000 people living in GNP, tourism alone cannot support every inhabitant of the Park. Furthermore, there are a few tourism hubs in the Park that contain natural and cultural sites and recreation areas, and most tourism in the Park concentrates around these sites, depriving inhabitants in the other areas of opportunities to capitalize on tourism (Burcevs, personal communication 2002). Environmental landuse restrictions in the Park (such as logging restrictions, chemical fertilizer prohibitions, hunting restrictions, and land development restrictions) without broad rural development policies or government subsidies to landowners (for instance, to maintain meadows or make only sanitary cuts in small forest patches) prevent many people from making a living from the land, and forces some to move to cities or to commute to jobs in the cities. Thus, many landowners cannot maintain their private farms, meadows, and forests, and the rural-urban migration leads to farmhouses falling into disrepair, all bringing about a degradation of the Latvian cultural and historic landscape. If broader development goals (agriculture, forestry, and environmentally sound industry) were encouraged in the Landscape Protection and Neutral Zones of the Park, as originally mandated for GNP (Melluma, personal communication 2004), landowners would be more likely to stay in the Park and manage their rural land, leading to a protection of the Latvian cultural and historic landscape. Interestingly, although biodiversity protection has been a priority for the GNP Administration, GNP has actually lost overall biodiversity since 1991, primarily due to the loss of plant and insect species in maintained meadows in the

Landscape Protection and Neutral Zones of the Park (Pilāts, personal communication 2004). According to Pilāts, through traditional landuse practices, Latvians have (until recently) maintained most of these meadow habitats, and plant and insect species have adapted to these habitats over many years. These maintained meadows are disappearing due to the lack of profitability of crop and grazing agriculture inside the Park. Thus, while the Park's goals have focused on preserving nature and biodiversity in its core areas, overall biodiversity is actually being lost, and could potentially be salvaged with broad development goals and landscape protection efforts. This concept will be further discussed in Chapter 5.

CONCLUSIONS

Protected areas throughout the world protect multiple resources, and multiple stakeholder groups espousing different value systems often have differing interests in these resources. GNP Director Strautnieks actively supports the preservation of biodiversity and finds an international structure to support his efforts. Representatives of the local inhabitants (e.g., Kocenis Mayor Burcevs and Krimulda Mayor Salminš) vie for increased freedom for landowners to use private Park lands for economic productivity. Landscape scientist and principal GNP founder, Aija Melluma, vies for preserving the Latvian cultural and historic landscape, in addition to preserving biodiversity and providing for economic development within the Park. Melluma said in an interview (2004) that concepts from abroad regarding the protection of national parks are not being satisfactorily adapted to the local environment and local customs. She advocates protecting the cultural landscape in GNP, because the cultural landscape is seen as an integral part of Latvia's national identity (Bunkše 2000, Schwartz 2001, Melluma 2004) and is a vehicle to promote rural development (Melluma 2004).

Countries throughout Eastern Europe are under similar internal pressures to preserve the cultural landscape for purposes of preserving national identity and to promote rural development opportunities for those living in and near protected areas. They are also under increasing pressure to conform to Western priorities of biodiversity protection through the influence of NGO's, Western governments, and the European Union. These countries are challenged with balancing the interests of multiple stakeholder groups, including these new influential stakeholder groups from the West, in the environmental and other arenas, in the face of the massive political, economic, and social reform that has occurred in this region over the previous two decades.

Chapter 3: Characterizing Change in Gauja National Park's Natural and Cultural Landscapes

Introduction

In the previous chapter, it was shown that the preservation of biodiversity and natural areas is of primary importance to some Park stakeholder groups, while the preservation of the Latvian cultural landscape is of primary importance to others. Furthermore, the preservation of the Latvian cultural landscape, while mandated as one of the original Park goals, is not high on the agenda of the current GNP Administration. As stated in the November 1999 Management Plan for Gauja National Park (Petersen 1999), "[t]he traditional rural landscape with its harmony and cosiness is of secondary significance after the primary – the ancient valley of the Gauja River and its tributary valleys." It was shown in Chapter 2 that this traditional rural landscape, however, is of great importance to some stakeholders.

The focus of this chapter is to understand how the GNP landscape has changed from the late Soviet era (1985) through modern times (2002), and more specifically, in what ways the changes have influenced both the natural and the cultural landscapes in the Park. The changes in landuse and landcover (LU/LC) composition and pattern are analyzed using remotely sensed data in a Geographic Information Systems (GIS) context, and discussed in terms of their effects on GNP's overall natural and cultural landscapes. The timing of these changes is examined to evaluate the effects of major events and land policy changes on the landscapes in the Park.

Research Goals

1) Characterize LU/LC at multiple time points (i.e., 1985, 1994, 1999, and 2002) in GNP through an assembled satellite image time-series by classifying landuse and landcover, and performing landcover change detections.

2) Examine how changes in composition and spatial structure of LU/LC have affected the protected natural and cultural landscapes within the Park throughout the study period.

Methods

The primary data used to characterize LU/LC in GNP at multiple time points is a time-series of four Landsat Thematic Mapper (TM) satellite images. Remote sensing techniques are used for these analyses due to the suitability of such data. Landsat Thematic Mapper (TM) satellite data were selected to monitor the landcover change, because of Landsat's sufficient historical archive, areal coverage, and its appropriate spectral, temporal, and radiometric resolutions. Wessels et al. (2004) makes the point that the appropriateness of satellite image resolutions in addressing biodiversity conservation depends both on the patch sizes of important habitats, and on the specific types of land cover changes threatening the biodiversity in that region. Wessels et al. (2004) used MODIS (250 and 500 meter resolutions) to map fractional landcovers in the Greater Yellowstone Ecosystem of the USA, and reported limited success in mapping smaller habitats (patches smaller than MODIS pixels), often important for biodiversity. Wessels (2004) used Landsat TM as reference data, which he claims was sufficient for the habitat mapping. Evans & Moran (2002) reports that high spatial resolutions, referred to as resolutions between 1 and 30 meters, are appropriate for detecting spatial patterns in spatially complex landscapes. In addition, Pedlowski et al.

(2005) successfully used Landsat TM to monitor deforestation in conservation areas in Rondônia, Brazil.

The image dates in this study were chosen to obtain temporal coverage from the late Soviet era through today, based on the availability of cloud-free images at leaf-on times of year. The specific images used were:

- 1985/06/25, Path 186, Row 20
- 1994/07/11, Path 187, Row 20
- 1999/08/02, Path 187, Row 20
- 2002/05/22, Path 187, Row 20

The 1985 and 1994 images were chosen because they straddle Latvia's independence (1991). The 1999 image date was chosen because 1999 essentially marks the end of the land restitution process in Latvia: close to 100 percent of claims had been settled by this date. Finally, the 2002 image gives insight into post-restitution processes taking place in GNP.

Fieldwork was conducted in the summer of 2001 to collect ground-control data for satellite image classification. A 1:100,000 scale topographic map of GNP and a set of orthophotos at 1:10,000 scale, taken in June and August of 1997, were used to navigate throughout the study site. The orthophotos were also used in conjunction with in-situ visualization to identify locations of at least 100 x 100m in area of uniform landcover type. During fieldwork, the exact landcover types at these locations were assessed, along with the collection of Global Positioning Systems (GPS) coordinates to define the center of these plots of uniform landcover. GPS data were also collected from nearby base stations, and Differential GPS was used to post-process the GPS data to increase the accuracy. At least 150 GPS points were collected and averaged for each location to further increase accuracy to

within +/- 3 meters. This accuracy was far more than necessary, because the goal was simply to be able to identify ground cover samples on the satellite images (30 meter resolution) for classification training purposes. In addition to collecting GPS data for all ground-control samples, the orthophotos were annotated using ESRI's ArcView with a laptop in the field to double check the locations. Ground control data were collected in GNP in the summer of 2001 to support LU/LC classification. One-half of the ground control samples of each landcover type were used for training purposes, and the other one-half were used for accuracy assessment. The classification system was based on the USGS Land Use/Land Cover Classification System for Use with Remote Sensor Data, but tailored to the specific study area and the goals of the research. Samples for 16 landcover classes were recorded:

1. predominantly spruce forest
2. predominantly pine forest
3. predominantly coniferous forest (mixed pine and spruce only)
4. predominantly hardwood forest
5. mixed forest (conifers and hardwood)
6. wet hardwood forest
7. young hardwood forest
8. young pine forest
9. partially cute pine
10. partially cut coniferous forest
11. partially cut hardwood forest
12. shrubs
13. crops

14. tall grass

15. short grass

16. Hogweed, a nuisance weed that GNP researchers are interested in mapping.

Note that predominance in the above classes is defined by at least 30 percent of the specified forest type. Upon classification of the satellite images (described below), the LU/LC classes were aggregated into the following 7 basic landcover types through a recoding operation:

1. predominantly hardwood forest
2. predominantly coniferous forest
3. shrubs
4. crops/pasture/grass
5. built-up
6. wetlands
7. water.

For most analyses, these two forest classes were again merged through another recoding operation, as the primary goal was to consider basic landuse change categories relating to changes in the Park's natural and cultural landscapes. For these analyses, the landcover classes used were:

1. forest
2. shrubs
3. crops/pasture/grass
4. built-up
5. wetlands
6. water.

Preparation of Satellite Images for Landcover Change Analyses

Projection information

The first step was to prepare the set of orthophotos obtained from the Gauja National Park Administration. These orthophotos were taken in June and August of 1997. They were taken at an initial scale of 1:10,000, with 1-meter resolution, and were then digitally scanned. For these analyses, the orthophotos were re-projected into the same projection/datum used for digital map data by the GNP Administration (see below). The Landsat TM images were later georectified to the orthophotos and placed in the same projection. The projection information is as follows:

- Transverse Mercator
- Scale factor at central meridian 0.9996
- Longitude of central meridian 24E
- Latitude of projection origin 0N
- False easting 50,000 meters
- False northing 0 meters
- Spheroid GRS80
- Datum GRS80.

Some of the vector layers (e.g., DEM, roads, and administrative boundaries) digitized from a stereo-plotter using 1:30,000 1998 air photo pairs by the Latvian State Land Service originally used the ETRF89 datum and the GRS80 ellipsoid. However, the GNP Administration uses the GRS80 datum (also with the GRS80 ellipsoid) for these data. To be sure the GRS80 datum and ellipsoid didn't introduce unacceptable error into the data, the horizontal spatial error was tested when using the GRS80 datum in place of the ETRF89

datum. The added horizontal spatial error from this datum substitution was far less than 1 meter within this study area, so the GRS80 datum was used without concern for poor registration.

Georectification of Satellite Images

The Landsat TM satellite image of GNP from August 2, 1999 (Path 187, Row 20) was rectified to the orthophotos. This image was first selected for rectification because the image date is nearest of the acquired images to the date of the air photos (a 2 year separation from 1997). ERDAS IMAGINE was used to rectify the image. An even distribution of Ground Control Points (GCP's) was selected to match the satellite image to the orthophotos. A second order polynomial transformation was employed to yield an RMSE (Root Mean Square Error) of 11.3 meters. The visual match between the satellite image and the orthophotos is excellent.

The other three Landsat TM images (listed above) were then each rectified to the 1999 image, also using second order polynomial transformations, yielding an RMSE of 4.0 meters (1985 image), 5.6 meters (1994 image), and 12.0 meters (2002 image). The visual alignment between all images is quite good. The Southwest corner of GNP falls outside of the 1985 image since it is from a different satellite path-row than the others. The majority of analyses are, therefore, limited to the major portion of GNP that falls inside the 1985 image.

Classification of Satellite Images

1999 Image

The first image to be classified was the 1999 image, because it was the image nearest in time and prior to the 2001 ground control fieldwork. The biggest risk associated to this 2-

year delay between field and image dates is that some ground-control landcover patches underwent major landcover change between these years. But this event was generally easy to spot visually on the satellite image (for instance, a small patch of recently cleared forest appeared very different from the surrounding remaining forest, and such instances were not used in the classification process). A vector layer of polygons was created to define training samples of ground cover types, based on ground-control fieldwork in 2001, that included GPS data, field sketches of the landcover patch locations, and recorded landcover types. The ground-control data were verified with the 1997 air photos to be sure the 2001 landcover was consistent with the 1997 landcover. For instance, an urban area can not become a lake in 3 years, but a forest could be cut to become a field in that time. A vector layer of reference landcover patches was also created for accuracy assessment.

A hybrid supervised/unsupervised method was used for the satellite image classification. Training sites were defined in ERDAS IMAGINE software using the vector polygon layer representing the ground-control training samples. Spectral signatures (using all 6 of the 30m resolution Landsat TM spectral bands) were created with a supervised classification approach using these training polygons. Signatures were created for 12 of the 16 original classes, excluding the partially cut forest classes and the mixed forest class. An unsupervised classification was then performed on the image data to produce 25 additional spectral signatures. The ISODATA method was used with a convergence threshold of 0.950, and the maximum number of iterations was set at 40. The two sets of signatures were then appended and analyzed using the transformed divergence measure. Signatures from the unsupervised classification that were inseparable from any signature in the supervised classification (using a cutoff of 1500) were deleted first. Transformed divergence scores

below 1700 imply that the separability between two classes is poor (Jensen 2004). A cutoff of 1500 was used instead in these analyses, because the transformed divergence between some of the coniferous forest and hardwood forest signatures from the supervised classification had values in the 1500's, and an attempt was made to distinguish between these classes for simple mapping of these two classes within GNP. Those signatures from the unsupervised classification that were inseparable from other unsupervised classification signatures were then deleted, again using a transformed divergence score of 1500 as a cutoff.

A supervised classification was then performed in ERDAS IMAGINE to classify every pixel of the satellite image using the remaining set of signatures as inputs. To choose a classification decision rule, the Minimum Distance Algorithm was tested, as was the Maximum Likelihood Method, and the Mahalanobis Distance Algorithm. Although the data in some of the bands clearly strayed significantly from normality, the Maximum Likelihood Method was far superior to the minimum distance algorithm (and slightly superior to the Mahalanobis Distance Method) when looking at the contingency tables, that tabulate how many pixels were correctly and incorrectly classified within the training pixels alone. Thus, the Maximum Likelihood Method was used.

The classes were then examined by looking at the spectral profiles of the classes in addition to seeing the locations of the classes on the orthophotos. When a class clearly contained more than one landcover type, the class was deleted and the final supervised classification re-run. This approach forces the classification procedure to re-allocate the pixels that were in the deleted class to other classes. Each of the deleted classes had at least one transformed divergence score under 1700. Using this procedure, the classes became more uniform in the landcover type they contained, as seen through comparison with the

orthophotos. Classes resulting from signatures from the supervised classification procedure were attributed to the 12 training classes. These classes were then recoded to one of the 7 aggregated classes. Classes resulting from the unsupervised classification were attributed using their spectral and spatial characteristics, and through comparison with the orthophotos as ground control.

The resulting classification was speckled with some 1-pixel patches of a landcover type inside of a larger patch of a different landcover type. When compared with the orthophotos, it was clear that these 1-pixel patches were almost always misclassified pixels, or "noise," with the correct class being that of the larger surrounding patch. A set of procedures were run in ERDAS IMAGINE to "de-speckle" the image. First, a Clump procedure was run to identify how many other pixels of the same class that each pixel was "clumped" with (or spatially adjacent to). A Sieve procedure was then run to identify those pixels that weren't clumped with any other pixels of the same class. An Eliminate procedure was then run to "eliminate" each pixel that wasn't clumped with any other pixels of the same class (so that its class could be changed to the background class in the next step). Finally, a 3x3 majority filter was run to reclassify each eliminated pixel as the class of the majority surrounding landcover class. This set of processes, a common solution to a common problem in remote sensing image processing, was successful in reducing the speckled nature of the image and, when visually compared with the orthophotos, the classification accuracy of the reclassified image clearly increased.

All Landsat TM images were classified using the same methods as was used for the 1999 image. However, following is a discussion of a few unique qualities of each image that required slightly different processing steps.

2002 Image

For defining training samples for the 2002/05/22 image, more focus was given to the 2001 ground control data than the 1997 orthophotos, because the ground control data were much closer in time than the orthophotos to the 2002 image. In a few cases, it was evident on the 2002 satellite image that some portions of ground control plots of forest had been cut between the 2001 fieldwork and the 2002 image date. In such cases, new boundaries for the training polygons were created, and the cut portions of forest were left out of these polygons.

Furthermore, the classification could not well distinguish between fields and shrubs for the 2002 image. With multiple runs of the classification procedure, at least one ambiguous class always resulted (obtained from the unsupervised classification) that seemed to contain both field patches and shrub patches. To deal with this, an additional round of fieldwork was conducted in the summer of 2004 to obtain ground control data for the ambiguous class. Vector outlines of the patches of the ambiguous class were overlaid onto the orthophotos using ArcView. A laptop with these data was brought into the field to help navigate to the ambiguous class patch sites. It was determined from this in-situ data collection whether each patch was a field or shrubs. Then these patches were digitized and used as training samples in a re-run of the supervised classification. This solved the problem of the ambiguous landcover class.

1985 Image

No reliable ground truth data were available for 1985. To get around this issue, the 1985 image was compared visually (and using full spectral profiles) with the 1999 image to find locations where both image years clearly had the same landcover type. Training polygons were created at these locations for supervised classification training of the 1985

image. Since no locations were assured of being shrubs in both 1985 as well as 1999 (due to the temporary nature of the shrub landcover class), no training polygons were drawn for the shrub class for the supervised classification. The spectral profile of shrubs (as seen in the 1999 and 2002 images) was used to find shrub patches (based on similar spectral profiles) to attribute to the appropriate classes from the unsupervised classification of the 1985 image.

1994 Image

The temporally closest ground-control data to the 1994 image was the 1997 orthophotos. This three year lag is too long to guarantee that shrubs in 1997 were shrubs in 1994. So shrub polygons were not used for supervised classification training in this image. Shrub classes were attributed to the unsupervised classification, and attribution decisions were made also based on the spectral profile of shrubs (based on similarities to the 1999 and 2002 images), as well as shape and proximity cues (e.g. shrubs are not likely to be found in the middle of a preserved wetland area, but likely to be found near agricultural areas – as fields left fallow). So, logical consistency of land change patterns and timing was used for images judged too temporally distant from the orthophotos and/or collected ground control.

Classification of the residential/built-up class was problematic for the 1994 image. With multiple classification attempts, this class was consistently overclassified (seen when compared with the 1997 orthophotos), and re-drawing the residential/built-up training polygons for input into the original supervised classification did not solve this problem. As the overall number of residential/built-up patches in the study site is quite small, the final classification (which overclassified this class) was used, and each patch in the study site that was classified as residential/built-up was manually checked. Residential/built-up patches in the 1994 image that were field/crops in the 1985 and 1999 images (or also in the 1997

orthophotos) were manually changed (from residential/built-up) to field/crops – under the assumption that this was much more likely to be a misclassified patch than a patch that was built up between 1985 and 1994, and then converted back into field/crops by 1997 or 1999.

Accuracy Assessment

An accuracy assessment was performed for the 1999 image; one-half of the ground-control samples from the 2001 fieldwork were reserved for this assessment. Each ground-truth sample was checked against the 1997 orthophotos to be sure the ground cover wasn't substantially altered between 1997 and 2001. Accuracy assessments were not done for the other images due to lack of ground-control data (even for the 2002 image, there was a risk that ground cover could have changed between 2001 and 2002, and there were no post-2002 alternatives to verify whether or not such a change had occurred). However, as described above, the classification processes for each image were very similar and great variations in classification accuracy between images is unlikely. Recall, also, that the LU/LC classes were simplified to improve overall accuracy, a well known result.

Classification Accuracy Assessment

As seen from Tables 3.1 and 3.2, below, the accuracy is quite good, both overall (including the Kappa statistic associated with change) and for each landcover class, save shrubs that had a producer's accuracy of only 50.0 percent and a user's accuracy of 65.9 percent. Shrubs were difficult to classify because they spectrally resemble long fallow fields. This is not too problematic, however, because shrubs also resemble long fallow fields in a land use sense. That is, they develop after a more extended fallow period.

Table 3.1. Classification error matrix.

