2005

Nebraska's Forests

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Cover: Eastern Nebraska landscape. Photo by Dacia Meneguzzo, U.S. Forest Service.

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Foreword

While Nebraska is primarily known as an agricultural and grassland state, our forest resources are surprisingly substantial and growing. Since 1983, the number of forested acres has increased by more than 500,000 acres to over 1.2 million — that's 352 million trees! The total volume of sawtimber has increased by nearly 1.7 billion board feet since 1994, enough to build about 85,000 new homes. Windbreaks, shelterbelts, and narrow wooded riparian strips account for an additional 400,000 acres of tree-covered land. Community forests add hundreds of thousands of acres to our total forest resources.

Nebraska hosts a unique and diverse array of important forest types. Our riparian forests along rivers throughout the State are home to forests of cottonwood, American elm, and green ash. Stately stands of ponderosa pine grace northwestern Nebraska's Pine Ridge. In the Niobrara Valley, central hardwood (oak and walnut), ponderosa pine/eastern redcedar, and remnants of the northern boreal (aspen and birch) forests form an ecologically unique confluence. Largely due to the lack of fire, eastern redcedar, a bane to ranchers but an opportunity for value-added specialty products and bioenergy businesses, is rapidly spreading across pasturelands and within pine and cottonwood forests. Overall, Nebraska's forests provide economic, social, and environmental benefits such as clean water and air, terrific hunting and recreational opportunities, and a steady flow of wood that supports jobs and increases rural incomes.

Nebraska's many thousands of miles of rivers are home to extensive riparian forests. Riparian forests are important to wildlife, especially songbirds and bald eagles. Cottonwood provides millions of board feet of lumber annually and is the primary commercial species (in volume) in Nebraska. Unfortunately, the number of cottonwoods is declining, primarily due to dams that prevent the scouring spring floods vital to its regeneration. As floods diminish, cottonwood is being replaced by eastern redcedar, mulberry, hackberry, and Russian olive.

Nebraska's forest resources are a vital component of rural economic development. Wood is used to produce a variety of products, such as lumber, furniture, gunstocks, pallets, wood pellets and chips for fuel, and decorative mulch. With 1.2 million acres of forest land producing more than 1.8 million tons of wood each year, these forests are a vastly underutilized resource. In this age of rapidly escalating costs for fuel oil and natural gas, Nebraska-grown wood is a carbon-neutral, clean-burning, renewable, and economic energy source waiting to be tapped.

As natural systems, Nebraska's forests and forest industries are undergoing dynamic change. Enduring drought and groundwater use have affected water availability in some riparian areas, killing trees and increasing invasion by both tree and herbaceous species. Drought, combined with unnatural fuel loads, creates conditions for huge forest-destroying wildfires that convert vast areas of mature ponderosa pine forests to sparsely-treed grasslands. Ironically, improved wildfire suppression in grasslands fosters the extensive spread of eastern redcedar.

Accurate, consistent data on our forest resources are essential to the sound management of the State's forest resources. The U.S. Forest Service's Forest Inventory and Analysis Program, in partnership with the Nebraska Forest Service, has inventoried Nebraska's forests several times since 1983. The latest inventory, completed in 2005, was conducted over a 5-year period (2001-05). These plots will be measured every 5 years to provide a continuous assessment of our forests.

This report highlights the current status of Nebraska's forests and discusses trends that affect this valuable resource. This information is fundamentally important for creating and implementing programs that foster forest-based rural economic development, improve forest health, productivity, and stability, and enhance environmental quality and services for current and future generations of Nebraskans.

Dr. Scott J. Josiah

State Forester and Director, Nebraska Forest Service

Contents

Highlights

On the Plus Side

- Forest land area in Nebraska has increased by nearly 300,000 acres since the last inventory in 1994.
- The number of live trees on timberland increased by more than 35 million between 1994 and 2005.
- The total dry biomass of live trees on timberland has increased by more than 10 million dry tons since 1994.
- Growing-stock volume on timberland increased by more than 449 million cubic feet between 1994 and 2005.
- Sawtimber volume on timberland increased by nearly 1.7 billion board feet since 1994.
- Treed lands, such as windbreaks and shelterbelts, add more than 400,000 acres of additional tree-covered land across the State.

Areas of Concern

- Eastern redcedar continues to establish and grow at a rapid rate. On average, cottonwood regeneration is only about one sapling per acre of forest land versus approximately 60 eastern redcedar saplings per acre.
- Nearly 70 percent of the sawtimber on timberland is of low grade. Of the high-quality sawtimber, 87 percent is in cottonwood, an aging resource with very little regeneration.
- Data collected on Phase 2 and Phase 3 field plots show there are at least 33 nonnative invasive vascular plant and grass species in Nebraska.
- Several nonnative tree/shrub species, e.g., Russian olive, are present in the State.
- Pine wilt, oak wilt, and the pine engraver beetle have caused moderate to heavy damage in Nebraska's forests.

Issues to Watch

- Increased demand for biofuels may lead to a reduction in forest land area as these lands are cleared for agriculture.
- Green ash is a major component of Nebraska's forests, so it is important that measures be taken to prevent the introduction of the emerald ash borer, a nonnative insect that kills ash trees.
- A significant amount of forest land will change ownership as older landowners pass on their land to younger generations. This will become an important issue because these new landowners may have different land-management objectives.
- Continuing drought conditions, current land uses, and dams are allowing cottonwood to be replaced primarily by eastern redcedar as well as species such as Rocky Mountain juniper, Russian olive, and hackberry.

Background

Green ash. Photo by Dave Cappaert, Michigan State University, bugwood.org

Beginner's Guide to Forest Inventory

What is a tree?

Trees are perennial woody plants having central stems and distinct crowns. The Forest Inventory and Analysis (FIA) Program of the Forest Service, U.S. Department of Agriculture, defines a tree as any perennial woody plant species that can attain a height of 15 feet at maturity.

What is a forest?

FIA defines forest land as land that is at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently developed for nonforest use. The area with trees must be at least 1 acre in size and wooded strips, such as those along roads, streams, and agricultural fields, must be at least 120 feet wide and 363 feet long to qualify as forest land.

What is the difference among timberland, reserved forest land, and other forest land?

From an FIA perspective, there are three types of forest land: timberland, reserved forest land, and other forest land. In Nebraska, 94 percent of the forest meets the definition of timberland, 1 percent is reserved forest land, and the remaining 5 percent is other forest land.

- Timberland is forest land that is not reserved and meets the minimum productivity requirements that other forest land does not.
- Reserved forest land is withdrawn from timber utilization through legislation or administrative regulation.
- Other forest land is incapable of producing 20 cubic feet per acre per year at its peak, often due to poor soil conditions.

In previous inventories, FIA measured trees only on timberland plots and did not report volume on all forest land. With the implementation of the new annual inventory system in 1999, FIA can now report volume on all forest land. As these annual plots (Fig. 1) remeasured in the years ahead, FIA will be able to report growth, removals, and mortality on all forest land. In this report, trend reporting is necessarily limited to timberland except for the area of forest land where individual tree measurements are not required.

How do we estimate a tree's volume?

Volume can be determined precisely by immersing a tree in a pool of water and measuring the amount of water displaced. Less precise but much cheaper, was the method used by the North Central Research Station. Using this method, detailed diameter measurements were taken along the lengths of several hundred cut trees to accurately determine their volume (Hahn 1984). Regression lines were then fit to this data by species group.

Using these regression equations, FIA can produce volume estimates for individual trees based on species, diameter, and site index. This method was also used to determine sawtimber volumes. FIA reports sawtimber volumes by the International 1/4-inch rule board-foot scale. Factors for converting to Scribner board-foot scale are available in Smith (1991).

How much does a tree weigh?

Building on previous works, the Forest Products Laboratory of the Forest Service developed estimates of specific gravity for a number of tree species (U.S. Dept. Agric. 1999). These estimates were then applied to estimates of tree volume to estimate the biomass of merchantable trees (the weight of the bole). This becomes somewhat complicated when determining live-tree biomass since the stump (Raile 1982) and the limbs and bark (Hahn 1984) must also be added. Currently, FIA does not report the biomass in roots and foliage.

Forest inventory can report biomass as green or oven-dry weight. Green weight is the weight of a freshly cut tree; oven-dry weight is the weight of a tree with no moisture content. On average, 1 ton of oven-dry biomass equals 1.9 tons of green biomass.

How do we compare data from different inventories?

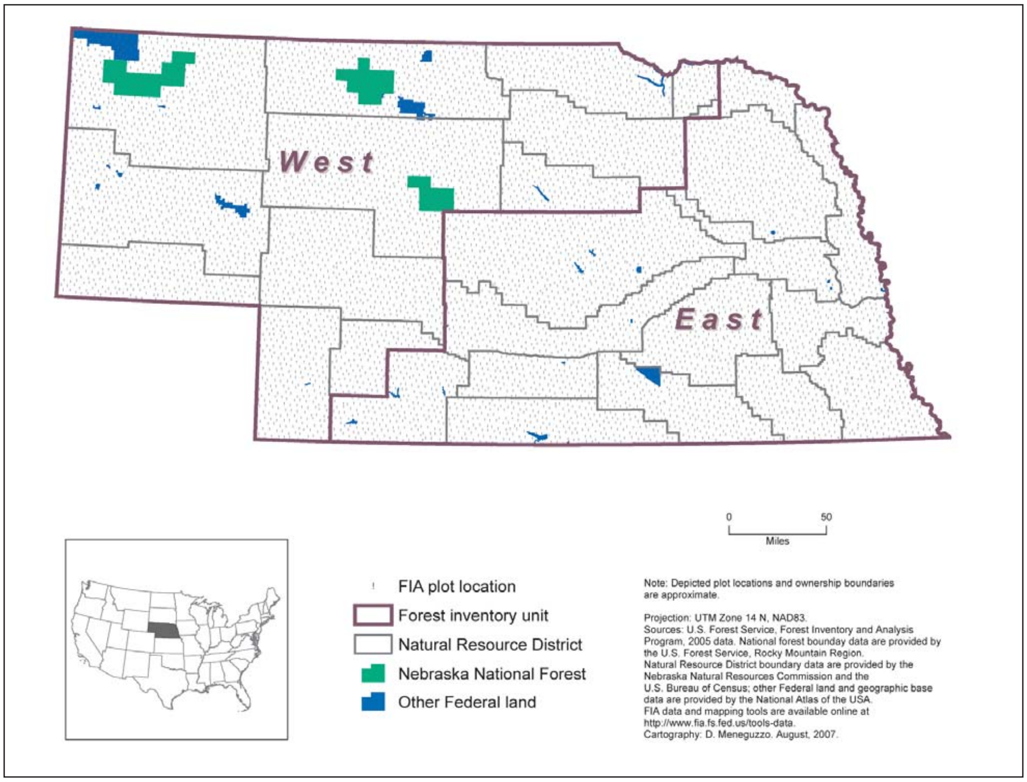
Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for comparisons to be valid, procedures used in the two inventories must be similar. As a result of FIA's ongoing efforts to improve the efficiency and reliability of the inventory, there have been several changes in procedures and definitions since the last Nebraska inventory in 1994. These changes will have little effect on statewide estimates of forest area, timber volume, and tree biomass, but they may have significant effects on plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare 2005 data tables with those published for 1994.

The greatest change between inventories was in plot design. For consistency, a new national plot design was implemented by all five regional FIA units in 1999. The plot design used in the 1994 Nebraska inventory consisted of variable-radius subplots. The new national plot design used in the 2005 inventory used fixed-radius subplots. Both designs have strong points but often produce different classifications for individual plot characteristics.

A word of caution on suitability and availability

FIA does not attempt to identify which lands are suitable or available for timber harvesting, especially since suitability and availability are subject to changing laws and ownership objectives. Because land is classified as timberland does not necessarily mean it is suitable or available for timber production. Forest inventory data alone are inadequate for determining the area of forest land available for timber harvesting because laws and regulations, voluntary guidelines, physical constraints, economics, proximity to people, and ownership objectives may prevent timberland from being available for production.

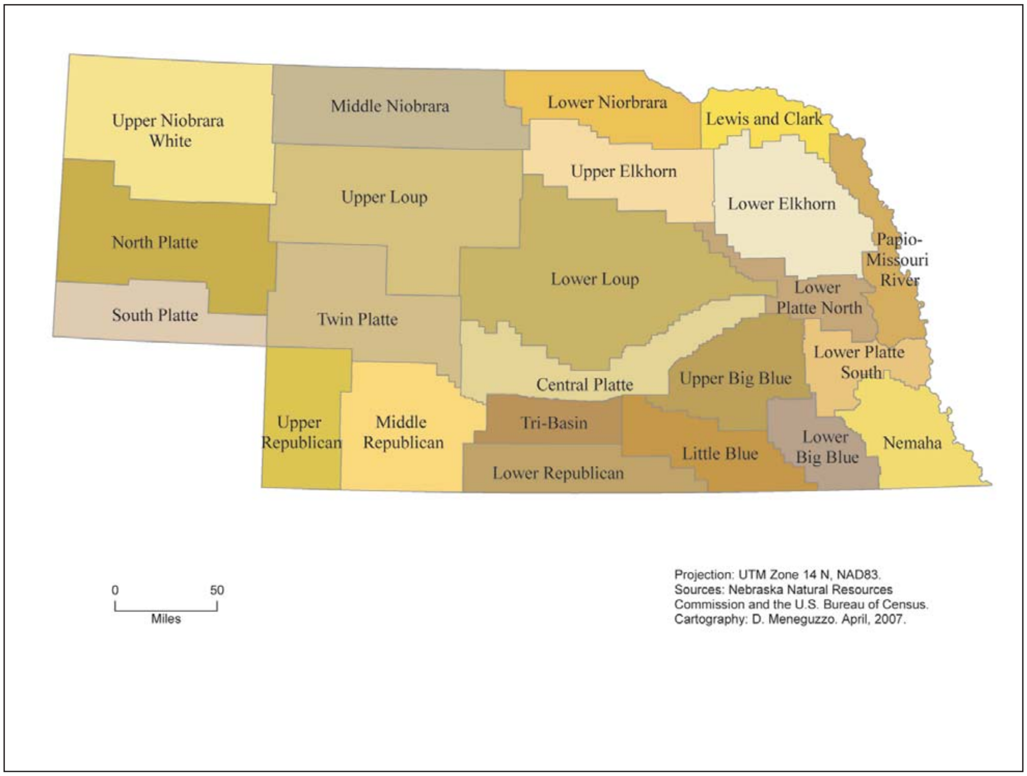
Figure 1.—Sampling locations and inventory units associated with the current forest inventory, Nebraska, 2005.



Nebraska's Natural Resource Districts

Nebraska contains 23 Natural Resource Districts (NRDs) that are based on watershed boundaries to more effectively manage and protect their natural resources (Fig. 2). This local management provides solutions for the unique challenges within each district. NRDs also encompass a variety of conservation projects and programs, for example, the Conservation Trees for Nebraska program that helps the State's landowners plant more than a million trees each year (http://www.nrdnet.org/nrd_programs/trees.html). This report often shows NRD boundaries in its maps and provides data summaries by NRD in addition to using county-level information.

Figure 2.—Nebraska's Natural Resource Districts.



Forest Features

Ponderosa pine in northwestern Nebraska. Photo by Dacia Meneguzzo, U.S. Forest Service.

Forest Land Area

Background

Measuring forest land area is important for understanding the current status of Nebraska's forest ecosystems as well as trends occurring over time. Since most of the State's forest land is found in woodlots and in riparian areas along streams and rivers, forest land is relatively scarce. Therefore, assessing changes in the forest land base is critical as these may be signs of important land-use changes or forest health conditions.

What we found

The current estimate of forest land area in Nebraska is 1.24 million acres, an increase of nearly 300,000 acres since the last inventory in 1994 (see Schmidt and Wardle 1998) (Fig. 3). This trend of increasing forest land area has occurred since the 1983 inventory. Prior to this, forest land had decreased by 185,000 acres between the first (1955) (see Stone and Bagley 1961) and second (1983) inventories as a result of forest lands being shifted to agricultural uses (Raile 1986). Figure 4 shows forest land area in the State using Moderate Resolution Imaging Spectroradiometer (MODIS) satellite pixels, which represent an area of approximately 15 acres on the ground; the value shown is the percent of the pixel that is forested. The top three Natural Resource Districts in forest land area are the Upper Niobrara White with more than 234,000 acres, the Lower Niobrara (123,500), and the Lower Loup (114,300) (Fig. 5).

What this means

The continuing trend of increasing forest land area seems to indicate that Nebraska will continue to gain forest land. However, future demand for products derived from agriculture crops, e.g., ethanol and biodiesel fuels, could lead to another reduction in forest land area. The first decrease occurred between the first and second inventories.

White oak. Photo by Bill Cook, Michigan State University, bugwood.org.

Figure 3.—Area of forest land by inventory year, Nebraska, 1955-2005.

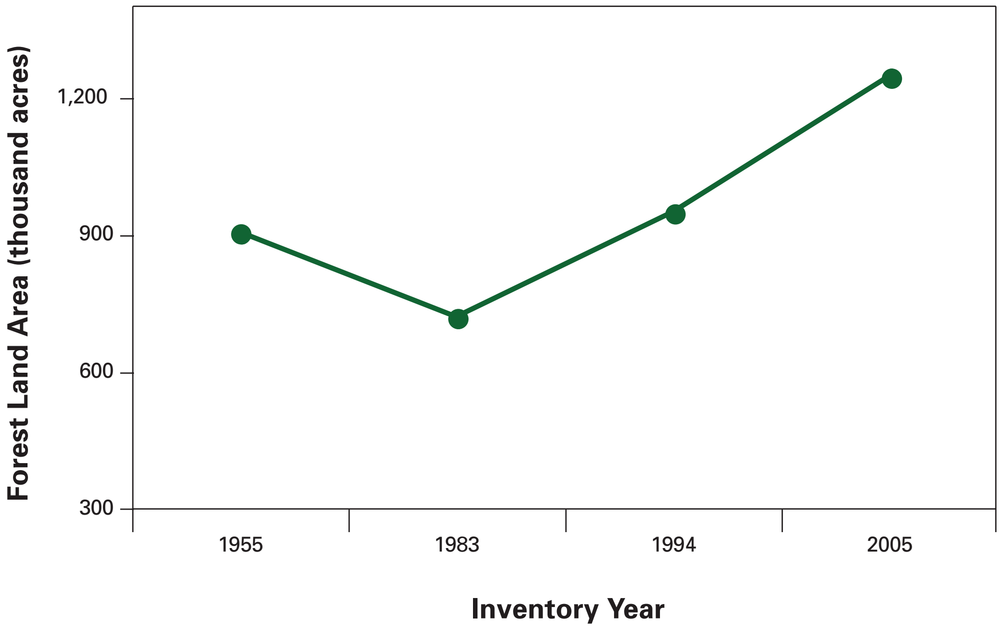


Figure 4.—Distribution of forest land, Nebraska, 2005.

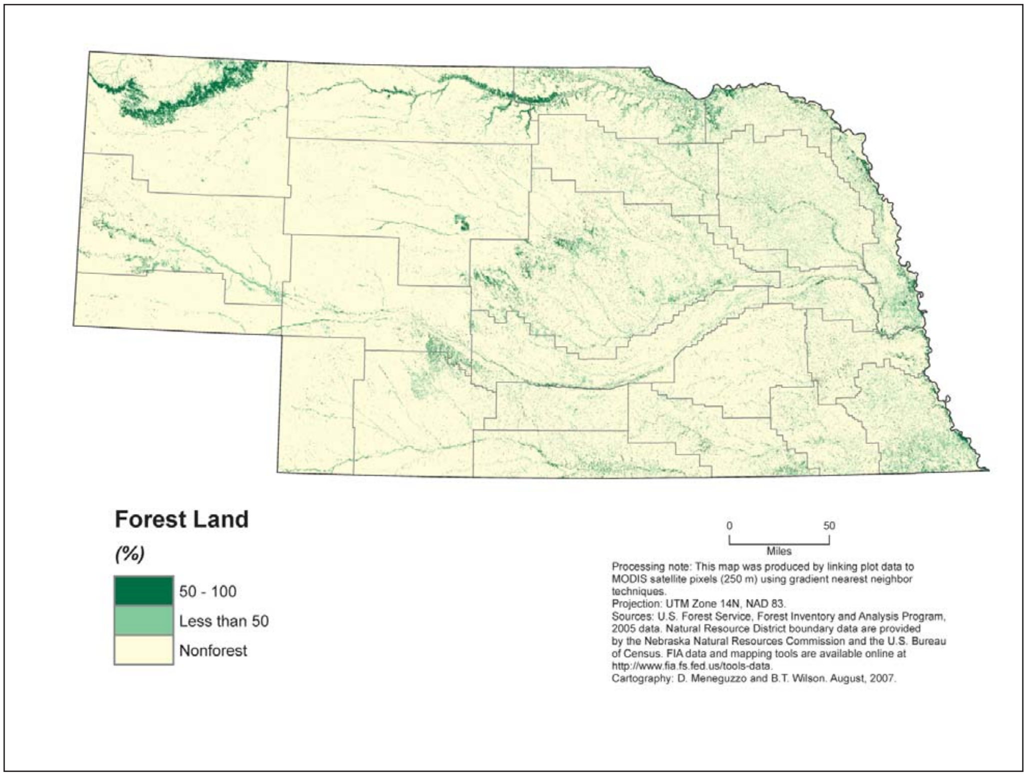
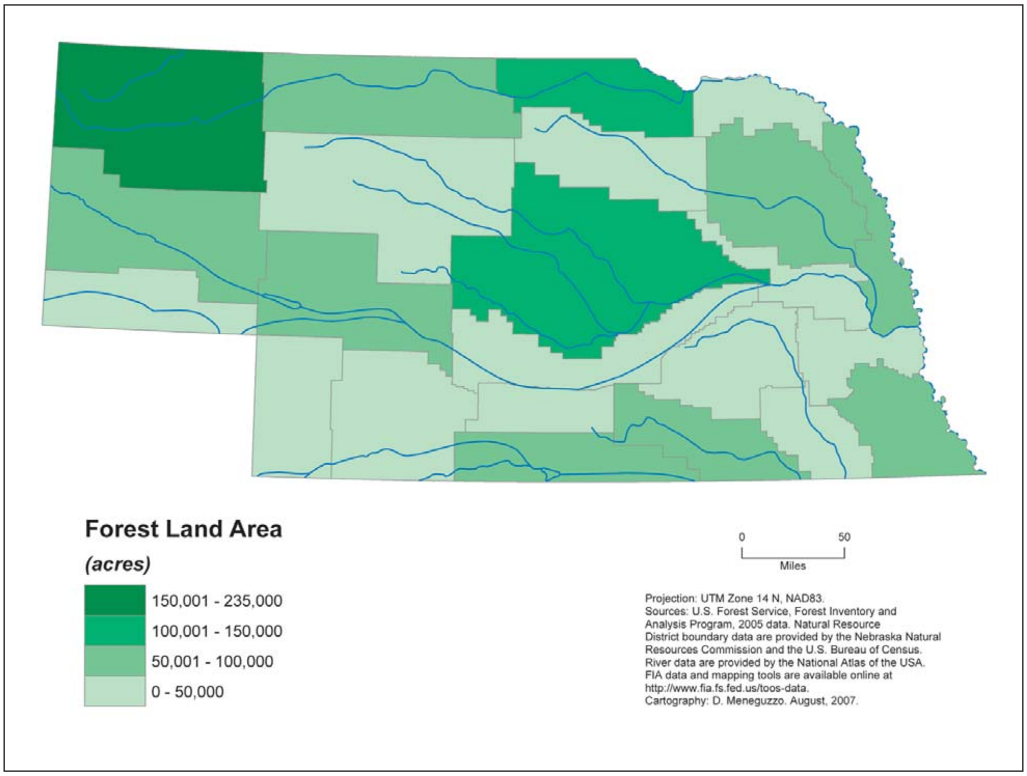


Figure 5.—Area of forest land by Natural Resource District, Nebraska, 2005.



Biomass

Background

Biomass is the aboveground total dry weight of all live components of forest trees, including stumps, boles, limbs and tops but excluding foliage. Estimates of total biomass and its distribution among stand components provide an indication of forest health trends and the sustainability of forest management practices across Nebraska's forest lands. These estimates also provide important information for analyses of carbon sequestration and for determining the amount of wood or fiber available for fuel.

What we found

The estimated total live-tree biomass on forest land is nearly 42 million dry tons. Privately owned forest land contains 86 percent of the State's total aboveground biomass (Fig. 6). On timberland, hardwood and softwood species contain 75 and 25 percent, respectively, of live-tree biomass. In addition, the boles of trees contain nearly three-fourths of the total biomass (Fig. 7). The distribution of live biomass (oven-dry tons) on forest land across Nebraska is shown in Figure 8.

The forests of Nebraska currently store 82.2 million metric tons (90.6 million tons) of carbon in their biomass. Soil and live trees (above and below ground components) account for 84 percent of the carbon sequestered; standing dead trees, the forest understory, down and dead trees, and the forest floor account for the remaining 16 percent (Fig. 9).

What this means

Most of the total live-tree biomass is on private land in the boles of hardwood trees. Large hardwood trees are of commercial importance so a significant portion of biomass and, consequently, carbon sinks, could be at risk from excessive harvesting. Related to this is management by private landowners since they own most of the total biomass. Their management objectives and decisions will have an important impact on the amount of biomass present on the forested landscape.

Figure 6.—Ownership of live biomass on forest land, Nebraska, 2005.

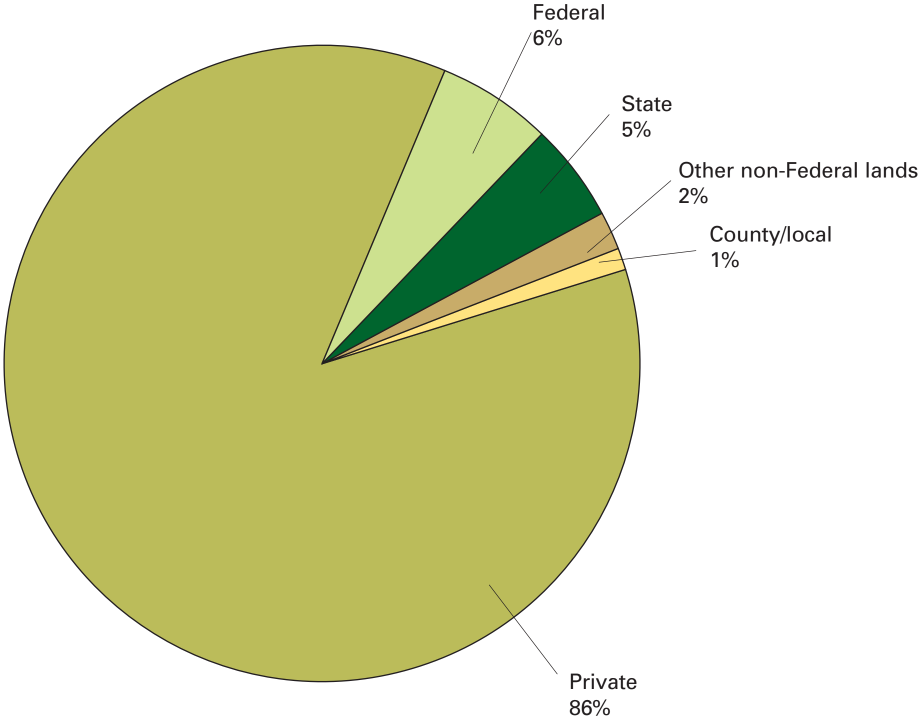
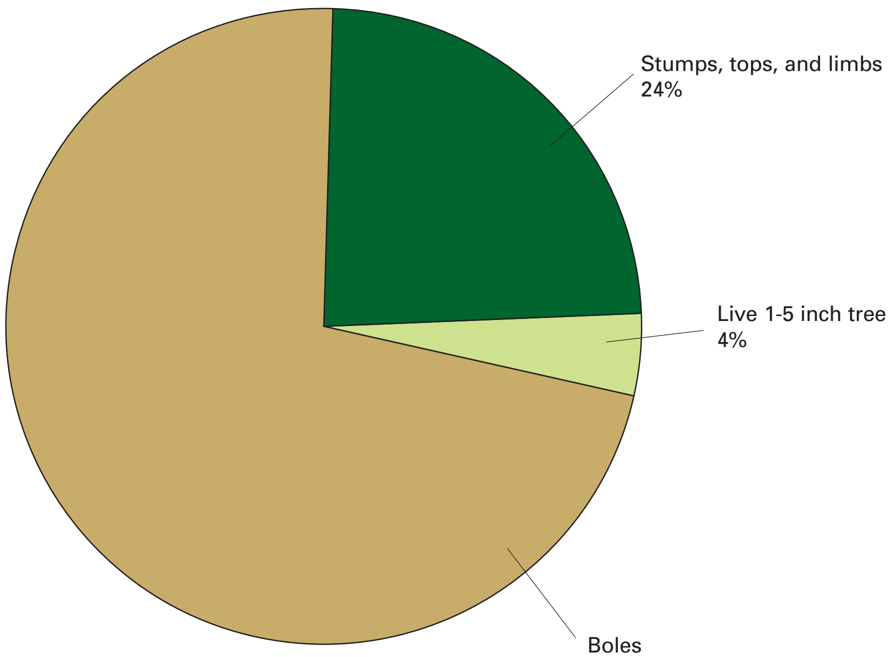


Figure 7.—Distribution of live biomass on forest land by tree part, Nebraska, 2005.