Classified pixels	Reference pixels							
	Conifer	**Shrubs**	**Hardwood**	**Fields**	**Wetlands**	**Built-up**	**Water**	**Total**
Conifer	130	0	0	0	1	0	1	**132**
Shrubs	0	29	1	28	0	0	0	**58**
Hardwood	0	3	184	28	8	8	0	**223**
Fields	0	12	5	504	4	7	0	**532**
Wetlands	0	0	0	0	365	0	0	**365**
Built-up	0	0	0	13	2	155	3	**173**
Water	0	0	0	0	0	0	1194	**1194**
Total	**130**	**44**	**190**	**573**	**380**	**162**	**1198**	**2677**

Overall accuracy: 95.7%

Kappa statistic: K-hat = 94.0%.

The Kappa statistic is a chance-corrected measure of agreement between the classification and the reference data, if the classification process were to be independent of the reference data (Congalton & Mead 1983, John Uebersax 2003).

Table 3.2. Producer's and user's accuracy summaries.

Class	**Producer's accuracy (1 – omission error)**	**User's accuracy (1 – commission error)**
Conifer	98.5%	100%
Shrubs	50.0%	65.9%
Hardwood	82.5%	96.8%
Field/agriculture	94.7%	88.0%
Wetlands	100%	96.1%
Built up	89.6%	95.7%
Water	100%	99.7%

Most pixels in residential areas in the study site contain one or more houses, part of a road, grasses, some trees, and sometimes a few garden crops. This residential greenery makes these areas difficult to distinguish from the field/crops class. Residential areas in each image are speckled with field pixels. Although accuracy for the classification of residential/built-up areas was high for the 1999 image, the time-series of classifications shows that the exact locations of the field and built-up pixels in residential neighborhoods

often changed between image dates, though the built-up pixels always remained clustered in these residential areas.

The analyses presented here are most concerned with landcover change reflecting a qualitative change in landuse, which generally does not require differentiating between forest types. Further, combining the two forest classes improves the classification accuracy. Although these two forest classes were not confused in the accuracy assessment, the samples used for these classes in the accuracy assessment were endmembers (90 percent or more conifer, and 90 percent or more hardwood). When classifications were performed, many of the forest pixels with closer to even mixes of conifer and hardwood often fluctuated between conifer and hardwood forest classifications between consecutive image dates. For these reasons, these two forest classes were combined for most analyses, though for some display purposes the classes were kept separate to show where the different forest types are located in the Park.

Landcover Change

The four classified satellite images were then overlaid and post-classification from-to landcover change summaries were calculated by pixel between consecutive image dates. The results from these analyses, presented in the next section, help to tell a story of how and when the landcover in GNP was changing in relation to the timing of land reform and events occurring in the Park, in Latvia, and in the former Soviet Union and Eastern Europe.

Landscape Pattern Change

A protected natural area serves multiple functions such as providing a refuge for biodiversity, absorbing air and water pollution, preventing regional soil erosion, protecting

microclimate, providing recreational space, providing carbon sinks to reduce greenhouse gases, and supporting a variety of educational and scientific research goals. The field of landscape ecology has established that the degree to which a protected natural area supports landscape functions, such as these, depends both on the composition and the spatial pattern of its landcover patches and background matrix (Forman & Godron 1986). Walsh et al. (2003, p. 125) writes that "pattern metrics offer an approach for characterizing landscape states and conditions across space and time as an indication of landscape form and function." Landscape pattern metrics have been used in conjunction with remotely sensed imagery to characterize landscapes in a variety of contexts, including to compare the level of similarity/differences in landscape change between two nearby settlements experiencing different community planning (Batistella et al. 2003); compare the similarity between multiple simulated landscapes (Messina & Walsh 2001); understand landscape spatial composition as a function of geographic, biophysical, and socio-economic variables on a household/farm level in the Ecuadorian Amazon (Pan et. al. 2004); statistically identify clusters of slopes within an alpine treeline ecotone on the basis of spatial and compositional patterns (Allen & Walsh 1996); and investigate the effects of landscape patterns on forest crown fire dynamics and the resulting ecological impact (Turner & Romme 1994). In this section, changes in spatial pattern of landcover within GNP are analyzed in relation to the function of the landscape in terms of nature protection, including the protection of specific species, and the evolution of the Latvian cultural landscape in the Park between during the study period (1985 – 2002). These landscape functions were chosen for analysis, because they represent the interests and values identified by Park stakeholders, as presented in

Chapter 2. The timing of the changes in landcover patterns is evaluated with respect to economic, political, and social influences in the Park.

The spatial pattern of the GNP landscape was characterized at each of the four satellite image dates by calculating pattern metrics using algorithms contained within the FRAGSTATS software (McGarigal & Marks 1995). Some metrics were calculated at the *landscape* "level". This refers to a type of measure that summarizes patterns of all landcover classes across the full landscape of interest. Some metrics were calculated at the "*class*" level. This refers to a type of measure that summarizes spatial patterns of just one landcover class throughout the full landscape of interest. The third and final type of measure that FRAGSTATS calculates was not used for these analyses. This type of measure is termed a "*patch*" level metric. These metrics calculate spatial pattern characteristics of just one landcover patch.

Due to the difficulty in interpretability of some landscape pattern metrics, a small number of metrics specifically applicable or designed for unique research questions are often used. In a study where Messina et al. (2006) compared landscape pattern metrics between simulated and sample landscapes over time in a protected area in the Ecuadorian Amazon basin, the following metrics were used: number of patches, patch area, mean patch size, and patch density. In the Pan et al. (2004) study investigating landscape composition as a function of household/farm level predictor variables, the patch density, landscape shape, and contagion metrics were calculated for each individual farm as inputs into regression models. Batistella et al. (2003) analyzed six pattern metrics, focusing on structural changes in the landscape, instead of functional landscape changes, to compare landscape changes in two settlements experiencing different community planning scenarios. Batistella et al. (2003)

applied and interpreted the following metrics: percentage of forest in landscape, the largest patch of forest (for inferences regarding biodiversity), mean patch size, patch size standard deviation, area-weighted mean shape index (to study edge/center relationships of patches), and mean core area index (to look at the average "core area", or area 90+ meters from the patch edge). In the current study, pattern metrics were calculated for each satellite image date. Similar metrics to those used by Batistella et al. (2003) were specifically chosen to describe protection of core forest areas as well as "patchiness" of the landscape, important for monitoring the evolution of the Latvian cultural landscape and the nature of its fragmentation.

Table 3.3. Landscape pattern metrics analyzed.

Metric name	Level	Definition	Meaning
Number of patches	Landscape	Number of patches in the landscape.	Total number of patches in GNP.
Mean patch area	Landscape	Total area (in m^2) of landscape divided by the number of patches; the result is divided by 10,000 to get the units in hectares.	Average size in hectares of all landcover patches in GNP.
Area of Largest Patch	Landscape	Area (in m^2) of largest patch divided by 10,000 to get units in hectares.	Size in hectares of largest patch in GNP.
Total Core Area	Class (forest)	The sum of all core (forest) areas (in m^2). Each core area is the area of each (forest) patch greater than a user-specified distance (250 m) from the patch edge.	The total forest area in the Park that is at least 250 meters from its patch edge.

Results

The results are first summarized with maps of the four classified satellite images. Although these maps (see Figures 3.1 through 3.4, below) show coniferous forest and hardwood forest to give the reader a better sense of the Park's distribution of vegetation, the two forest classes were combined into one forest class for the analyses, since changes from

and to forest are sufficient to characterize landscape changes associated with the evolution of the natural and cultural landscapes. Changes in amounts of gross landcover between image dates are then summarized and discussed in relation to the timing of economic, social, and policy events affecting GNP. Following, from-to landcover change matrices are presented, describing the number of pixels that changed from each landcover class to each landcover class between consecutive satellite images. These changes are then interpreted with respect to the timing of changing economic, social, and policy conditions. Finally, the changes in pattern metrics between image dates are summarized and discussed in terms of likely causes, as well as effects on the protection of nature/biodiversity and the Latvian cultural landscape.

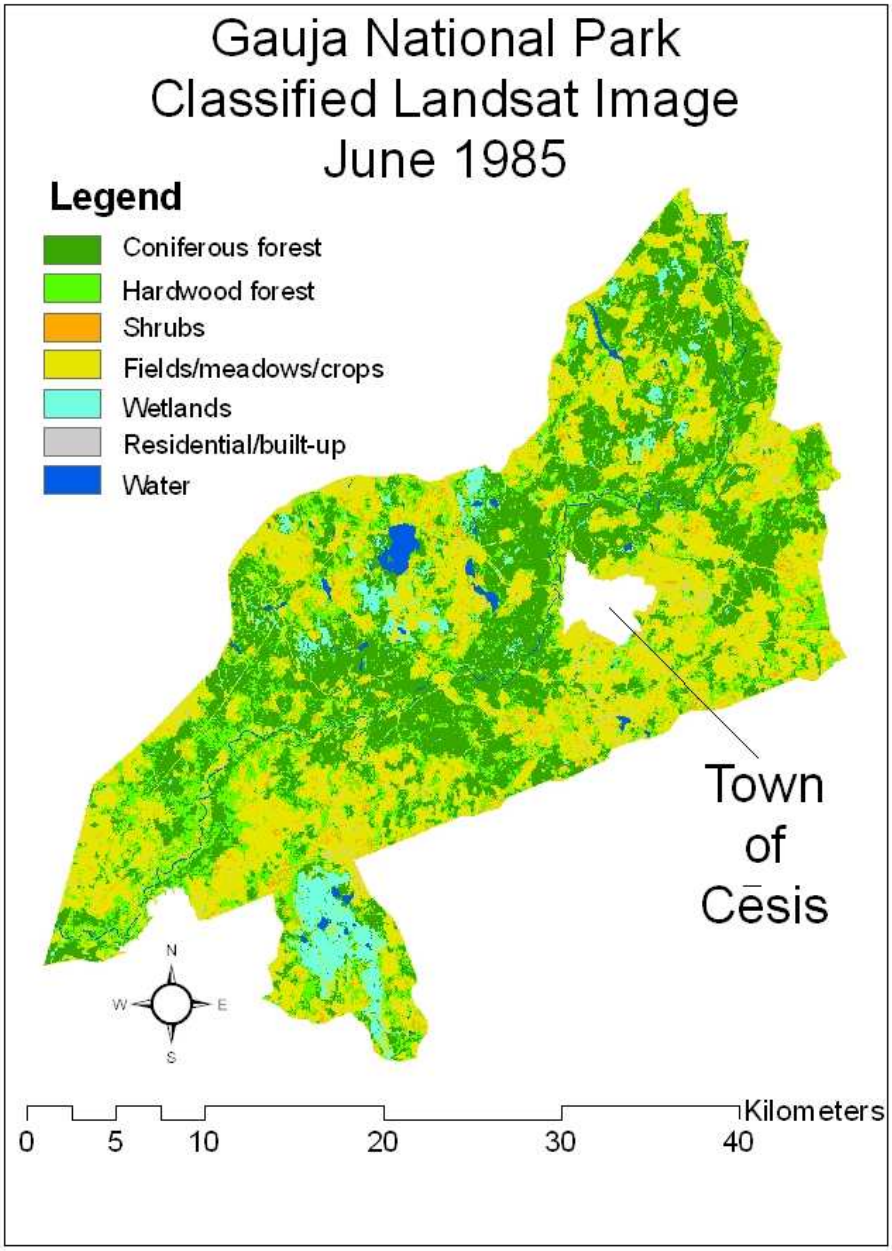


Figure 3.1. Landcover classification of Gauja National Park, June 1985.

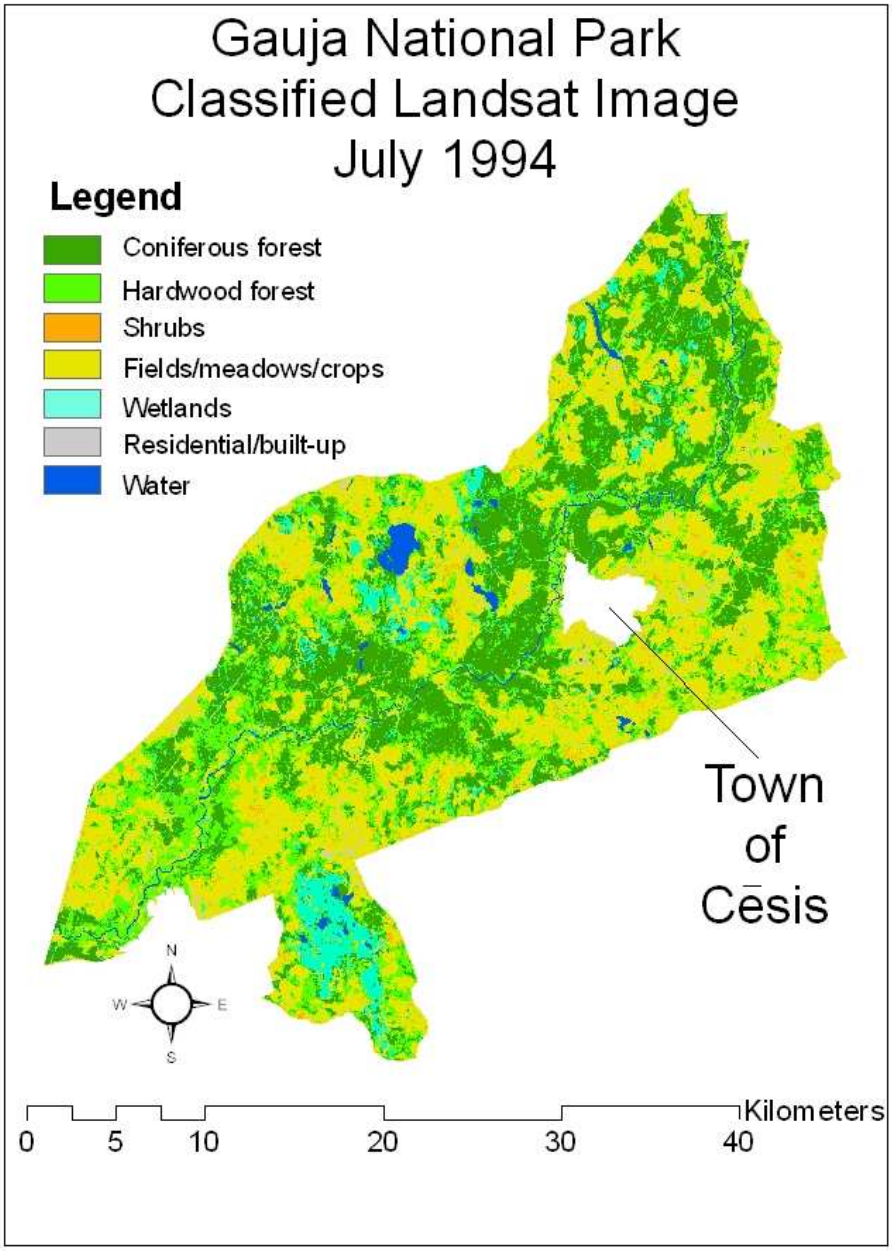


Figure 3.2. Landcover classification of Gauja National Park, July 1994.

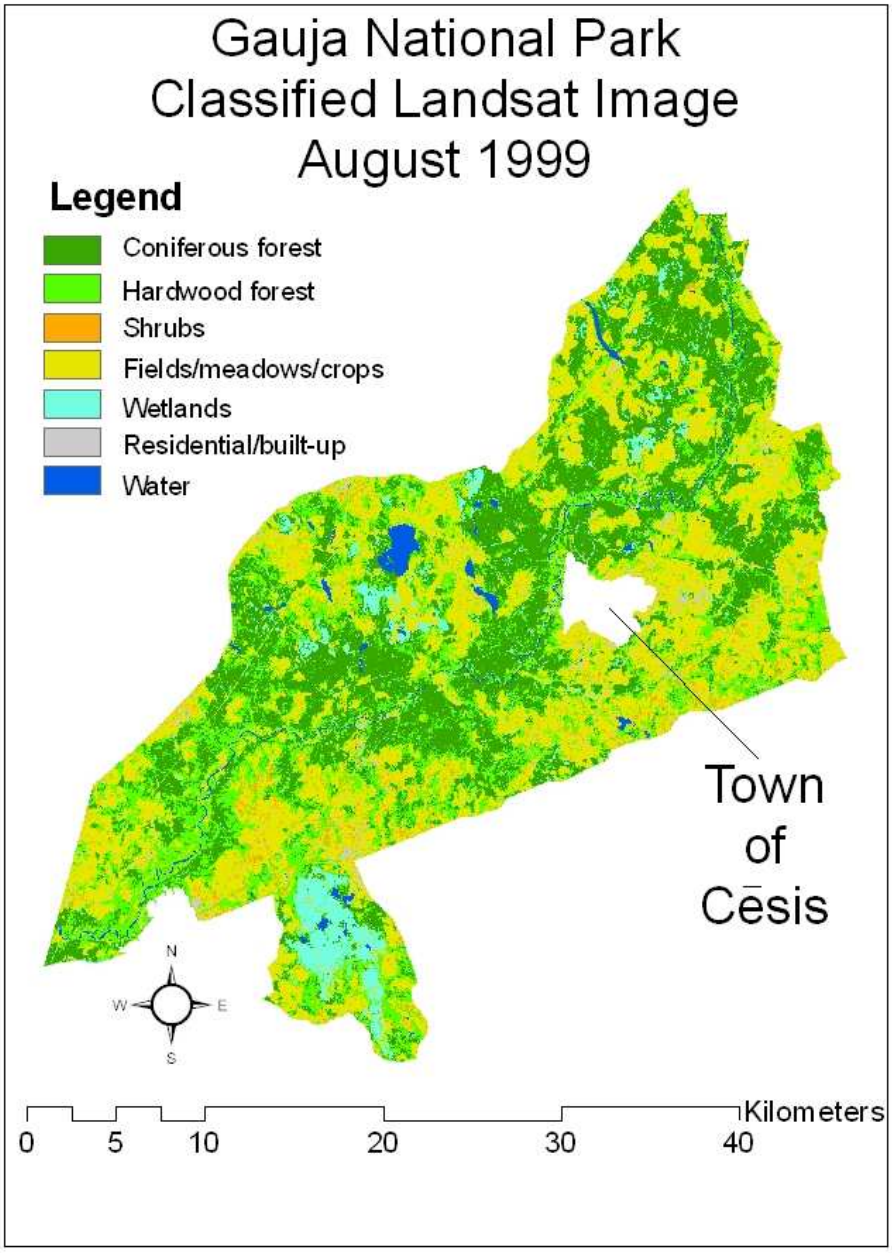


Figure 3.3. Landcover classification of Gauja National Park, August 1999.

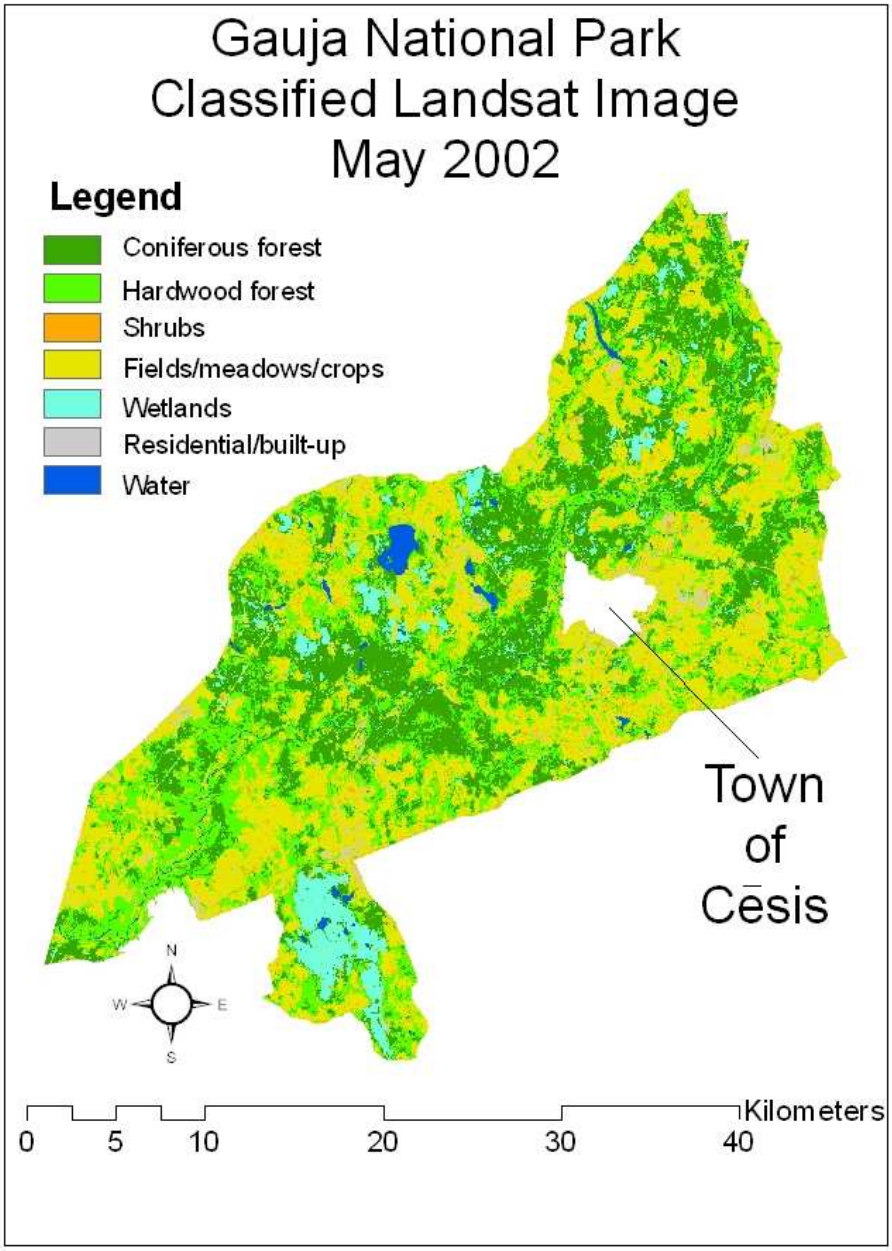


Figure 3.4. Landcover classification of Gauja National Park, May 2002.

Overall Landcover Changes Between Image Dates

The total hectares of each landcover type are shown for each of the four satellite image dates in Table 3.4.

Table 3.4. Landcover types in each satellite image (hectares).

Landcover type	1985	1994	1999	2002
Forest	44,633	42,426	47,012	45,985
Shrubs	3,249	1,083	1,765	3,298
Field/agriculture	34,524	37,017	32,043	31,604
Wetlands	4,120	5,715	5,135	5,121
Built up	981	1,006	1,411	1,806
Water	1,408	1,668	1,550	1,105

Contrary to expectations, there was a decrease in forest area (2,207 ha) within the Park between 1985 and 1994. Although land restitution began in 1990, only about 3 percent of land parcels in Latvia had been restituted by 1994, so the disappearing forest is not likely the result of actions of returnees to their land (Balsevics 2004). This loss of forest is likely due to cutting by profiteers taking advantage of a chaotic legal system regarding forest cuts during the early independence years, criminal illegal cutting, and managed forest cuts by the GNP Administration on State lands to fund the GNP Administration budget (Salminš, personal communication 2002). With weak law enforcement and chaos regarding landuse laws just after Latvian independence, and with a new legal market for selling timber beginning in 1991 (due to the disappearance of the centrally planned Soviet economy), many forest cuts took place during this period (Salminš, personal communication 2002).

A sharp increase in forest area is noted in Table 3.4 between 1994 and 1999 (a 4,586 ha increase over 5 years). Much of this increase in forest area may be due to regrowth of forest cuts just after independence. Pixel-to-pixel landcover conversion matrices are explored below, but much of the increase in forest area comes from fields left fallow

beginning in the very early 1990's (also explaining the 5,413 ha decrease in fields/agriculture between 1994 and 1999), due to the severe economic depression and the breakup of State and communal farms at this time. Note that Latvia's Gross National Product per capita fell from 3,909 USD in 1990 to 2,135 USD in 1993 (calculated in 2000 US dollars, Central Statistical Bureau of Latvia 2002).

Furthermore, a new set of laws were set forth by the Ministry of Environmental Protection and Regional Development in 1994 regarding the protection and management of GNP, replacing the former Soviet era laws. The new laws were more appropriate for the mixed ownership land that ensued in the Park after independence, and were more able to protect the forests in the Park than were the previous laws. During Soviet times very little forest cutting took place, and practically no clear cutting took place in the Park (Sēstulis, personal communication 2002, Nikodēmus, personal communication 2003). Under the Soviet GNP regulations (written by the Soviet Ministry of Forestry of Latvia and put into action in 1974), permits were required for all tree fellings. However, the specific laws of the Park were not clear regarding exactly when and where trees could be cut – only general guidelines were outlined for each of the seven management zones (though a permit was required for any tree felling). An example of such general guidelines is the 1974 law stating that limited production in the Extensively Utilized Recreation Zone is allowed after the GNP Administration approves it (Ministry of Forestry 1974). These general guidelines were ambiguous enough so that between independence in 1991 and the adoption of the new GNP laws in 1994, when cuts were allowed by private individuals, it is likely that people took advantage of the ambiguous nature of these laws in order to obtain permits and fell timber in Park forests. The 1994 laws were more specific regarding tree felling, and particularly

regarding clear cutting. For instance, the law states that in the Natural Landscape Restricted Regime, the Culture-Landscape Restricted Regime, Recreation-Landscape Restricted Regime, and Extensively Utilized Recreation zones, clear-cutting is forbidden, except for sanitary clear-cuttings, and in each sanitary clear-cutting case the GNP authorities must make the decision as to whether or not to allow the clear-cut (Ministry of Environmental Protection and Regional Development 1994). When the Park's land was State-owned during Soviet times, the 1974 general guidelines for Park landuse may have been sufficient for the Park's protection, but when private ownership was introduced, clearer forest cutting laws were needed to protect the Park. After the new laws were introduced in 1994, the amount of forest in the Park increased again, according to the analysis of the Landsat TM images.

The consistent increase in built up areas is as expected, since development continued throughout this period, especially in the later years as economic prosperity increased, and because the built-up landcover category is usually an absorbing class (once built up, land generally does not revert to other non-built up classes). An exception to this rule (built up landcover being an absorbing class) in Latvia, including inside GNP, is that many farmsteads were bulldozed during the Communist era and the land incorporated into the large agricultural plots of State and cooperative farms (Melluma 1994). This was done both to make room for large communal farms and to squelch nationalist tendencies, as a landscape of rural farmsteads is a source of national identity and pride for the Latvians, as discussed in the previous chapter. According to Melluma (1994), the majority of the conversions of farmsteads to agricultural lands took place before 1985, particularly in the early 1970's, and therefore this transition is not likely seen in the satellite images, the earliest of which is 1985. However, it will be seen below in the pixel-to-pixel landcover change matrices that the

conversion of the built-up class to agriculture is common. This is due to the poor classification results of the built-up class, as discussed above. Although the built-up class is often confused with fields/agriculture, the built-up pixels are clustered and the number of such pixels increases over time, thus the general pattern of increased development is evident from the classified image time series even though there is error regarding the locations of the built-up class pixels. Again, the continual increase in development is as expected, as development has been allowed throughout the majority of GNP throughout all three iterations of the GNP laws (Ministry of Forestry 1974, Ministry of Environmental Protection and Regional Development 1994, Latvia's Cabinet of Ministers Law 352, 2001).

Table 3.4 shows a decrease of 1,027 ha in the total forest area in GNP between 1999 and 2002. The bulk of the land restitution process in Latvia took place in the late 1990's. Although land restitution in Latvia began in 1990 and was completed (except for a small number of cases) in 1999, only 40 percent of land restitution claims had been resolved by January of 1997 (Freedom House 1998, Balsevics 2004). Since 60 percent of Latvian restitution claims were settled between 1997 and 1999, the majority of the loss in forest between 1999 and 2002 is likely due to cutting activities of recent returnees to their land. Some forest loss is also due to the GNP Administration's managed forest cuts on State lands to support the Administration budget.

Landcover Change between Temporally Adjacent Image Dates

1985 – 1994

Table 3.5. Landcover change matrix for Period I (1985 – 1994), in pixels (from-to: vertical-horizontal, respectively).

	shrubs	fields	wetlands	built-up	water	forest	TOTAL:
shrubs	739	28597	404	360	27	5975	36102
fields	10089	309895	10730	8951	1021	42913	383599
wetlands	0	5365	30309	10	344	9755	45783
built-up	113	8502	242	1461	15	568	10901
water	0	492	212	1	13217	1721	15643
forest	1093	58451	21605	397	3914	410467	495927
TOTAL:	12034	411302	63502	11180	18538	471399	987955

As seen in Table 3.5, the landcover change that occurred in the largest quantity (58,451 pixels, or 5,261 ha) between these years was from forest to fields. It is hypothesized that the majority of this change was due to forest cutting for timber during the transition period after independence in 1991, for the reasons discussed above.

There was also a substantial transition from fields to forest between 1985 and 1994 (42,913 pixels, or 3,862 ha). However, this is, by far, the smallest such transition per year between image dates. Most of this transition during this Period is hypothesized to result from the typical practice of fallowing farmland for a few years, with the added factor that the economy deteriorated after 1991, and as a result many fields were left fallowed for a longer period of time, allowing more than typical growth into young forests.

It can be also seen in Table 3.5 that a substantially larger amount of pixels (11,850 pixels, or 1,067 ha) transitioned from forest to wetlands than transitioned from wetlands to forest between 1985 and 1994. This is likely due to the fact that the recently cut forested lands can easily become inundated and appear on a Landsat image as wetlands, though after a

few years of re-growth may quickly become shrubs and then revert back to forest, as seen through the images.

Finally, the mediocre classification accuracy for the built-up class is evident from this table. Most of the built-up class pixels in both of these image dates (78 percent of the 1985 image and 80 percent of the 1994 image) are field class pixels in the other image date. As previously mentioned, this is due to classification error because of all the greenery around built-up (mostly residential) areas in the Park. Again, although the classification error is high, the residential pixels are well clustered in developed areas in each image, and this shows the general pattern of development throughout the Park.

1994 – 1999

Table 3.6. Landcover change matrix for Period II (1994 – 1999), in pixels (from-to: vertical-horizontal, respectively).

Pixels	shrubs	fields	wetlands	built-up	water	forest	TOTAL:
shrubs	824	9399	33	64	4	1710	12034
fields	16661	304262	9541	9668	685	70485	411302
wetlands	197	8356	30398	793	274	23484	63502
built-up	178	7913	115	2494	8	472	11180
water	91	865	857	1068	13386	2271	18538
forest	1663	25240	16115	1588	2860	423933	471399
TOTAL:	19614	356035	57059	15675	17217	522355	987955

It is interesting to note that approximately the same number of hectares of forest was converted per year during Period II (1994 – 1999) as during Period I (1985 – 1994). According to these classified Landsat TM images, on average, 854 ha of forest were lost per year during Period II, while 855 ha of forest were lost per year (on average) during Period I. These are relatively modest amounts compared with the Period III (1999 – 2002), when an average of 2,172 ha of forest was lost per year. It is hypothesized that forest cutting on State lands in GNP was consistently modest during Period II, though more cutting on private forest

lands occurred at the end of the period due to forest cutting by landowners who were recently restituted with lands (as previously stated, approximately 60 percent of land restitution in Latvia took place between 1997 and 1999). Cutting during Period I was varied – the first one-half of the period experienced very little cutting in the Park, and the second one-half experienced a significant increase, averaging to a rate similar to Period II. The early part of Period I was the late Soviet period (1985 – 1991). Very little forest cutting took place during this period (Sestulis personal communication 2002, Nikodēmus 2003), because the State owned the land at that time and performed cuts only for special purposes such as forest cleaning and maintaining trails and scenic views. At the end of Period I (the early independence period, 1991 – 1994), forestry and nature protection laws were unclear and in flux in Latvia due to the legal chaos that erupted with the fall of the Soviet Union. As previously mentioned, many took advantage of the unclear laws and weak law enforcement during this period, which sparked a high rate of forest cutting, according to an interview with elected Jūris Salminš (2002), Mayor of the Krimulda municipality (a municipality that is partially contained inside GNP). Although stricter felling laws in place during Period II kept forest cutting at a slower rate than that which was likely for late Period I (the early independence period, 1991 – 1994), the rate of forest loss during Period II was similar to the average of the rates of forest loss for the pre-Soviet portion of Period I (1985 – 1991) and the early independence portion of Period I (1991 – 1994).

A high rate of change from fields to forest occurred during Period II (a total change of 70,485 pixels, or 6,344 ha), in addition to 16,661 pixels (1,499 ha) changing from fields to shrubs during this time period. Forest re-growth on recently felled forested lands likely explains a large portion of the conversion of fields to forest during the period. The increased

forest cutting that occurred near the end of Period I (1991 – 1994) left many formerly forested lands in fields as of 1994. These lands would likely have re-grown into shrubs or young forest by 1999, as supported by the data. In addition to the forest re-growth between 1994 and 1999, much of the change from fields to forest (and to shrubs) during this Period is likely attributable to the substantial reforestation that took place on land long held in pasture and crops (Bunkše 2000). Particularly during the severest economically depressed years in the mid-1990's, much of the abandoned State and cooperative farms were not yet being cultivated again, and fallow fields grew into shrubs and young forests (Pilāts, personal communication 2002). Abandonment of farms and pastures is common in parts of the former Soviet Union. For instance, Petek (2001) reported that shrubs and forested areas are increasing from overgrown fields and grasslands in post-Soviet Gorenjsko, Slovenia. According to Zellei et al. (2002), regions throughout Central Europe are experiencing reforestation on former agricultural fields and pastures, and, according to the World Conservation Union (IUCN 2004), this reforestation often occurs as a monoculture tree crop, often reducing biodiversity in the area.

1999 – 2002

Table 3.7. Landcover change matrix for Period III (1999 – 2002), in pixels (from-to: vertical-horizontal, respectively).

Pixels	shrubs	fields	wetlands	built-up	water	forest	TOTAL:
shrubs	1326	15115	40	426	17	2674	19598
fields	22378	282394	3506	12746	152	34365	355541
wetlands	1610	4075	34017	446	163	16692	57003
built-up	634	6748	967	4732	451	1960	15492
water	135	426	319	56	11014	5264	17214
forest	10361	42055	18039	1466	479	449799	522199
TOTAL:	36444	350813	56888	19872	12276	510754	987047

It is hypothesized that land restitution was an impetus for forest cutting. It is expected that most of the restitution-induced forest cutting will be seen in Period III, because the majority of the land in the Park was restituted only at the end of Period II. Those who cut forests on their newly restituted land had first to obtain permission to cut each tree from Park rangers before performing the cuts (Timze, personal communication 2002). This process led many who received their land in the late 1990's to perform cuts after the summer of 1999 (the 1999 image is from August 2). In support of this hypothesis, Table 4 shows a substantial increase in forest loss (2,172 ha per year, on average) during Period III (1999 – 2002), as compared with 854 and 855 ha per year (on average) in the previous two periods.

One of the concerns for nature protection in countries that undergo sudden massive political, economic, and social changes is that the legal system is in flux and loopholes often arise that temporarily allow environmentally unsound practices that could have long-lasting effects. A unique timing loophole in Latvian law allowed for a particularly high rate of forest cutting in GNP during Period III. Latvian forestry laws require that a forest stand is mature before it may be cut. The definition of maturity (in terms of age) for forest stands differs depending on stand type. Latvian forest laws were in place since 1993 requiring that,

before being cut, forests in reserves or Nature Parks must be allowed to grow for 20 to 40 more years (depending on forest stand type) than was required for other forests (outside of reserves and Nature Parks). These forest laws became invalid on December 31, 1999. New forest laws for the entire country (not just for protected areas) took effect March 17, 2000 (Parliament of Latvia 2000). These new laws did not specify the need for the 20 – 40 year additional waiting Period in protected areas. With a new legal structure beginning in 2000, the additional waiting period for protected areas was to be specified by separate nature protection laws. Specific nature protection laws for GNP specifying the requirement for this additional waiting period became effective on August 11, 2001 (Latvia's Cabinet of Ministers Law 499, 2001). Temporary laws specific to GNP were put in place for the interim, the period from January 1, 2000 through August 11, 2001. These temporary laws were not as detailed regarding timber harvesting as were the August 2001 laws and did not specify the need for the 20 to 40 year additional wait. During this time (January 2000 through August 2001), felling laws were based on the 2000 (temporary) GNP laws and the general forest laws of Latvia, neither of which specified the need to wait 20 to 40 additional years, relative to regular forests, before felling. During this interim period many people used this temporary legal loophole to cut forests that were mature with respect to laws for general forests in Latvia, but not with respect to the more stringent definitions for protected areas, i.e., those forest stands in the 20 – 40 year window beyond the definition of maturity for general forests (Timze, personal communication 2002).

It is also interesting to note that Period III saw a substantial increase in the rate of change from fields to shrubs (a rate of 671 ha per year), relative to a rate of 300 ha per year for Period II, and a rate of 101 ha per year for Period I. It is hypothesized that most of this

shrub growth was from re-growth of recently cut forests. Since the majority of land restitution in Latvia took place between 1997 and 1999, it is expected that, of the restitution-induced forest cutting that occurred in Period II (1994 – 1999), most of it occurred at the end of that period (1997 – 1999). Such land would register as fields in the 1999 satellite image and would likely re-grow to shrubs by the 2002 image date.

Landscape Pattern Metrics

The changes in value between image dates of each landscape metric is summarized, followed by a discussion concerning likely reasons for the changes, and implications for the natural and cultural landscapes in GNP.

Number of patches and mean patch area

These two landscape level metrics are analyzed together. They give slightly different measures of the same phenomenon – overall patchiness of the landscape (regarding patches of all landcover types). As the mean patch area is simply the total area of the Park divided by the number of patches in the Park (and the area of the Park stays constant), these two metrics have a simple inverse relationship.

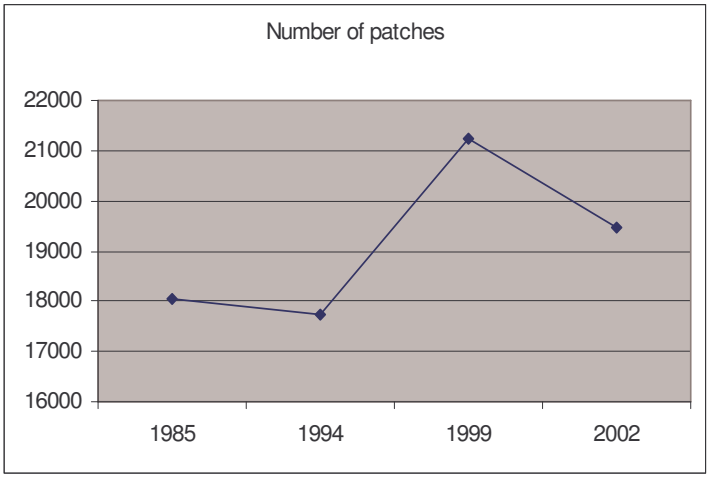


Figure 3.5. Number of landcover patches in GNP for four satellite image dates.

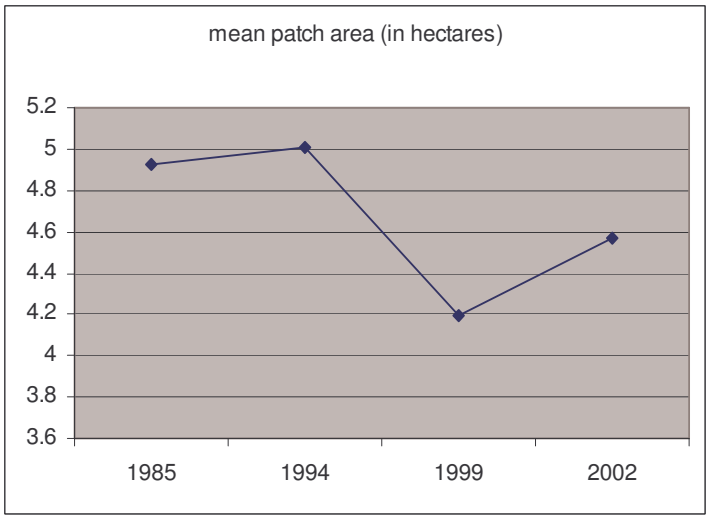


Figure 3.6. Mean patch area in GNP for four satellite image dates.