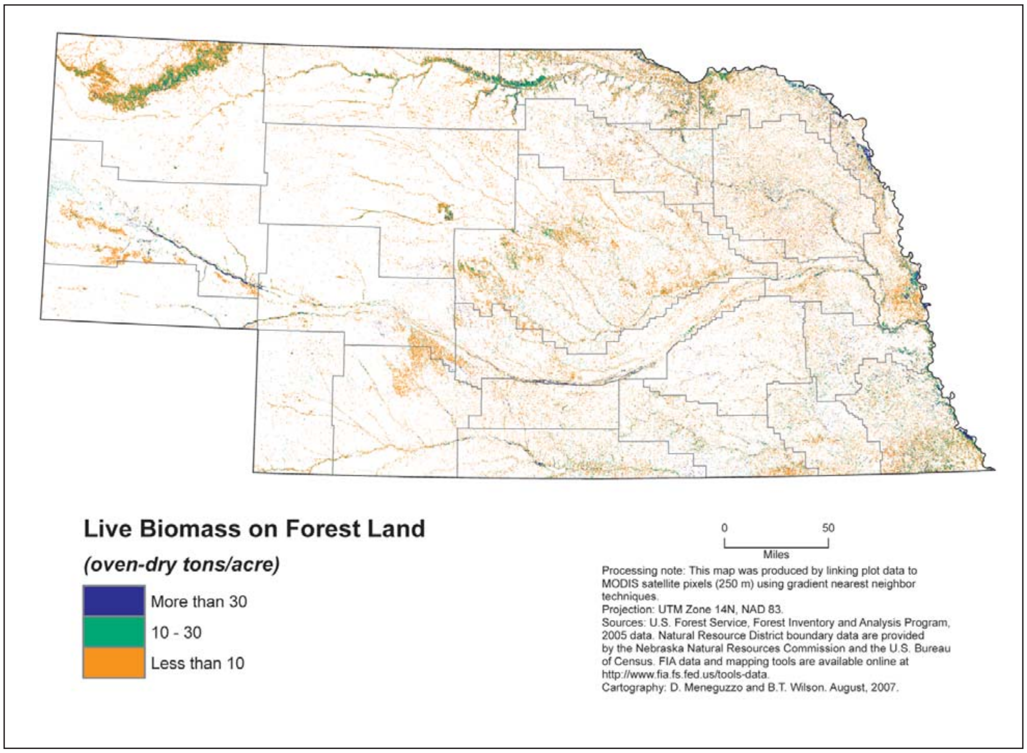


Figure 8.—Distribution of live biomass on forest land, Nebraska, 2005.

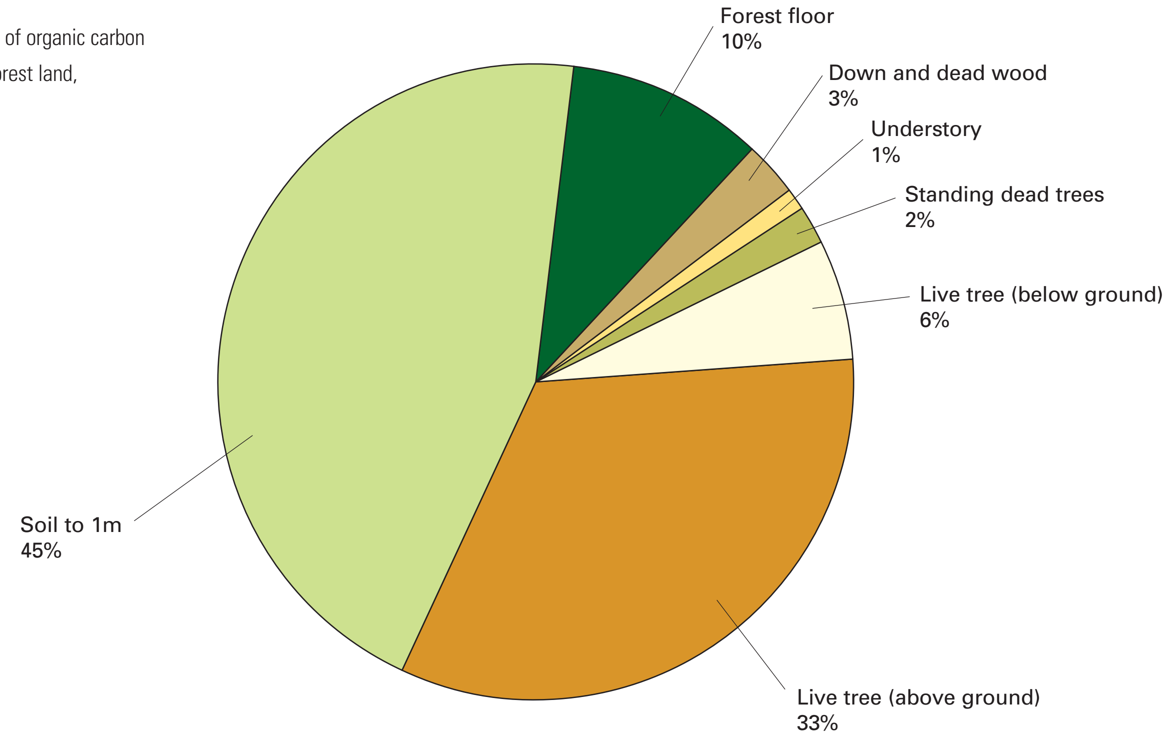


Figure 9.—Distribution of organic carbon by ecosystem pool on forest land, Nebraska, 2005.

A Profile of Nebraska's Forests

Background

The dynamics of a forest stand's growth, development, and ecosystem function is driven by its species composition. Assessing forest ecosystems with respect to species composition and density measures provides information on current and potential forest conditions. Such information also is important for proper and effective forest management.

What we found

Nebraska's forest lands contain nearly 352 million live trees, or an average of nearly 283 trees per acre. These live trees contain more than 1.8 billion cubic feet of total volume. The distribution of this live-tree volume on forest land is shown in Figure 10. The other eastern softwoods species group (Rocky Mountain juniper, eastern redcedar, and ponderosa pine) has the most trees (Fig. 11) and the second highest amount of live volume (Fig. 12) in the State. The cottonwood and aspen species group has the most volume but ranks seventh in number of trees.

On timberland, the elm/ash/cottonwood forest-type group occupies the most area, followed by the ponderosa pine and juniper groups (Fig. 13). Sixty-six percent of the timberland area is occupied by large-diameter stands; medium- and small-diameter stands occupy 26 and 8 percent of timberland area, respectively.

What this means

The elm/ash/cottonwood forest-type group currently is the most voluminous in the State, though the other eastern softwoods group is gaining and has more trees. Although the elm/ash/cottonwood forest-type group occupies the most timberland area, particularly in large-diameter stands, the juniper type, which comprises of eastern redcedar and Rocky Mountain juniper, has significantly more timberland area in the medium and small stand-size classes. This is most likely due to the prolific regeneration of eastern redcedar.

Ponderosa pine stand. Photo by Chris Schnepf, University of Idaho, bugwood.org.

Figure 10.—Distribution of live volume on forest land, Nebraska, 2005.

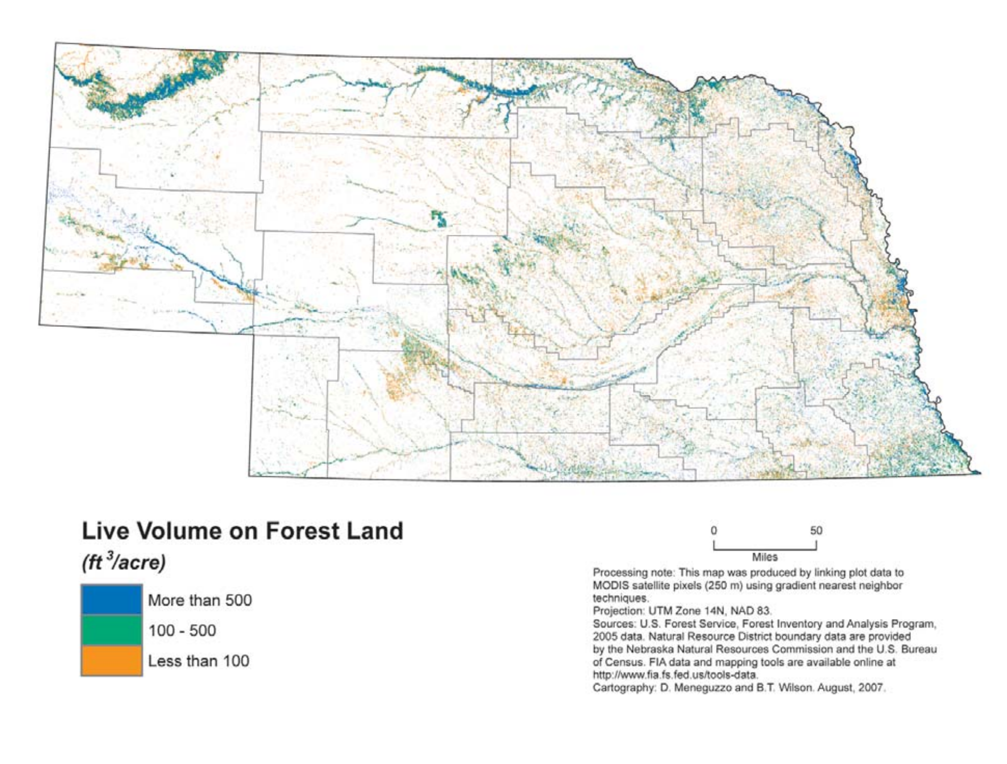


Figure 11.—Top 10 species groups in terms of number of live trees on forest land, Nebraska, 2005.

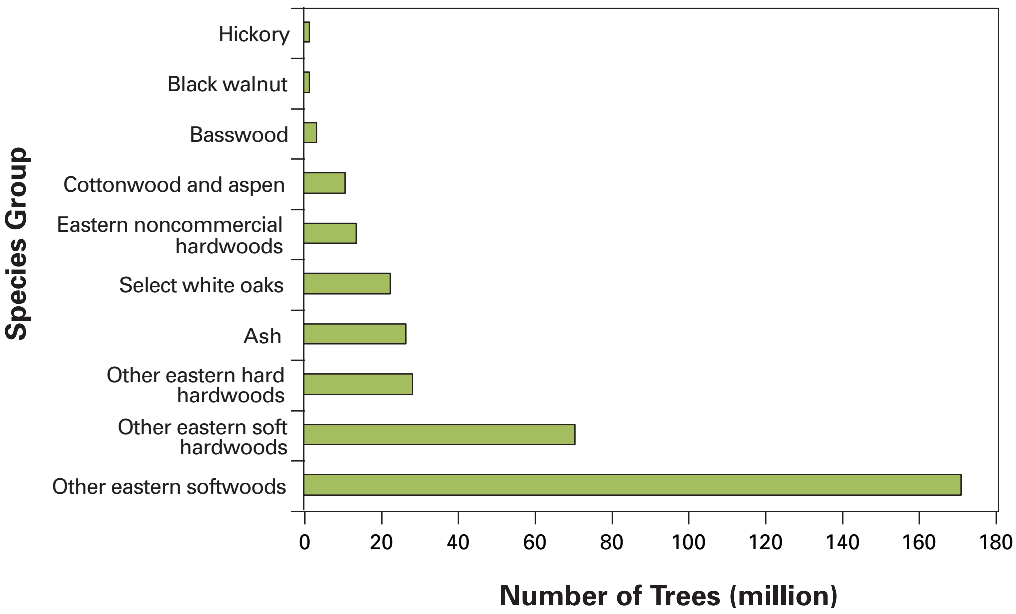


Figure 12.—Top 10 species groups in terms of live volume on forest land, Nebraska, 2005.

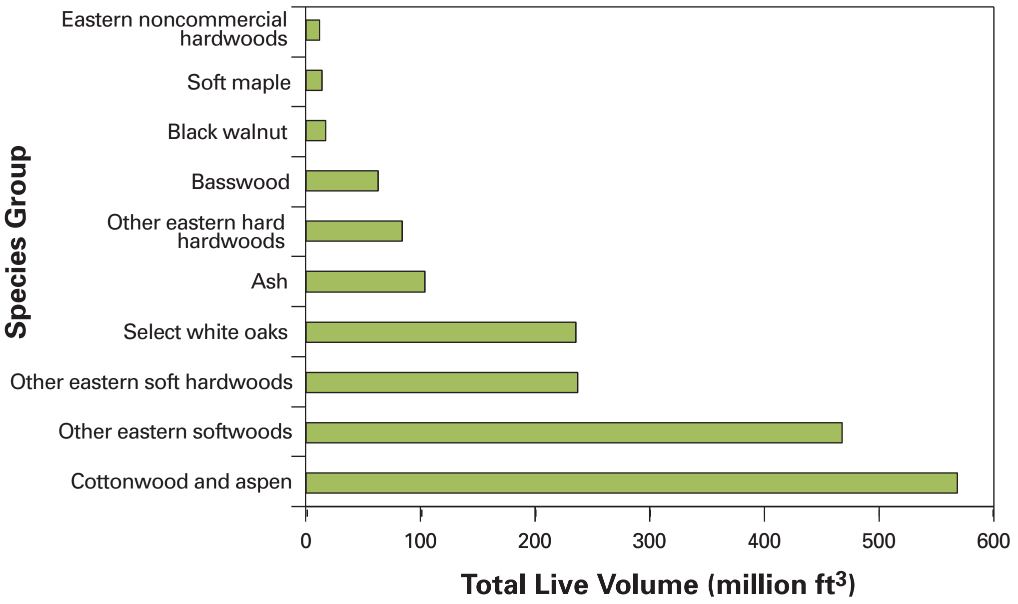
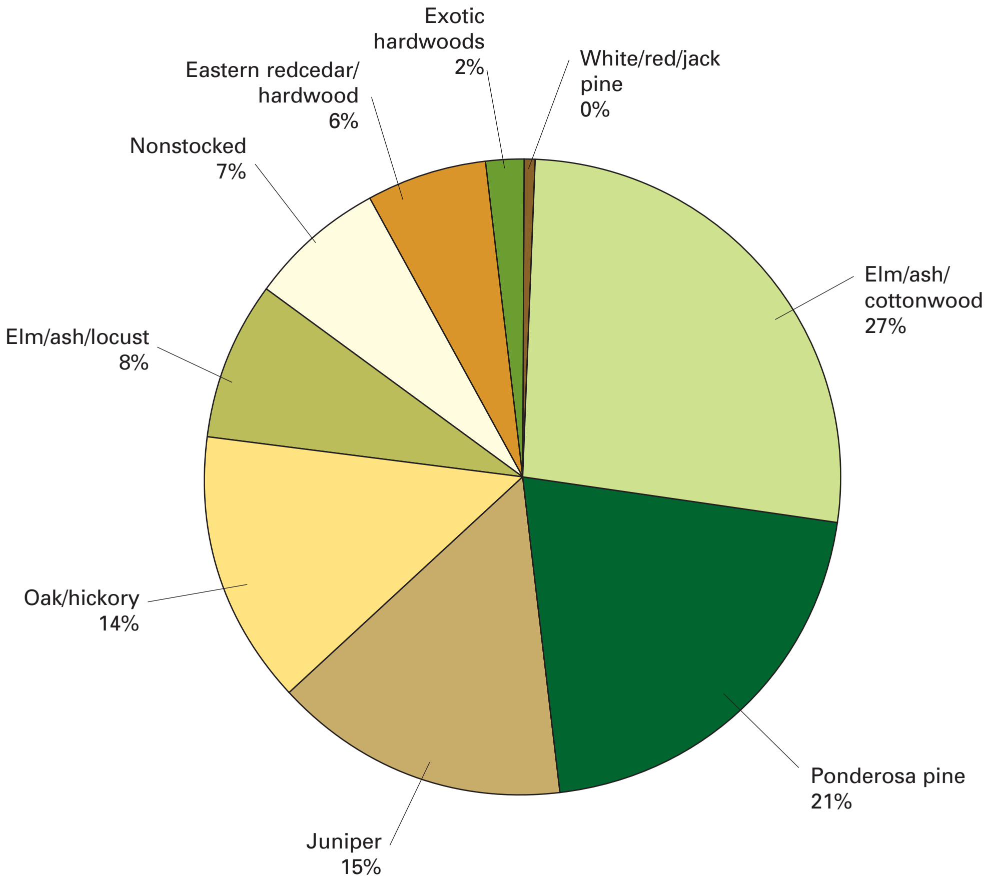


Figure 13.—Distribution of timberland area by forest-type group, Nebraska, 2005.



Diversity

Background

Diversity is an important measure of a forest's contribution to the landscape: wildlife cover and food supply, aesthetic qualities, recreation opportunities, and wood production. The level of diversity reflects the ecosystem services provided by a particular forest at a particular time. Different wildlife species and different Nebraskans might prefer one type of forest over another for various reasons. Depending on the disturbance that helped establish a forest, stands in Nebraska may be dominated by a single species or a mix of species. Each forest stand provides a particular suite of benefits for the State's residents.

What we found

Forty different tree species were measured on field plots during this inventory. There is little diversity in species within the forests of western Nebraska. Predominantly ponderosa pine (planted or natural) or Rocky Mountain juniper, the disturbance history and challenging climatic and site conditions limit opportunities for other tree species to become established and grow in this part of the State. Species diversity increases from west to east and is highest in southeastern Nebraska (Fig. 14).

The Shannon Diversity Index was used to measure species (Fig. 14) and structural (diameter and height) diversity (Figs. 15-16). A larger number indicates a higher level of diversity. In Nebraska, indices of structural diversity are substantially higher than those for species diversity. Statewide, diameter diversity is at the higher end of the scale, whether in the ponderosa pine forests of western Nebraska or the hardwood forests in the east. Height diversity is less pronounced than diameter diversity but more pronounced than species diversity.

What this means

Higher site-condition locations generally should have higher species diversity. Disturbances such as fire, floods, and windstorms can influence stand dynamics, driving diversity one way or the other. For example, frequent fires would favor fire-dependent (e.g., aspen) or fire-resistant species (e.g., ponderosa pine) but not fire-susceptible species such as maples.

Flooding at a certain interval might encourage species such as eastern cottonwood while discouraging others. The presence of natural ponderosa pine likely reflects a fire regime that established a seedbed for regeneration. The presence of eastern redcedar in low-diversity stands implies that those sites have not experienced fires since they were established. Overall, forests that range in levels of diversity provide an array of benefits and are valuable components of the landscape.

Figure 14.—Shannon Diversity Index for tree species, Nebraska, 2005.

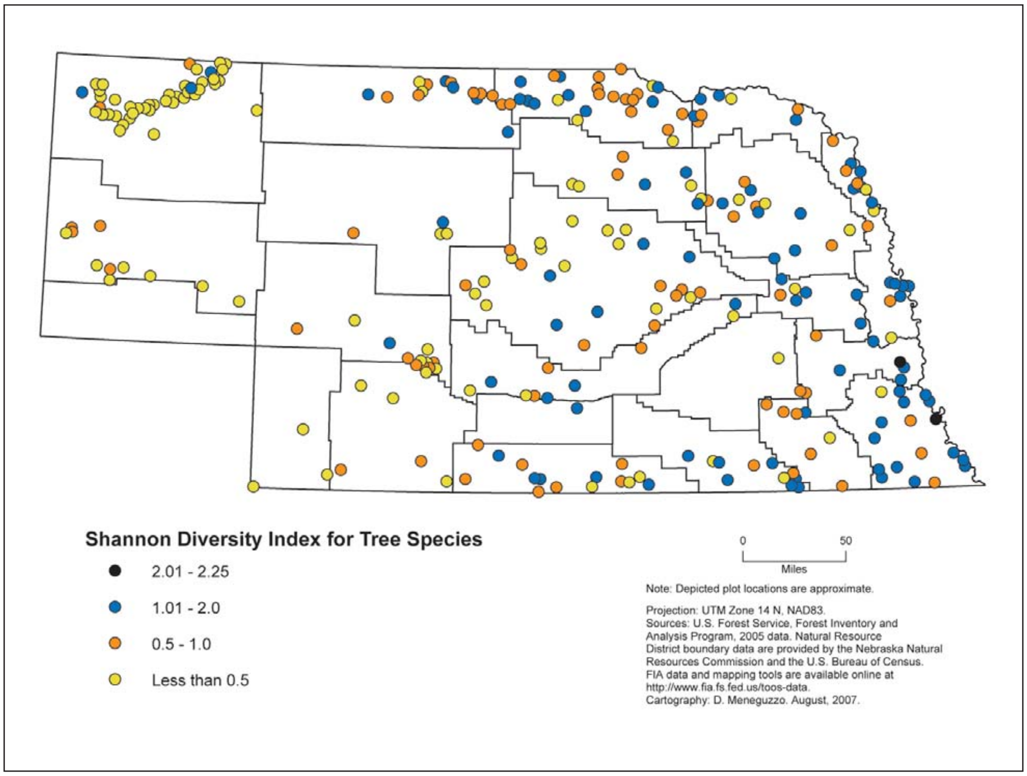


Figure 15.—Shannon Diversity Index for diameter, Nebraska, 2005.

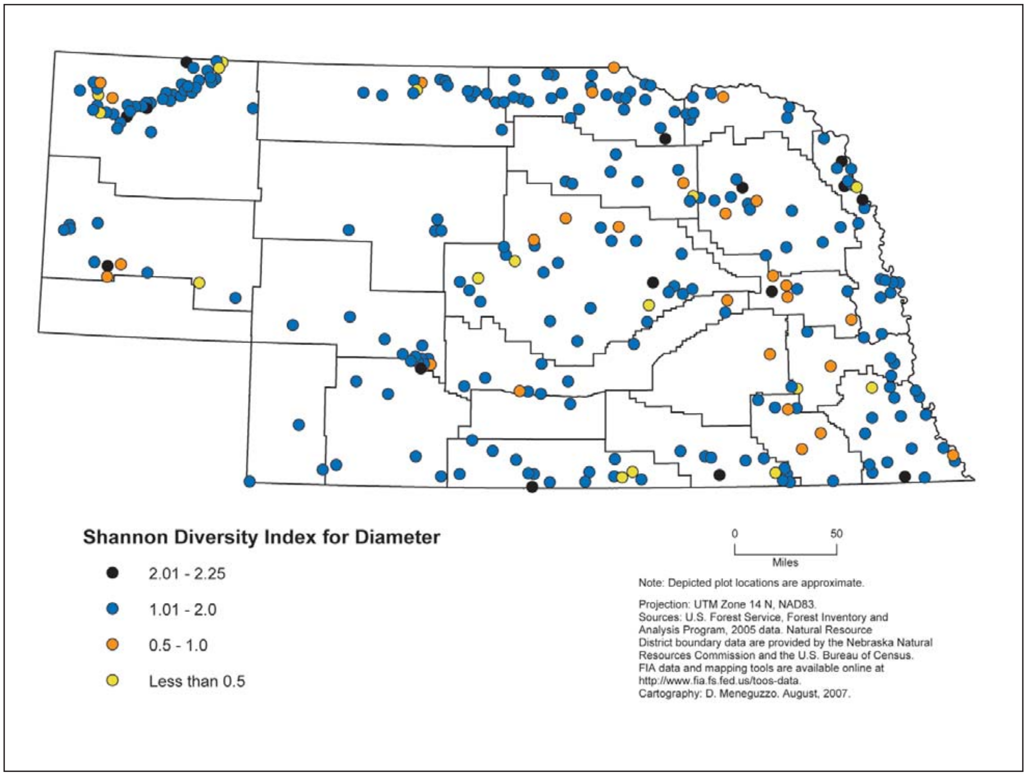
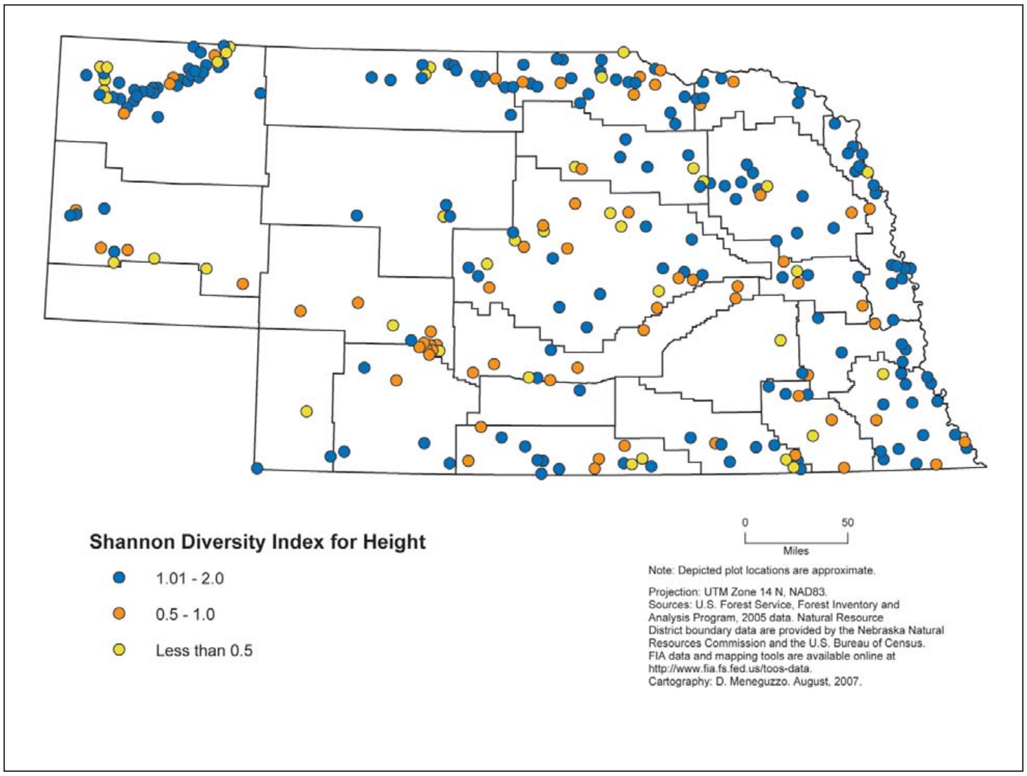


Figure 16.—Shannon Diversity Index for height, Nebraska, 2005.



Forest Age

Background

Stand age can describe both past and current conditions of a forest. It provides a summary of the forest's history and indicates where the forest is with respect to succession and its capacity to provide ecosystem services and wood products. For example, older stands might provide more merchantable timber while younger stands may be more diverse and provide habitat for various wildlife species.

Stand age is estimated from core samples taken from dominant and codominant trees on the plot. This age may not be representative of all trees on the plot, some will be older and some will be younger, but it is a reasonable and useful estimate.

What we found

While most of the older forests are found in the north and west, the oldest forests are in southeastern Nebraska (Fig. 17). Forests in the southeast are also the most diverse in age. Overall, most forests in the State are 25 to 100 years old. Of the 10 most significant forest types, ponderosa pine is the oldest, followed by the oak/hickory type (Fig. 18).

What this means

The age of forests in Nebraska reflects three influences: 1) older ponderosa pine in the dry uplands of the western part of the State; 2) younger stands in riparian areas that change from control of flooding in the east; and 3) the steady encroachment of eastern redcedar due to lack of natural fires or controlled burns. All three trends reflect disturbance or the lack of it. The older natural ponderosa pine likely regenerated after a fire whereas eastern redcedar has been encroaching on areas that are no longer grazed and/or burned. Many of the forests in the riparian areas are influenced by the presence of and intervals between flooding events.

Uneven-age ponderosa pine stand. Photo by Scott Roberts, Mississippi State University, bugwood.org.

Figure 17.—Distribution of forested sample plots by stand-age class, Nebraska, 2005.