The above graphs show that in Period I (between 1985 and 1994) very little change occurred – a slight decrease in the number of patches and a slight increase in mean patch size. The next two periods show more substantial changes. It is hypothesized that the key events triggering the changes in the first period are the break up of State and communal farms after 1991 and the return of these large farms to individual family farms via land restitution, and the key event triggering the change in the second period is then consolidation in the early 2000's.

State and communal farms dissolved along with Latvian independence in 1991. Large agricultural fields often went fallow and, by 1994, some had begun to grow into shrubs and young forests. This process often occurred uniformly across such fields since most of the land had not yet been restituted to new owners and was not tended to by anyone. Uniform change of patches such as this does not substantially alter the number of patches in the landscape. If some new forest growth bridged other forest patches, then it could have the effect of slightly decreasing the total number of landcover patches in the landscape, a change supported by the data.

The substantial increase in number of patches (and decrease in mean patch size) seen between 1994 and 1999 is likely due to land restitution. Upon receipt of their land, many new landowners cleared portions of their recently afforested agricultural lands. Note that it was legal to clear all recently afforested lands – only lands traditionally held in forest had strict laws governing when they could be cleared. As documented by the qualitative interviews with several Park landowners in July 2002, partial land parcels were often cleared for gardening, agriculture, pasture, and/or small-scale development, and each interviewee who addressed the issue claimed that only a portion of the former communal or State farm on which they owned land was in production in 2002. The result of such small-scale land alteration by so many new landowners is an increase in the number of small patches in the landscape, as seen by the above graphs.

The 2002 interviews with Park landowners provide anecdotal evidence that, in recent years (prior to the 2002 interviews), wealthy individuals were buying and consolidating agricultural lands for larger scale agricultural production. It is hypothesized that this practice

was key to the increase between 1999 and 2002 in the mean patch area (and thus the decrease in number of patches).

The trajectory of the number of landcover patches in GNP tells an interesting story about the effects of land restitution and the market economy on the Latvian cultural landscape. As stated in the Chapter 2, based on research by Bunkše (2000), Latvia's (rural) cultural landscape "is characterized not by rural villages, but by a dispersed rural settlement pattern of family farmsteads made up of small clusters of distinct buildings (including a main house, barn, stable, sauna, and small granaries), surrounded by a matrix of small, well-maintained forest patches, agricultural fields and meadows, with churches and pubs interspersed throughout the landscape". Although an increase in number of patches does not ensure a path towards the restoration of the Latvian cultural landscape, it is reflective of processes that create the landscape pattern that defines this landscape. Between 1985 and 1994, the slight decrease in the number of patches was reflective of a lack of tending to the fields and forests of former communal and State farms, moving the landscape even farther away from the Latvian cultural ideal than when these large farms were in production during Soviet times. Between 1994 and 1999, as the number of patches increased substantially, the landscape was on the path of restoration to its cultural ideal: many new landowners began cultivating small plots and maintaining the forest on their land, in addition to restoring the clusters of buildings that make up the farmsteads. Finally, between 1999 and 2002, the new market-driven process of agricultural land consolidation led to a decrease in the number of landcover patches, as well as a move away from the Latvian cultural landscape ideal.

The mean patch area and number of patches tell little about nature protection in the Park, as these give little information about large, undisturbed forest areas, considered by the international community to be key for the protection of nature and biodiversity.

Area of largest forest patch

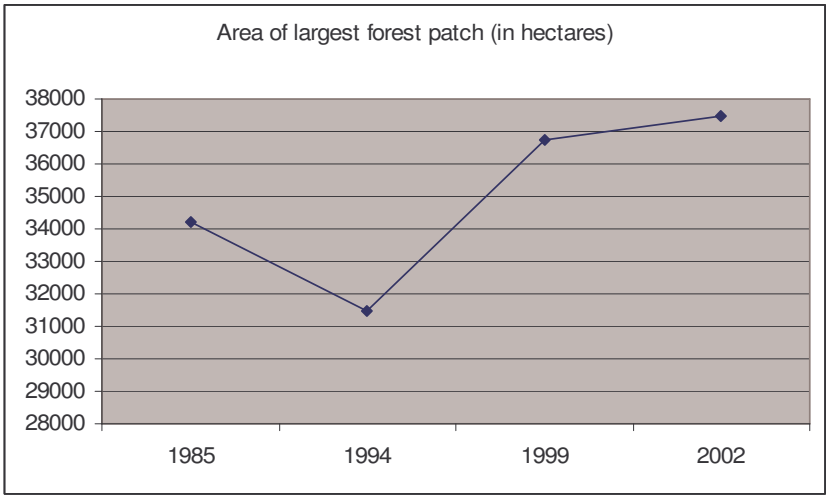


Figure 3.7. Area of largest forest patch for four satellite image dates.

The largest forest patch in GNP is the patch that follows the Gauja River. This patch consumes the majority of the area of what has recently been termed by Park officials as the core area of GNP (Schwartz 2001, Strautnieks, personal communication 2002). Since the late 1990's, the GNP Administration considers "[of] primary [importance] – the ancient valley of the Gauja River and its tributary valleys" (Petersen 1999). The trajectory of the area-of-largest-forest-patch metric shows that, since 1994, these Administration goals have been successful (see Figure 3.7). Between 1985 and 1994 there was a substantial decrease in the area of largest forest patch. This may be due to the forest cutting that took place during early independence. The surprising magnitude of this decrease may be due to forest cutting during that period that cut off one or more "bridges", or connecting pathways, between the main forest patch and other forest patches of substantial size. If these forest "bridges" grew

back into forest by 1999, it would also explain the substantial increase in size of the largest forest patch between 1994 and 1999.

Core forest area

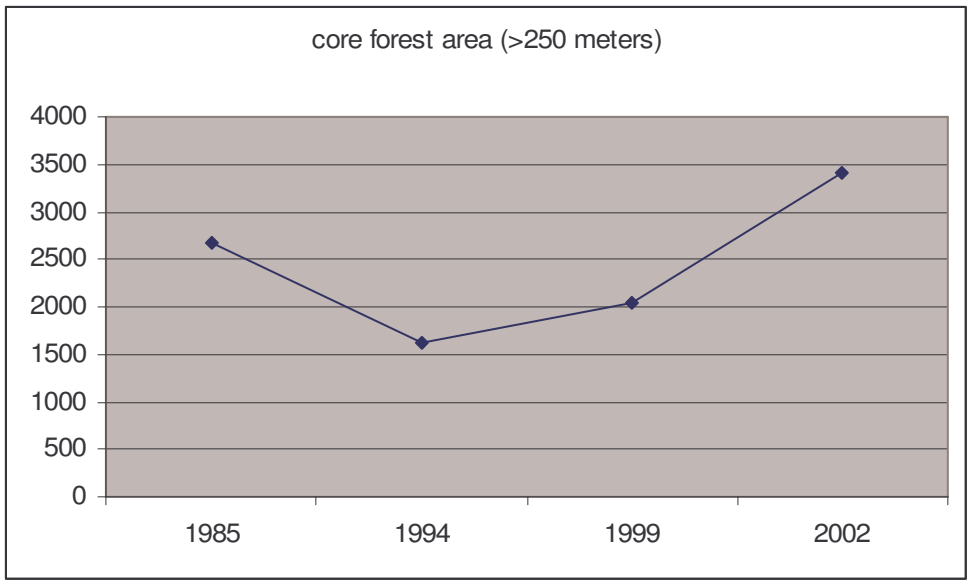


Figure 3.8: Core forest area for four satellite image dates.

The Black Stork (*Ciconia nigre*) and Lesser Spotted Eagle (*Aquila pomarina*) are rare birds that inhabit GNP. In addition to other rare species, these birds are of particular importance to Latvia as they are icons of the country and a source of national pride, and furthermore, they are on the European Council's Birds Directives list (European Council 1979). Before Latvia joined the European Union (EU) in May of 2004, compliance with European Council Directives was important for EU accession. Compliance continues to be important for good standing within the EU. These birds require particularly large forest tracts for habitat and generally nest at least 250 meters from the forest edge (the Lesser Spotted Eagle will usually nest between 500 meters and 1 kilometer from the forest edge) (Auninš, Pilāts, personal communication 2002). It is therefore interesting to monitor the area within GNP of forest that is at least 250 meters from the forest edge. For this analysis, the

core-forest-area metric was defined as the amount of forest area (in hectares) within the Park that is at least 250 meters from the forest patch edge. Figure 3.8 shows that between 1985 and 1994 the core forest area was substantially reduced. The intense forest cutting that took place soon after independence was a likely cause for this reduction in core forest area. The drastic increase in core forest area between 1994 and 2002 show that the GNP policies focused on preserving core zones of the Park were not only able to increase the total number of hectares of forest and the largest forest patch, but were also able to substantially increase (more than double) the amount of remote forest areas important for maintaining key species of national interest.

Conclusion

Remote sensing is useful for monitoring landcover change and the evolution of natural and cultural landscapes in protected areas. With appropriate temporal availability of satellite image data, the influence of land policy changes on the landcover can be monitored. Of course, true cause and effect cannot be determined without other information, since endogenous factors such as severe weather or fire and exogenous factors such as political and economic changes also affect landcover change, in addition to land policy. While a summary of gross amounts of landcover at multiple time points is useful, a more detailed understanding is possible by creating landcover change matrices between consecutive image dates, and by characterizing changes in landcover pattern in addition to changes in landcover composition. Choice of pattern metrics for landscape characterization should be based on the landscape processes of interest. This case study shows that analyses of changes in pattern metrics can be useful for monitoring the evolution of natural and cultural landscapes through time.

When LU/LC change is analyzed through a time series of remotely sensed images in conjunction with the gathering of other information (such as regional economic data, specific written laws, and qualitative interview data with stakeholders), a coherent story can be told about the changing landscape. Each method supports the other, and the combination of the two methods gives a more complete picture than either would alone.

Chapter 4:
Assessing Drivers of Landuse/Landcover Change and Landowner Attitudes to National Park Regulation

Introduction

Chapter 3 told a story about how landuse and landcover was changing in Latvia's Guaja National Park between 1985 and 2002. Through classifying Landsat TM satellite images, performing change analyses between consecutive image dates, and analyzing landscape pattern metrics, the landscape composition and patterns provided useful insights into the processes taking place in the landscape. These processes were contextualized by the political, social, and economic transition in the region occurring during the study period. Analyses were tailored to findings ascertained from the qualitative interview data of key informants presented in Chapter 2, and results presented here corroborate some of the findings in Chapter 2.

This chapter assesses the drivers of landuse and landcover change (LU/LCC) in this post-Soviet context within a national park of regional significance. Gauja National Park is Latvia's first and largest national park, created in 1973 as the second Soviet national park, and is visited by over 1 million tourists each year (Figure 1.1). Understanding the drivers of LU/LCC in GNP will be of interest to policy professionals and stakeholders in protected areas in the region, and landuse scholars interested in assessing the causes and consequences of LU/LCC.

Recall from the brief history of GNP land ownership described in Chapter 1 that the land comprising GNP was privately owned prior to the Soviet period, and most of the land was State owned during the Soviet period. Since Latvian independence in 1991, approximately 80 percent of the land in GNP was given back to its former owners through Latvia's policy of land restitution (Strautnieks, personal communication 2002). The restituted land in the Park is now privately owned, but subject to increased landuse restrictions relative to land outside the Park. Changes in land tenure have been found to affect LU/LCC patterns in a Wildlife Reserve in the Ecuadorian Amazon (Mena et al. 2006). This chapter further examines how land restitution affected LU/LCC in post-Soviet GNP.

In addition to land restitution, a key influence on landuse in GNP is Latvia's post-independence transition to a market economy – the economic depression taking place in the early- and mid-1990's, followed by Latvia's economic boom beginning in the late 1990's, particularly in the nearby urban capital, Riga. Chapter 2 showed that environmental interests of global NGO's, Western governments, and supra-government institutions affect landuse in protected areas through pushing global environmental agendas focused primarily on preserving biodiversity. Furthermore, local actors influence landuse in GNP, and their interests focus mostly on economic development, preserving recreational lands, and preserving the local cultural landscape. The above global forces have had a stronger influence on the Park Administration's management goals in the last decade, and the Administration has focused on protecting its core natural areas and biodiversity (Schwartz 2001). The original Park goals included the protection of the Latvian cultural landscape within the Park, a goal that has become less important to the Park Administration in this new global context (Schwartz 2001, Melluma, personal communication 2004). Since the 1990's,

the Park Administration has focused protection efforts on the forests and wetlands of the core zones of the Park (the Nature Reserve and Nature Conservancy Zones), allowing substantial cutting of forests in other zones, in addition to reforestation of meadows and agricultural lands in these non-core zones.

This study assesses the drivers of landuse change inside Gauja National Park, but there are similar forces acting on landuse change inside and outside of protected areas throughout the former Soviet Union and Eastern Europe. Bičik & Stepanek (2001) found that the most important post-independence processes that influenced land use changes in the Czech Republic were land restitution, the partial privatization of state property, an increased environmental awareness due to the environmental tragedies throughout the Soviet Union in the late Soviet era (e.g., the Aral Sea drainage, the Chernobyl disaster, the widespread overuse of natural resources, the widespread air pollution at toxic levels, the pollution of Lake Baikal and other waterways, etc.), the post-Soviet transformation of Cooperative farm policies, the opening up of previously forbidden zones along the borderlands of the 'Iron Curtain", and the development of a land market (with limited accessibility to non-Czech citizens). Petek (2001) found that socioeconomic factors, elevation, slope angle, and slope aspect were all important variables for predicting landuse in the alpine environment of post-Soviet Gorenjsko, Slovenia.

This research uses multivariate statistical models to assess the effects of land management zones, political boundaries, and endogenous and exogenous geographic variables on LU/LCC. The outcome variables (representing landcover change) for these regression models are determined using the post-classification change analysis of a time series of Landsat TM satellite images spanning from the late Soviet era (1985) through recent

times (2002), discussed in Chapter 3. Multiple data layers organized in a Geographic Information Systems (GIS) database are used to represent independent variables from the aforementioned categories, explaining variation in the LU/LCC variable. Changes over time in the predictor variables (i.e., in their predictive value for the outcome landcover change variable) are analyzed to understand how drivers of landcover change are transitioning with Latvia's post-Soviet transitional period.

To understand the broader effects of key drivers of LU/LCC, this study also analyzes how those factors are linked to the relationship of GNP landowners to the Park. This is a particularly important link, because of the feedback mechanisms to LU/LCC, as the GNP landowners directly affect the land in the Park. A spatially-referenced social survey of 160 GNP landowners is statistically analyzed to understand how the factors most important in driving landuse/landcover change affect the attitudes of Park landowners towards living within the borders of this national park. This analysis adds a unique perspective to LU/LCC and human dimensions research by not only acknowledging that the factors driving LU/LCC also affect local populations, but by studying how these factors affect the relationship of the local population to the land, in this case, to the national park in which they live.

Research Questions

1. What are the important drivers of landuse/landcover change in GNP, and how have they changed over time?
2. How are these factors associated with landowner opinions regarding management of the Park?

Methods

To answer the first of the two research questions (i.e., to determine the important drivers of LU/LCC in GNP), statistical regression and classification models are developed in a GIS framework using spatially-referenced data. Regression models have been employed by several researchers to investigate the geographic, biophysical, and socioeconomic drivers of LU/LCC (Walsh et al. 1999, Mertens et al. 2000, Mena et al. 2006), and landcover patterns (Pan et al. 2004). To answer the second research question, (i.e., assess how the drivers of LU/LCC are associated with landowner opinions regarding Park management), statistical cross-tabulations are conducted to determine association between the drivers of LU/LCC identified in Part 1, and responses to key questions in a social survey of Park landowners.

Part I: Drivers of LU/LCC

The social, biophysical, geographic, and political drivers of LU/LCC in GNP were analyzed using statistical models. Spatially-explicit variables were created within a GIS context, and then statistically analyzed, as described by Pan et al. (2004). The dependent variable in these models measures change in landcover composition in GNP, and was assessed by the four classified Landsat TM satellite images at the 30-m pixel level. For each pair of consecutive Landsat images, and for the 1985 – 2002 image pair, a classification tree analysis and a multinomial logistic regression model were developed. The landcover change (dependent) variable is defined at the Landsat TM pixel level. These analyses do not focus on identifying where landcover change occurred (relative to where it did not occur), but rather the type of changes that occurred (i.e., from-to changes), and the variables that drive different types of compositional change. Thus, these statistical analyses were restricted to

pixels that underwent change between consecutive image dates. These change pixels represented 22.1 percent of the pixels in the 1985 – 1994 image pair, 21.1 percent of the pixels in the 1994 – 1999 image pair, 20.4 percent of the pixels in the 1999 – 2002 image pair, and 23.8 percent of the pixels in the 1985 – 2002 image pair. These analyses thus disregard potentially interesting information about factors contributing to landcover remaining constant between image dates; this is an area for further research. For each "change" pixel, the outcome variable was defined as the landcover class that the pixel *changed to*. This choice was made to limit the results to a manageable number of outcomes; if pixels were defined by both the *change from* and the *change to* classes, there would be 30 outcome classes (6 classes in the earlier image multiplied by 6 classes in the latter image would yield 36 classes, minus the 6 no-change classes, resulting in 30). The *change to* class was determined to be more important than the *change from* class, because the class that land is converted to gives insight into the processes of landscape dynamics. The creation of these landcover change variables required intensive data collection and data processing, and were described in Chapter 3. The following is a description of the independent variables used in the statistical analyses.

Independent Variables

There were 8 independent variables entered simultaneously into the statistical models. These variables were chosen based on aforementioned results of previous LU/LCC research in the former Soviet Union and Eastern Europe, as well as information relevant to GNP, specifically (such as the land management zones). The drivers of LU/LCC in this region of the world share similarities with that of other regions. For instance, Pichon (1997),

Bilsborrow (2000), and Walsh et al. (2003) outline local factors that may affect landuse in the Amazon region, which may be relevant around the world:

- proximity of farms to the nearest large town – due to likelihood for off-farm employment for household members,
- farm size,
- household size and farm population density – due to the effect of the number of individuals working the land,
- access to health care and family planning,
- household education level – due to knowledge about good landuse practices, and potential for off-farm employment,
- population size of local towns – due to size of local market for farm produce sales,
- distance to a major city – due to ease of bringing farm produce to market, and increased settlement desirability for access to services provided by the city,
- availability of credit,
- resource endowments of site (topographic features, soil fertility),
- road infrastructure,
- land tenure, and
- in the Ecuadorian Amazon specifically, land subdivisions among heirs, which are more likely for older heads of household and for houses close to a major road and a large town.

Each of the following variables was entered into the statistical models after being geographically referenced and converted to a raster format using the same 30 x 30 meter grid of the Landsat images. They are described as follows:

1. **Slope**. The estimated average slope angle within each 30 x 30 meter grid cell was derived from a 10-meter vertical resolution Digital Elevation Model (DEM), digitized from Latvian topographic maps, created in 1991.
2. **Aspect**. Aspect was derived from the same DEM.
3. **Distance to water**. The distance was calculated from each grid cell to the nearest large lake or river, as determined from digital hydrography data, updated by the GNP Administration in 1999.
4. **Distance from Riga**. The distance was calculated from each grid cell to the center of Latvia's capital, Riga.
5. **Distance to roads**. The distance was calculated from each grid cell to the nearest road. The roads were digitized from the 1997 orthophotos.
6. **Distance to nearest large town**. The distance was calculated from each grid cell to the nearest town border (for towns with population greater than 10,000, which includes only the nearby towns of Sigulda, Cesis, and Valmiera) (see Figure 1.1).
7. **Municipality**. Digital municipality borders were used to designate the municipality in which each grid cell lies. There are 19 municipalities within GNP.
8. **Management zone in 1993**. The management zone boundaries were used to designate the management zone in which each grid cell lies. This variable uses the 7 original management zones and the boundaries drawn in 1993, as previously discussed. These boundaries were digitized from a map from GNP.

9. **Management zone in 2000**. For statistical analyses incorporating the 1999 and/or the 2002 Landsat image, the new (2000) management zone boundaries were used to designate the new management zone in which each grid cell lies (new management zone system was discussed in the Chapter 1). The 2000 management zone boundaries were used in statistical models involving the 1999 Landsat image, because knowledge of the imminent changes in zonation may have affected landuse decisions prior to January 1, 2000.

Statistical Analyses

Statistical analyses were carried out to (a) identify the important drivers of LU/LCC in GNP, (b) understand the effects of these drivers on landcover change, and (c) determine how the influence of certain drivers changed over time. Similar to a study by Mertens et al. (2000) that investigates the influence of macroeconomic changes in Cameroon on land use using statistical models, this study of changes over time in drivers of LU/LCC in GNP is framed in the political, social, and macroeconomic contexts of post-Soviet Latvia. A classification tree analysis and a multinomial logistic regression model were run for each pair of consecutive image dates, and for the 1985 – 2002 image pair. In each case, the analysis was done at the pixel level. To reduce the expected influence of spatial autocorrelation, the pixels were systematically sampled, and every 10^{th} pixel was used in the analysis, bringing the total number of pixels used from approximately one million to just fewer than 100,000. For each model, the observations were further restricted to those pixels that represented change in landcover type between the two image dates. For the 1985 – 1994 image pair, the total number of pixels (n) used in the analysis was 21,803. For the 1994 – 1999 image pair, n

was 20,851; for the 1999 – 2002 image pair, n was 20,105; and for the 1985 – 2002 image pair, n was 23,483.

Four pairs of models were run (a pair being a classification tree analysis and a multinomial logistic regression), each with different dates for the dependent landcover change variable, but with the same set of independent variables. The first three model pairs used pairs of consecutive image dates, and the fourth model pair used the pair of dates straddling the full study period:

1. 1985 – 1994
2. 1994 – 1999
3. 1999 – 2002
4. 1985 – 2002.

The only exception was that the 2000 management zones were not used as an independent variable in the 1985 – 1994 models, because these zones were not yet created at the time the images were taken, nor were the new zones even in discussion. The 2000 management zones were used in the 1994 – 1999 model, because although they had not yet gone into effect during that period, the 2000 management zones had already been designated by 1999 and knowledge of the new zone boundaries and forthcoming landuse laws had influenced landuse decisions for some time, particularly on the part of the GNP Administration, the organization that created the new zones.

Classification Trees

In classification trees, binary splits of data are performed on the independent variables, based on their predictive value (in decreasing order) of the dependent variable. A classification tree then allocates each observation to a particular class (of the categorical

dependent variable) based on a set of binary indicators of the independent variables. For example, if an observation has a value of variable #1 (suppose it is continuous) that is (for instance, greater than) x, then the observation is determined to be in one of the 2 major branches of the classification tree (note that variable #1 need not be the first variable in the list of independent variables – it is the variable determined to be the most significant in predictive value of the dependent variable); then if the observation's value of variable #2 (suppose it is categorical) is among an element of a subset, ω, of classes, then it is determined to be in one of the 2 sub-branches of the first branch; then if the observation's variable #3 (suppose it is continuous) is (for instance, less than) y, then this observation is determined to be in one of the 2 sub-branches of the previous sub-branch, etc. This process continues to the lowest branch of the tree, where the observation is allocated (and determined most likely to belong to) one of the classes, z, of the categorical dependent variable. Each successive split further down on the tree always has lower predictive value (than the higher up branches) of the dependent variable. The goals of these analyses were, for each classification tree, to (a) determine the most important splits in the independent variables in their predictive value for landcover change, (b) determine how the variables affected probability of landcover change, and (c) assess how the most important splits in independent variables changed over time (from one classification tree to the next). The S-plus software was used to run the classification tree analyses.

To avoid generating relatively meaningless splits on variables (at the bottom of the classification trees) involving an insignificant number of observations, the classification trees were run with the following parameters: each branch of a split on a variable was constrained to a minimum of 500 observations, the minimum node size to allow a split was 1000

observations, and the minimum node deviance before tree growing was stopped (if the other constraints were not yet satisfied) was set to 0.01. Note that there were approximately 20,000 observations (pixels) for each tree. Once the full trees were created, they were pruned by cutting off the least important nodes, in terms of both the values of the node deviances and the scientific relevance of the splits, as determined through an analysis of branch size. In summarizing the results, the most important of these branches are discussed. The effects of the splits (and therefore the effects of the independent variables) on the probability of the outcome variable (the landcover type the pixel *changed to*) were analyzed by examining the relative probabilities (between the branches of each important split) of each outcome at each node. Large differences in probabilities were noted in the results.

Multinomial Logistic Regression Models

The goals of the multinomial logistic regression models were to (a) assess the statistical significance of each variable in its predictive value for landcover change, (b) examine the effects of specific variables on specific types of landcover change, and (c) assess how these effects changed over time. The SAS program was used to run the multinomial logistic regressions.

Multinomial logistic regression is a regression method that can be used when the dependent variable is a categorical variable with more than two levels. Instead of modeling the dependent variable directly against the independent variables, the log of the probability of the dependent variable occurring in one class relative to a referent class, $\log(P_i/P_r)$, is modeled, where P_i is the probability that the dependent variable is in class i, and P_r is probability that the dependent variable is in the referent class. One of the benefits of multinomial logistic regression is its freedom from some of the assumptions of ordinary least

squares (OLS) regression. Multinomial logistic regression models have the following important freedoms from the restrictive assumptions of the OLS model (Garson 1998):

1) although the $\log(P_i/P_r)$ must have a linear relationship between the dependent and the independent variables, the outcome variable itself need not have a linear relationship with the independent variables,
2) there is no homogeneity of variances assumption, and
3) the error terms are not assumed to be normally distributed.

As mentioned, the observations were restricted to those pixels that underwent change between the two image dates. Each multinomial logistic regression took the following form, simultaneously estimating these 5 equations (each equation with one of 5 different levels of i):

$\mathbf{Log(P_i/P_6) = ß_0 + ß_1X_1 + ß_2X_2 + \ldots + ß_jX_j + \varepsilon}$, where:

i = 1, 2, .., 5, representing each landcover type, excluding forest, the reference category,

j is the number of independent variables,

P_i = the probability of a pixel changing to landcover class i,

P_6 is the probability of a pixel changing to the forest (referent) class,

$X_1, X_2, \ldots X_j$ represent the j independent variables,

$ß_1, ß_2, \ldots ß_j$ represent the j parameter estimates, and

ε represents the independent, identically distributed error terms.

Note: j = 9 variables except for the model using the 1985 – 1994 image pair, where j = 8, since the 2000 management zone variable was not included in this model.

Part II: Drivers of LU/LCC and Landowner Attitudes toward GNP Management

To understand how the drivers of LU/LCC in GNP are associated with landowner opinions regarding management of the Park (Research Question 2), household survey data from GNP landowners are integrated and analyzed in conjunction with the GIS and remotely sensed data of the Park. While there can be prohibitive logistical difficulties with linking household survey data to remotely sensed data at the household level, particularly for a large number of households, there are risks of introducing "ecological fallacies" by linking household survey data to remotely sensed data at aggregate levels. Lambin (2003) makes the point that the optimal level of analysis for linking household survey data with remotely sensed data depends on the research question. In case studies in Southern Cameroon and the buffer zone of the Masai Mara Natural Reserve in Kenya, Lambin linked household survey data to remotely sensed data at the level of the village and at the level of groups of households following a similar landuse strategy. Other studies have linked remotely sensed data directly with extensive household survey data at the household/farm level (Geoghegan et al. 2001, Walsh et al. 2002, Walker et al. 2002, Moran et al. 2003, Pan et al. 2004, Mena et al. 2006). These studies required a substantial amount of effort to geo-register the household survey data via GPS technology to GIS databases containing satellite images of farms associated with these households. In this study, 150 landowner questionnaire responses were geocoded through address-matching between the physical questionnaire responses and a GIS database of addresses of living quarters in GNP. The GNP Administration distributed 1500 voluntary questionnaires by mail to GNP landowners in 1999, receiving back 575 valid responses. All the questionnaires whose respondents recorded valid addresses that were unique and locatable inside the Park, and claimed to live at that address, were geocoded as

part of this research. The landowner questionnaire was designed by the GNP Administration to learn about the landowners' opinions towards the Park's protection and development problems (see Appendix for the landowner questionnaire). Due to the relatively small sample size (150 geocoded questionnaires), cross-tabs were developed to analyze how the independent variables in the previous analyses (Part I) affected survey responses. This household level study allows analyses without risk of ecological fallacies.

Results

Part I: Drivers of LU/LCC

Classification trees

The trees are presented in Figures 4.1 – 4.4, with the lengths of the branches shown in proportion to node deviance, and the node numbers represent the most likely landcover class based on the respective branches. For the most significant variables that showed up in these pruned classification trees, the following variable definitions were used:

- **dist.bigwater**: the distance of a pixel from the nearest large water body (in meters),
- **dist.roads**: the distance of a pixel from the nearest road (in meters),
- **municipality**: the municipality in which each pixel lies (each letter denotes a different municipality),
- **slope**: the slope at each pixel, and
- **zone99**: the management zone that went into effect in 2000. Each zone is represented by the following letters:
    - a - Landscape Protection zone
    - b - Nature Conservancy zone
    - c - Neutral zone.

- d - Cultural Historic zone
- e - Nature Reserve (strict regime) zone

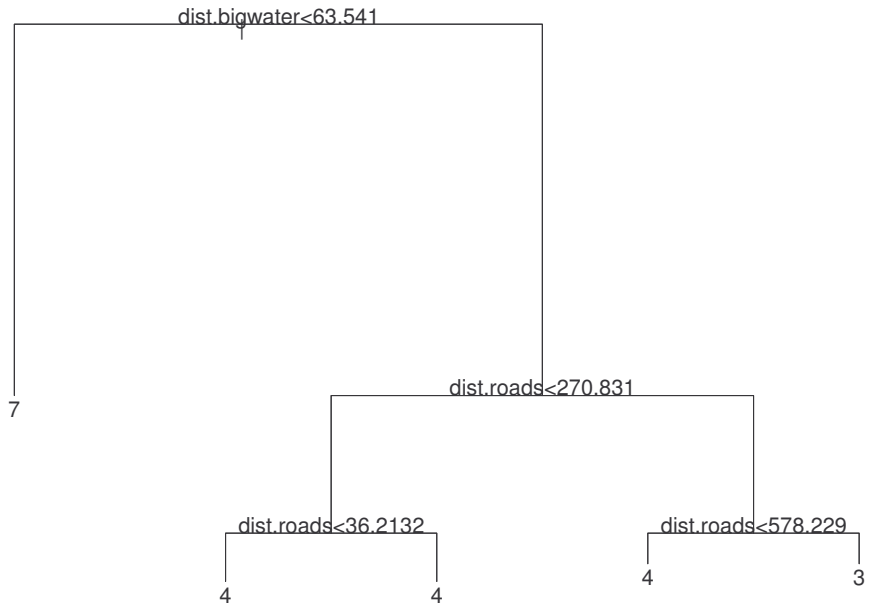


Figure 4.1. Classification tree 85 – 94 images: S-plus output.

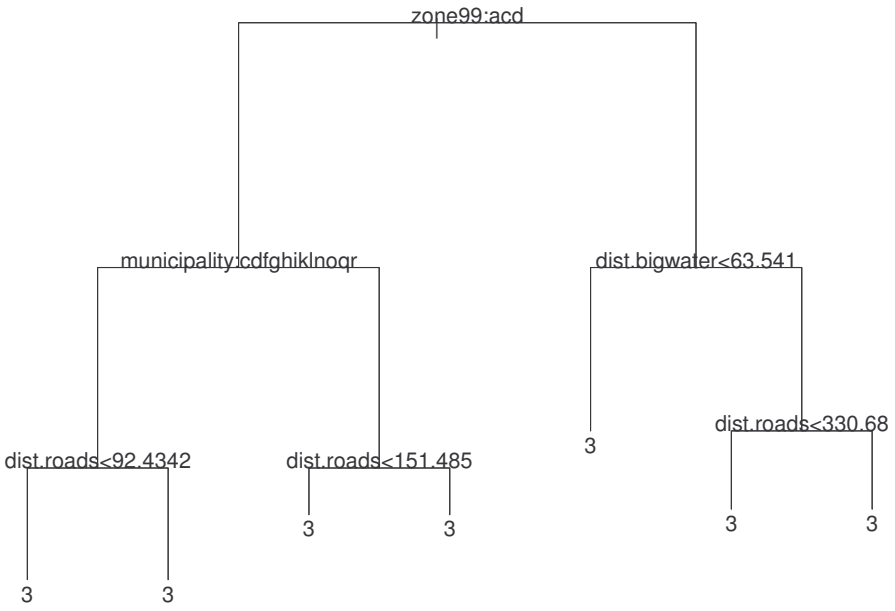


Figure 4.2 Classification tree 94 – 99 images: S-plus output.

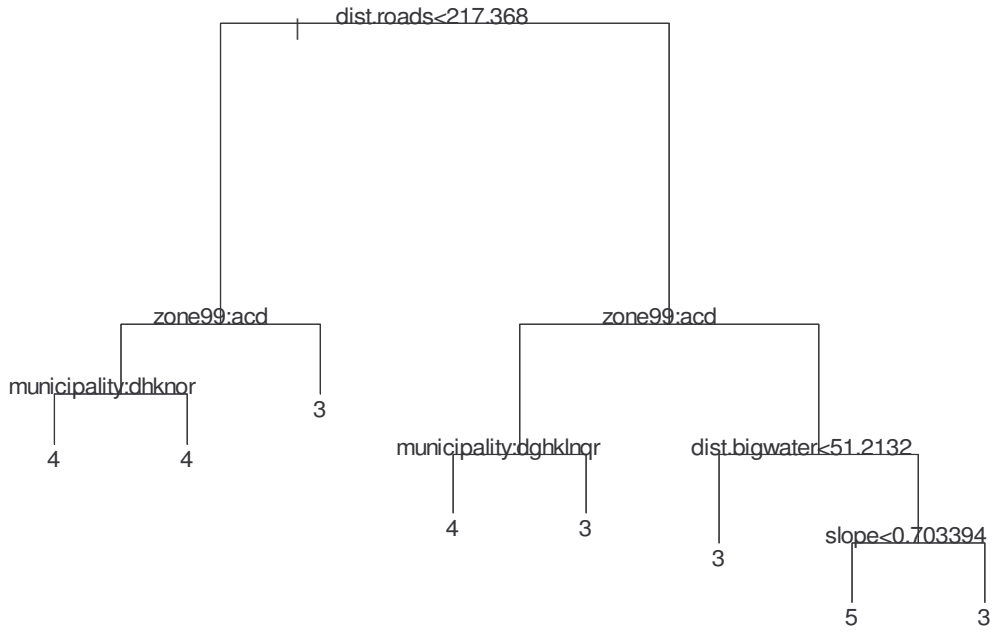


Figure 4.3 Classification tree 99 – 02 images: S-plus output.

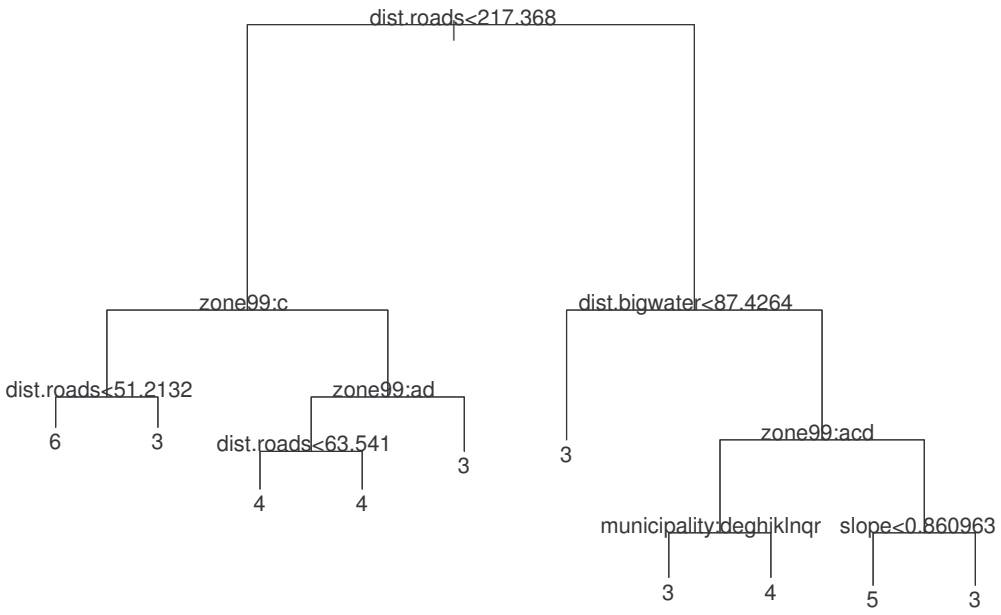


Figure 4.4 Classification tree 85 – 02 images: S-plus output.

Most Important Predictor Variables

Although all variables were found to be significant predictors of landcover change in at least one of the 4 models, the most important predictors across all pairs of image dates (assessed by the number of times the trees have splits based on these variables, and the level of hierarchy at which these splits occur) were:

1. the distance from the nearest road,
2. the management zone in 2000, and
3. the distance to the nearest water body.

After these three variables, the next most important predictors were:

4. the municipality in which the satellite pixels lies, and

5. the slope.

In each case (among all classification trees) where splits were made based on distance from the nearest road, pixels nearer to roads were consistently more likely to convert to built-up and/or fields. This result was expected since field crops are easier to bring to market when they are harvested near roads (discussed further below). The management zones in 2000 demarcate areas with very different landuse laws within the Park, and therefore have a strong effect on landcover change. It is interesting that the 1993 management zones did not show a strong effect. There are two likely reasons for this: (1) many similarities exist between the zone boundaries of both zoning dates, and the effect of the 2000 management zones masks the effect of the 1993 management zones; and (2) some of the 1993 management zones were quite similar to one another in landuse management regime (the Extensive Mass Recreation Area, the Intensive Mass Recreation Area, and the Protected Mass Recreation and Scenic Area), reducing the effect of the different zones on LU/LCC. The effect of the distance to the nearest water body is likely due to GNP laws, written in 1990 and 1991, that severely restrict landowners from developing land near water bodies (the distance is dependent upon the type of water body) (Gauja National Park 1999). The effects of the management zones and the distance to the nearest water body show that Park laws significantly affect landuse change. The directions of the effects are also consistent with Park Administration's intentions, as discussed below. The effects of the municipality on landcover change shows that the conversion of land (and by inference, of development) has occurred unevenly throughout the Park, as discussed below. Finally, also presented below, the influence of slope primarily affects where new wetland and water landcover classes are found, as is to be expected since wetlands and water only occur in flat areas.

Specific Effects of Predictor Variables

The distance from roads had a consistent effect, as can be seen in Figures 4.1 – 4.4, across all classification trees, and in some cases at multiple levels with one classification tree: the nearer to roads, the more likely each pixel was to convert to built-up and/or fields. This result mirrors the findings of Rudel & Horowitz (1993) and Pichon (1997, 1999) that roads are associated with land clearing in the Ecuadorian Amazon; of Pan et al. (2004) that found that farm proximity to roads is significantly associated with farm-level landscape patterns in the Ecuadorian Amazon; of Chomitz & Gray (1996) that roads facilitate nearby development in Belize; and of Pedlowski et al. (2005) that found that deforestation in conservation areas (called conservation units) in Rondônia, Brazil occurred more frequently near the road network.