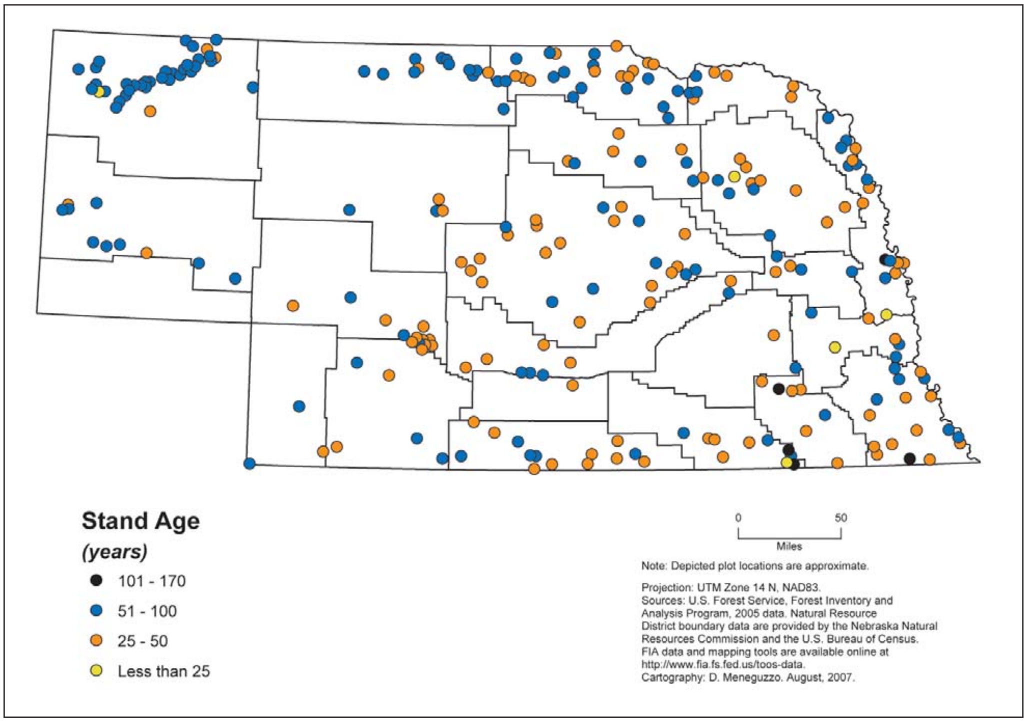
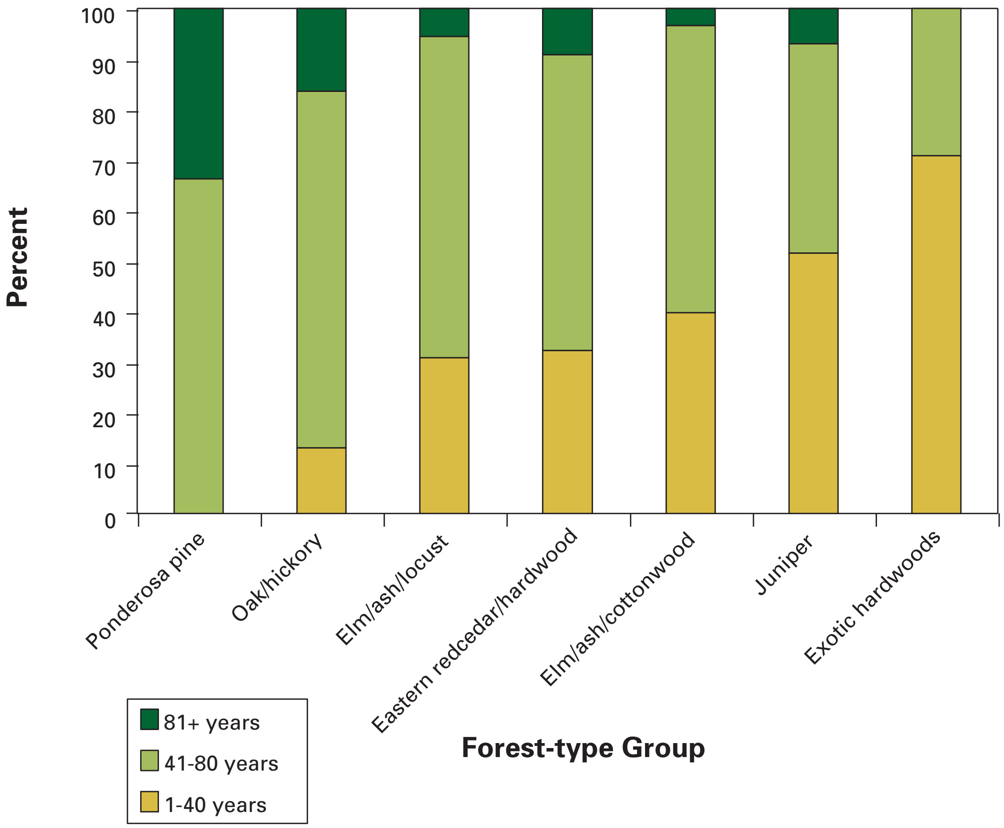


Figure 18.—Percentage of forest land by age group and forest-type group, Nebraska, 2005.



Forest Ownership

Background

The future of Nebraska's forests is dependent on their owners. Ownership information serves as the social complement to the inventory of the biophysical forest resources and allows a better understanding of the forest resources and the factors affecting them. The data presented here are based on survey responses from 50 randomly selected families and individuals who own forest land in Nebraska. Although this sample size is relatively small, the trends for Nebraska are consistent with those for the region as a whole. The small sample size results in large sampling errors but the general trends seem accurate. For additional information on the National Woodland Owner Survey (NWOS), please visit: www.fia.fs.fed.us/nwos.

What we found

The FIA-conducted NWOS was used to increase our understanding of who owns the forest, why they own it, and what they intend to do with it (Butler et al. 2005). Ownership of Nebraska's forest land is distributed among private owners (88 percent) and public agencies (12 percent). Most of the forest land, 1.1 million acres or 85 percent, is owned by an estimated 63,000 families and individuals (Fig. 19). An additional 34,000 acres are owned by other private groups, corporations, tribes, associations, etc. Although 74 percent of the family forest owners hold fewer than 10 acres of forest land each, 90 percent of the family forest land is in holdings of 10 acres or greater (Fig. 20) (Butler 2008).

Family forest owners have diverse ownership and forest management objectives. The most common reason for owning forest land is related to the land being part of a farm (Fig. 21). More than three-fourths (78 percent) of the family forest land is associated with farms. Other common reasons for ownership are related to nature protection, the beauty and scenery that forests provide, the land being a legacy to pass on to heirs, and for hunting or fishing.

An estimated 42 percent of the family and individual owners who hold 49 percent of the family forest land in Nebraska have harvested trees from their land in the past 5 years, but less than 1 percent reported having a written forest management plan. A slightly higher proportion, 3 percent of those who own 14 percent of the family forest land, have received advice about their forest land. As the size of an owner's landholdings increases, so does the likelihood that he or she has harvested trees, has a written management plan, and has sought management advice. Consequently, percentages based on the area of forest land owned by people who have harvested trees, have a management plan, and have sought management advice, are higher (Butler 2008).

Dealing with property taxes, trespassing, and keeping the land intact for heirs are significant concerns among those who own more than half of the family forest land in Nebraska. Other prevalent concerns are related to vandalism, dumping and other misuses of their forest land, and negative impacts associated with invasive and other undesirable plants.

What this means

There will be a change in forest ownership as current owners age and pass on their forest holdings to heirs who may have different objectives that could change the future of Nebraska's forests. Although most family forest owners plan to do relatively little with their forest land in the near future, about 1 in 5 acres is owned by someone who plans to transfer their land to an heir or otherwise sell it within the next 5 years. This is related in part to the age of the owners. Twenty-one percent of the family forest land is owned by people 75 years of age or older and an additional 29 percent is owned by people 65 to 75 years old (Fig. 22). A large-scale intergenerational shift would change the characteristics of the family forest owners, influence how owners view, interact, and relate to their land, and, as a result, alter future forest characteristics.

Figure 19.—Distribution of forest land by ownership class, Nebraska, 2005.

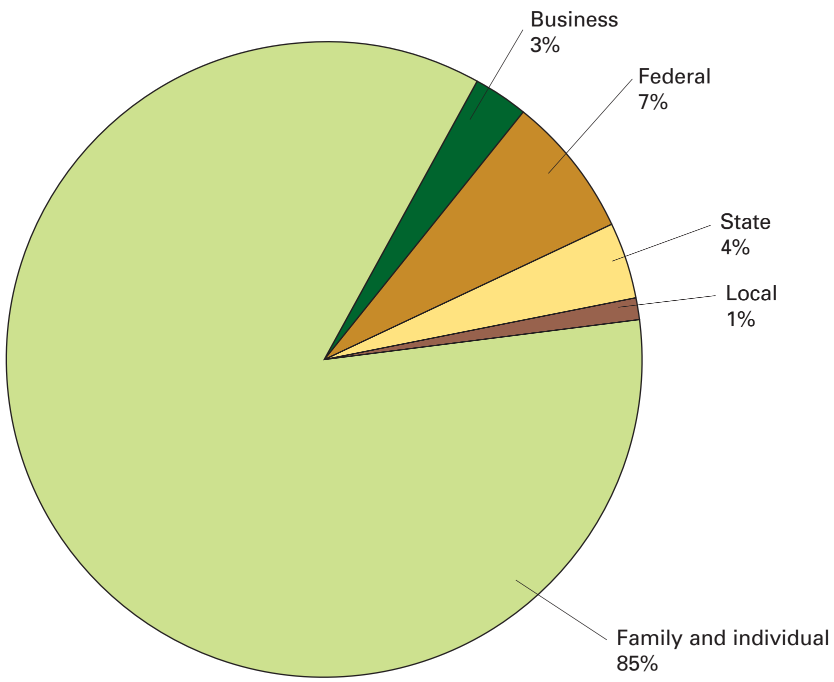


Figure 20.—Area and number of family-owned forests by size of holding, Nebraska, 2005.

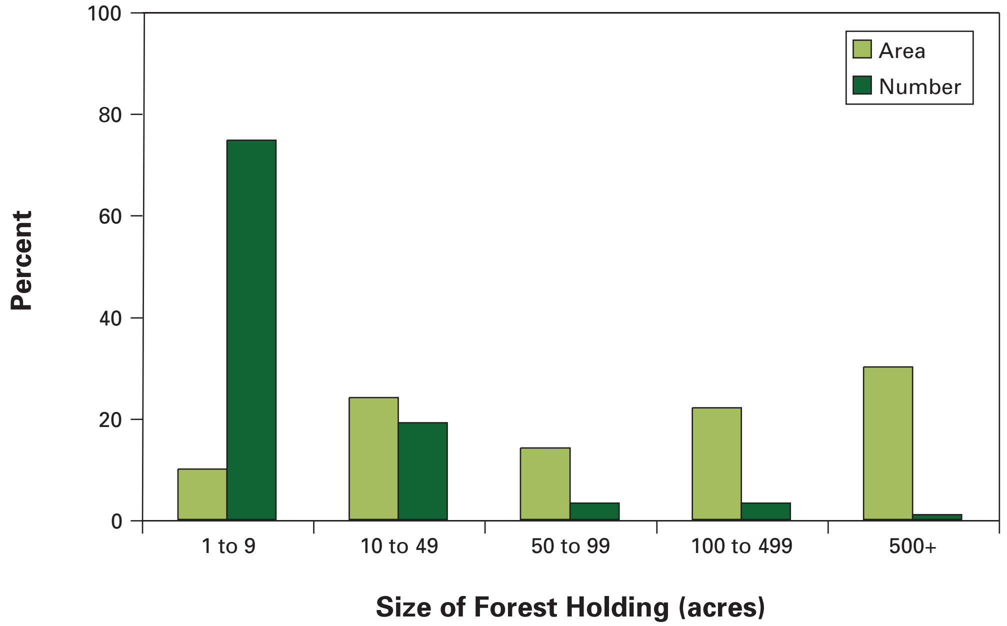


Figure 21.—Area of family-owned forests by reason for owning forest land, Nebraska, 2005.

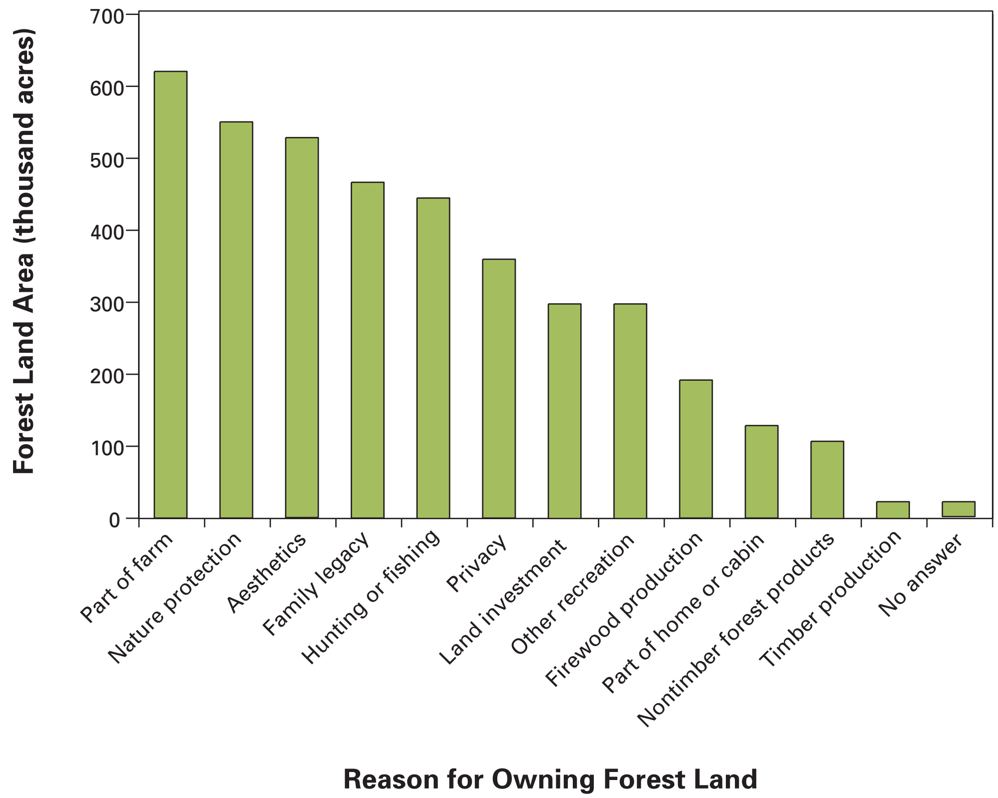
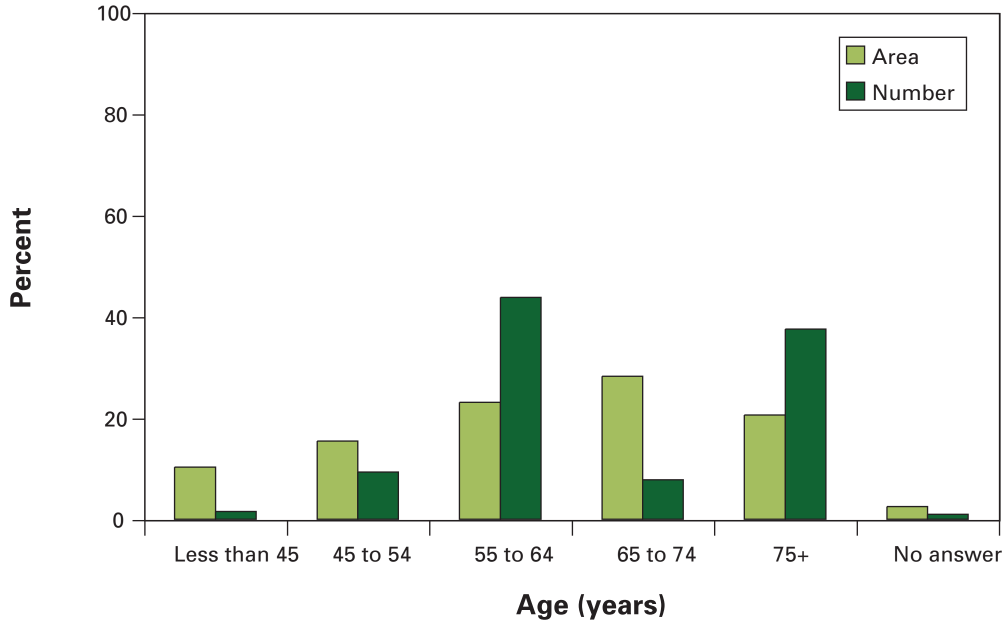


Figure 22.—Area and number of family-owned forests by age of owner, Nebraska, 2005.



Riparian Forests

Background

Riparian forests in Nebraska are a unique and critically important resource. Riparian forests are those woodlands that serve as an interface between aquatic and terrestrial ecosystems (Montgomery 1996). Although these areas are not usually extensive in area, they often are more diverse in stand structure and more productive than surrounding upland areas (Montgomery 1996). Riparian forests are a vital resource because they: provide habitat for a variety of wildlife species and serve as connectors between habitats; help mitigate or control nonpoint source pollution and remove surplus nutrients and sediment from surface runoff; provide shade for streams, which keeps the water temperature cool; stabilize streambanks and help slow floods; and provide numerous recreational opportunities (Montgomery 1996).

Maps of forest land and the map of forested wetlands from the National Wetlands Inventory (U.S. Fish and Wildlife Service) (Fig. 23) clearly show significant amounts of forest along the major rivers in the State. Riparian forests also are an important source of merchantable timber and other forest products for Nebraska.

What we found

Forested plots were divided into physiographic classes based on the general effect of landform, topographic position, and soil moisture available to trees. These classes were grouped by site: xeric (dry), mesic (impeded drainage), and hydric (wet). Although most of the plots in Nebraska occur on mesic sites, a significant portion of the remaining plots are on xeric sites in the western part of the State (Fig. 24). By grouping mesic sites (narrow and broad flood plains/bottomlands, and other mesic) with hydric sites to form a "riparian" category, it was estimated that there are more than 329,000 acres of riparian forest land in Nebraska, or 26 percent of total forest land area (Table 1).

What this means

More than one-fourth of the total forest land in Nebraska is adjacent to streams and rivers. These forests are a vital part of the State's forested ecosystems and improve the quality of life for both people and wildlife. These areas also are essential for the regeneration and survival of cottonwood, the primary commercial tree species in Nebraska. However, riparian forests are often threatened by human activities such as development, agriculture, irrigation, livestock grazing (Montgomery 1996), and dam construction for water improvement/flood control, so it is important that they be protected through careful management.

Figure 23.—Forested/shrub wetland areas in Nebraska according to data from the National Wetland Inventory conducted by the U.S. Fish and Wildlife Service.

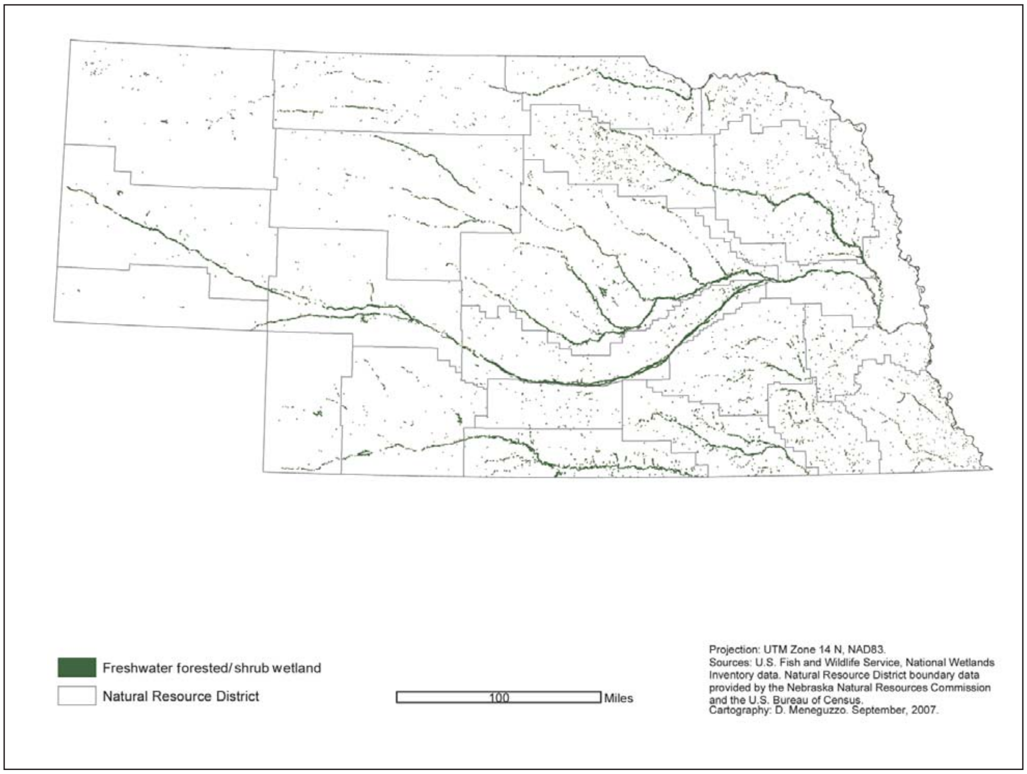


Figure 24.—Distribution of forested sample plots by physiographic class, Nebraska, 2005.

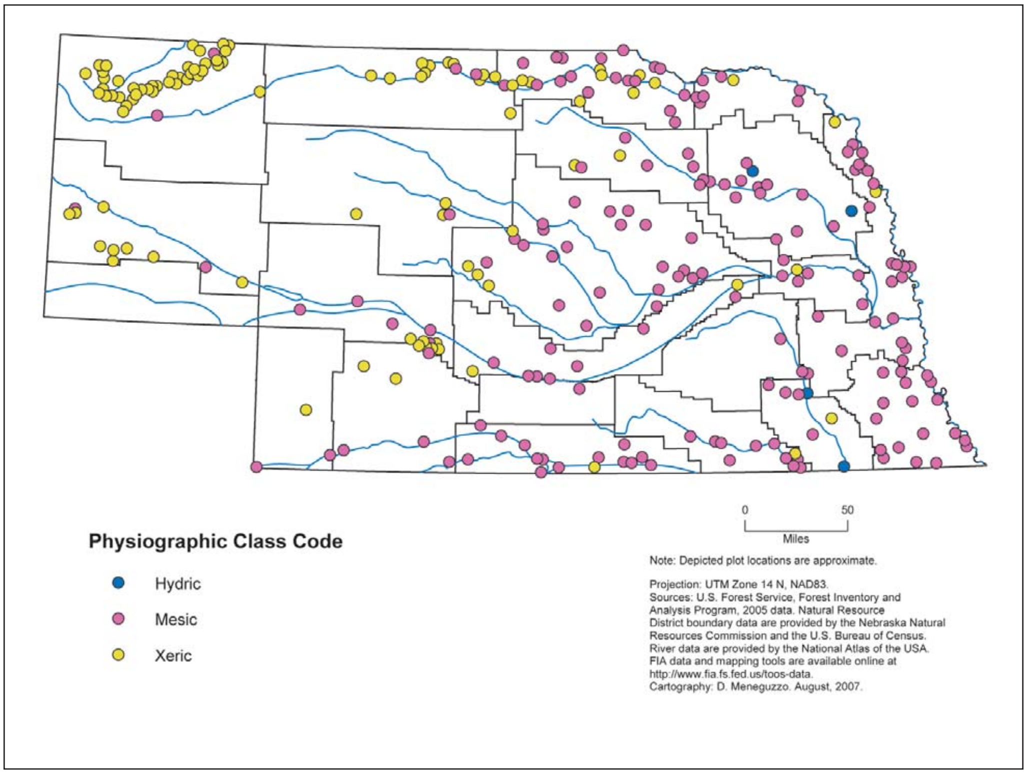


Table 1. —Distribution of forest land area by physiographic class code and riparian designation, Nebraska, 2005.

Physiographic class code	Forest land area	Riparian area
Xeric	**Number of acres**	**Number of acres**
Dry tops	10,657	0
Dry slopes	391,336	0
Deep sands	71,879	0
Other xeric	5,979	0
Mesic		
Flatwoods	27,717	0
Rolling uplands	357,625	0
Moist slopes and coves	50,172	0
Narrow floodplains/bottomlands	83,426	83,426
Broad floodplains/bottomlands	217,204	217,204
Other mesic	13,849	13,849
Hydric		
Small drains	14,988	14,988
Total	**1,244,832**	**329,467**

Treed Lands

Background

FIA defines forest land as land that is at least 10 percent stocked with trees of any size or formerly having had such tree cover and not currently developed for nonforest use. The area with trees must be at least 1 acre in size, and wooded strips, such as those along roads, streams, and agricultural fields, must be at least 120 feet wide and 363 feet long to qualify as forest land.

Many treed-land areas in Nebraska do not meet this definition, yet these trees are a very important resource, particularly in a state where forest land is scarce and agriculture dominates the landscape. For example, Nyland (1996) listed the important functions of windbreaks and shelterbelts:

- Interrupt or redirect air movement to reduce wind erosion or slow surface evaporation.
- Shelter or protect crops, domesticated animals, home sites, roads, and recreation areas.
- Provide unique habitats for wildlife.
- Create visual diversity across a landscape.
- Provide recreation sites for landowners and nearby residents.
- Yield nuts, fruits, and other foods for people, cattle, and wildlife.
- Provide limited amounts of wood for fuel and other purposes.

In addition, these treed lands in Nebraska are likely to include riparian areas, so they are also important for the reasons listed in the Riparian section of this report.

What we found

In Phase 1 of FIA's annual inventory land-use codes are recorded in a database for all plots. From these codes, one can obtain an estimate of treed-land area that does not meet FIA's definition of forest land. These land uses are cropland with trees, pasture and rangeland with trees, wooded strips, idle farmland with trees, marsh with trees, narrow windbreaks (< 120 feet wide), shelterbelts, and urban land with trees. So, in addition to forest land, there are an estimated 408,800 acres of treed lands in Nebraska (Table 2). In some NRDs, there is almost as much treed-land area as forest land area (Fig. 25). Four NRDs (South Platte, Twin Platte, Upper Big Blue, and Tri-Basin) actually have more treed-land area than forest land area.

What this means

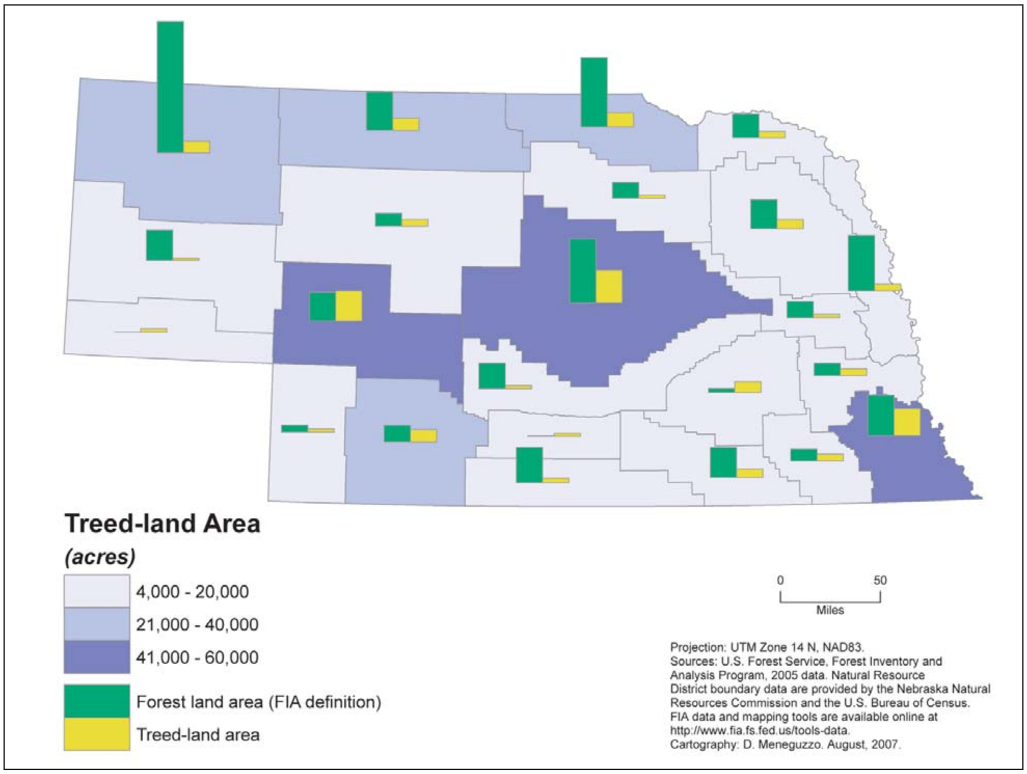
Nebraska contains a significant amount of treed lands and it is important that these areas continue to be monitored and protected as they are vital for protecting soil, wildlife, domestic animals, homes, roads, water sources, and recreational areas. Without them, soil erosion would increase, water quality would be degraded, there would be fewer places for wood-gathering or recreating, and domestic and wild animals would have less habitat and protection. In other words, the quality of life in Nebraska would be reduced without these treed lands.

Eastern redcedar shelterbelt. Photo by Dacia Meneguzzo, U.S. Forest Service.

Table 2.—FIA estimates of treed-land area by land use, Nebraska, 2005.

Land use	Number of acres
Cropland with trees	15,500
Pasture and rangeland with trees	162,500
Wooded strip	45,500
Idle farmland with trees	9,100
Marsh with trees	1,100
Narrow windbreak (<120 ft)	54,100
Shelterbelt	35,800
Urban and other with trees	85,200
Total	**408,800**

Figure 25.—Comparison of treed-land area versus forest land area by Natural Resource District, Nebraska, 2005.



Eastern Redcedar/Rocky Mountain Juniper and Cottonwood

Background

Eastern redcedar is a native tree species that is expanding rapidly across Nebraska due to its prolific natural regeneration from planted trees, e.g., those in shelterbelts and windbreaks (Burns and Honkala 1990a). Its ability to grow on a wide range of soil types and under extreme environmental conditions allows for successful regeneration and establishment. In the absence of fire, this species can invade abandoned farmland, pastures that are not mowed, and open hardwood stands (Burns and Honkala 1990a). Lack of fire has also allowed it to become established under ponderosa pine forests in the Niobrara Valley. Eastern redecedar's continuing expansion is of concern because this is the main species that is replacing cottonwood, which is the most economically important hardwood species in the State. Despite its negative impact, eastern redcedar does have many uses. It is an important species for wildlife as it provides food, nesting habitat, and thick, protective cover. This species can also be used for fenceposts and fuelwood (Burns and Honkala 1990a) and the lumber from small sawlogs is used for lining chests and closets.