The influence of the 2000 management zones on landcover change shows that the Park's management zones had their intended effects. In each tree model, except for the 1985 – 1994 model (which did not include the 2000 management zones variable), tree splits were made showing that the core zones (Nature Reserve and Nature Conservancy) had consistently higher probabilities of conversion to forest and wetlands, whereas the non-core zones (Cultural Historic, Landscape Protection, and Neutral) had consistently higher probabilities of conversion to built-up and fields. This reflects the Park Administration's commitment to preserving the natural landscape in the core areas of the Park, which has, in recent years, superseded the Park Administration's commitment to preserving the existing landscape in the non-core zones, as discussed in Chapter 2. As stated in the November 1999 Management Plan for Gauja National Park (Petersen 1999), "[t]he traditional rural landscape with its harmony and cosiness is of secondary significance after the primary – the ancient valley of

the Gauja River and its tributary valleys." The "ancient valley of the Gauja River and its tributary valleys" fall within the core zones of the Park, and it is the non-core zones that house the majority of the "traditional rural landscape" within the Park. These results show that the non-core zones have undergone considerable development and transition to agriculture. When land changed in the core zones, however, it more often changed to elements of the natural landscape (forest and wetlands), which make up the landscape that the core zones were designated to protect.

The distance to the nearest large body of water was found to be an important predictor of landcover change, with one major split in each regression tree. This variable showed both expected and unexpected results. The expected result was that, in each classification tree, pixels nearer to large water bodies were more likely to convert to water than pixels farther from large water bodies (splits were made among the four classification trees at different distances from large water bodies – between 51 and 87 meters). This is likely the result of expanding or fluctuating boundaries of lakes and rivers. In addition, pixels near large water bodies were more likely to convert to forest and less likely to convert to fields than pixels farther from large water bodies. This finding may be due to the aforementioned GNP law (Gauja National Park 1999) that severely restricts landowners from altering land near water bodies (the specified distance depends on the type of water body). This shows that the GNP policies have been successful in limiting landcover changes near water bodies. There was one exception to this: in the 1994 – 1999 model, for areas within core zones, change pixels that were less than 64 meters from large water bodies were less likely to convert to forest and more likely to convert to built-up than pixels greater than 64

meters from large water bodies. This could be due to small sample size problems, as the number of affected pixels was limited.

Splits were made based on the municipality of each pixel in three of the four classification trees (not in the 1985 – 1994 model). There were certain municipalities in which pixels were more likely to change to forest and wetlands in all three models. The effects, however, of municipality on the probability of pixels changing to shrubs, built-up, and fields varied from model to model. This finding suggests that the rates of different types of landcover change differ from region to region within the Park. This reflects the fact that economic development has occurred at uneven rates in different regions of the Park throughout this time period. This finding is consistent with the claim of Vilnis Burcevs, Mayor of the Kocenis municipality (30 percent of which lies inside GNP), who reported in an interview in 2002 that economic development was occurring unevenly throughout the Park, and that most development was occurring in and near the Park's tourist centers (Burcevs, personal communication 2002). Burcevs lobbies for municipalities like Kocenis, where little development was occurring, so that they could be subsidized by the Park's tourism revenues to compensate residents for landuse restrictions in the Park.

Changes over Time in Importance of Predictor Variables

A time-series of satellite images is particularly useful for tracking *when* landuse/landcover changes occurred. This analysis was able to determine *when* certain variables were most important in predicting landcover change.

It is interesting that the municipality variable was not one of the most important predictors in the 1985 – 1994 model, yet it was important in the later models. In the 1985 – 1994 model, the municipality variable does not present in the pruned tree (Figure 4.1),

though in the un-pruned model (not shown because the un-pruned tree is too large to display graphically on one page) it appears in the 3rd and 4th levels of the tree hierarchy, with relatively small node deviance values. The municipality variable does present in the pruned trees for the 1994 – 1999 model and the 1999 – 2002 models. This shows that the municipality variable was more important in the models for later periods than in the model for the early period (1994 – 1999). For the majority of the time period in the 1985 – 1994 model, Latvia was still part of the Soviet Union (1985 – 1991), and the economy was centrally planned. The effects of local government were weak during this period, and many landuse planning decisions were made at higher political levels. As land restitution took place in Latvia (including within GNP) throughout the mid- and late- 1990's, and as local governments became more influential with time, local-level political and economic factors increased in importance regarding landcover change in the Park, and therefore may have led to differentiation in levels of development between regions of the Park.

It is also interesting that, although distance from the nearest road was important in each model, it was the most important predictor of landcover change only in the 1999 – 2002 model. A possible explanation for this is that Latvia's economy began to grow very quickly by this period, and land conversion for economic activities became more common. It is possible that proximity to roads tends to have a stronger effect on landuse change during economically prosperous periods.

Multinomial Logistic Regression Models

In multinomial regression models, a p-value for significance is calculated for each independent variable regarding the overall effect it has on all levels of the dependent variable in the full model (Table 4.1). In addition, a separate parameter is estimated (and a p-value

for significance is calculated) for the effect of each independent variable on each level of the dependent variable relative to the reference class (the reference class is forest in these models). A summary follows of results relevant to determining the key drivers of landuse/landcover change, and understanding the types of associations between the above variables and the specific types of landcover change. All effects referred to as "significant" are significant at or above the 0.05 level.

The overall effect of each independent variable on the dependent variable (shown in Table 4.1) was statistically significant in each of the four regression models, except for the **aspect** variable in the 1994 – 1999 model (p-value = 0.1419) and the 1999 – 2002 model (p-value = 0.1840), and the **distance from Riga** variable in the 1994 – 1999 model (p-value = 0.7227).

Table 4.1. Results for multinomial logistic regression: significance of each independent variable on all levels of the dependent variable (type of landcover change).

Independent variable	Degrees of freedom	Wald Chi-square	P-value
1985 – 1994 model:			
Aspect	5	22.4	0.0004
Distance from nearest large water body	5	322.1	< 0.0001
Distance from Riga	5	17.2	0.0042
Distance to nearest road	5	896.0	< 0.0001
Distance to nearest town	5	38.8	< 0.0001
Municipality	90	665.5	< 0.0001
Slope	5	94.0	< 0.0001
1993 management zone	35	706.4	< 0.0001
1994 – 1999 model:			
Aspect	5	8.3	0.1419
Distance from nearest large water body	5	99.1	< 0.0001
Distance from Riga	5	2.9	0.7227
Distance to nearest road	5	442.2	< 0.001
Distance to nearest town	5	12.6	0.0281
Municipality	90	1028.1	<0.0001
Slope	5	99.9	< 0.0001
1993 management zone	35	331.1	< 0.0001
2000 management zone	20	498.3	< 0.0001
1999 – 2002 model:			
Aspect	5	7.5	0.1840
Distance from nearest large water body	5	103.0	< 0.0001
Distance from Riga	5	27.8	< 0.0001
Distance to nearest road	5	1156.4	< 0.0001
Distance to nearest town	5	13.6	0.0181
Municipality	90	768.2	< 0.0001
Slope	5	66.5	< 0.0001
1993 management zone	35	463.5	< 0.0001
2000 management zone	20	601.3	< 0.0001
1985 – 2002 model:			
Aspect	5	11.6	0.0409
Distance from nearest large water body	5	146.4	< 0.0001
Distance from Riga	5	21.6	0.0006
Distance to nearest road	5	1218.9	< 0.0001
Distance to nearest town	5	26.9	< 0.0001
Municipality	90	715.6	< 0.0001
Slope	5	60.9	< 0.0001
1993 management zone	35	362.0	< 0.0001
2000 management zone	20	699.0	< 0.0001

The significance of the effect of the **aspect** variable on landcover change decreased with the passage of time from 1985 to 2002. This result is interesting, because the **aspect** variable is less related to market forces than all the other variables in the models. This result shows that as time since independence passed and the free market matured, this environmental variable, essentially unrelated to market forces, became a less important predictor of landcover change, relative to variables more closely associated with market conditions.

It is also interesting that 1994 – 1999 was the only period that the **distance from Riga** variable was not significant. During this period, the land restitution process was taking place, but only at the very end of the period did land actually come into the hands of the new or restored owners. Thus, most land during this period was not controlled by private owners, and the State had little incentive to alter land as it was soon to relinquish control. In the prior period, the State had incentive to change the landuse, and in the subsequent period, the new owners had incentive to change the landuse. This result shows that incentive to change landuse may modify the distance from Riga as a predictor of landuse change, as only during periods when the State or private owners had incentive to change landuse was the distance of the land from Riga important in determining the type of landuse change.

Another interesting result is that in every model an increase in slope was significantly associated with an increased likelihood that change pixels would change to forest. As opposed to a human-induced change, a change to forest is often a naturally occurring landcover change after a fire, landslide, wind damage, or after human-induced land clearing. Thus, this result shows that high slopes reduce the likelihood of human-induced landcover changes. This result mirrors those found in Monroe County, Indiana in the USA, where

Evans & Moran (2002) found that when good flat lands are available, land conversion to development and agriculture is rare on steep slopes. In addition, Veldkamp et al. (2002) found that high slopes are associated with forested areas in Central America. Further, Pan et al. (2004) found that slope was significantly associated with landscape patterns at the farm level in the Ecuadorian Amazon.

In all models, pixels that were nearer to roads were more likely to convert to built-up, fields, or shrubs than they were to convert to forest. This effect was significant for each of these landcover types in each model. This conversion of land to built-up, fields, and shrubs is usually the result of human-induced landcover change: a new built-up area is clearly a human-induced landcover change; new fields are generally the result of land clearing for agriculture or of forest cutting for timber (in rare cases they are the result of fire, wind, or water damage); and the emergence of shrubs is usually due to a fallowing period of agriculture or regrowth of a forest stand recently cut for timber. So this result corroborates that of the classification tree analysis, and those of Rudel & Horowitz (1993), Chomitz & Gray (1996), Pichon (1997), Pan et al. (2004), and Pedlowski et al. (2005), showing that proximity to roads increases the likelihood of human-induced landcover change.

The effect of the **distance to nearest large town** variable differed between models. In the 1985 – 2002 model, the nearer pixels were to large towns, the more likely they were to convert to fields. This may show that those receiving restituted lands near towns were more likely to make economic use of their lands. Potential reasons for this are that taking up full time residence on restituted lands (and managing the land) was more attractive to those whose land was near a large town, or simply that landowners near large towns could more easily bring crops to market, as Veldkamp et al. (2002) found in Central America that there is

less crop production in areas whose nearest port is remote from US and European markets. Pichon (1999) found in the Ecuadorian Amazon that increased distance of farms from towns was associated with increased forest on the farm. However, McCracken et al. (1999) found the reverse effect, that the distance of farms from the nearest town in Pará, Brazil was associated with more deforestation. McCracken explains that this may, however, be due to the confounding factor of settlement date, which is associated with the distance from the nearest town, and may also be associated with deforestation on the farm. Pichon & Bilsborrow (1999) and Pan & Bilsborrow (2005), however, put both settlement date and distance to nearest community in the same statistical model: they found that, controlling for settlement date, proximity to the nearest community was significantly associated with increased land allocated to pasture at the farm level.

In the 1985 – 1994 model, pixels nearer to a large town were also significantly more likely to convert to fields. By 1994, however, land had not yet been restituted, so the processes driving this association must have been different than those described above regarding the likelihood of returnees moving to land near towns, and their being more likely to farm lands near towns. One process that could explain the significant result is that illegal timber harvesting in the first 3 years after independence (1991 – 1994) could have taken place most often near towns. Another explanation is that during the late Soviet era (1985 – 1991), agricultural activity was more intense near large towns, and the conversion of fallow fields (represented as shrubs or young forest) to crop fields was more common near these towns than far from them.

Another set of significant findings was that in the 1985 – 1994 and 1994 – 1999 models, pixels near to large towns were less likely to convert to shrubs, and in the 1999 –

2002 model, pixels near to large towns were *more* likely to convert to shrubs. Shrubs appear in this landscape primarily through two processes: the fallowing of fields and the regrowth of forests cut for timber. The fact that land near large towns was less likely to convert to shrubs between 1985 and 1999 shows that agricultural fields and meadows were more likely to be maintained near large towns during that period, relative to those far from them. The fact that land was more likely to convert to shrubs near large towns between 1999 and 2002 could be a result of the higher number of new fields occurring near large towns during the period (1985 – 1994), and these fields were due for a fallow period after 1999. In addition, some owners of restituted lands may have cut forest stands on their property just as they received their lands, which occurred near the end of the second period (1994 – 1999), and the increased likelihood of shrubs near large towns could indicate that landowners near these towns were more likely to cut forest stands than landowners far from these towns. These findings generally show that lands near large towns were more heavily managed for economic use than lands far from large towns.

In the 1985 – 1994 model, as **distance to water** decreased, land was significantly more likely to convert to forest, relative to any other landcover type. This shows that very little human-induced landcover change took place near water bodies during the late Soviet period and the very early Independence period. The significant results from the 1994 – 1999 model related to the distance from water bodies were that land near water bodies was significantly more likely to convert to water, wetlands, and built-up, relative to forest. This mirrors the result in the classification tree analysis: it is intuitive that pixels near water bodies are likely to convert to water and wetlands due to expanding water bodies/wetness, yet it is unexpected that land near water bodies would be more likely to convert to built-up,

especially given the restrictions on landowner landuse change for lands near large water bodies. This effect could be due to small sample size problems. The significant results of interest regarding the **distance to water** variable from the 1999 – 2002 model and the 1985 – 2002 model are that in both cases, pixels nearer to water bodies were less likely to convert to fields, relative to forest, showing that land conversion for economic purposes occurred less frequently near to water bodies, as opposed to far from them. The law restricting landowners from altering land near water bodies could explain this result.

As expected, the management zone (both the 1993 and the 2000 management zones) in which pixels are located had significant effects on the probabilities of the type of land conversion. An interesting result, found to be significant in all models except the 1994 – 1999 model, is that pixels in the Extensive Mass Recreation Areas were, in adherence with the designation of this zone, less likely to convert to built-up, relative to forest, than were pixels in the Neutral Zone. In addition, in the 1985 – 1994 model, pixels in this zone were less likely to convert to shrubs and fields, relative to forest, than were pixels in the Neutral Zone. But in the 1994 – 1999 model, pixels in this zone were *more* likely to convert to shrubs and fields, relative to forest, than were pixels in the Neutral Zone. This shows that after the initial post-independence economic decline (ending in the mid-1990's), human-induced land change increased in this zone, showing less of a regard for preserving this landscape.

When GNP was created, the zones were developed to protect one or more of the stated values of the Park: education, science, nature protection, landscape protection, development, and recreation (Melluma, personal communication 2004). According to Melluma, the Neutral Zone was intended to encompass those areas within the borders of the

Park that were not directly useful for one of these defined values. With one exception, in each of the three time periods (between temporally adjacent satellite image dates), pixels located in the Protected Natural Landscape Zone and the Protected Cultivated Landscape Zone were significantly more likely to convert to fields and shrubs, relative to forest, than were pixels in the Neutral Zone. The only exception was a non-significant result for the 1985 – 1994 model, where pixels in the Protected Natural Landscape Zone were estimated to be less likely to convert to fields, relative to forest, than were pixels in the Neutral Zone (p-value = 0.683). Since land conversion to fields and shrubs generally reflects economic use of land (for pasture, agriculture, or tree farming), this result is expected for the Protected Cultivated Landscape Zone, because this zone was intended to maintain precisely this cultivated landscape (consisting of patches of fields and fallow fields, or shrubs), and the Neutral Zone was not specifically intended for this purpose. However, this result is not expected for the Protected Natural Landscape Zone, which was intended to protect the forests, wetlands, and natural meadows it contains – a conversion of such land to fields or shrubs is rare through natural processes.

With the rezoning of the Park in 2000, the Neutral Zone was designated primarily for development, including agriculture and timber farming (Strautnieks, personal communication 2002). As expected, in the 1994 – 1999 and the 1999 – 2002 models, with one exception, pixels in the Neutral Zone were significantly more likely to convert to fields, shrubs, and built-up than were pixels in the Nature Reserve Zone. The exception was that in the 1994 – 1999 model, pixels in the Neutral Zone were not significantly more likely than pixels in the Nature Reserve Zone to convert to shrubs, specifically (p-value = 0.903). The result may be due to forest cutting that took place in the Neutral Zone throughout the mid- and late-1990's.

Only after 1999 was there enough regrowth for some of this cut forest to convert to shrubs; before 1999, much of the altered landscape in the Neutral Zone hadn't yet had the time to convert to shrubs. Since independence in 1991, the GNP Administration has funded the majority of its budget through selling timber rights on Park lands, primarily in the current Neutral and Landscape Protection Zones (Gauja National Park 2001; Strautnieks, personal communication 2002). The conversion of land in the Neutral Zone to fields and shrubs since 1994 reflects new agriculture and pasture lands, as well as timber farming on both private and public lands.

In the 1994 – 1999 model, the 1999 – 2002 model, and the 1985 – 2002 model, land in the Landscape Protection Zone of the 2000 management zone scheme was significantly more likely to convert to fields, relative to forest, than was land in the Nature Reserve Zone. The Landscape Protection Zone is intended for development and the protection of the cultural landscape (which includes agriculture fields and pastures), and is also used for some tree farming on public and private lands. These three land uses (agriculture, pasture, and cut forest) were classified as fields in the satellite images, and thus this result is expected. Note, however, that Latvian landscape scientist Olgerts Nikodēmus claims that to protect the Latvian cultural landscape, land in the Landscape Protection Zone should not undergo forest clear-cutting, and meadows should not be allowed to overgrow into shrubs (Nikodēmus, personal communication 2003). Based on these analyses, there is some ambiguity as to the fate of the Landscape Protection Zone regarding its intended uses as described by Nikodēmus, as it is unknown what percentage of the conversion to fields is for agricultural use and what percentage is from tree farming.

Another interesting set of results is that in the 1994 – 1999 model, the 1999 – 2002 model, and the 1985 – 2002 model, land in the Cultural Historic Zone of the 2000 management zone scheme was significantly more likely to convert to fields and built-up, relative to forest, than was land in the Nature Reserve Zone. The laws concerning landuse are the strictest for the Nature Reserve Zone, and, therefore, it is not surprising that land conversion to fields was more common in the Cultural Historic Zone. In addition, the Cultural Historic Zone contains monuments that often draw tourists, and, therefore, it is not surprising to see the increase in built-up areas in this zone, likely related to an increase in tourist facilities.

Part II: Drivers of LU/LCC and Landowner Attitudes toward GNP Management

The 150 responses in the geocoded GNP landowner questionnaires (see Appendix I) were used to analyze the effects of the important drivers of landcover change, as determined in Part I, on GNP landowners' opinions towards the Park's protection and development policies.

As almost all households are located near roads, the distance from the nearest road was not analyzed in relation to the landowner questionnaire, even though it was shown to be an important driver of landcover change. Also, due to the small sample size of valid, geocoded questionnaire respondents, statistically valid analyses were not possible using the municipality variable, because these respondents are distributed throughout 14 different municipalities, leaving too many cross-tab cells with expected values under 5. Finally, slope, also shown to be an important factor influencing the type of landuse change, was not

analyzed, because the slope was only shown to increase the likelihood of change to wetlands and water, and both of these changes are rarely due to human land conversion.

The geocoded locations of households representing the landowner questionnaires were used to determine in which 2000 management zone each landowner lived. In the first analysis, cross-tabs were calculated for the management zones and the responses to questions from the questionnaires. Because there were only 9 respondents living in the Cultural Historic zone and only one respondent lived in the Nature Reserve zone, responses from these 10 landowners were deleted so that each cell in the cross-tabs was sufficient for running valid chi-square tests of significance.

The question determined to be the most important in the questionnaire, giving the overall opinion of the landowners towards living in the Park, was the question "If during the re-planning of the Gauja National Park territory, you would be able to choose to stay or not to stay in the GNP territory, what would you choose?"

Among all three management zones analyzed, 80 percent responded that they would stay in GNP, and 20 percent responded that it would be better to stay outside the GNP territory.

Table 4.2. Crosstab: 2000 management zone vs. landowner choice to stay inside or outside GNP.