Rocky Mountain juniper is very similar to eastern redcedar. It is also resilient and can grow under harsh conditions, but this species is also highly susceptible to fire (Burns and Honkala 1990a). Given that these species are so alike, they are often grouped together in the discussion that follows and shown as a single group on maps even though eastern redcedar is the primary species replacing cottonwood.

Cottonwood is a large, short-lived, fast-growing, commercial species (Burns and Honkala 1990b). It is dependent on moisture so it is most often found in riparian areas along rivers and streams in pure, even-aged stands (Burns and Honkala 1990b). Cottonwood is a dominant species on the fine stringers of the river floodplains, stream bottomlands, river sandbars, and overflow land along larger rivers; it can also be found in intermittent streambeds (Burns and Honkala 1990b). Regeneration usually occurs after the overstory has broken up and full sunlight is available as cottonwood is very intolerant of shade. Constant moisture is necessary for successful establishment, growth, and survival of cottonwood (Burns and Honkala 1990b). Like eastern redcedar and Rocky Mountain juniper, cottonwood is also highly susceptible to fire (Burns and Honkala 1990b).

What we found

Forest land area dominated by eastern redcedar/Rocky Mountain juniper has more than tripled since the last inventory, increasing from 51,900 acres (5 percent of forest land) in 1994 to 172,200 acres (14 percent) in 2005 (Fig. 26). In addition, there are nearly 86,500 acres of the eastern redcedar/hardwood forest type in Nebraska (Fig. 26). The area of cottonwood also increased, but not as dramatically. Between 1994 and 2005, the forest land area of this type increased from 102,600 to 140,200 acres (Fig. 26).

The total number of live eastern redcedar/Rocky Mountain juniper trees on forest land increased significantly, from approximately 21 million in 1983 to 113 million in 2005 (Fig. 27). This is a threefold increase in live-tree density on forest land, from about 29 trees per acre to almost 91 trees per acre. Cottonwood, on the other hand, experienced a decline in the number of live trees and in tree density between the 1994 and 2005 inventories. The total number of live cottonwood trees on forest land decreased from almost 14 million (nearly 15 trees per acre) to 10.7 million (about 9 trees per acre) (Fig. 27). The current distributions of live density of eastern redcedar/Rocky Mountain juniper and cottonwood trees on forest land are shown in Figures 28 and 29, respectively. The findings for regeneration are similar. The sapling data show there are more than 60 eastern redcedar/Rocky Mountain juniper saplings per acre of forest land versus only about one cottonwood sapling per acre.

The total volume of live eastern redcedar/Rocky Mountain juniper trees on timberland has also increased significantly, from 13 million cubic feet in 1983 to 143.9 million cubic feet in 2005 (Fig. 30). However, total cottonwood volume has increased more dramatically, from 148.6 to 547.8 million cubic feet during the same time (Fig. 30). The current distributions of live volume of eastern redcedar/Rocky Mountain juniper and cottonwood on timberland and forest land are shown in Figures 31-34. A considerable proportion of cottonwood volume, 22 percent, is found along five major rivers (Elkhorn, Niobrara, Missouri, Platte, and Republican) in Nebraska (Table 3). Overall, cottonwood contains much more volume than eastern redcedar/Rocky Mountain juniper; however, when broken down by stand-size class, eastern redcedar/Rocky Mountain juniper has more volume in the medium and small stand-size classes (Fig. 35).

In terms of total biomass of live trees on forest land, there are approximately 3.7 million oven-dry tons of eastern redcedar/Rocky Mountain juniper biomass and 10.2 million oven-dry tons of cottonwood biomass. Ninety-three percent of the eastern redcedar/Rocky Mountain juniper biomass is almost evenly distributed in the medium and large stand-size classes, while 97 percent of the cottonwood biomass is in the large stand-size class alone (Fig. 36). On a per-acre basis, there are nearly 3 oven-dry tons of eastern redcedar/Rocky Mountain juniper biomass and 8.2 oven-dry tons of cottonwood biomass.

Growing-stock volume has increased for both eastern redcedar/Rocky Mountain juniper and cottonwood since 1983, but the increase in cottonwood volume is more dramatic (Fig. 37). Cottonwood has much more growing-stock volume in nearly every diameter class; however, eastern redcedar/Rocky Mountain juniper dominates in the three smallest diameter classes (Fig. 38).

What this means

In addition to what is observed on the landscape in Nebraska, there is considerable evidence that cottonwood is being replaced primarily by eastern redcedar/Rocky Mountain juniper. Current data indicate that these species are continuing to expand in forest area, number of trees, density (trees per acre), and volume. Cottonwood decreased in number of trees and, consequently, tree density. Additionally, there is very little cottonwood regeneration while eastern redcedar saplings alone are the most abundant by far.

There are other signs that eastern redcedar/Rocky Mountain juniper is establishing and expanding while cottonwood, a mature resource with virtually no regeneration, is beginning to decline. One indicator is the change in volume by stand-size class between 1994 and 2005. Volume increased in all stand-size classes for eastern redcedar/Rocky Mountain juniper while cottonwood increased only in the large stand-size class and decreased significantly in the small stand-size class. There is a similar pattern for biomass of live trees on forest land. Nearly all of the cottonwood biomass is in the large stand-size class while there is very little biomass in the smaller stands to replace the large trees after they die or are harvested. Similarly, Figure 38 shows eastern redcedar/Rocky Mountain juniper's encroachment as the dominant species over cottonwood in growing-stock volume. The expansion of eastern redcedar/Rocky Mountain juniper on forested sample plots from 1983 to 2005 is illustrated in Figures 39 and 40. Finally, the last two figures show the current distribution of cottonwood (Fig. 41) and cottonwood combined with eastern redcedar/Rocky Mountain juniper (Fig. 42) on forested sample plots.

Drought conditions, current land uses, dams, and the lack of scouring floods during the spring when cottonwood seeds ripen have made it very difficult for this species to regenerate. By contrast, the hardy nature of eastern redcedar/Rocky Mountain juniper allows these species to establish and grow successfully under extreme conditions. Their expansion will most likely continue so long as environmental conditions remain similar to those of the past decade.

Eastern redcedar and cottonwood. Photo by Dacia Meneguzzo, U.S. Forest Service.

Table 3. Live volume of cottonwood by major river, Nebraska, 2005.

River	Cottonwood volume (ft³)
Elkhorn	14,930,900
Missouri	9,642,100
Niobrara	9,482,700
Platte	68,519,100
Republican	16,558,400
Total	**119,133,200**

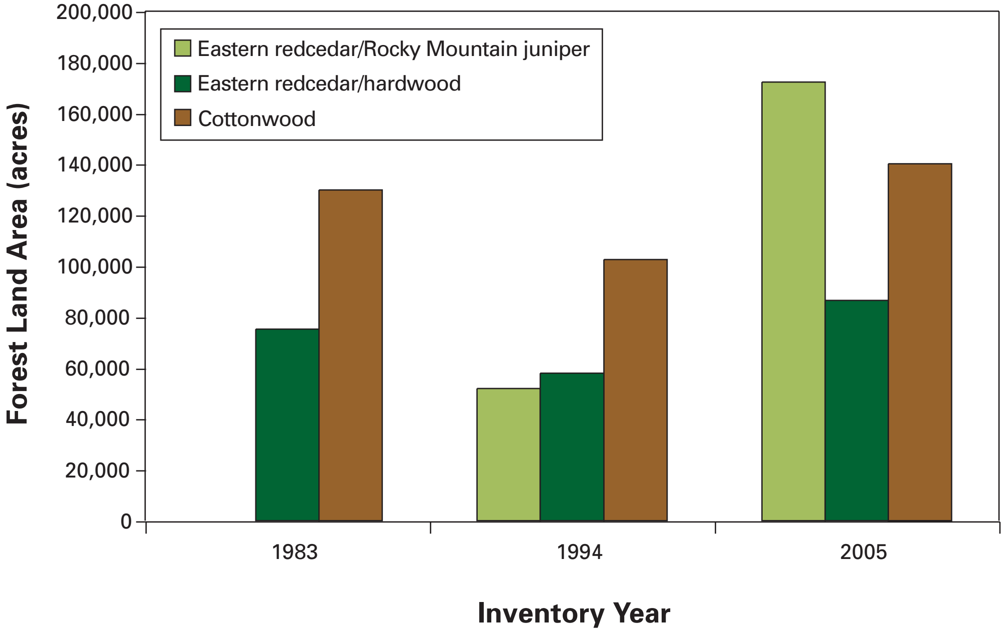


Figure 26.—Area of forest land dominated by eastern redcedar/Rocky Mountain juniper, eastern redcedar/hardwood, and cottonwood by inventory year, Nebraska, 1983-2005.

Figure 27.— Number of live Eastern redcedar/Rocky Mountain juniper and cottonwood trees on forest land by inventory year, Nebraska, 1983-2005.

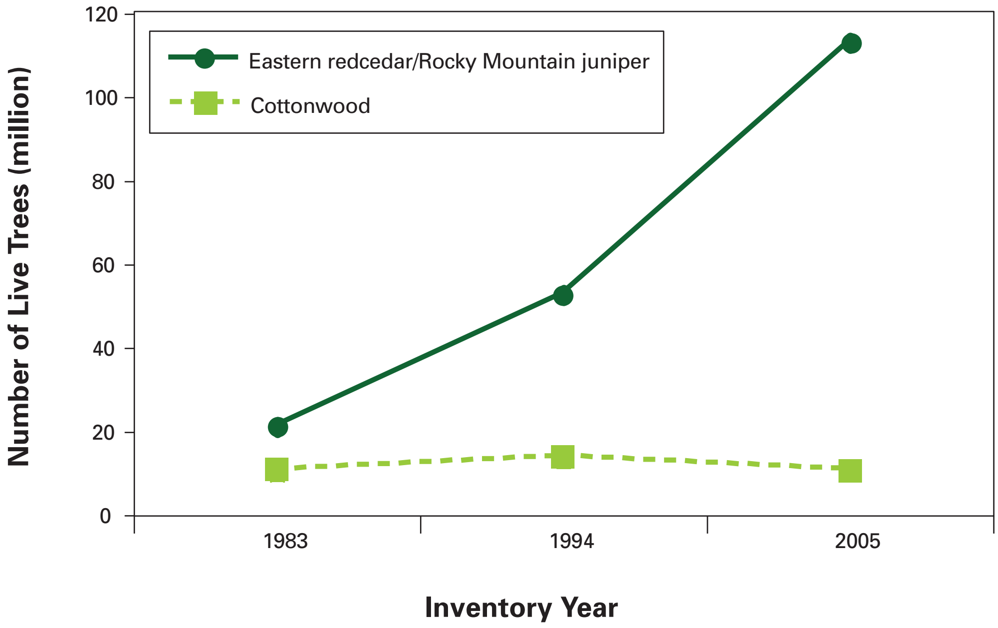


Figure 28.—Distribution of live eastern redcedar/Rocky Mountain juniper density on forest land, Nebraska, 2005.

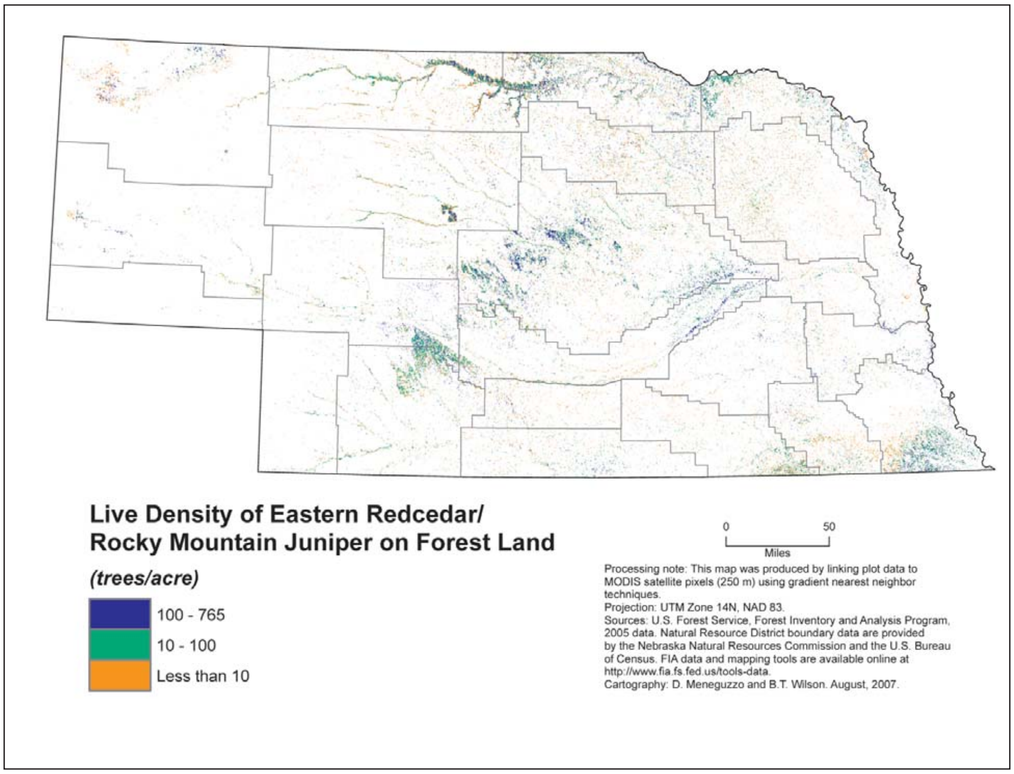


Figure 29.—Distribution of live cottonwood density on forest land, Nebraska, 2005.

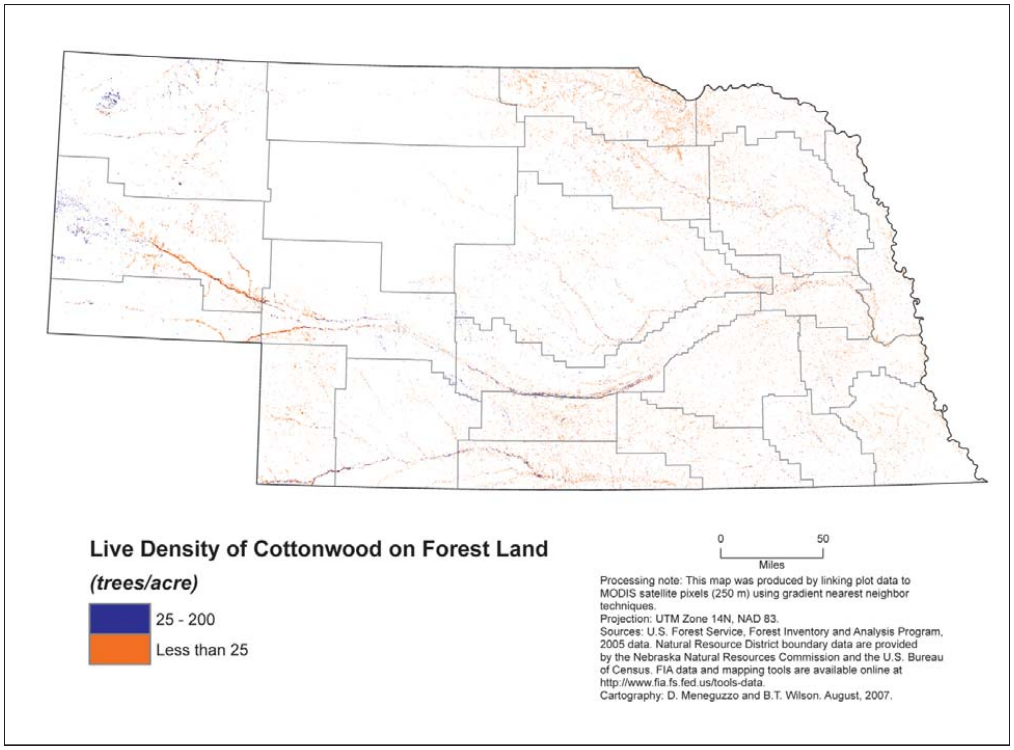
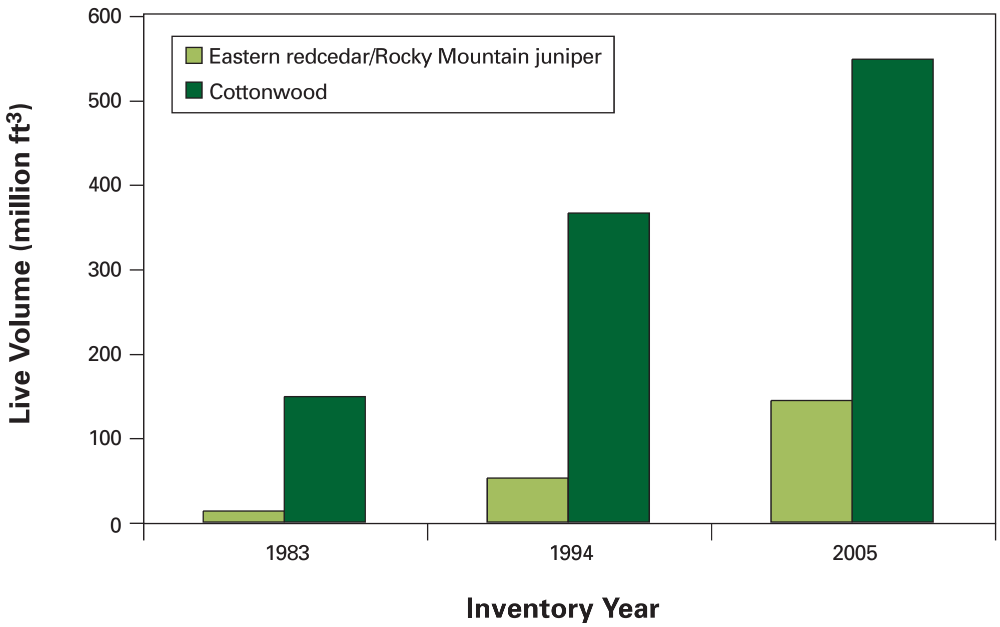


Figure 30.—Live volume of eastern redcedar/Rocky Mountain juniper and cottonwood on timberland by inventory year, Nebraska, 1983-2005.



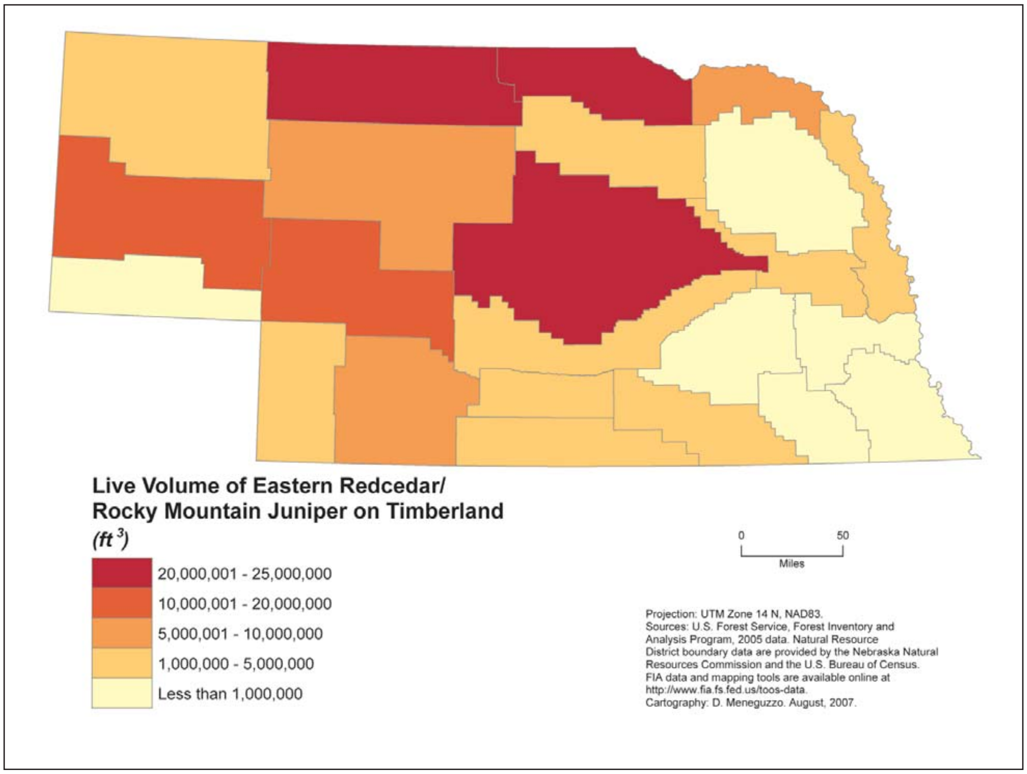


Figure 31.—Live volume of eastern redcedar/Rocky Mountain juniper on timberland by Natural Resource District, Nebraska, 2005.

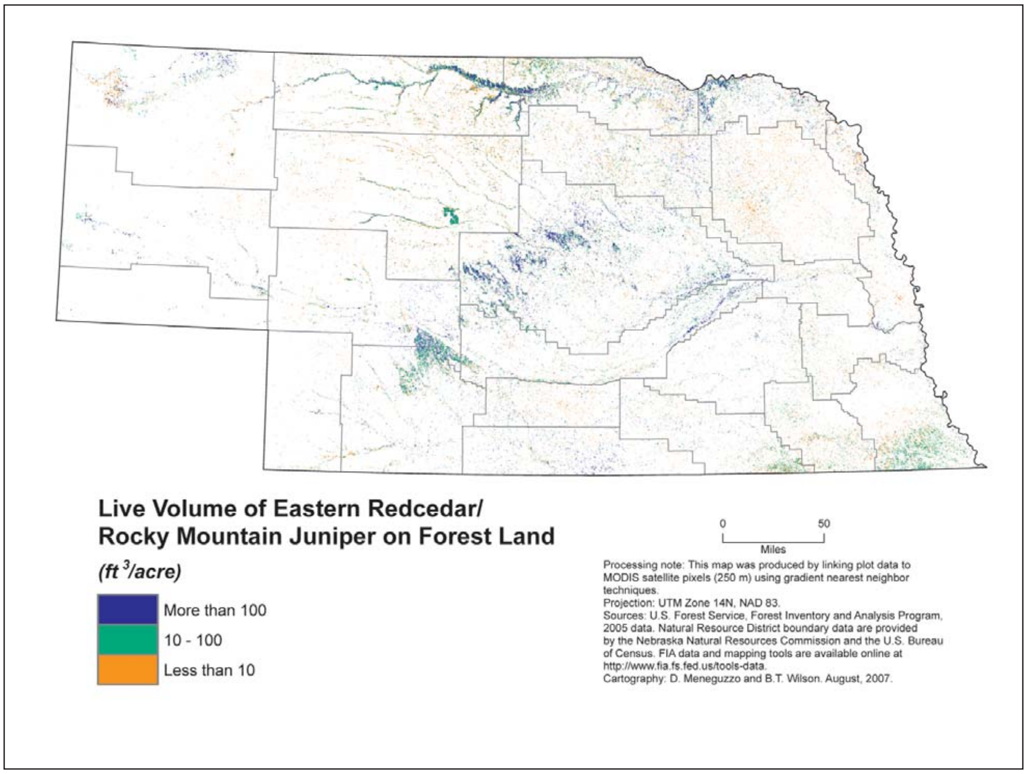


Figure 32.—Distribution of live eastern redcedar/Rocky Mountain juniper volume on forest land, Nebraska, 2005.

Figure 33.—Live volume of cottonwood on timberland by Natural Resource District, Nebraska, 2005.

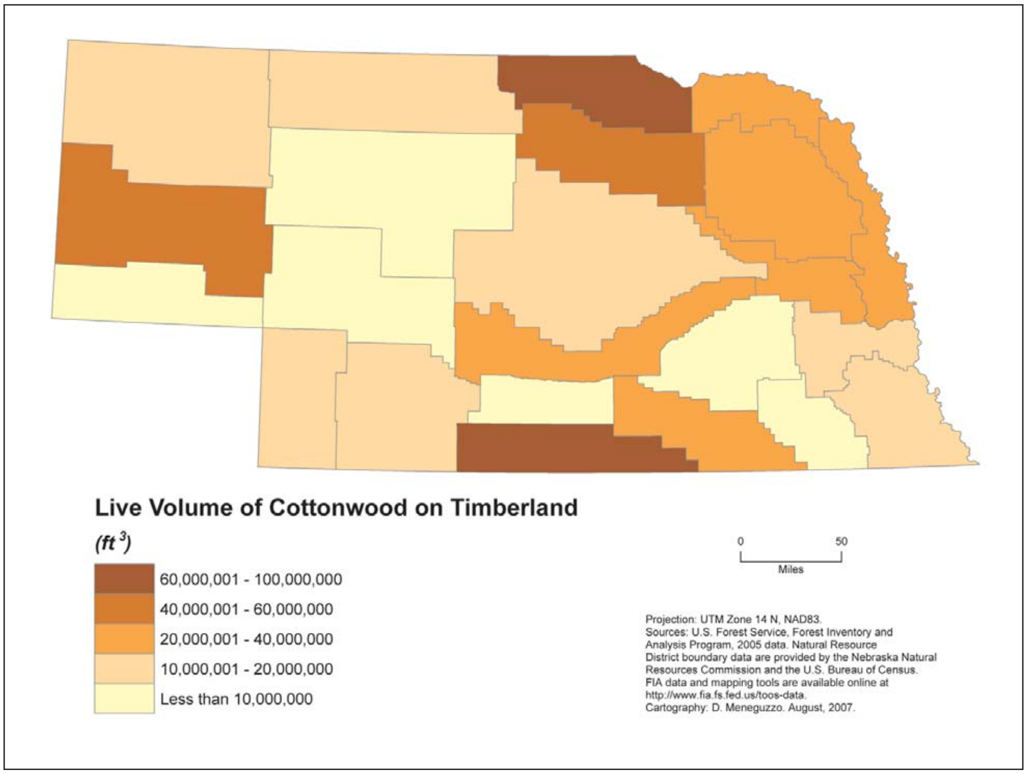


Figure 34.—Distribution of live cottonwood volume on forest land, Nebraska, 2005.

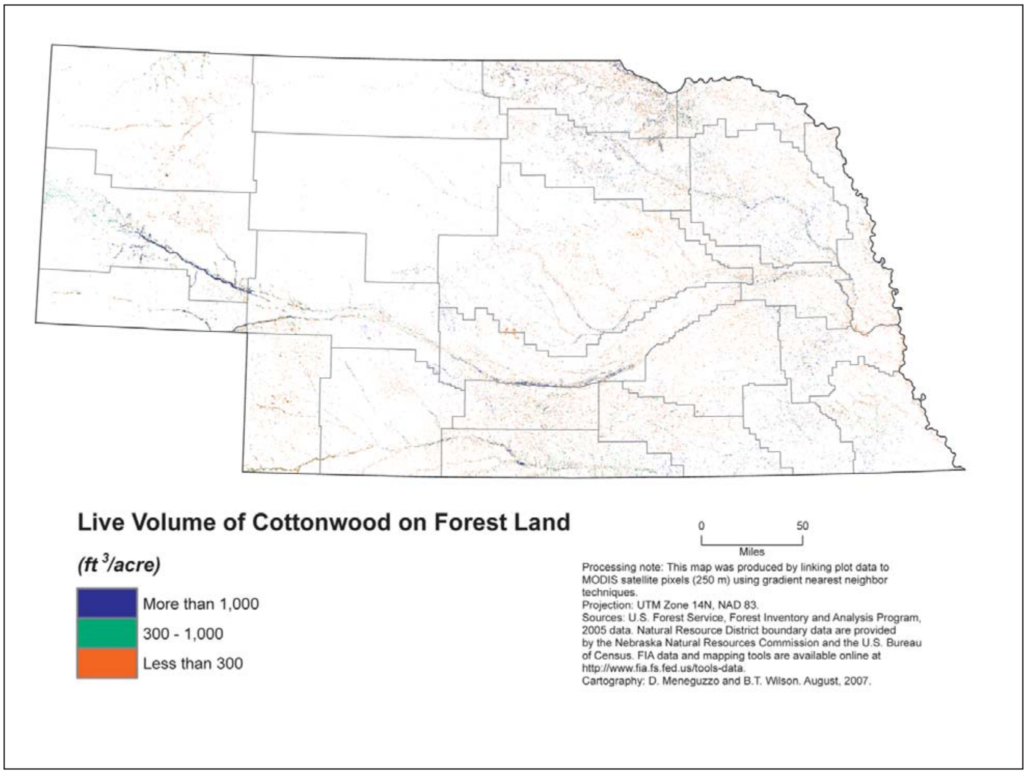


Figure 35.—Live volume of eastern redcedar/Rocky Mountain juniper and cottonwood on timberland by stand-size class, Nebraska, 2005.