	Nature Conservancy	Landscape Protection	Neutral
Stay inside GNP	38 (90%)	60 (80%)	11 (55%)
Stay outside GNP	4 (10%)	15 (20%)	9 (45%)

The chi-square test shows a significant p-value of 0.005. Because the expected value of one of the cells in this cross-tab is under 5 (the expected value of the Neutral zone and those wanting to stay outside GNP is 4), the sample size is just under the sufficient level for a truly valid p-value. Since the p-value is so small, we can still assume the result is significant.

The result is very interesting, and shows that the more restrictions on landuse imposed on the respondent, the more likely the respondent is to want to stay *inside* the Park. Although this may first seem counterintuitive, this result may be due to landowner expectations for landuse and the sense of being in a protected area. Those in more protected areas may have lower expectations for using their land for economically productive purposes, while those in the Landscape Protection and Neutral Zones can, and do, use their land for agriculture and forestry, but are legally restricted compared to others who do so outside the Park. Furthermore, those living in the more protected zones may enjoy the natural beauty of those zones and feel pride associated with living in a national park. Respondents may also be content with the landuse restrictions, because they may consider taking advantage of tourism, although only 10 of the 140 respondents claimed they currently offer services for tourists.

The mean and median distances of each surveyed household to the nearest large water body (defined as either a lake or the Gauja River) were calculated for two groups: the first group is of those who responded that they would choose to "stay inside GNP," and the second group is of those who responded that they would choose to "stay outside GNP" in the above question. The results are shown in Table 4.3.

Table 4.3. Crosstab: the mean and median distances of a household to the nearest large water body for groups who, given the choice, claimed they would stay inside or outside GNP.

	Stay inside GNP	Stay outside GNP
Mean distance	1069 meters	1582 meters
Median distance	1003 meters	1597 meters

A pooled-variance, two-tailed t-test was calculated for a difference in means between these two groups. The difference in means was statistically significantly greater than 0, with a p-value of 0.0025, indicating that those living nearer to bodies of water were more likely to

choose to stay inside GNP than those living farther from bodies of water. As with the analysis presented in Table 4.2, a possible explanation is that living near water bodies may make residents feel more connected to the natural and/or cultural landscape in the Park. When they feel connected to the Park's preserved landscape, they may be more inclined to want to continue to live inside the Park's borders.

Another question from the landowner questionnaire was analyzed along with distance from large water bodies. This question was phrased "What do you think about the nature protection laws in the GNP territory?" Possible responses were:

- The regulations are too strict.
- The regulations are normal.
- The regulations are not strict enough.
- I don't know anything about the regulations.

The responses "I don't know anything about the regulations" were left out of this analysis, as were missing values. The remaining data constituted 132 responses. The mean and median values for the distance from the household to the nearest large body of water were calculated for the three groups (the three remaining responses to the above question), and the results are shown in Table 4.4.

Table 4.4. Crosstab: the mean and median distances of a household to the nearest large water body for groups who responded that the nature protection laws in GNP are of the following strictness:

	too strict	normal	not strict enough
Mean distance	1389 meters	1175 meters	1119 meters
Median distance	1512 meters	1108 meters	795 meters

A one-way ANOVA was run to test whether or not the means of these three groups are significantly different. The ANOVA test was not significant, and had a p-value of 0.78.

However, the sample size in the 'too strict' group is only 6, and, therefore, the ANOVA has low power. The direction of the effects, however, is consistent for the mean and median distances, and they resemble the analysis of the previous question. The farther from water bodies that the landowners live, the stricter they perceive the landuse laws to be. A hypothesis to explain this is that those who live near water bodies are more invested to preserve the landscape than those living farther from water bodies, and those living farther from water bodies are therefore less content with the nature protection laws affecting their landuse capabilities.

Conclusions

These analyses identified important drivers of LU/LCC in Latvia's Gauja National Park extending from the late Soviet era (1985) through recent times (2002). Through the use of multiple statistical models for analyzing landcover change between consecutive pairs of Landsat TM image dates, changes over time in important drivers of LU/LCC were examined. Furthermore, by integrating the GIS data with that of a landowner survey, statistical analyses gave valuable insight into the links between the drivers of LU/LCC and landowner opinions towards Park management.

Results showed that proximity of land to the nearest road increases the likelihood of land conversion, and this effect was more important in the latest study period (1999 – 2002). In addition, the GNP Administration's post-Soviet goals focused on protecting the Park's natural landscape have been successful. Also, at shorter distances from the nearest large water body, less landuse change occurred for economic purposes, perhaps due to GNP laws promoting the protection of areas near water bodies. Furthermore, the significant effect of the municipality on landcover change shows that development (built-up areas and land

conversion to fields and agriculture) has occurred unevenly throughout GNP. In addition, proximity to a large town was found to be important for predicting landuse changes related to economic uses of land. Another interesting finding was that the Park's management zones had substantial influence on the types of landcover change that occurred. Development and agriculture increased over time in the Extensive Mass Recreation Areas (based on 1993 zones) and in the Landscape Protection Zone (based on the 2000 zones), fulfilling the goal of those zones to facilitate development, but falling short of some goals to protect the cultural landscape (such as maintaining meadows, and limiting tree felling) in those zones. Finally, landowners living in the core management zones and landowners living near large bodies of water tended to embrace the Park's landuse restrictions more than those living outside of the core zones (where fewer landuse restrictions exist) and those with homes farther from water.

This analysis shows that proximity to roads increases the likelihood of human land conversion, in accord with research of Chomitz and Gray (1996), Pan et al. (2004), and Pedlowski et al. (2005). Furthermore, this analysis shows that this effect was strongest during the last period studied (1999 – 2002). This period is also the period of highest economic growth in Latvia. It is possible that an interaction effect exists, and that the effect of proximity to roads on landcover change is magnified with increased economic growth.

These findings show that the management zones were a key driver of landcover change. Land in the core zones was most likely to convert to naturally occurring landcover types (forest and wetlands), while land in the non-core zones was most likely to undergo human land conversion to fields and built-up. This reflects the Park Administration's primary goal: preserve the existing landscape in the core zones of the Park (Petersen 1999). A GNP law stemming from this goal severely restricts landowners from altering land near

water bodies. These results show that this law has been effective because, except for the 1994 – 1999 case, land near water bodies was less likely to convert to fields and more likely to convert to water or forest than was land far from water bodies.

Since Latvia's independence, control over the land in GNP has become decentralized, and the GNP Administration has delegated much of its authority to the municipalities in the Park (Melluma, personal communication 2004). This lack of stewardship of the non-core zones on the part of the GNP Administration has led to uneven development throughout the Park. According to these analyses, this phenomenon increased in importance over time (recall that the municipality variable was one of the most important predictor variables only in the later models). This mirrors a much larger process taking place along with decentralization in Eastern Europe and much of the former Soviet Union, and has led to uneven development throughout the region, with the majority of Latvia's post-Soviet economic growth taking place in Riga. Unwin (1998) writes about this phenomenon in Estonia, a country that focused on minimizing state interference in the economy and maximizing the influence of competition, including international companies, which, Unwin claims, has led to uneven development in Estonia.

Results from analyses of the landowner survey showed that landowners in management zones with more restrictive landuse laws reported that they would prefer to stay inside GNP, given the choice, more often than landowners in less restrictive zones. Also, the closer to water bodies that households are, the more likely the landowners are to be content with the Park's nature protection laws and would want to stay inside GNP, given the choice. A potential explanation is that when landowners live in non-core zones or far from water bodies, they may feel less invested in preserving the landscape and may resent laws that limit

their landuse and are primarily designed to protect other areas of the Park. It is possible that when Park landowners feel connected to the Park, they are more likely to want to live inside the Park and support Park protection policies.

This study examined the drivers of LU/LCC in the context of environmental protection and post-Soviet land restitution and land reform through the use of GIS, remote sensing, and statistical models. This study also gave insight into the feedbacks involved in landuse change at a landscape level in a protected area through an examination of how the drivers differentially affected landowner attitudes towards the Park, based on the landowners' geographic characteristics.

Chapter 5: Conclusions

The goals of this research were to (a) analyze the patterns and processes of LU/LC dynamics in post-Soviet Gauja National Park (GNP) Latvia; (b) understand important political, social, economic, and geographic forces that drive LU/LC change in the Park; and (c) understand the effects of these changes on the interests of GNP stakeholders. To this end, Chapter 2 was an analysis of GNP stakeholder interests and the conflicts that have developed between stakeholders since Latvian independence. Chapter 3 was an analysis of the changes in patterns and composition of LU/LC that took place in GNP from the late Soviet era through recent times (2002), and these analyses were focused on identifying and examining the landscape changes identified as primary interests in Chapter 2 by the Park stakeholders. Chapter 4 used statistical modeling to determine the most important political, social, economic, and geographic drivers of LU/LC change in post-Soviet GNP; understand the ways in which these drivers affected LU/LC changes in the Park; and assess how these drivers affected the attitudes of GNP landowners towards Park landuse restrictions.

One of the important contributions of this research to Land Change Science is its demonstration of the benefits of integrating multiple methodologies in local or regional land change studies. This research combines analyses using GIS and remote sensing technologies with qualitative interviews of key informants. The integration of methodologies gives both a broader and deeper understanding of the drivers, patterns, and processes of landuse and landcover change. The results from the qualitative research provide a context within which

to undertake GIS/remote sensing and statistical analyses. In this study, for instance, the qualitative research helped determine important stakeholder values that were then monitored in the GNP landscape with the time-series of satellite images, such as the natural landscape, the cultural landscape, and specific species habitats. The understanding gained from the qualitative research can help interpret findings from the quantitative analyses (e.g., the interviews gave indication that the reason for the greater than expected forest cutting, observed before 1994 in the satellite images, may have been due to cutting by profiteers that took advantage of a chaotic legal system regarding forest cuts during the early independence years). In addition, results from each method can be used to verify the other (e.g., in this study, the statistical models revealed uneven development patterns throughout the Park, and that was verified by complaints from local mayors regarding uneven development and uneven economic opportunity for their constituents in the Park). In conjunction, these methods were useful to understand how political, economic, and social forces acted on landscape composition and patterns within GNP, giving insight into the processes affecting the landscape over time.

As many countries of East Europe and the former Soviet Union transform from centrally planned economies and relative isolation from the rest of the "Western" world to market economies, many of them have become well-integrated with Europe, and massive changes have taken place in the political, economic, social, and environmental spheres throughout the region. These primary changes are from a centralized political and economic planning structure in Moscow to a conglomeration of autonomous states, an economic collapse just after the fall of the Soviet Union and the ensuing sustained period of economic growth throughout much of the region, an increase in personal freedoms throughout most of

the region, and a conceptual shift regarding the environment from the Soviet focus on conquering and controlling the environment to a Western concept of sustainable development of environmental resources (Pryde 1991). These changes include region-wide land reform and landuse policy transformations in each country that have impacted landuse and landcover throughout the region. Furthermore, Western governments and NGOs now exert influence on LU/LC change in protected areas in the region in the form of technical assistance and funding for specific nature protection projects. Cellarius (2004) writes that in Bulgaria, global concern about biodiversity conservation has been imported into Bulgaria in the form of Western-supported projects. The European Union regulates nature protection policy through its Birds and Habitats Directives, influencing member and prospective member countries to focus nature protection efforts according to international guidelines. However, all protected areas are likely to have multiple stakeholder groups, each with different sets of values and interests regarding these protected areas. Pedlowski et al. (2005) writes that to protect conservation areas in Rondônia, Brazil, coalitions of multiple stakeholders, often with competing interests, need to be formed for cooperative management of the region. According to Pedlowski et al. (2005), the various stakeholders in the conservation areas for this region of the Brazilian Amazon are squatters, poachers, illegal logging companies, state and federal agencies funded by the World Bank, and environmental NGOs.

The stakeholders in Gauja National Park were identified, and their interests regarding the Park were examined and described in Chapter 2. GNP was founded during the Soviet era as a multiple-use Park, and one of its key goals was to preserve Latvia's cultural landscape during an oppressive Soviet regime that maintained a policy to quash nationalism among its member states. As Latvia's cultural landscape is closely tied to its national identity (Bunkše

2000, Schwartz 2001), the GNP goal to preserve the cultural landscape had nationalist overtones (Melluma, personal communication 2004). Although key post-Soviet Latvian domestic policies have also focused on preserving national identity, in addition to restoring power primarily to ethnic Latvians (such as Latvia's citizenship laws, language laws, and its land restitution policy), the goals set forth by the post-Soviet GNP Administration have shifted focus from the Park's original goals incorporating development and the preservation of the cultural landscape to new goals focused on preserving its core natural landscapes and biodiversity (Gauja National Park 2004). This shift in focus was shown in Chapter 2 to be influenced by Western environmental principles, promoted by NGOs, Western governments, and supra-national organizations. However, some local stakeholders, such as the Park's principal founder, Aija Melluma, and landscape scientist, Olģerts Nikodēmus, value the GNP's cultural landscape and its connection to Latvia's national identity, in addition to its function as a landscape for economic productivity and development. In interviews, mayors of municipalities in the Park expressed interests in either having compensation for restricted landuse on land in the Park, or fewer restrictions on landuse inside the Park so their constituents may exercise more flexibility in conducting activities such as agriculture, forestry, hunting, tourism, and forest extraction of non-timber forest goods in some zones of the Park (Burcevs, Salminš, personal communication 2002). Furthermore, the results of the analyses in Part II of Chapter 4, integrating the geocoded landowner survey with the GIS data of the Park, showed that landowners in the less restrictive zones of the Park (such as the Neutral Zone and the Landscape Protection Zone, intended to preserve the Latvian cultural landscape) were more likely to feel opposed to Park landuse restrictions. The negative attitude of landowners in these zones towards Park landuse restrictions has the potential to

put the Park's Latvian cultural landscape even more at risk. Chapter 2 showed that the goal to preserve the Latvian cultural landscape inside GNP and the economic goals of local stakeholders have come into conflict with some of the Park policies focused on the protection of its natural landscapes and biodiversity. Problems such as these are commonly faced by managers of protected areas, because, as Cellarius (2004) notes, most parts of the earth have people with historically legitimate claims to land.

As discussed in Chapter 3, by dividing large communal agricultural lands into small private plots of rural land, land restitution led to a revival of the cultural landscape within GNP during the 1990's. There is evidence from the Landsat TM images, corroborated by GNP resident interviews, that since the late 1990's, farms are being bought by large farmers and they are being consolidated. As a result, since 1999, the GNP landscape has deviated from the Latvian cultural landscape towards one with larger patch sizes and farms operating at larger scales. In addition, due to the landuse restrictions on lands inside the Park, traditional landuses associated with Latvia's cultural landscape are less economically viable (e.g., due to restrictions on fence building, hunting, and pesticide and fertilizer use). Thus, there is a need to consider alternative economic landuses for Park residents.

There is ample opportunity to concurrently pursue biodiversity and landscape protection in the Park, and in doing so, to offer economic opportunities for Park residents. The opportunity lies in developing mechanisms to promote locals to maintain the cultural landscape. While the strict nature protection in the core areas of the Park preserves biodiversity and human recreation areas, landscape protection in the buffer zones of the Park (the Neutral Zone, the Landscape Protection Zone, and the Cultural-Historic Protection Zone) could preserve not only the Latvian cultural landscape, but also many species that have

adapted to the cultural landscape. According to Bacharel & Pinto-Correia, some cultural landscapes in Alentejo, Portugal "represent rich flora and fauna communities" (1999, p. 74), and in Alentejo's management plan, both natural and cultural values are considered for the management of each type of landscape. According to an interview with the Director of Research at GNP, Valdis Pilāts (personal communication 2004), GNP is currently losing overall biodiversity, mostly due to the loss of maintained meadows, and the plant and insect species that thrive in them. Similarly, Mander & Palang (1999) reports that in recent years (dates unspecified) in Estonia, a decrease in the amount of extensively used meadows (primarily for sheep grazing) has resulted in a loss of some flora species and the endangerment of others. Maintained meadows are a key element of the Latvian cultural landscape, as described by Melluma (1994) and Bunkše (2000), and though once prominent in GNP, maintained meadows are now becoming rare in the Park. According to Latvian ornithologist, Ainars Auninš (personal communication 2002) and GNP Research Director, Valdis Pilāts (personal communication 2004), there is also evidence that several local bird and small mammal species have adapted to, and prefer, the human-influenced landscape matrix of the cultural landscape relative to the purely natural areas of the Park. Many of the local fauna species rely on habitats comprised of mixed-use land with forest and fields in close proximity. For instance, the Lesser Spotted Eagle (*Aquila pomarina*), listed on the EU Birds Directive Annex for protected species, generally nests between 0.5 and 1 kilometer from the edge of undisturbed forests, and feeds in nearby agricultural fields (Auninš, personal communication 2002). The White Stork (*Ciconia ciconia*) is an iconic species of national pride in Latvia and builds massive nests, weighing up to two tons, drawing many tourists. They usually nest on the chimneys of farmsteads, water towers, or other posts found

in the cultural landscape. These birds feed on small animals – young birds, frogs, small mammals, and snakes, for instance, that are plentiful in fields and agricultural lands that are managed, but not intensively managed (Auninš, personal communication 2002). These non-intensively managed fields are typical in Latvia's cultural landscape due to historic farmland management customs in Latvia. Since lands are more intensively farmed in Western Europe, the animals on which White Storks prey are not as common there, and White Storks have far fewer habitat opportunities in these countries (Auninš, personal communication 2002), making the need to maintain these habitats in Latvia all the more important. The Wild Boar (*Sus scrofa*) and Moose (*Alces alces*) also require habitats of this mix of forest and fields (Pilāts, personal communication 2002). Therefore, to preserve some important species and biodiversity in Latvia, cultural landscapes that have been persistent in Latvia should be maintained. Protecting the natural areas in the Park's core zones at the expense of protecting the cultural landscape in the Park's buffer zones may be counterproductive for preserving overall biodiversity in Gauja National Park. Therefore, preserving the cultural landscape in the Park's buffer zones would fulfill the interests of multiple Park stakeholders – including the goal of preserving biodiversity held by the Park Administration and the Western influences that support it (e.g., European and American government organizations, NGOs, and the European Union), and the goal of preserving Latvia's cultural landscape, held by Latvian landscape scientists with nationalist interests (e.g., landscape scientist Olģerts Nikodēmus, and landscape scientist and principal GNP founder, Aija Melluma).

Furthermore, the goal to allow Park landowners and residents to make better economic use of the land in the non-core zones of GNP could be met through programs to motivate them to preserve the cultural landscape (specific program opportunities are

discussed below). More generally, instead of focusing protection efforts on natural landscapes alone, the model of Integrated Conservation and Development Projects (ICDP's) may be more appropriate. ICDP's combine standard protected area management strategies with strategies to provide incentives for rural development opportunities to reduce pressure on natural habitats and resources by promoting sustainable extractive reserves and the sustainable use of wildlife (Mackinnon 2001). Schwartzman et al. (2000) claims that inhabitants of tropical forests protect more forest overall than do protected areas. He writes that indigenous and traditional peoples often have the most to gain from preserving forest – and they often preserve them due to the long-term economic sustainability of their extensive (as opposed to intensive) extractive practices. In addition, these forest peoples have political power to maintain large areas under their control in these extensively utilized areas. Schwartzman et al.'s point is that indigenous and extractive reserves can preserve far more forested area than can people-free reserves, and therefore the promotion of indigenous and extractive reserves should be policy priorities. Schwartzman et al. (2000) claims that there may be considerable power backing indigenous and extractive reserves, because this power is not based merely on the economic value of the extractable resources, but on the political power of grassroots organizations that support these sustainable uses of the forest. A parallel can be drawn between the forests of the tropics and the cultural landscape of Latvia: based on Schwartzman et al.'s theory, the power in Latvia behind the protection of the cultural landscape would rest in the grassroots political support that leaders such as Latvian landscape scientists Aija Melluma and Olģerts Nikodēmus could attract. With such grassroots support, the large area of the non-core zones (totaling 55,422 hectares) of GNP could be preserved for sustainable use, maintaining the cultural landscape and the biodiversity it houses, in addition

to the 36,323 hectares of the core zones preserved for natural areas and biodiversity. Terborgh (2000) disputes Schwartzman et al.'s theory, claiming that extractive and indigenous reserves are likely to overexploit resources in the relatively near future, and that the best strategy for maintaining biodiversity is to designate large portions of land to be administered by state agencies. In the case of Gauja National Park, just over one-third of the Park is owned and administered by the GNP Administration, as he recommends – but to maintain Latvia's cultural landscape (which was developed through private ownership), private ownership seems the most likely candidate – when accompanied by appropriate landuse restrictions and incentives.