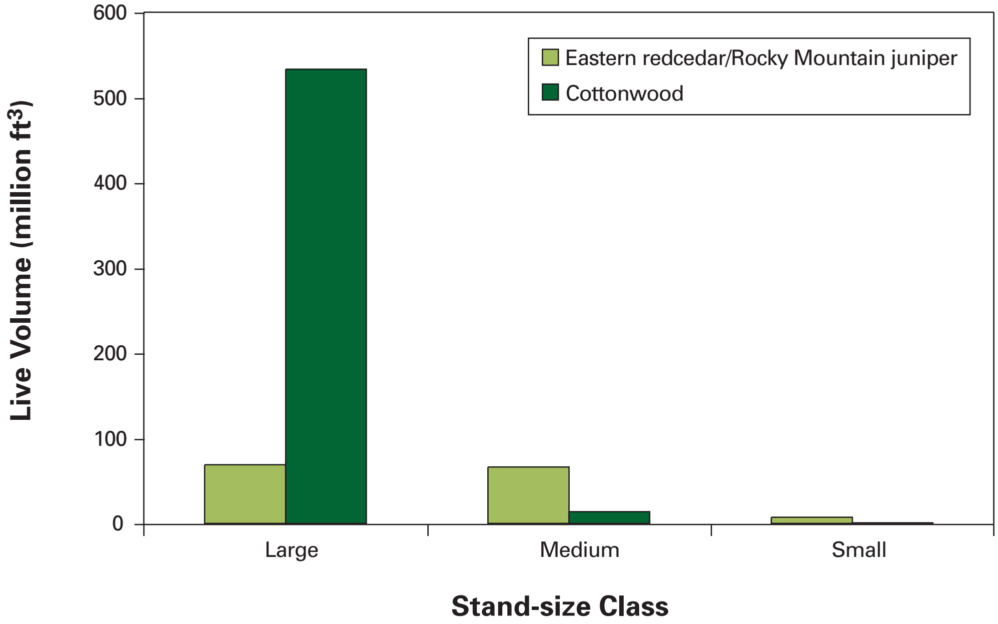
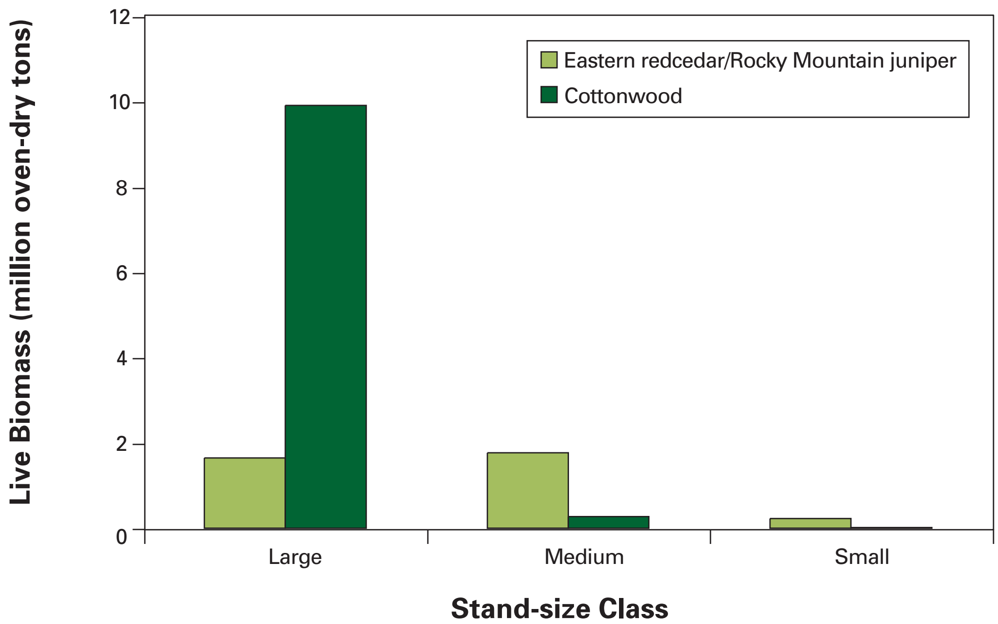


Figure 36.—Live biomass of eastern redcedar/Rocky Mountain juniper and cottonwood on forest land by stand-size class, Nebraska, 2005.



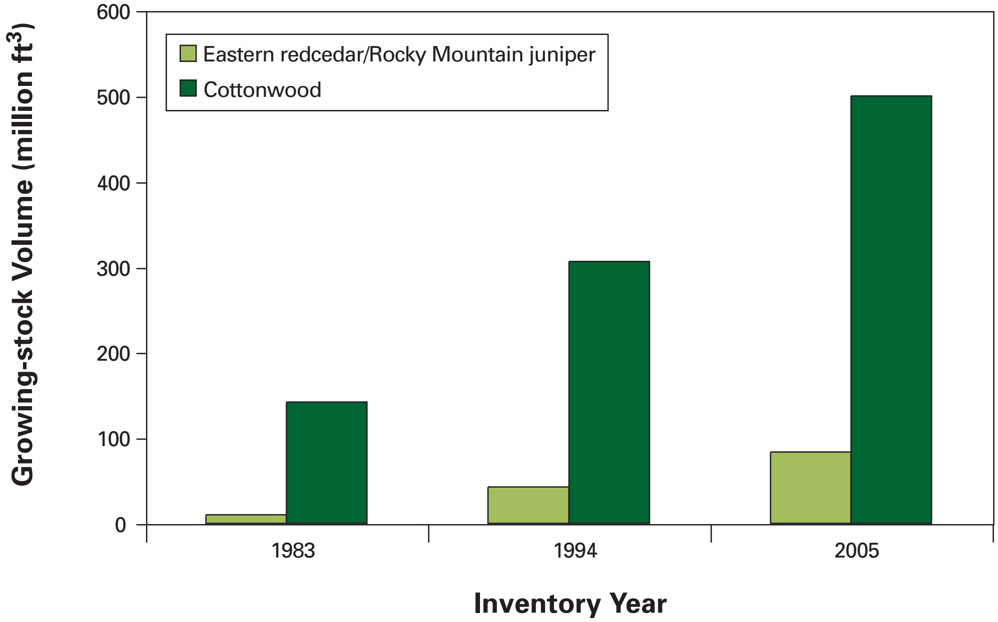


Figure 37.—Growing-stock volume of eastern redcedar/Rocky Mountain juniper and cottonwood on timberland by inventory year, Nebraska, 1983-2005.

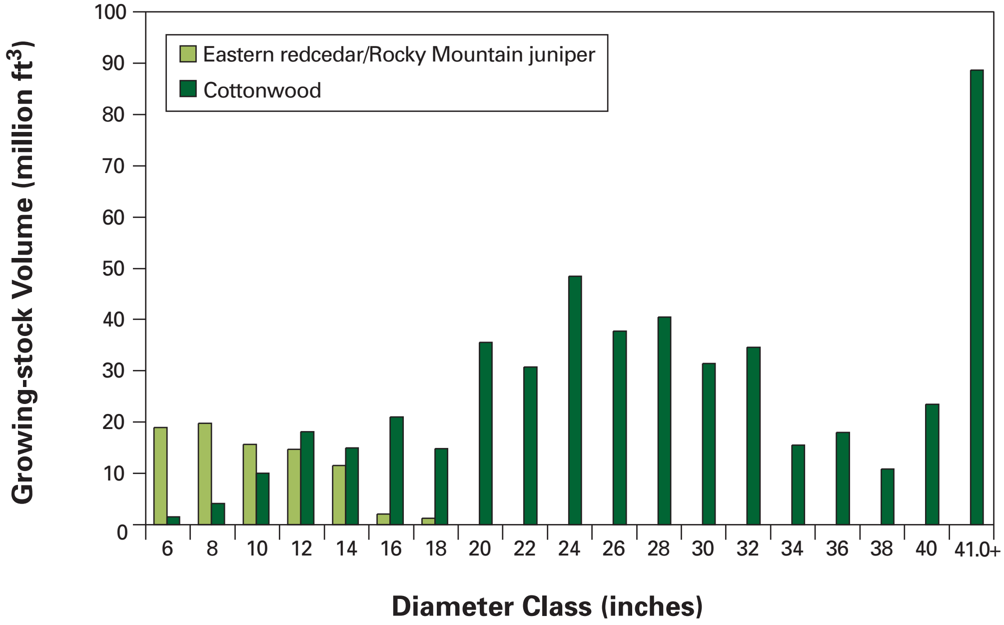


Figure 38.—Growing-stock volume of eastern redcedar/Rocky Mountain juniper and cottonwood on timberland by diameter class, Nebraska, 2005.

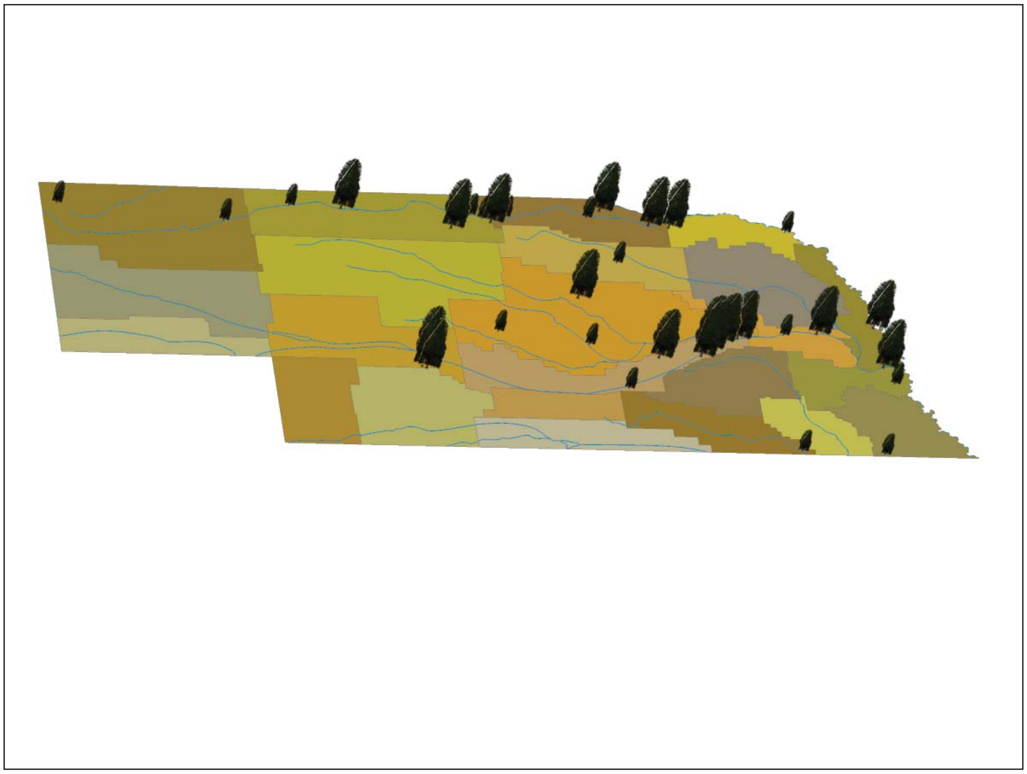


Figure 39.—Representation of eastern redcedar/Rocky Mountain juniper on forested sample plots, Nebraska, 1983; depicted plot locations are approximate. Small trees represent fewer than 100 trees per acre; large trees represent 100 to 635 trees per acre.

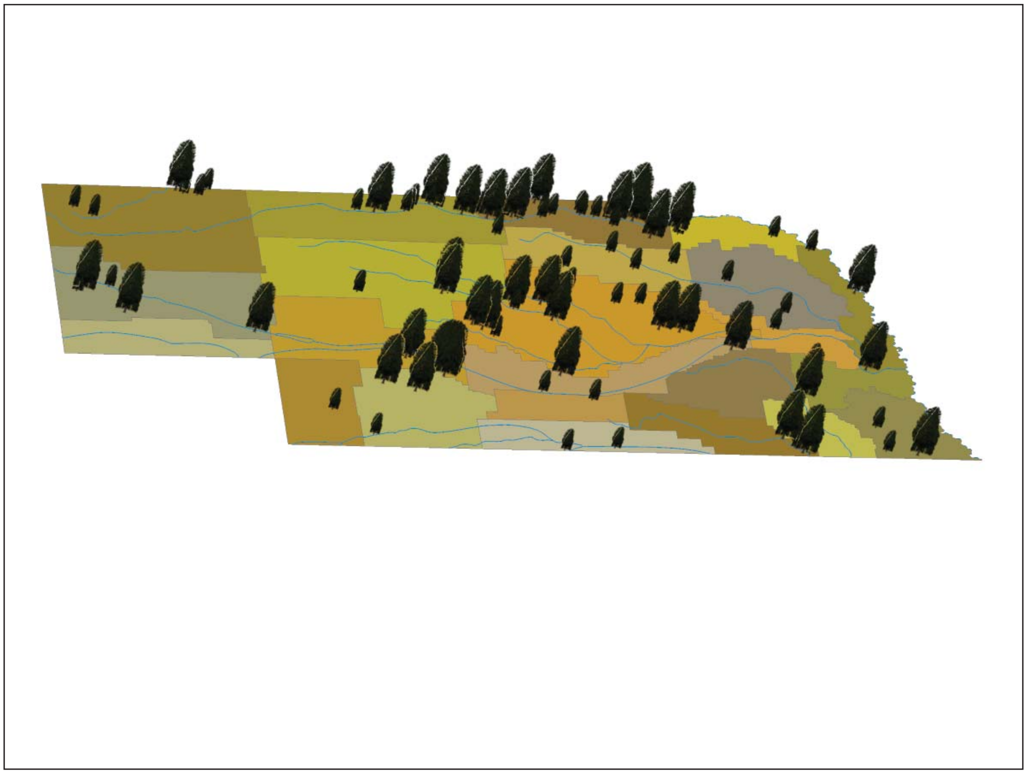


Figure 40.—Representation of eastern redcedar/Rocky Mountain juniper on forested sample plots, Nebraska, 2005; depicted plot locations are approximate. Small trees represent fewer than 100 trees per acre; large trees represent 100 to 765 trees per acre.

Figure 41.—Representation of cottonwood on forested sample plots, Nebraska, 2005; depicted plot locations are approximate. Small trees represent fewer than 100 trees per acre; large trees represent 100 to 140 trees per acre.

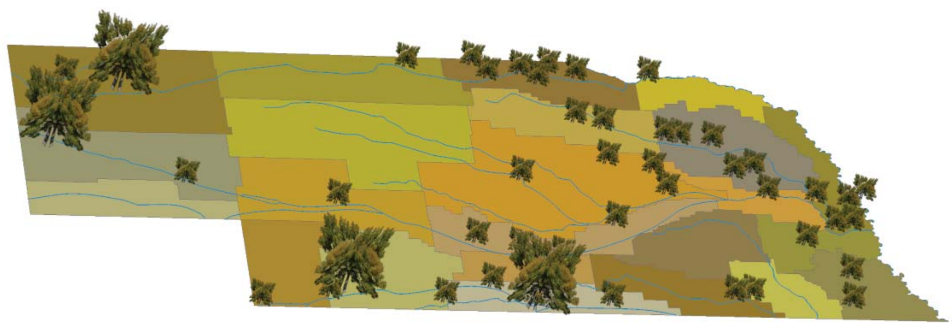
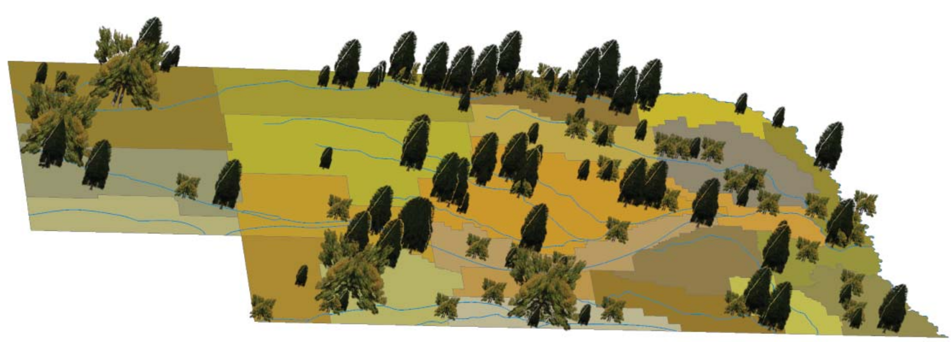


Figure 42.—Representation of cottonwood and eastern redcedar/Rocky Mountain juniper on forested sample plots, Nebraska, 2005 (Figures 40 and 41 combined). Depicted plot locations are approximate. Small trees represent fewer than 100 trees per acre for all species; large trees represent 100 to 140 trees per acre for cottonwood and 100 to 765 trees per acre for eastern redcedar/Rocky Mountain juniper.



Forest Health Indicators

Plains cottonwood and Russian olive. Photo by David Powell, U.S. Forest Service, bugwood.org.

Insects and Diseases

Background

The health of Nebraska's forests is influenced by the activity of insect and disease pathogens. Monitoring the status of insects and diseases is an important part of assessing the current and changing trends on the State's forest land.

What we found

In 2002, populations of pine engraver beetle (*Ips* spp.) began to build in jack pine and ponderosa pine stands on the Nebraska National Forest following defoliation by the jack pine budworm (*Choristoneura pinus pinus* Freeman) and drought; Ips populations remained high throughout 2003 and 2004 (Fig. 43). There was a high incidence of pine wilt in southeastern Nebraska. Caused by the microscopic pinewood nematode (*Bursaphelenchus xylophilus*), pine wilt is a native disease that largely affects exotic pines. Scotch pine is highly susceptible to pine wilt and experienced high mortality; Austrian pine is susceptible to a lesser extent. Diplodia blight (*Sphaeropsis sapinea*) affected Austrian and ponderosa pine in windbreaks and landscapes in eastern Nebraska, and on forest land in northwestern Nebraska and the Bessey District of the Nebraska National Forest. Elm trees in riparian forests and urban areas continued to be affected by Dutch elm disease (*Ophiostoma ulmi*). Along Nebraska's eastern border, oak wilt (*Ceratocystis fagacaerum*) was an important cause of oak mortality. Successive droughts plagued trees throughout the State in 2002 and 2003, though conditions improved in eastern Nebraska in 2004. Herbicide use in pest-management plans for crops resulted in increased damage to planted trees and trees in windbreaks. Pine tip moth (*Rhyacionia* spp. and *Dioryctria* spp.), bagworm (*Thyridopteryx* spp.), Cercospora blight of juniper (*Cercospora sequoiae*), European pine sawfly (*Neodiprion sertifer*), and lilac borer (*Podosesia syringae*) also caused noticeable damage.

What this means

Many insects and diseases were active in Nebraska's forests between 2001 and 2005. The extent of injury by these agents ranged from heavy to moderate. The activity of insects, diseases, and abiotic agents can affect the composition and structure of stands, timber, nursery and wood products industries, and recreation. The introduction of exotic insects, such as the emerald ash borer, presents a potential future risk to the health of Nebraska's forests.

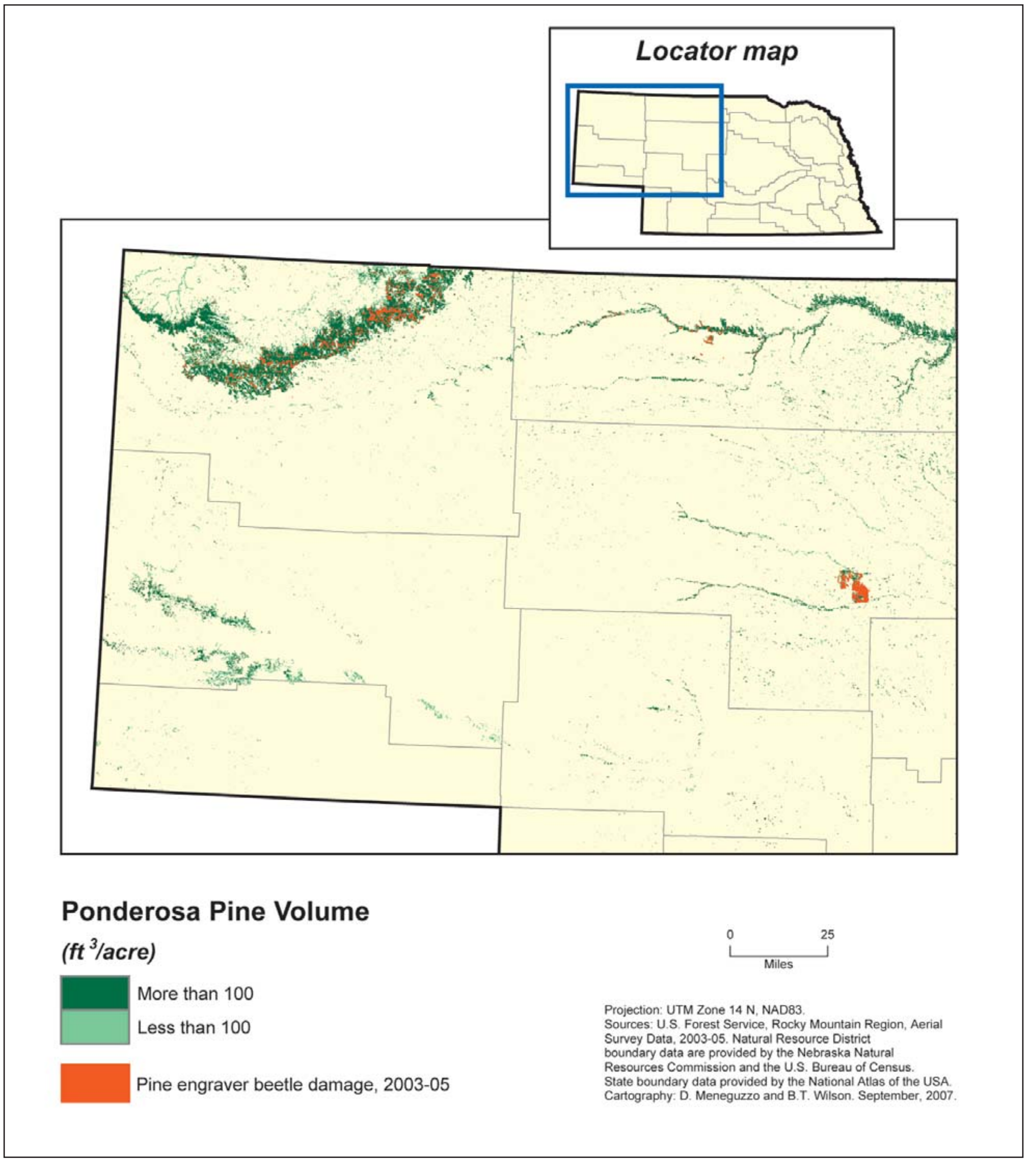


Figure 43.—Damage by pine engraver beetle detected by aerial survey, Nebraska, 2003-05.

Emerald Ash Borer

Background

The emerald ash borer (EAB; *Agrilus planipennis*) is an exotic wood-boring beetle that was first identified in the United States in 2002 (Anonymous 2007). Since that time, the emerald ash borer has spread throughout much of the north-central and eastern portions of the U.S. It is a pest of all major species of ash, including green, white, black, and blue ash, and all ash cultivars (Cappaert et al. 2005). Ash trees infested with EAB die within 1 to 3 years (Poland and McCullough 2006). Tree size and vigor have minimal influence on host selection, at least when insect density is high or moderate. Healthy and stressed trees and trees ranging in size from 1 to 59 inches in diameter have been attacked (Cappaert et al. 2005).

What we found

Green ash is the only ash species that has been observed on Nebraska's forest land. Although found throughout much of the State, it is concentrated in central to eastern Nebraska (Fig. 44). With an estimated 26.6 million trees, green ash is the third most abundant tree in the State and accounts for 8 percent of live-tree species on forest land. It ranks fifth in total live-tree volume with 104.3 million cubic feet, or 6 percent of total volume on forest land. Green ash is present on about 421,100 acres, or 34 percent of forest land (Fig. 45) and makes up less than 25 percent of total live-tree basal area. Forty-one percent of green ash trees are in floodplain/riparian forests (Fig. 46).

What this means

Green ash is an important component of Nebraska's woodland and riparian forests and is planted widely in urban areas and windbreaks. Should the EAB be introduced to the State, it will have a detrimental effect on Nebraska's forest resources and industries related to wood products and recreation, and to nurseries. The loss of ash in riparian zones would affect species composition, water quality, erosion, and the availability of food and habitat for macroinvertebrates and other wildlife. Spread of the EAB has been facilitated by human transportation of infested material. Already a devastating pest in the Midwest where it has caused substantial ash mortality, the EAB is a potential threat to Nebraska and could have a major influence on the structure and composition of the State's forests.

Figure 44.—Distribution of live ash density on forest land, Nebraska, 2005.

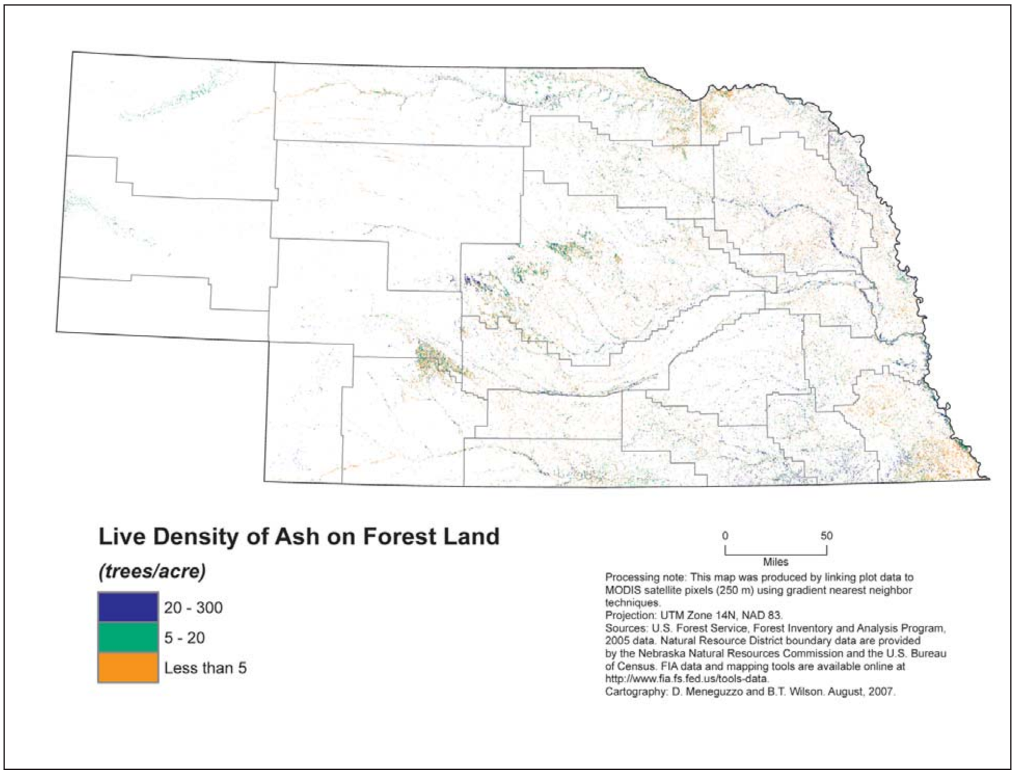


Figure 45.—Presence of ash on forest land, Nebraska, 2005.

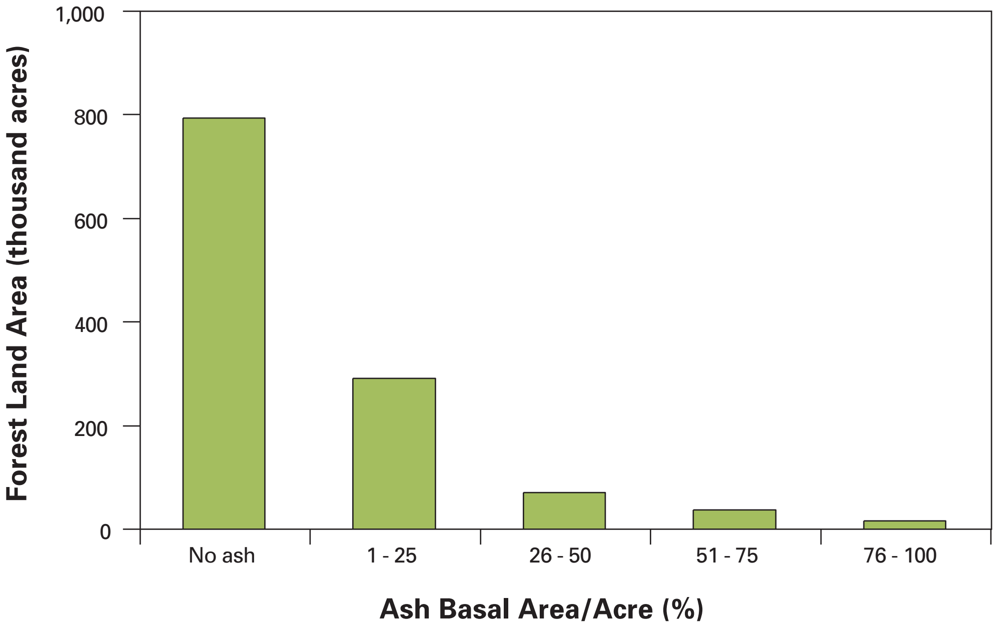
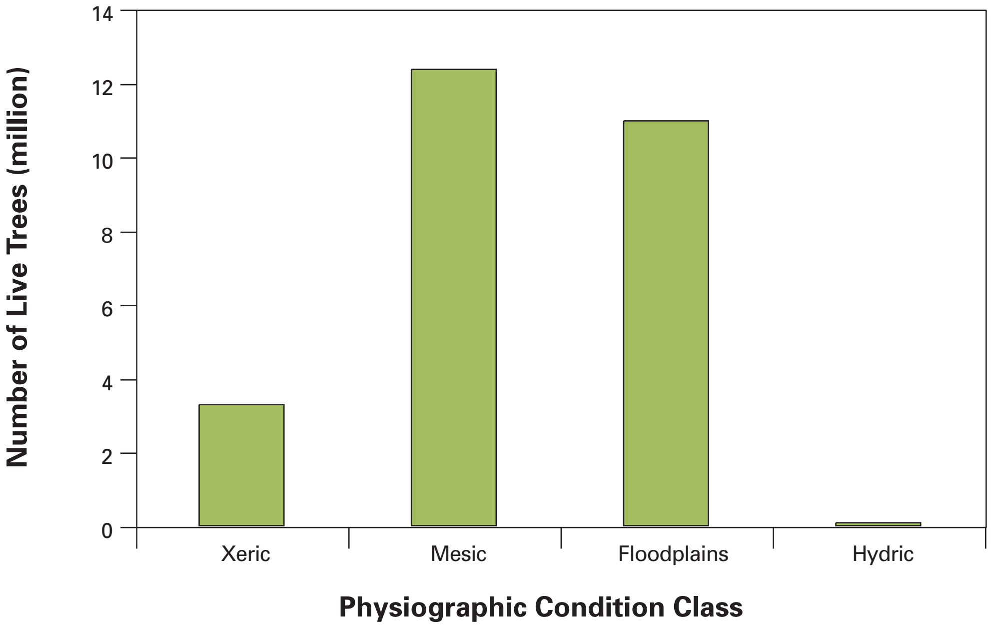


Figure 46.—Number of live green ash trees on forest land by physiographic condition class, Nebraska, 2005.



Emerald ash borer. Photo by Dave Cappaert, Michigan State University, bugwood.org.

Nonnative Plant Species

Background

Nonnative plants can be detrimental to native forest ecosystems. Because they are able to establish and grow quickly, these plants often out-compete and replace native vegetation in a short amount of time. As a result, ecological diversity is threatened and forest management costs increase as these plants impact forest tree regeneration and growth.

What we found

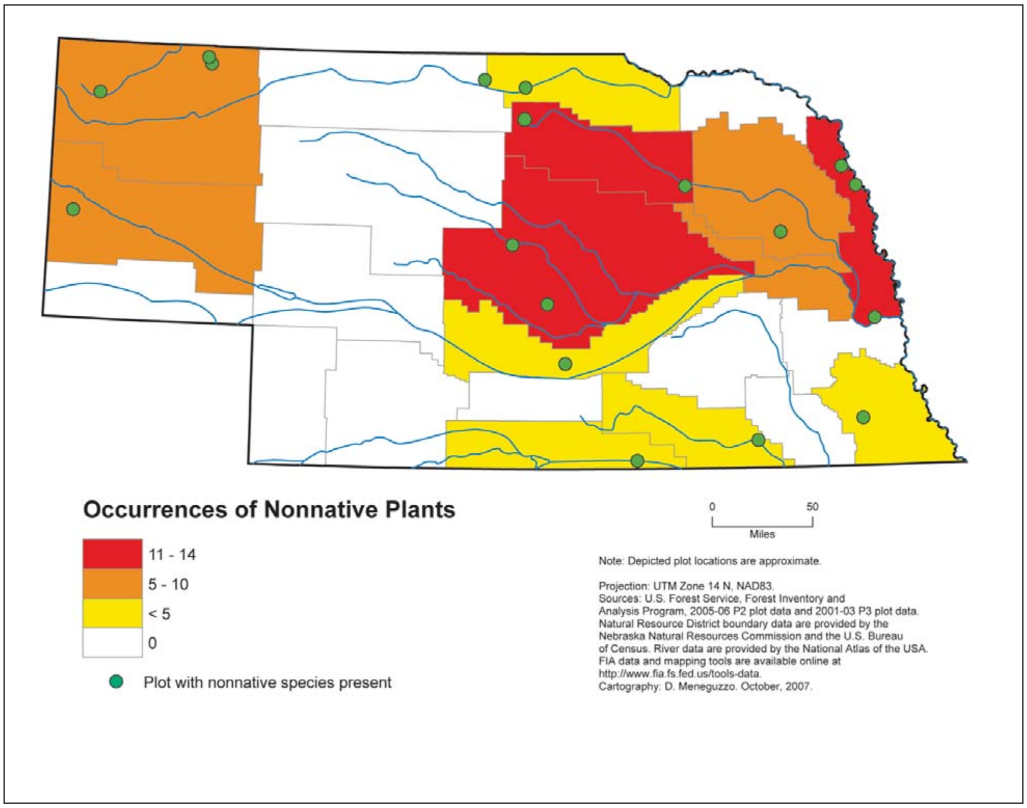
Data on nonnative plant species were collected on Phase 3 (forest health) field plots in 2001, 2002, and 2003 and on Phase 2 field plots in 2005 and 2006. One or more species were found on 18 plots (Fig. 47). In all, 36 species of nonnative and potentially invasive plants were observed in Nebraska, 34 of which were found on forest health plots. Five species were identified on Phase 2 field plots but only two of these species had not previously been observed on forest health plots.

Vascular plants were the most common type of nonnative invasives, with 27 species present. There were also five species of introduced grasses, three introduced tree/shrub species, and one vine. The three nonnative tree/shrub species are Russian olive, Siberian elm, and white mulberry; the latter was the most common. Lesser burrdock was the most prevalent nonnative species overall with 10 occurrences across the State.

What this means

The presence of at least 36 nonnative and potentially invasive plant species has been confirmed in Nebraska. The ability of these plants to spread quickly and widely is a serious threat to the ecosystems in which they are found. Forest edges are more highly susceptible to invasion, placing much of the State's forest land at risk. Furthermore, the fact that many of these plants are found in some type of riparian habitat is especially alarming as riparian forests are a vital resource in Nebraska. The loss of native vegetation and the inability of native tree species to regenerate due to the competition from nonnative invasive plants could lead to the decline and eventual loss of the State's riparian forests.

Figure 47.—Occurrences of nonnative and potentially invasive plant species in Nebraska.



Lesser burrdock. Photo by Mary Ellen Harte, bugwood.org.

Down Woody Materials

Background

Down woody materials in the form of fallen trees and branches fulfill a critical ecological niche in Nebraska's forests. These materials provide valuable wildlife habitat in the form of coarse woody debris and are an important component of carbon sequestration, but they can also contribute toward forest fire hazards via woody surface fuels.

What we found

Down woody materials can be measured in terms of the time it takes for their fuel moisture to change. Very small down woody pieces (<0.25 inches in diameter) may experience fuel moisture changes within 1 hour while very large woody pieces (>3.0 inches in diameter) may take over 1,000 hours for their moisture status to change. The fuel loadings of down woody materials (time-lag fuel classes) are not exceedingly high in Nebraska (Fig. 48). When compared to the neighboring states of Kansas and Iowa, Nebraska's fuel loadings of all time-lag fuel classes are not significantly different (for time-lag definitions, see Woodall and Monleon 2008).

The distribution of coarse woody debris (CWD) by size class is heavily skewed (89 percent) toward pieces less than 8 inches in diameter at the point of intersection with plot sampling transects (Fig. 49). With respect to the distribution of CWD by decay class, pieces in the early stages of decay (decay class 2) dominate at 57 percent (Fig. 50). Such pieces are structurally sound but experiencing initial decay typified by sloughing bark, soft sapwood, and loss of fine branches. Lastly, there appears to be an upward trend for CWD volume among classes of live-tree density. The highest amounts of CWD volume were found in stands with the highest amounts of standing live-tree density (Fig. 51).

What this means

The down woody fuel loadings in Nebraska's forests are not exceedingly different from those in neighboring states, with 10-hour fuels constituting the largest fuel loading at slightly more than 1 ton per acre. These low amounts of fuels would pose a hazard across the State only in times of extreme drought. Volumes of coarse woody debris also were relatively low and represented by small, moderately decayed pieces. This likely indicates a limited amount of wildlife habitat. Because fuel loadings are not exceedingly high across Nebraska, possible fire dangers are outweighed by the benefits of down woody materials.

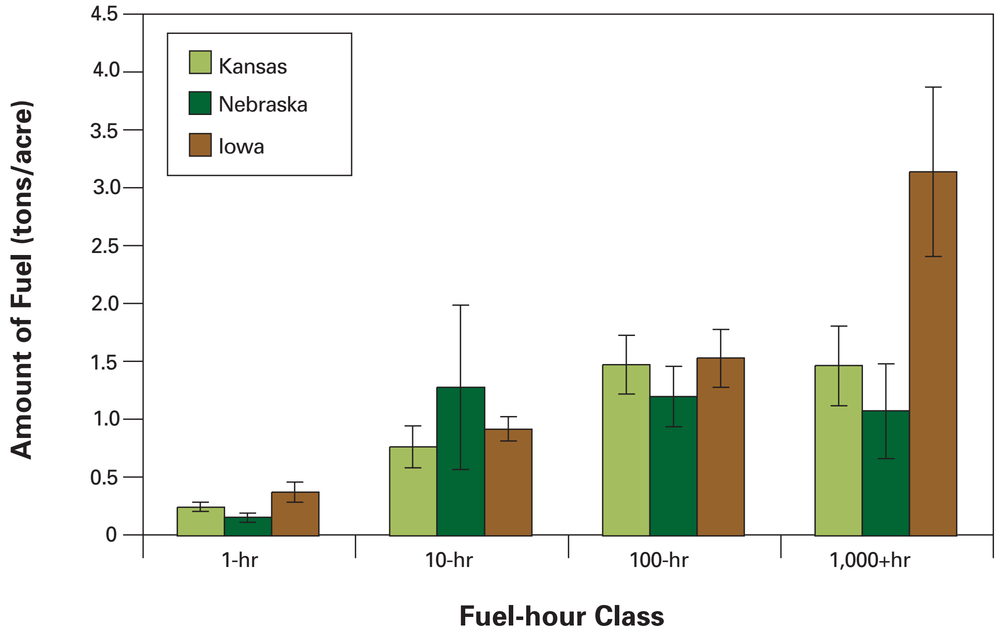


Figure 48.—Estimates of mean fuel loadings by fuel-hour class on forest land for Kansas, Nebraska, and Iowa, 2005 (error bars represent 66-percent confidence interval around the estimate).

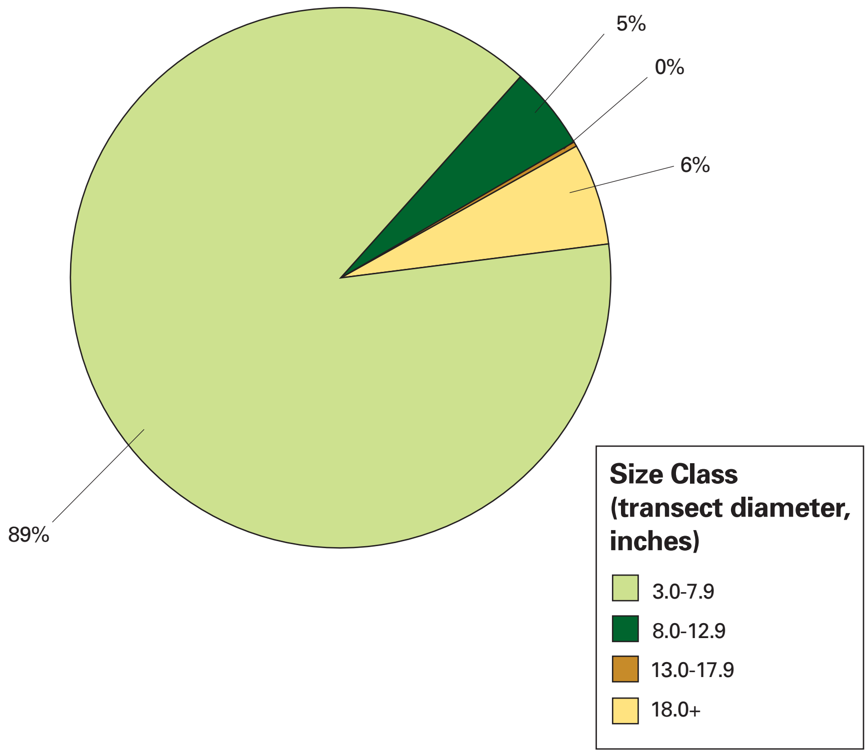


Figure 49.—Mean distribution of coarse woody debris (pieces per acre) by size class (inches) on forest land, Nebraska, 2005.

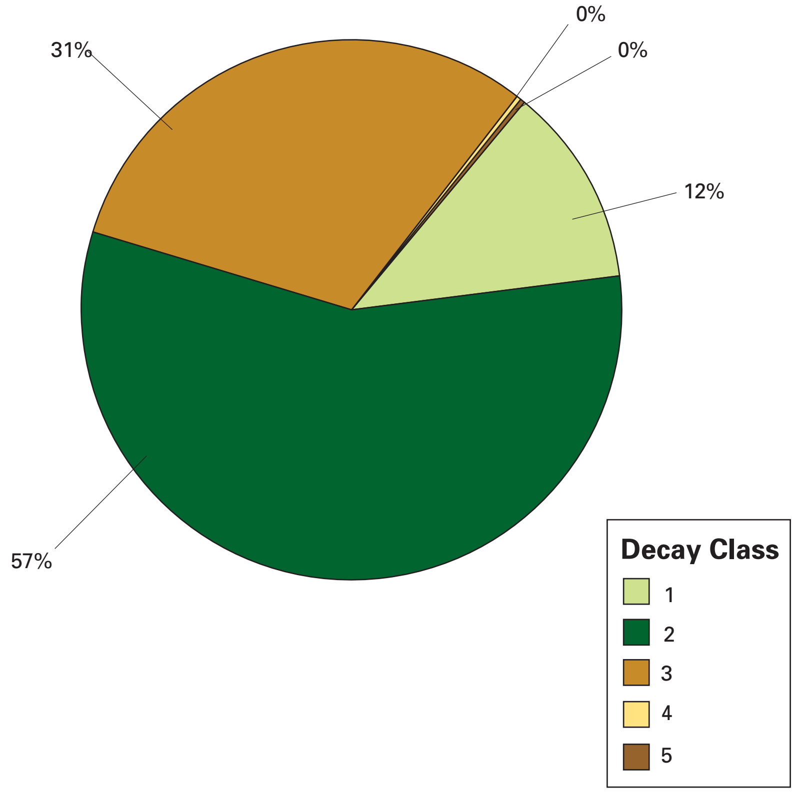


Figure 50.—Mean distribution of coarse woody debris (pieces per acre) by decay class (1 = least decayed, 5 = most decayed) on forest land, Nebraska, 2005.

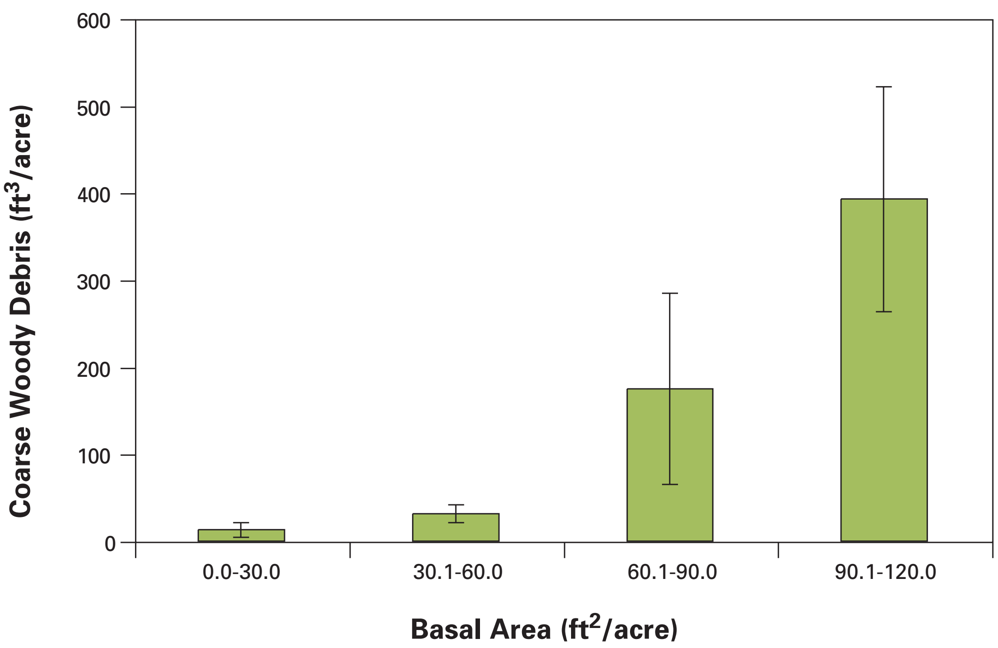


Figure 51.—Estimates of mean volume from coarse woody debris by stand density on forest land, Nebraska, 2005 (error bars represent 66-percent confidence interval around the estimate).

Forest Soils

Background

Rich soils are the foundation of productive forest land. Inventory and assessment of the forest-soil resource provides critical baseline information on forest health and productivity, especially in the face of continued natural and human disturbance.

What we found

Field data are available from 2001 to 2004. The sample locations in Nebraska are distributed across several forest-type groups, but it is possible to make broad generalizations using data from other Plains States (North Dakota, South Dakota, and Kansas). Forest-floor accumulations under Nebraska's forests are generally less than that observed in neighboring states (Fig. 52). Additionally, the ponderosa pine forest-type group is found on much thinner soil than either of the deciduous forest-type groups (Fig. 53).

The content of soil carbon in the forest floor and mineral soil was calculated from laboratory measurements. The forest floor under Nebraska's forests generally stores less carbon than in neighboring states, but the elm/ash/cottonwood forest-type group is an interesting exception. The forest floor under this group, while thinner than in neighboring states, is more carbon rich, so the total carbon storage is greater than otherwise expected (Fig. 54). Similarly, the juniper forest-type group stores less forest floor carbon but more mineral soil carbon than in neighboring states (Fig. 55). In the 10- to 20-cm layer, carbon storage is more consistent across the region.

The Soil Quality Index (SQI) is a new metric designed to combine the distinct physical and chemical properties of the soil into a single, integrative assessment (Amacher et al. 2007). Overall, the soil quality in Nebraska is comparable to that observed in Kansas and South Dakota. North Dakota has higher SQI values but it also has a limited number of samples from which to draw conclusions (Fig. 56).

What this means

Soil carbon is significant for several reasons. First, carbon is the primary component of soil organic matter, which has a number of important functions, including increasing water holding capacity, retaining some nutrients by cation exchange (e.g., Ca^{2+}, Mg^{2+}, K^{+}), releasing other nutrients as it decays (e.g., N, P, and S), and capturing potential toxic agents (e.g., Hg) (McBride 1994). Carbon is also inventoried nationally and internationally to track the sequestration of certain greenhouse gases.

The SQI data suggest that while the forest soils of Nebraska are similar to other soils in the region, they are storing less carbon. That being said, these forests may have an opportunity to play an important role in future sequestration programs, particularly when compared to other forms of land management.

Figure 52.—Observations of forest-floor thickness by forest-type group, Nebraska and other Plains States, 2004.

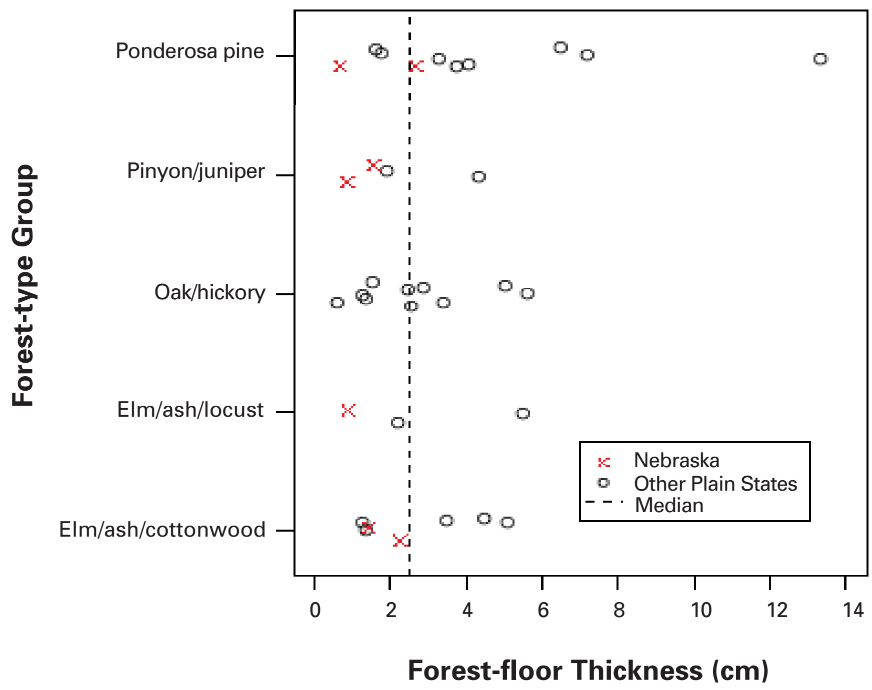
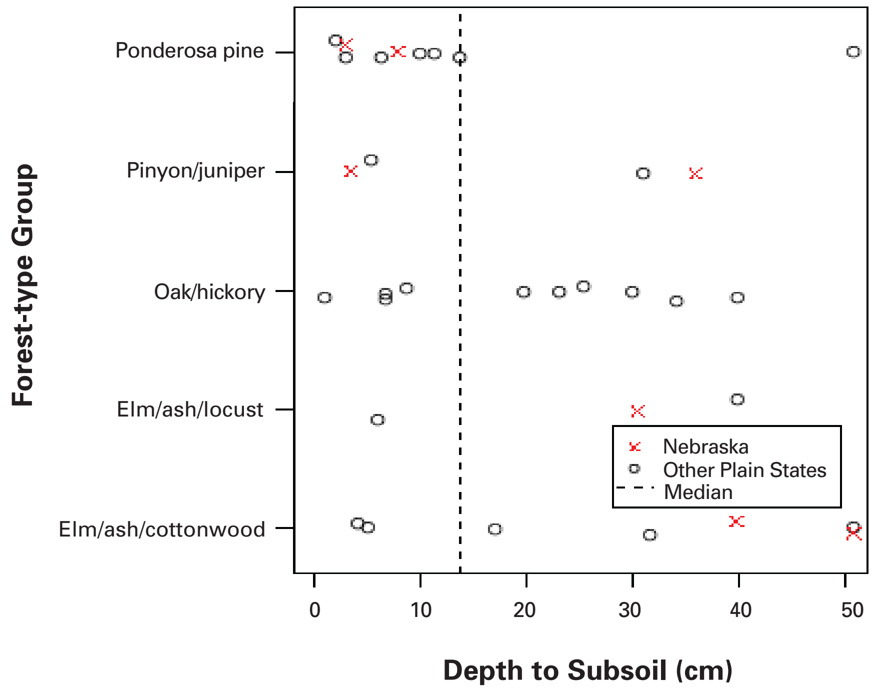


Figure 53.—Observations of depth to subsoil, Nebraska and other Plains States, 2004.



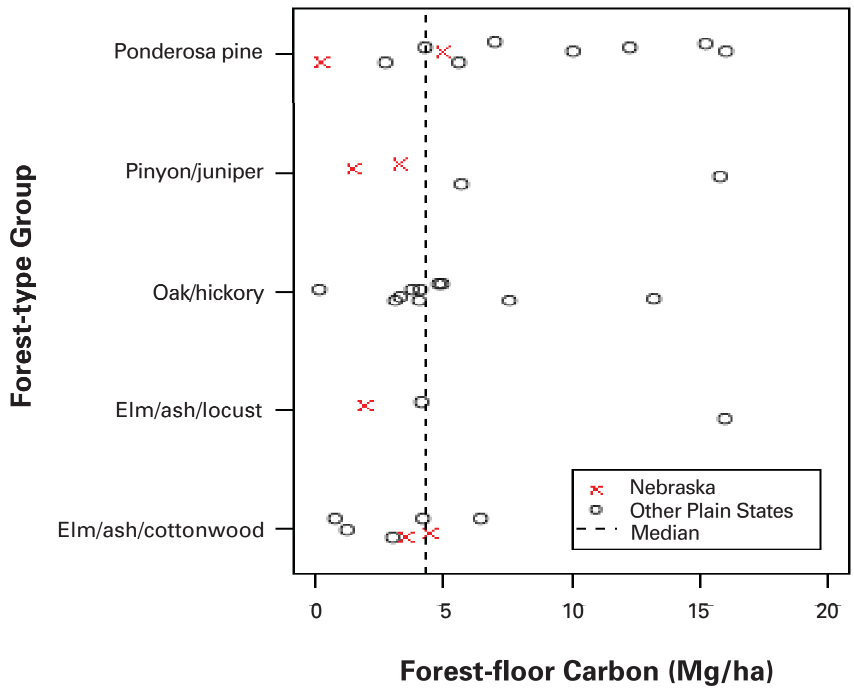


Figure 54.—Observations of forest-floor soil-carbon content, Nebraska and other Plains States, 2004.

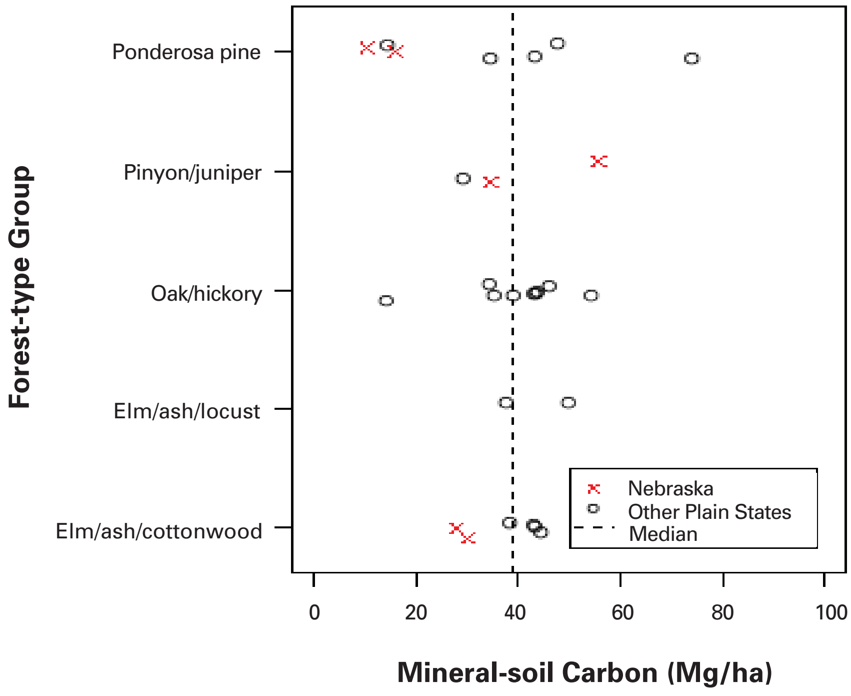
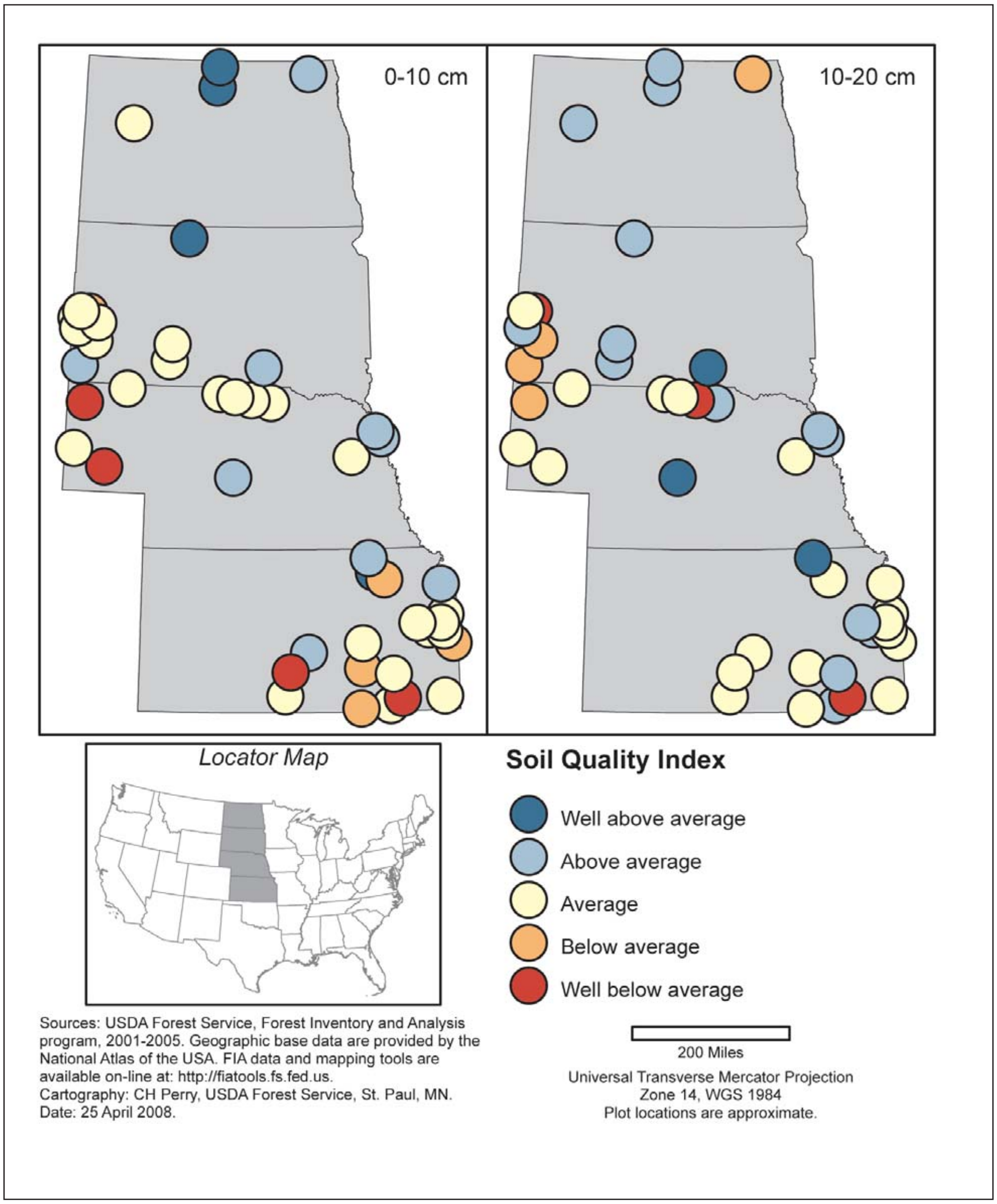


Figure 55.—Observations of mineral-soil carbon content, 0-10 cm, Nebraska and other Plains States, 2004.