For maximum impact on biodiversity preservation, Peres & Zimmerman (2001) advocates an interconnected system of people-free preserves embedded in a larger extractive reserve of traditional or indigenous people. He claims this is more politically viable than large, purely people-free reserves. In addition, the background matrix of the extractive reserves managed in traditional ways allows the people-free reserves to act as population sources to replenish some of the sink areas that may be over-harvested in the peopled reserves. The effects of the strict reserves are, in essence, leveraged by the surrounding extractive reserves. Similarly, Cellarius (2004) makes the point that protection efforts must be extended into populated areas to protect entire ecosystems, instead of merely isolated patches of wilderness. According to Mander & Palang (1999), the protected areas in Estonia are set up with such a structure: there is an ecological network in Estonia of nature protection areas, forests, bogs, meadows, and coastal waters, and this network "…can be regarded as a subsystem of the anthropogenic landscape. Such a network counterbalances the impact of anthropogenic infrastructures in the landscape and preserves the main

ecological functions of landscapes…" (p. 182), which, among other functions, include the preservation of biodiversity. According to Cellarius (2004), 60 percent of the nature reserves in Bulgaria are embedded within national parks, so these national parks function as buffer zones for the nature reserves, and leverage the utility of these nature reserves to preserve biodiversity, similar to the Estonian ecological network and the above model advocated by Peres & Zimmerman (2001). Gauja National Park was designed in this way, with core zones (including the people-free Strict Nature Reserve Zone), embedded in a network of extractive/productive reserves (the non-core zones), where sustainable forest extraction and agricultural production are allowed. This system will only be fully functional if the non-core zones continue to be preserved as the extractive and productive cultural landscapes for which they were intended. In addition, the protection of GNP may be further leveraged on a larger scale, because GNP is part of a network of protected areas throughout the larger Baltic region called the "Green Lungs of Europe" (Turnock 2001), as well as the Natura 2000 network of protected areas in Europe.

Tickle & Clark (2000) writes that protected areas require economically sustainable human landuses to maintain both cultural landscapes and habitats. There are several types of programs that have been implemented around the world that may be applied in GNP to help landowners and residents preserve the Park's cultural landscape and make economic use of the land. Muller & Albers (2004) recommends the implementation of agricultural development programs as a focus of management plans for protected areas in some developing country settings: in GNP, agricultural development programs for small/family farms in the Park would help preserve the cultural landscape and its biodiversity. Programs could provide education and technical assistance for family farmers regarding the sustainable

extraction of forest products and the cultivation of organic and alternative produce. According to Cellarius (2004), examples of such agricultural development programs exist in Bulgaria, where NGOs have set up programs to promote environmental education about the cultivation of medicinal plants and sustainable practices for harvesting forest products. In addition, special loan programs could be adopted to help small farmers receive capital for farm equipment. Muller & Albers (2004) also recommends direct conservation payments as part of a management plan for protected areas in some developing country settings: in GNP, payments could be paid directly to landowners for maintaining meadows and forests in traditional manners, and for restoring and/or maintaining the farm houses, manor houses, and castles that help comprise the cultural landscape. Muller & Albers (2004) further recommends a focus on enforcement of protection laws in some protected area scenarios in developing countries: in GNP, enforcement could be stepped up regarding the existing landuse laws that help maintain the cultural landscape. Heal (2004) writes that ecotourism can integrate development and biodiversity conservation. Cellarius (2004) reports success of NGOs in promoting ecotourism as a means to protect the landscape in Bulgaria. With GNP receiving over 1 million tourists per year, a coordinated effort to promote ecotourism with a focus on Latvian culture within the Park could provide for more tourism-related income opportunities for Park residents, and would help motivate landowners to maintain the cultural landscape and the biodiversity it houses. The above programs are examples of win-win or small loss-big gain opportunities that DeFries et al. (2004) promotes for all stakeholders involved in landuse management for overall ecosystem function.

Orlove & Brush (1996) wrote that to understand biodiversity conservation issues, one should look at the relationship of local communities to the plants and animals, the

relationship of the local communities to the organizations promoting biodiversity, and the interests and concerns of the multiple stakeholder groups. Jānis Rozītis, Forest Program Manager of the Worldwide Fund for Nature (WWF) in Latvia, said in an interview (personal communication 2002) that "there are poor social relations between the GNP Administration and the local communities." GNP Director, Jānis Strautnieks, said in an interview (personal communication 2002) that the GNP community is poorly organized, and it is difficult to meet with representatives of the community. This poor relationship may be a key factor inhibiting some of the local residents from influencing the GNP Administration to focus management efforts more on the local goals of cultural landscape protection and economic development, rather than the more global goals of nature and biodiversity protection. Landscape scientist and principal GNP founder, Aija Melluma, stated in an interview (personal communication, 2004) that Latvia "must adapt concepts from abroad to the local environment", and that toward this goal, Latvia is currently doing a poor job. For many countries to effectively pursue such global and local environmental goals in tandem, global civil society and government institutions must have a broader recognition that in many parts of the world, species have adapted to long-term local landuse patterns, and that supporting the preservation of these landuse patterns may be essential to preserving global biodiversity. In addition, protecting these landuse patterns, in addition to natural landscapes, addresses a broad set of stakeholder values, by preserving local customs and cultural landscapes, and by providing economic opportunities for rural populations in and around protected areas.

Future Work

Five goals have been identified for future work related to aspects of this dissertation. First, targeted interviews with Park stakeholders, focus groups, and Public Participation

Geographic Information Systems (PPGIS) will be used to develop solutions to some of the identified management problems in GNP. For instance, an environmental NGO, such as Conservation International, will be approached to consider purchasing land in GNP to co-manage with the GNP Administration. The revenue received by the Park from such a purchase could be used to help fund the GNP Administration's budget, instead of relying on timber harvest from Park forests. Stakeholders will be interviewed using PPGIS tools to identify appropriate Park lands for sale to the purchasing environmental NGO. Park stakeholders, local biologists and ecologists, and landscape scientists will be convened in focus groups to develop programs to maintain Latvia's cultural landscape and the disappearing biodiversity (existing primarily in maintained meadows in non-core zones) within the Park.

Second, to address the important issue of maintaining biodiversity in GNP, changes over time in locations of potential key species habitat in the Park will be determined. To accomplish this, spatial landcover pattern information, in addition to more subtle distinctions in spectral information from satellite images (as opposed to the gross landcover categories used in this study), will be used to identify potential habitats at multiple time periods (multiple satellite image dates) of key species. This will allow for monitoring increase and/or decrease of potential habitat areas for these key Park species.

Third, additional interviews with Park stakeholders will be conducted to increase understanding regarding the level of support in Latvia for cultural landscape protection. In this dissertation, key Latvian figures (landscape scientists, the principal founder of GNP, and academic writers on Latvia) asserted the importance of maintaining Latvia's cultural

landscape. However, at this point it is not known how widespread in Latvia support is for protection of the cultural landscape.

Fourth, methodology will be developed to track the "performance" over time of Latvia's cultural landscape. The cultural landscape will be characterized in more detail by quantifiable measures that may include spatial landcover pattern information, species distribution, evidence of physical and economic rural development, restoration of cultural sites, and other measures to be determined based on interviews with landscape scientists. With such measures in place, the "health" of Latvia's cultural landscape in GNP and elsewhere may be tracked over time, to support planning efforts to maintain this landscape.

Fifth, this work may be extrapolated to other parks in Eastern Europe and the former Soviet Union. A similar approach, combining GIS/remote sensing analyses with qualitative interviews and a review of relevant documents, will be used to determine stakeholder values and conflicts in other parks in the region, characterize LU/LCC, and to understand similarities and differences in management issues in parks throughout the region.

Appendix I. GNP resident questionnaire.

Interviews with Gauja National Park landowners

Interview beta-testing July 2002

Primary researcher: Greg Taff

Fieldwork translator and co-interviewer: Sandra Tece

1. Do you live on this land now? If not, find another respondent or do not interview this household.
2. Date
3. Name of respondent
4. Municipality
5. Address
6. Gender
7. Age
8. Level of education
9. Married?
10. Children?
    a. How many?
    b. How many live with respondent?
11. Have long have you lived here?
12. Where did you live before you moved here?
13. How did you come to own this property? For instance,
    a. Original post-independence recipient

b. Family member (which?)

c. Friend

d. New buyer of land

e. other

14. Who lived here before you did?

15. Who was the original recipient of this land after independence?

    a. If respondent is not original recipient, do you know why the original recipient left?

16. Is this the same house that was on the land before Soviet occupation?

    a. If not, when was this house built?

17. About what percentage of people living in this area would you estimate arrived here since independence? “This area” is to be taken as the area of GNP about which you are knowledgeable.

    a. In your estimation, about what percentage of post-independence land owners in the area have left the area (since they received their land)?

18. Was part or all of your land part of a Soviet cooperative or State farm during Communism?

    a. Was it a cooperative or State farm?

    b. Were you a member of the cooperative or State farm?

    c. About how much of the former cooperative or State farm that was under production during communism would you estimate is currently in production (crops or pasture for grazing animals).

d. What percentage of the land in production in this area is in crops, and what percentage is being used as pasture?

19. Who is buying land in this area?

a. Small farmers?

b. Land speculators?

c. City people looking for an extra country house?

d. Large farmers?

e. Others? Who?

In the following questions "you" refers to any or all household members involved in landuse decisions.

20. Do you receive income from your land?

a. From gardening/farming?

b. Timber production?

c. Peat extraction?

d. Berries/mushrooms?

e. Toursim?

f. Other?

21. Is your land being farmed? If no, go to #23.

22. If yes, by you (and your household) or someone else?

a. If someone else, who?

b. Is this person (or people) paying you? In what form? How much?

23. How many hectares of land do you have on this plot?

24. Do you own other plots in Gauja National Park?

a. If so, how many total hectares including this plot?

25. Do you own land outside of Gauja National Park within Latvia?
    a. If so, how many total hectares do you own outside the Park?
26. How much of your land (in Ha) did you use for crops this year?
    a. List the crops you grew.
27. How much (in Ha) of your land was in forest/shrubs since before independence?
28. How much (in Ha) of your land was not in forest/shrubs before independence, and is now reverting to forest/shrubs?
29. Have you or has anyone you know consolidated resources with neighbors to be more profitable?
    a. Who?
    b. In what ways?
    c. Do you think this is common is this area?
30. Is it common among landowners to grow narrow forest/shrub corridors at property boundaries?
31. Have you or has someone else sold timber from this land since Latvian independence? If no, go on to question #32.
    a. Is this an ongoing timber enterprise?
    b. How much timber has been sold from your land since you acquired it?
    c. What kinds of wood have been harvested and sold?
    d. Do you know what the price per cubic meter is of these wood types?
    e. How have the sales prices of these woods changed since you or someone else began selling wood from your land?

f. How much profit have you received from timber

i. during the past 12 months?

ii. Since you moved here?

32. Do you know which category of the GNP management zones your land falls in?

33. Do you know what the landuse laws are for this management zone category?

34. How were you notified about these laws?

35. By who were you notified about these laws?

36. Do you know whom you can contact for information/clarification about landuse laws on your land?

37. What are the laws regarding types and amount of agriculture allowed on land in this management zone?

38. What are the laws regarding types and amount of timber production on land in this management zone?

39. Do you need to submit a request in order to alter your land?

40. To whom should you submit such a request?

41. Have you or has anyone else in your household abandoned work on your land in favor of wage labor elsewhere?

a. Where does this person work now?

b. Is this work currently more lucrative for this person than working on the land?

c. Has this person relocated for this work (does she/he spend more than half of the year at another address)?

42. Is someone from this household studying or working abroad?

a. Studying or working?

b. In what country?

c. Does this person hope to earn money from living/working abroad?

d. Does she/he expect this to be more lucrative than working in Latvia?

e. Does this person expect to return to live in Latvia permanently?

43. Has someone offered to buy your land from you? If yes,

a. Did you sell?

b. Are you considering selling?

c. Who is offering to buy?

i. Family member

ii. Friend

iii. Other individual

iv. Farm company

v. Other

d. For what reasons would you choose not to sell? (if response is difficult to generate, may prompt with these potential reasons)

i. Family

ii. Economic

iii. Personal

iv. Social/to stay in the community

v. Because it is your family's land

Appendix II. Landowner questionnaire.

Gauja National Park landowner survey

This questionnaire is to find out more about your opinion towards the Park's protection and development problems.

The first hundred questionnaire respondents will receive a presents.
Please fill out this form to help us.

Dear Ms. or Dear Mr.:

We, like you, care about Gauja National Park today and in the future. Our interests are similar, so it would be sensible to cooperate. To find out and compare our views, we invite you to participate in this survey. Your suggestions will be taken into consideration while working on the new Gauja National Park re-planning project.

In answering the questions, we ask you to circle the number. If none of the options given comply with your opinion, then write down your opinion.

-GNP Administration

Questions

1. What is your attitude towards the fact that you live in Gauja National Park territory?

1) I like it.
2) I don't like it.
3) I don't care.
4) _____

2. If during re-planning the Gauja National Park territory you would be able to choose to stay or not to stay in the GNP territory, what would you choose?

1) To stay in GNP.
2) Better stay outside GNP territory.

Why did you choose or decide this?

3. How big is your property?

1) Total area (in ha)
2) Area of forest (in ha)

4. Do you have on your property any of GNP's protected nature or cultural objects?

1) Yes, what kind?
2) No.
3) Don't know/haven't been informed.

5. Do any of GNP regulations restrict (limit) your farmwork production/commercial activity?

1) Yes, how?
2) No.
3) Don't know/haven't been informed.

6. Do any of Gauja National Park regulations bother you as a citizen of GNP territory or make your life harder in some respects?
1) Yes, which regulations?
2) No, there are no disturbing regulations.

7. Do any tourists disturb you near where you live? If so, how?
1) Disturb peaceful living.
2) Do harm to your commercial activity.
3) In general they don't, except in some cases.
4) I wish there were more tourists.
5) _____

8. Do your offer any services for tourists?
1) Yes, what kind?
2) No, but would be ready to offer.
3) No, would like to stay away from that.

9. What are your suggestions for tourism organizers in GNP? What should we definitely do (forbid, allow, create) to improve tourism within GNP?
_____

10. Have any wild animals done any harm to your estate?
1) Yes, what kind?
2) No.

11. What do you think about nature protection laws in the GNP territory?
1) Regulations are too strict.
2) Regulations are normal.
3) Regulations are not strict enough.
4) I don't know anything about the regulations.

12. In past years have you noticed any incidents near where you live when the environment around you has been damaged?
1) Yes, what kind of incidents?
2) No.

13. What do you think of your family's level of information about GNP regulations that determine life and order in GNP territory? For example, your level of information is good if you have read the GNP regulations. You have a medium level of information if you have heard about the regulations and approximately know their main ideas. You have low level of information if you know nothing about the regulations and activities in GNP.

What is your family's level of information?

	Good	Medium	Bad
GNP rules	1	2	3
Regulations on GNP protection and management	1	2	3
Events and activities in the GNP territory	1	2	3

14. Have you ever read any of 'NP Vestis' (National Park News – a printed leaflet)? What do you think of it?

1) I have read it.
a) Good idea, should continue publishing.
b) Do not feel a necessity for it.
c) _____
2) I haven't read it.
a) Would love to.
b) Not willing to read it.

15. What do you think of the relationship between the GNP administration and the locals?

1) Good enough, well-oriented towards cooperation.
2) Neutral – everybody does their job, and does not bother each other.
3) Slightly negative – often have conflicts of/differing interest.
4) _____

Why do you think so?

16. How would you evaluate the necessity of the work of GNP nature protection inspectors?

1) Inspectors do good and necessary work.
2) Inspectors are not needed.
3) Don't know/can't judge.
4) _____

17. We are now re-planning the GNP territory. What should be necessarily taken into consideration in the new plan? What changes have to be made in the existing plan and in the existing regulations?

_____

18. Would you like to participate in the future in GNP development and work?

1) Yes, we'd love to be informed about important things happening in GNP.
2) Yes, we'd love to participate in important decision-making.
3) We'd love to be informed and participate in decision-making regarding my property.
4) No. GNP questions are not of interest to me.
5) _____

A few facts about you

19. Place of living – municipality, house address.

20. Family size _____. Number of children (up to 18 years) only _____.

21. Main sources of income:
1) Employed, work in a company.
2) Agriculture production.
3) Timber production.
4) Other commercial activity.
5) Pension.
4) Benefits (social benefits)
6) Other sources. (What sources?)_____

22. Respondent: gender: 1-male; 2-female. Age _____years.

Thank you for your help. We hope for cooperation in the future!

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Bajars, Gunārs, Professor of Tourism and Management, Vidzeme University College, November 10, 2002.

Bebris, Rolands Arturs, Director of Environmental Protection Department in the Ministry of Environmental Protection and Regional Development, November 13, 2002.

Burcevs, Vilnis, Elected Mayor of Kocenis and Head Deputy of Kocenis, December 10, 2002.

Ivashina, Dace, Assistant to Maaris Sestulis (Head of the Cesis Head Forestry Office), State Forestry Service, November 22, 2002.

Kokorevicha, Ilga, Director of the Valmiera Regional Environmental Board, October 25, 2002.

Krukliite, Saiva, Administrator in the Valmiera county region of the State Land Service, November 11, 2002.

Lagūns, Guntars, Board Director of the Latvian Forest Certification Council and Consultant for Forest 2000, Ph.D. student in Forest Politics and Economics in Forest Department of The Latvian University of Agriculture, November 27, 2002.

Melluma, Aija, Professor of Geography at the University of Latvia, and founder of Gauja National Park, July 27, 2004.

Niklass, Maaris, Governor of Cesis Region, Vice-president of the GNP Consultative Board, December 4, 2002.

Nikodēmus, Olģerts, Professor of Geography, Specialty: Landscape Scientist, University of Latvia, January 2, 2003.

Østergaard, Aase, Landscape Architect, Project Manager at Carl Bro Intelligent Solutions – Implementation of Latvian Biodiversity Action Plan, November 13, 2002.

Ozola, Dace, Senior officer of the Nature Protection Dept in the Ministry of Environmental Protection and Regional Development (MEPRD): Protected Nature Territories and Management Plans, December 13, 2002.

Ozolinsh, Jānis, Deputy Head of the Game Management Dept. of the State Forest Service of the Ministry of Agriculture, previously of the State Forest Inventory Institute, Doctorate in Biology, November 8, 2002.

Ozols, Arviids, Director of Large-scale mapping, State Land Service, November 8, 2002.

Pakālne, Māra, Professor of Botany and Ecology at the University of Latvia, Riga, November 1, 2002.

Pilāts, Valdis, Biologist and Director of Research for Gauja National Park, November 23, 2002.

Pilāts, Valdis, Biologist and Director of Research for Gauja National Park, August 12, 2004.

Pilāts, Valdis, Director of Research at Gauja National Park, direct email contact, 2005B.

Ratfelders, Rolands, Senior officer of the Nature Protection Dept in the Ministry of Environmental Protection and Regional Development: Lawyer and specialist on EU integration, December 13, 2002.

Rozītis, Jānis, Forest Program Manager in the WWF (Worldwide Fund for Nature), December 12, 2002

Salminš, Jūris, Elected Mayor of Krimulda municipality, Riga County Representative on the GNP Consultative Board, December 5, 2002.

Sēstulis, Māris, Head Forester of the Cesis Region of the State Forest Service, December 9, 2002.

Strautnieks, Jānis, Director of Gauja National Park, December 11, 2002.

Timze, Iveta, Department Director of the State Environmental Inspectorate in Gauja National Park, November 28, 2002.

Vanadzinsh, Andris, Writer for Druva, a local newspaper in Cesis, December 9, 2002.

Vēveris, Ilmārs, Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, Environmental State Inspectorate – Nature Protection Control Division, Sector of Species and Habitat Control, October 31, 2002.