Figure 56.—The Soil Quality Index (Amacher et al. 2007) highlights differences in the chemical and physical condition of the soil, Nebraska and other Plains States, 2004.



Tree Crowns

Background

The overall condition of live tree crowns can provide an indication of the current health of a forest stand. Uncompacted live crown ratio, crown dieback, and crown transparency are measured to evaluate tree crowns. Uncompacted live crown ratio estimates the portion of the tree height that supports live foliage. Crown dieback is the percentage of branch tips in the crown that are dead. Crown transparency measures the amount of sunlight that passes through the tree crown. A high percentage of crown dieback, low crown ratios, and/or high transparency can be signs of poor site conditions or insects and diseases that affect tree foliage.

What we found

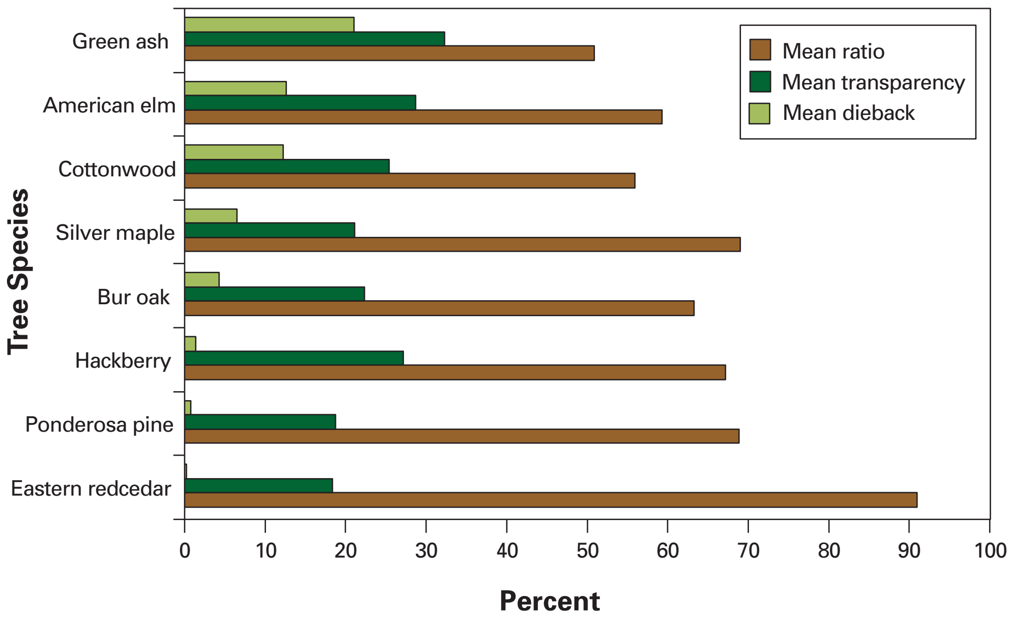
Crown indicators are only measured on a subset of forest land plots. The following data is from 20 Phase 3 plots or 264 trees. There is relatively little crown dieback in Nebraska. Ninety percent of the sampled trees had no dieback, 4 percent had light dieback, another 4 percent had moderate dieback, and 2 percent had severe dieback. Six species had moderate dieback: American elm, bur oak, cottonwood, green ash, silver maple, and slippery elm. Severe dieback was found on American elm and green ash. The three species with the highest percentages of moderate to severe dieback were cottonwood (26 percent), green ash (21), and American elm (16). These species also had the highest average crown dieback (Fig. 57).

The average healthy hardwood tree transparency is 15 to 20 percent. Tree species with average crown transparencies above this threshold were green ash (32 percent), American elm (29), hackberry (27), cottonwood (26), bur oak (22), and silver maple (21) (Fig. 57).

What this means

According to crown indicator data, there does not appear to be major forest health issues in Nebraska. However, the data suggest that there are some health problems for several species. American elm, green ash, and cottonwood had the most severe crown dieback, high crown transparencies, and the lowest uncompacted live crown ratios. Drought and water-retention dams are likely the primary causes of these conditions, particularly for cottonwood and green ash, which are common in riparian and/or floodplain areas. Also, cottonwood is mature or over mature and is in senescence. Continued monitoring of tree crowns will provide more conclusive evidence of forest health in the future.

Figure 57.—Mean crown dieback, crown transparency, and crown ratio for selected tree species, Nebraska, 2005.



Crown dieback. Photo by U.S Forest Service, Region 8 archives, bugwood.org.

Ozone Damage

Background

Ground-level ozone is a serious threat to forests worldwide. It is formed primarily from nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Industrial processes and automobile engines are responsible for most of the production of the compounds that result in ozone pollution. Ground-level ozone is a major constituent of smog and part of the mix of greenhouse gases.

The national ozone biomonitoring program uses ozone-sensitive plants to monitor air quality and the potential impacts of tropospheric ozone (smog) on the Nation's forests. Damage to forest plants and trees from ozone includes reduced growth and vigor, reduced seed production, and increased susceptibility to insects and disease. Long-term stress caused by ozone could lead to changes in species composition, reduced species diversity, and simplification of ecosystem structure and function.

What we found

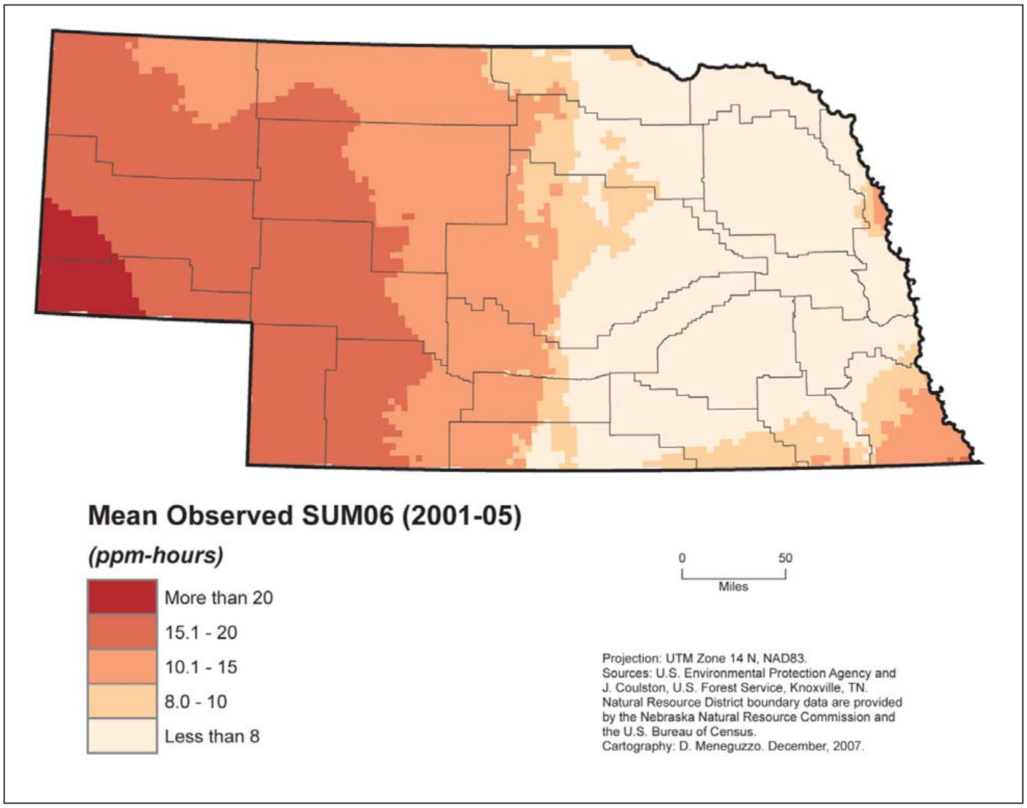
The national ozone grid surveys a number of biosites annually in each state. These field surveys are conducted to detect foliar injury related to ground-level ozone stress on bioindicator species. Typically, each biosite includes three or four bioindicator species and as many as 30 individuals of each species are evaluated. In Nebraska, 31 biosite visits were conducted between 2002 and 2006. No ozone injury was found on the 3,226 bioindicator plants that were evaluated. As a result, the average biosite index for the State was zero, indicating that the relative air quality is good. Species evaluated included spreading dogbane, western wormwood, common and tall milkweed, evening primrose, ponderosa pine, black cherry, skunk bush, coralberry, and mountain snowberry.

Ground-level ozone exposure is often reported as SUM06, the total duration of exposure to ozone concentrations greater than 0.06 parts per million (ppm). Ozone can cause leaf damage at levels exceeding 8 ppm-hour, and the growth of seedlings in natural forest stands is affected at 10 to 15 ppm-hour (Heck and Crowling 1997). Average SUM06 values for Nebraska range from 1.0 to 23.5 with a mean of 11.4. This is lower than the national average range of 0.0 to 84.4 (mean of 15.1).

What this means

Most of the forest land in Nebraska is exposed to slightly to moderately elevated ground-level ozone concentrations (Fig. 58). Eastern forests are essentially not at risk of foliar injury and other harmful impacts. However, western forest land is exposed to the highest seasonal ozone concentrations where foliar injury, reduced growth, and increased susceptibility can occur. Foliar injury has not been detected in field surveys. For additional information on ozone, access http://www.nrs.fs.fed.us/fia/topics/ozone/default.asp.

Figure 58.—Average observed ground-level ozone reported as SUM06 (total amount of time ozone concentration exceeds 0.06 ppm), Nebraska, 2001-05.



Forest Products

Millyard log deck. Photo by U.S. Forest Service, Rocky Mountain Research Station, bugwood.org.

Sawtimber Quantity and Quality

Background

Sawtimber is the wood in the saw log portion of a tree, or the section of a tree's bole measured from a 1-foot stump to a minimum top saw log diameter (9.0 inches for hardwoods and 7.0 inches for softwoods). To qualify as sawtimber, softwood trees must be at least 9.0 inches in diameter and hardwoods must be at least 11.0 inches in diameter. Sawtimber volume is measured using board feet; a board foot measures 1 ft by 1 ft by 1 inch. Live sawtimber volume is one measure of the monetary value of wood volume in a tree, or the amount of usable product that might be manufactured from that volume. The quality of live sawtimber volume is rated using tree grades 1 to 3 that are based on diameter and the presence or absence of defects such as knots, decay, and curvature of the bole. Grade 1 indicates the highest quality. Softwood sawtimber is valued primarily for lumber while hardwood sawtimber is valued for other products like flooring and furniture.

What we found

Total sawtimber volume on timberland has increased significantly in Nebraska since the 1983 inventory (Fig. 59). Between 1994 and 2005, sawtimber volume per acre of timberland increased from 3,755 to 4,314 board feet. Currently, there are more than 5 billion board feet of sawtimber volume on timberland in the State; most of the volume (42 percent) is grade 3. Eighteen percent of all sawtimber volume meets the requirements for grade 1. Hardwoods contain 75 percent of the total sawtimber volume with nearly 3.8 billion board feet. Softwood sawtimber volume exceeds 1.2 billion board feet.

The top five species in sawtimber volume are cottonwood, ponderosa pine, bur oak, eastern redcedar, and American basswood (Fig. 60). Cottonwood dominates in total sawtimber volume, accounting for 47 percent of all sawtimber volume. This species makes up 87 and 47 percent of all grades 1 and 2 sawtimber volume, respectively. Ponderosa pine accounts for 46 percent of all grade 3 sawtimber volume and is the second most voluminous species. However, 95 percent of the volume of this species is in the lowest quality category. Eastern redcedar ranks fourth in the State in sawtimber volume. As with ponderosa pine, 96 percent of its total volume is grade 3.

What this means

Total sawtimber volume has continued to increase significantly and steadily in Nebraska since the 1983 inventory. Cottonwood is the most important species with respect to high-quality sawtimber. Other species that contain sawlogs that meet grade 1 requirements are American basswood, bur oak, and hackberry. However, their combined sawtimber volume is only about 15 percent of that of cottonwood alone. The fact that cottonwood is an aging resource with little regeneration indicates an eventual decline in volume that will have a significant impact on the State's timber-products industry.

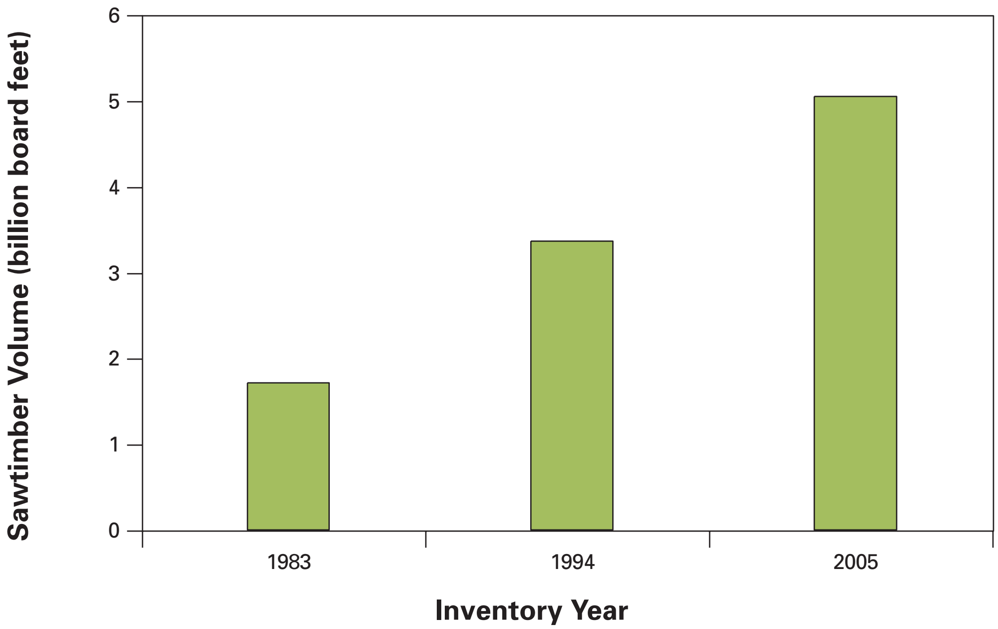
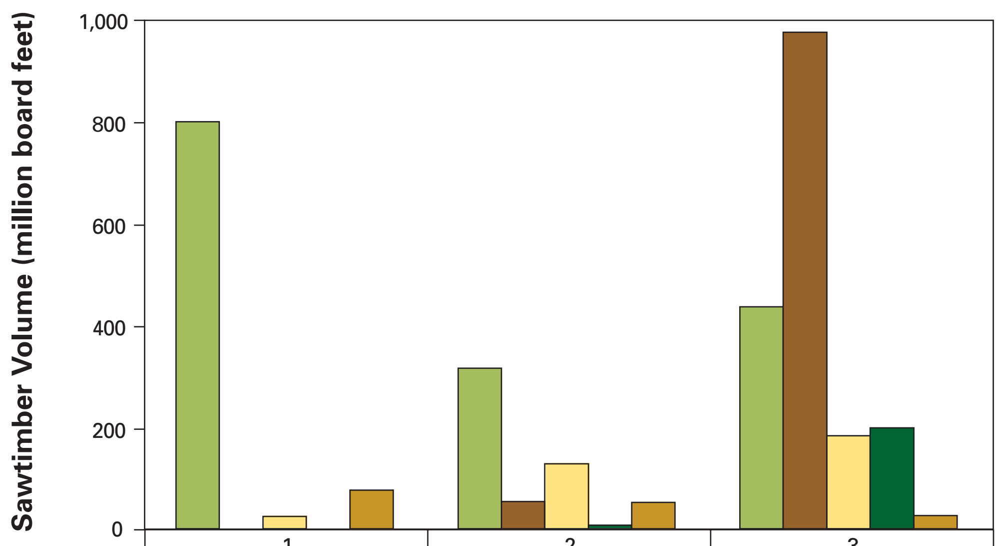


Figure 59.—Sawtimber volume on timberland by inventory year, Nebraska, 1983-2005.



	1	2	3
Cottonwood	798,245,000	314,511,000	436,105,000
Ponderosa pine	0	53,008,000	974,147,000
Bur oak	24,203,000	126,635,000	182,189,000
Eastern redcedar	0	7,419,000	197,291,000
American basswood	76,457,000	51,895,000	26,508,000

Tree Grade

Figure 60.—Sawtimber volume by tree grade for the five most voluminous species on timberland, Nebraska, 2005.

Timber Product Output

Background

Nebraska's wood-products industry employs more than 2,200 workers with a monetary output of approximately $286 million (U.S. Census Bur. 2005). Sawmills are the primary wood-using industry in the state. To properly manage and sustain Nebraska's forests, it is essential to obtain information on the location and species of timber that supply these industries.

What we found

In 2006, a mill survey was conducted of all known primary wood-using mills in Nebraska. Information was collected on the size of the industry, the amount of roundwood harvested, and its uses. Information on the generation and distribution of wood residues was also obtained. Approximately 72 percent of the roundwood produced in Nebraska came from the eastern unit (Fig. 61). The top three hardwood species harvested in the State were cottonwood, black walnut, and white oak; ponderosa pine was the top softwood species harvested (Fig. 62).

Sawlogs accounted for 78 percent of all the roundwood produced, excelsior/shavings and other miscellaneous items made up 14 percent, and veneer logs, industrial fuelwood, and posts together accounted for the remaining 8 percent (Fig. 63). More than 8.3 million cubic feet of wood material was harvested for industrial roundwood from Nebraska's forests in 2006: nearly 74 percent was used for products, 17 percent was logging slash, and 9 percent was logging residue.

In 2006, 76 percent of the State's saw log production went to Nebraska mills. The remaining 24 percent was exported to mills in South Dakota (18), Wyoming (5), and Iowa (1). Totals from sawmill receipts indicate that 90 percent of the wood coming into the mills is home grown. Iowa exports equaled 8 percent of the sawmill receipts, and the remaining 2 percent came from South Dakota.

What this means

A comparison of the 2000 and 2006 timber products inventories shows a small decrease in industrial roundwood production, from nearly 6.3 to 6.1 million cubic feet. Despite the slight drop in production, the number of active mills in the State has increased considerably, with the largest increase in the number of small mills.

The number of active primary wood-using mills in Nebraska increased from 34 to 53 between the 2000 and 2006 mill surveys. Medium sawmills (annual lumber production of 1 to 5 million board feet) decreased by 3 mills and the number small sawmills (lumber production of 50,000 to 1 million board feet annually) increased from 25 to 42. The number of large sawmills (annual lumber production exceeding 5 million board feet) increased by one.

Cottonwood remains the most commonly harvested species in the State, partly because the cottonwood forest type covers an estimated 140,000 acres of timberland and partly due to the strong competitive nature of the pallet manufacturing industry. Ponderosa pine continues to be the top softwood species harvested; most of the sawlogs of this species are shipped out of state.

Lumber and building materials. Photo by Stephen Bratkovich, U.S. Forest Service, bugwood.org.

Figure 61.—Industrial roundwood production by inventory unit, Nebraska, 2006.

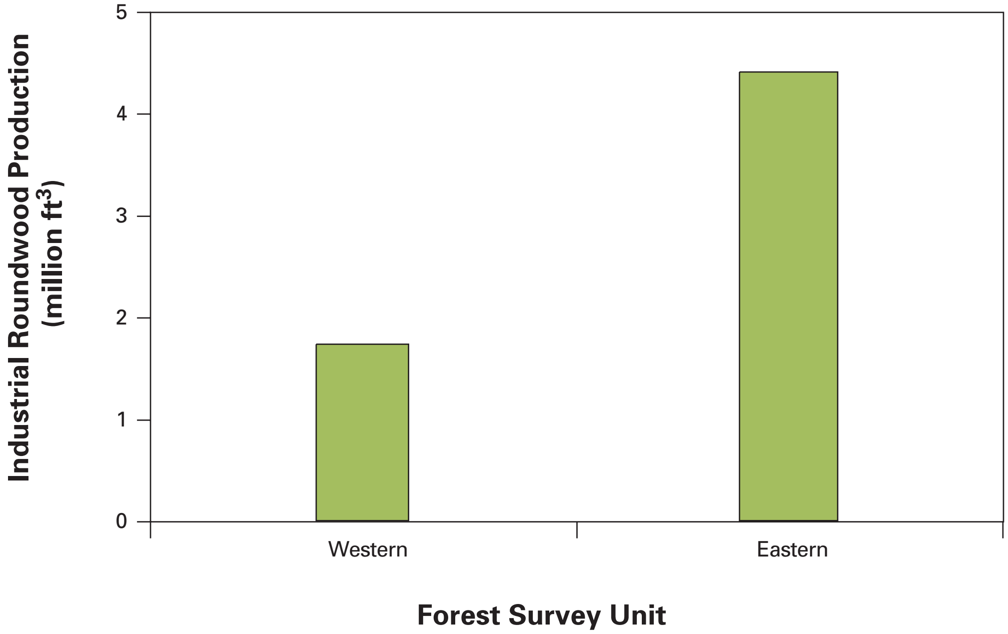


Figure 62.—Industrial roundwood harvested by select species group, Nebraska, 2006.

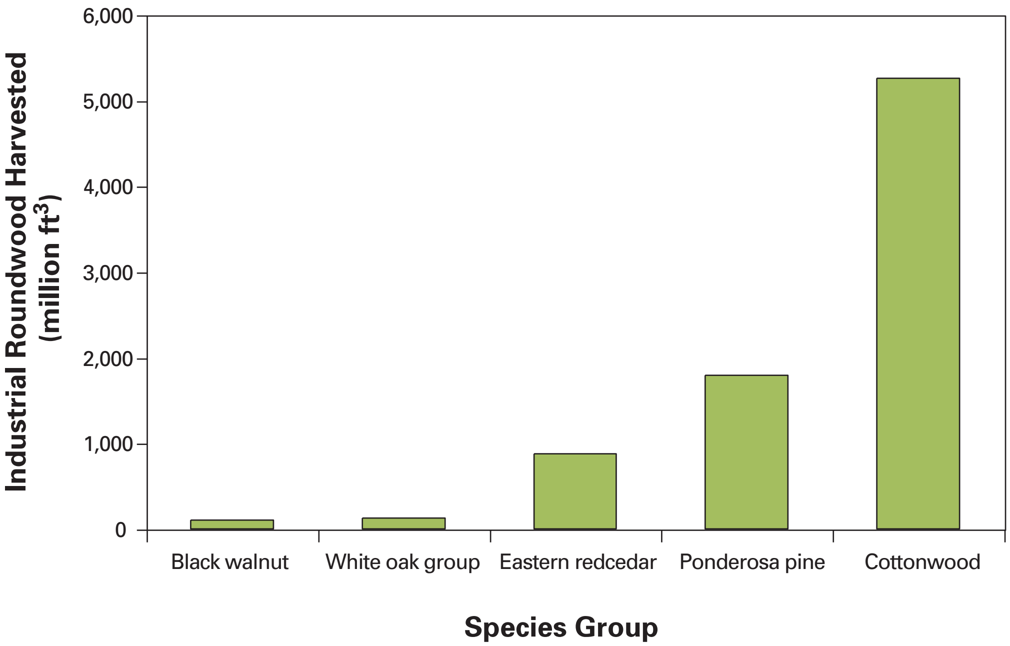
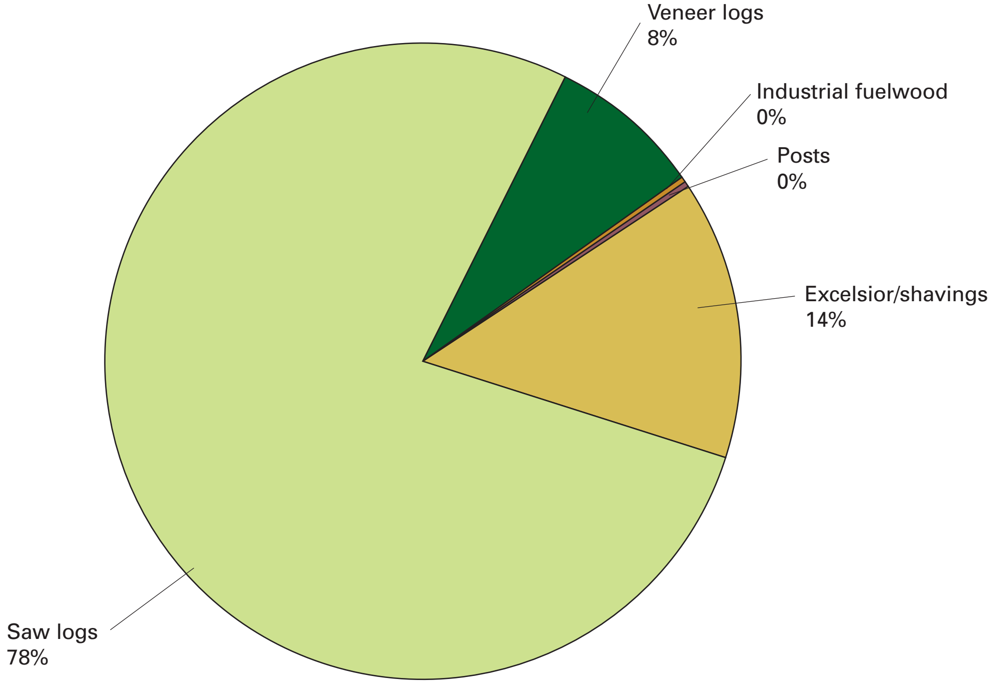


Figure 63.—Industrial roundwood production by product, Nebraska, 2006.



Growing-Stock Volume

Background

Growing-stock volume is used to estimate the amount of wood that is suitable for manufacturing wood products. The volume of growing stock is wood in standing trees that are healthy, sound, reasonable straight, and more than 5 inches in diameter at breast height (d.b.h.). Estimating the amount of growing stock that is potentially available for wood products is important for economic planning and development, and is a useful metric for evaluating the effects of sustainable forest-management practices.

What we found

Growing-stock volume in Nebraska has increased steadily since 1983 with a current estimate of more than 1.3 billion cubic feet (Fig. 64), or an average of 1,112 cubic feet per acre of timberland. The top five species in the State in growing-stock volume are cottonwood, ponderosa pine, bur oak, eastern redcedar, and green ash. These species account for 81 percent of the growing-stock volume in Nebraska. Cottonwood accounts for 38 percent of all growing-stock volume with nearly 500 million cubic feet. Increases in volume were significant in many of the diameter classes, while merchantable classes, e.g., 16-and 18-inch classes, increased only slightly or even decreased in volume (Fig. 65).

What this means

Much of the increase in growing-stock volume was in the low and highest diameter classes. Growth of the largest trees as well as those in the 10- to 14-inch classes added a substantial amount of growing-stock volume. Harvesting is likely responsible for the decrease in the 18-inch class. Cottonwood contains virtually all of the growing-stock volume in the 30-inch and higher diameter classes. This will have a major impact on the total amount of growing-stock volume available when this species begins to decline. Also, changing species composition (i.e., the large increase in eastern redcedar) due to lack of cottonwood regeneration will affect the State's timber-products industry in the future.

Figure 64.—Growing-stock volume on timberland by inventory year, Nebraska, 1983-2005.

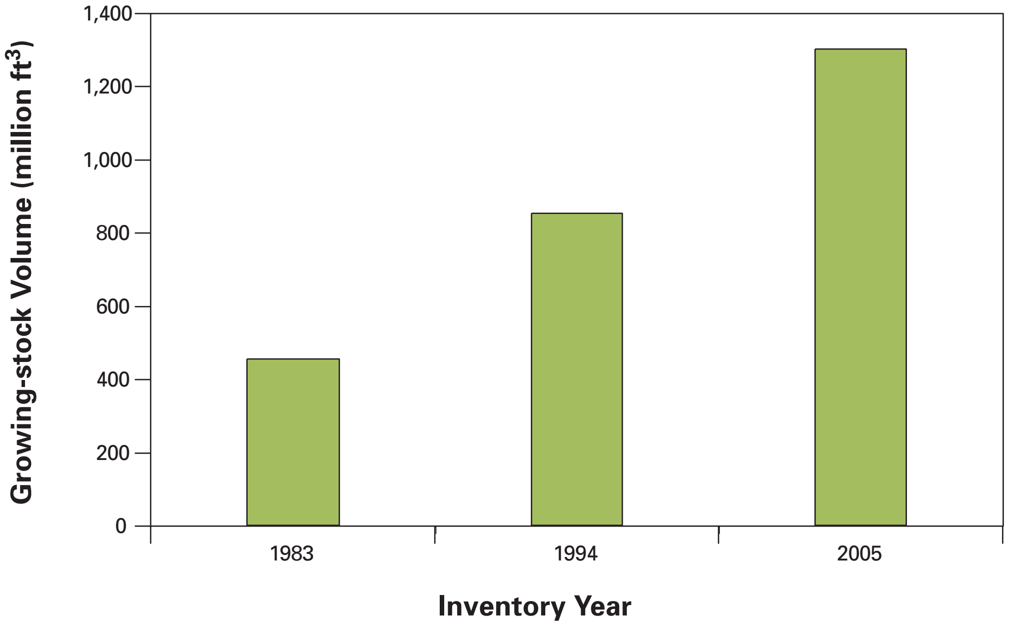
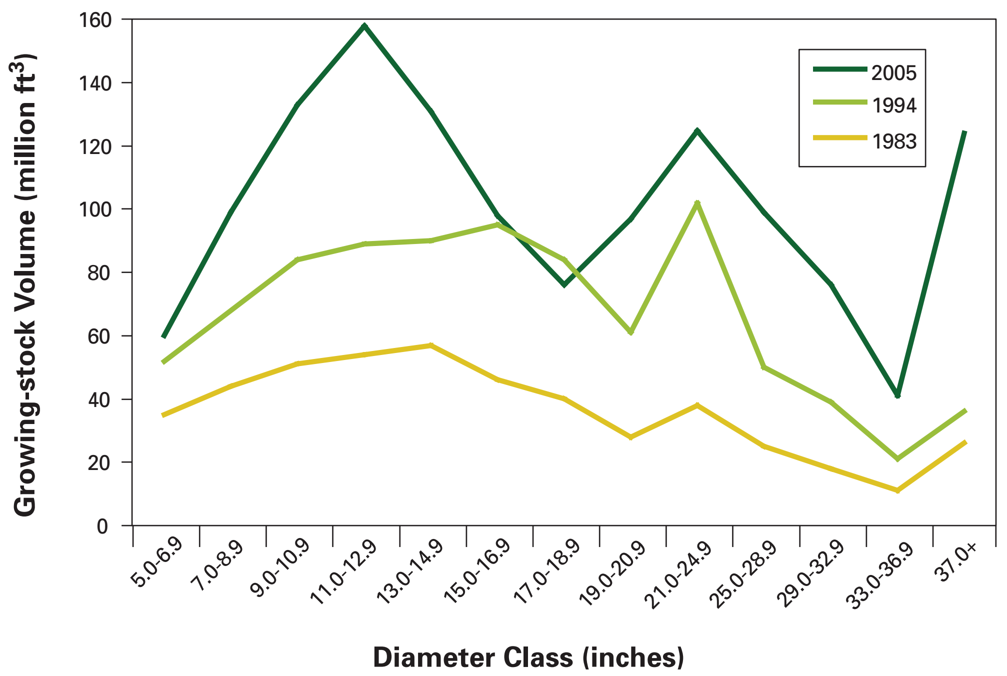


Figure 65.—Distribution of growing-stock volume on timberland by diameter class and inventory year, Nebraska, 1983-2005.



Low-grade Trees: an Important Source of Biofuel

Background

Biomass in the form of low-grade trees that are unsuitable for manufacturing wood products can provide an important source of renewable energy. FIA provides estimates of volume and biomass for trees that are 5 inches or more in d.b.h. as well as grade information for trees that meet the requirements for sawtimber (see Sawtimber Quantity and Quality section). These data are valuable in determining the amount of wood available for both manufactured products and biofuels.

What we found

Nebraska's forest land contains more than 1.8 billion cubic feet of wood volume in live trees that are 5 inches or more in diameter. This equates to almost 42 million oven-dry tons of biomass contained in stumps, boles, limbs, and tops. Forty-nine percent of the total volume is in low-grade trees (grades 3, 4, 5) and 34 percent is in trees that are not of sawtimber size (no grade).

Low- and no-grade volume and biomass are concentrated in the northern part of the State, but areas with high concentrations are found across Nebraska (Figs. 66-69). Six counties have more than 75 percent of their total live volume in low-grade sawtimber trees (Fig. 70). There are 10 counties with more than 75 percent of their total live volume in trees that are not graded (Fig. 71).

What this means

Nebraska's forests contain an important source of renewable energy. A significant proportion of the total live volume is in low-grade sawtimber and in trees that are too small to be graded. This indicates a plentiful supply of fuel wood. For example, it takes 4.5 to 7 cords of wood to heat a home for one year, according to the Cooperative Extension Service Institute of Agriculture and Natural Resources. Using the higher value of 7 cords and an estimated 774,843 homes in Nebraska (U.S. Census Bur. 2007), there is sufficient volume in low-grade trees alone to heat every home in the State plus an additional 221,697 homes for 1 year. However, it is important to note that not all trees are available for harvest and that proper harvesting should be used to maintain this renewable resource.

Counties with a high proportion of their total volume in low- or no-grade volume (Figs. 70-71) are particularly good candidates for thinning operations to obtain this resource and help concentrate growth on the remaining trees.

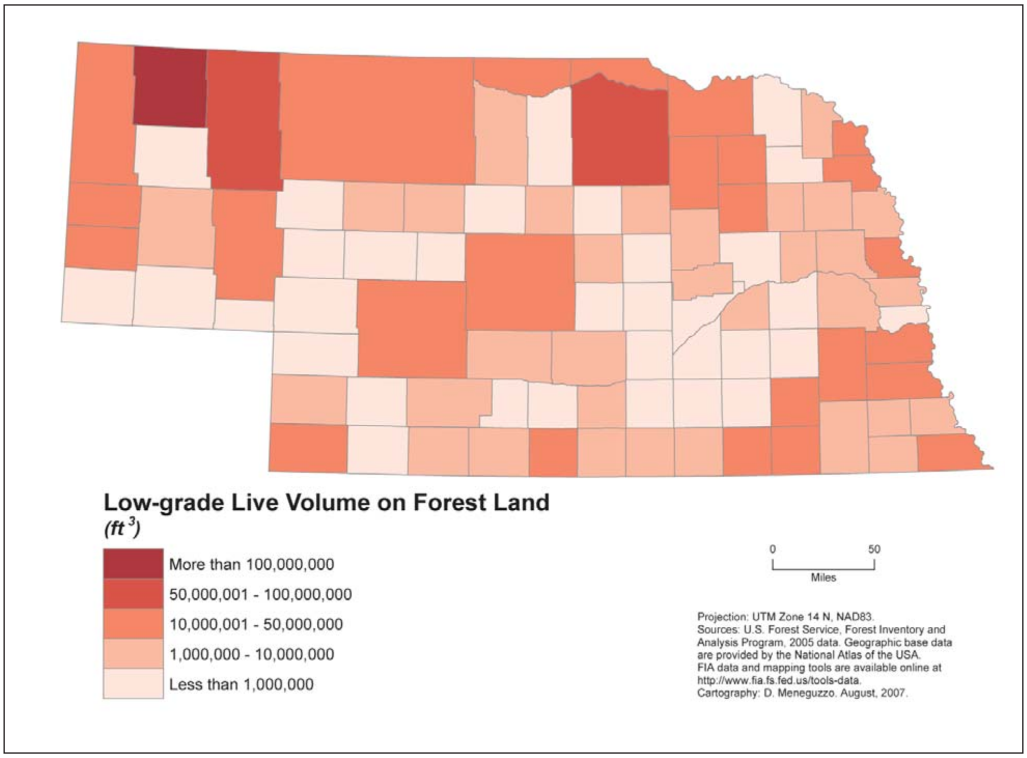


Figure 66.—Low-grade live volume on forest land by county, Nebraska, 2005.

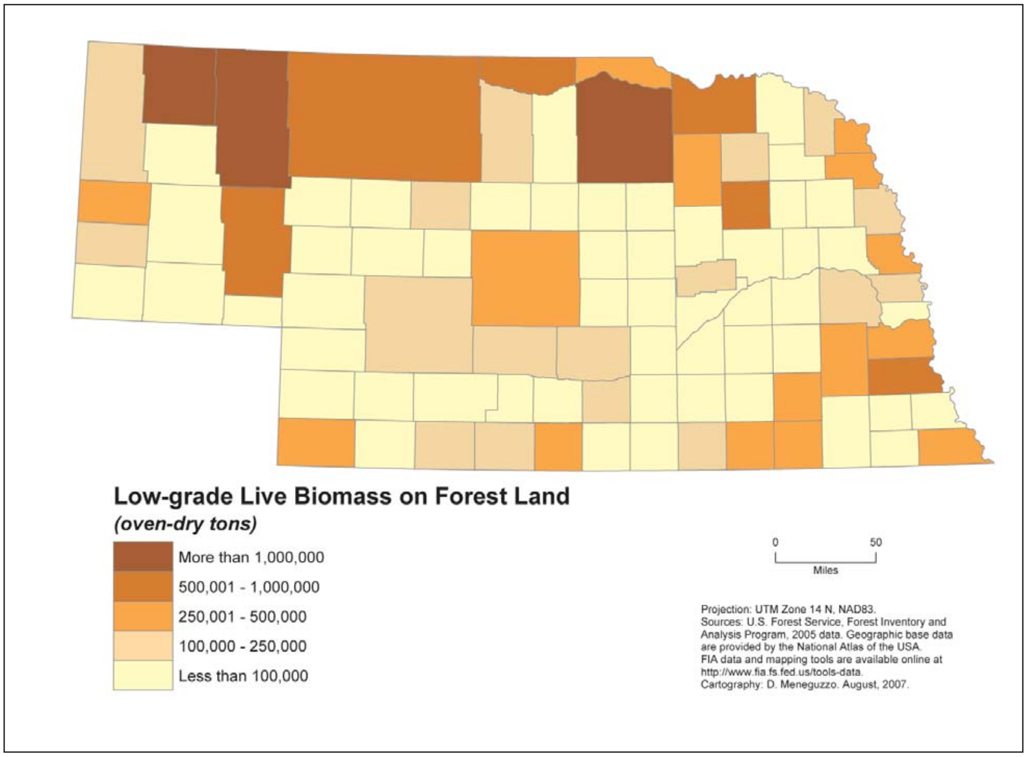


Figure 67.—Low-grade live biomass on forest land by county, Nebraska, 2005.

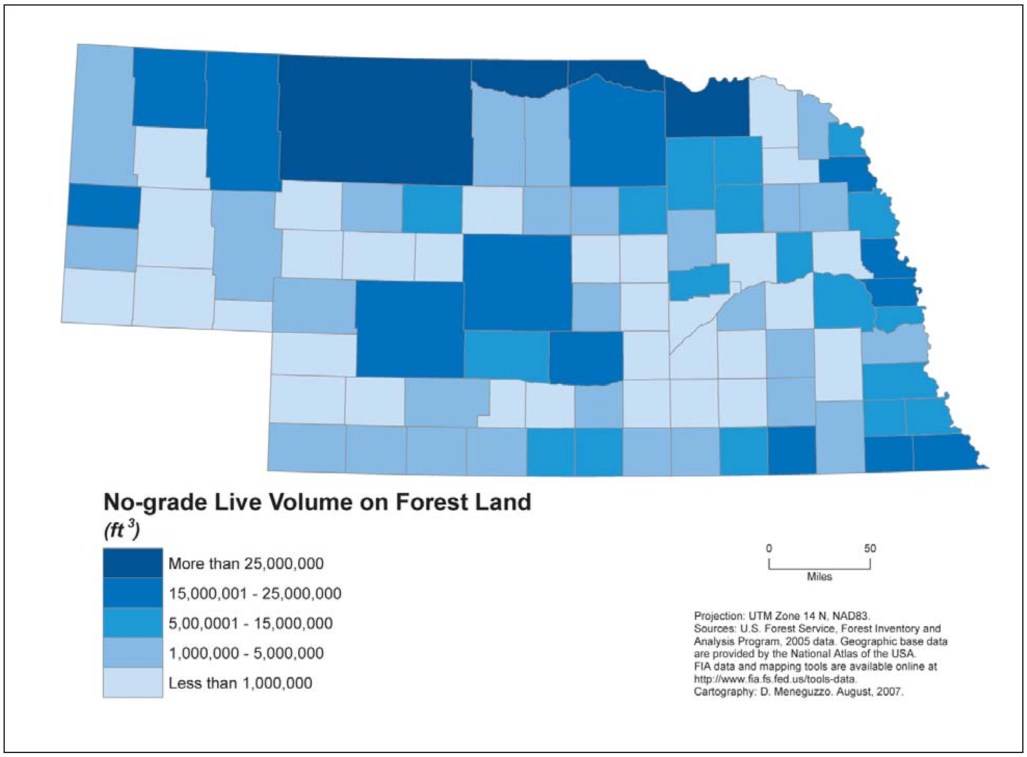


Figure 68.—No-grade live volume on forest land by county, Nebraska, 2005.

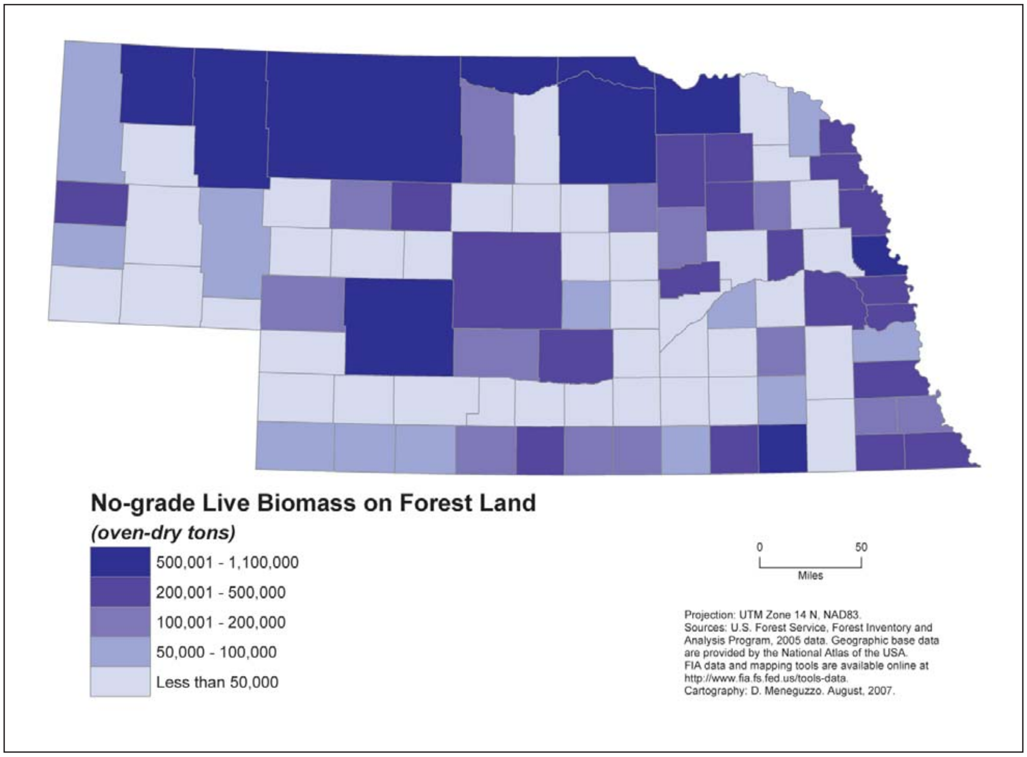


Figure 69.—No-grade live biomass on forest land by county, Nebraska, 2005.

Figure 70.—Proportion of low-grade live volume on forest land by county, Nebraska, 2005.

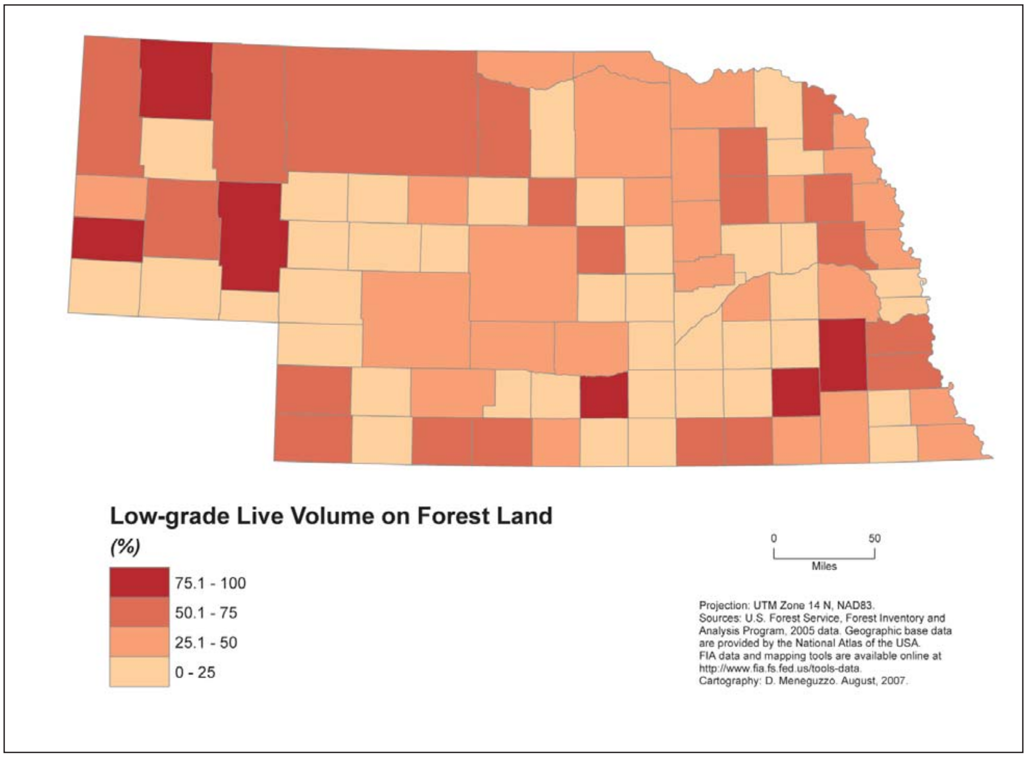
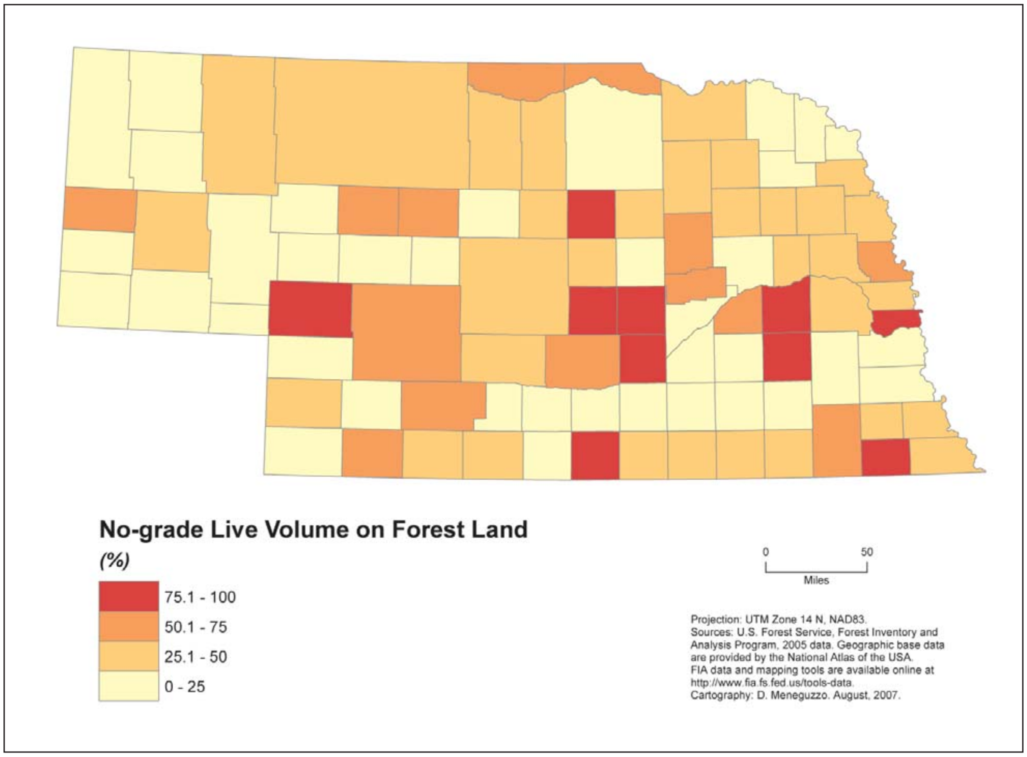


Figure 71.—Proportion of no-grade live volume on forest land by county, Nebraska, 2005.



Data Sources and Techniques

Nebraska landscape. Photo by Dacia Meneguzzo, U.S. Forest Service.

Forest Inventory

The fourth complete inventory of Nebraska was based on a three-phase inventory conducted from 2001 to 2005. The first phase used classified satellite imagery to stratify the State and digital orthophotos to select field plots for measurement. In the second phase, field crews measured the traditional FIA suite of mensurational variables. The third phase focused on a set of variables related to forest health.

The only lands that could not be sampled were private land where field personnel could not obtain permission from the owner to measure the plot or areas where plots could not be accessed due to a hazard that threatened the safety of field personnel. The methods used in the preparation of this report make the necessary adjustments to account for sites where access was denied or hazardous.

In Phase 1, FIA used classified satellite imagery to form two initial strata: forest and nonforest. Pixels within 60 m (2-pixel widths) of a forest/nonforest edge formed two additional strata: forest/nonforest and nonforest/forest. Forest pixels within 60 m on the forest side of a forest/nonforest boundary were classified into a forest edge stratum. Pixels within 60 m of the boundary on the nonforest side were classified into a nonforest edge stratum. The estimated population total for a variable is the sum across all strata of the product of each stratum's estimated area and the variable's estimated mean per unit area for the stratum.

During Phase 2, the traditional suite of FIA variables are measured. Current FIA precision standards for annual inventories require a sampling intensity of one plot for approximately every 6,000 acres. FIA has divided the entire area of the United States into nonoverlapping hexagons, each of which contains 5,937 acres (McRoberts 1999). An array of field plots was established by selecting one plot from each hexagon. This array of plots is designated the Federal base sample and is considered an equal probability sample. Measurement of Phase 2 plots in Nebraska is funded by the Federal Government.

The total Federal base sample of plots was systematically divided into five interpenetrating, nonoverlapping subsamples or "panels." Each year, the plots in a single panel are measured, and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots can be considered an independent systematic sample of all land in a state. Field crews measure vegetation on plots forested at the time of the last inventory and on plots currently classified as forest by trained photointerpreters using digital orthophotos.

In the final phase, Phase 3 plots are visited and measurements taken for both the full suite of FHM vegetative and health variables as well as all of the measures associated with Phase 2 plots. Phase 3 plots must be measured between June 1 and August 30 each year to accommodate the additional measurement of nonwoody understory vegetation, ground cover, soils, and other variables. The inventory for Nebraska consisted of 274 forested Phase 2 plots and 20 forested Phase 3 plots.

The new national FIA plot configuration was first used for data collection during the 2001 inventory of Nebraska and will be used in subsequent years. The national plot configuration requires mapping forest conditions on each plot. Due to the small sample size (20 percent) of plots measured each year, precision associated with change factors such as mortality will be relatively low. Consequently, we will not report change estimates until at least three annual panels have been remeasured, and even then we anticipate that estimates of change will be limited in detail.

The overall plot configuration for the new design consists of four subplots. The centers of subplots 2, 3, and 4 are located 120 feet from the center of subplot 1. The azimuths to subplots 2, 3, and 4 are 0, 120, and 240 degrees, respectively. The center of the new plot is located at the same point as the center of the previous plot if a previous plot existed within the sample unit. Trees that are 5 inches and larger in d.b.h. are measured on a 24-foot-radius (1/24- acre) circular subplot. All trees less than 5 inches d.b.h. are measured on a 6.8-foot-radius (1/300- acre) circular microplot located at the center of each of the four subplots. Forest conditions that occur on any of the four subplots are recorded. Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on any subplot is identified, described, and mapped if the area of the condition is at least 1 acre in size. For details regarding the sample protocols for Phase 2 variables and all Phase 3 indicators, access http://fia.fs.fed.us/library/fact-sheets/.

National Woodland Owner Survey

Information on family forest ownership was obtained from the National Woodland Owner Survey (NWOS), which is sponsored by the FIA Program. The survey began in 2002 and is designed to increase our understanding of private forest land owners in the United States and enable policymakers, resource managers, and others interested in the Nation's forest resources to better understand the social context of forests and formulate more informed opinions and decisions. The people identified by the FIA forest inventory as private forest land owners formed the sample for the NWOS. Every year, a different set of approximately 6,500 owners from across the United States are invited to participate in the survey. Data are gathered via a mailed questionnaire and divided into the following categories: (1) forest land characteristics, (2) ownership objectives, (3) forest use, (4) forest management, (5) sources of information, (6) concerns and issues, and (7) demographics. For details about the methods used to design, implement, and process the data for the NWOS, access http://www.fia.fs.fed.us/nwos. Summary findings from the survey are also available at this website.

Forest Health Monitoring Program

Information on the insects and diseases affecting Nebraska's forests was obtained from the Forest Health Monitoring (FHM) program of the Forest Service's Rocky Mountain Region (RMR) and the Nebraska Forest Service. Damage polygons were obtained from RMR aerial survey data. To view and download aerial survey data for Nebraska, access http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/download/. Additional information on the RMR's FHM program is available at http://www.fs.fed.us/r2/fhm/. For more information on the health of Nebraska's forests, contact the Nebraska Forest Service.

Timber Products Output Inventory

Information on timber products output and use was obtained from the 2006 Nebraska Timber Product Output and Use Assessment study, a cooperative effort between FIA and the Nebraska Forest Service. Using a questionnaire designed to determine the size and composition of the State's forest-products industry, its use of roundwood (round sections cut from trees), and its generation and disposition of wood residues, Nebraska Forest Service personnel visited and/or contacted via telephone all primary wood-using mills in the State. As part of data editing and processing, all industrial roundwood volumes reported on the questionnaires were converted to standard units of measure using regional conversion factors.

Mapping Procedures

Maps in this report were created by one of three methods. In the first method, categorical coloring of Nebraska's NRDs or counties is used according to various forest attributes, e.g., forest land area. These are known as choropleth maps. In the second method, a variation of the k-nearest-neighbor (KNN) technique is used to apply information from forest inventory plots to remotely sensed MODIS imagery (250-m pixel size) based on the spectral characterization of pixels and additional geospatial information. In the third method, colored dots or 3-D tree symbols are used to represent plot attributes at approximate plot locations.

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Meneguzzo, Dacia M.; Butler, Brett J.; Crocker, Susan J.; Haugen, David E.; Moser, W. Keith; Perry, Charles H.; Wilson, Barry T.; Woodall, Christopher W. 2008. Nebraska's forests, 2005. Resour. Bull. NRS-27. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 94 p.

Results of the first annual inventory of Nebraska's forests (2001-05) show an estimated 1.24 million acres of forest land; 1.17 million acres meet the definition of timberland. Softwood forest types account for one-third of all forest land area, with ponderosa pine being the most prevalent type. Hardwood forest types comprise 58 percent of Nebraska's forest land. Elm/ash/cottonwood is the predominant forest-type group in the State, accounting for 26 percent of all forest land area. Live-tree volume on timberland increased from 1.3 to 1.8 billion cubic feet between the 1994 and 2005 inventories. This report includes information on forest attributes, forest health, and agents of change: the introduction of nonnative invasive plants, insects and diseases, and the rapid expansion of eastern redcedar.

KEY WORDS: inventory, forest statistics, forest health, forest land, timberland, riparian forest, timber products, volume, biomass

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