Biennial Forest Health Report

North Dakota 2013-2014

North Dakota Forest Service
1/26/2015

Table of Contents

Overview 3

Forestland Ownership Distribution 4

Conditions of North Dakota's Forest Resources 5

- Native Forests 5
- Riparian Forests 6
- Aspen Forests 7
- Rural Forests 8
- Community Forests 9

Section I. Weather-Related Trends 10

Section II. Cooperative Forest Pest Surveys 12

- Gypsy Moth 12
- Emerald Ash Borer 12
- General Health of Spruce Plantings Across North Dakota 13
- Meyer Spruce Needle Disease Survey 13

Section III. Recent Insect Trends of Concern 16

- Elm Bark Beetles: Population Changes 16
- Redheaded Ash Borer 17
- Zimmerman Pine Moth 17
- Japanese Beetle 18

Section IV. Recent Diseases of Concern 19

- Apple Diseases: Fire Blight, Black Rot and Apple Scab 19
- Cottonwood Canker Fungi 20
- Spruce Health Issues: Needle Diseases and a Possible New Phytoplasma Disease 20
- Chlorosis 21

Section V. Other General Tree Health Trends of 2013-2014 22

- Ponderosa Pine Windbreak Decline in Burleigh, Kidder and Stutsman Counties 22
- Porcupine Damage in the Native Ponderosa Pine Forest Resources of Slope County 23
- Winterburn of Conifers 24
- Herbicide Injury 24

Section VI. Aerial Survey 2013 and 2014 25

- Overview of 2013 Aerial Survey Results 25
- Overview of 2014 Aerial Survey Results 26

Section VII. Forest Health Program Activities 28

- Emerald Ash Borer First Detector Training 28
- Emerald Ash Borer Awareness Week 29

Appendices 30

References 35

Overview

This report summarizes forest pest conditions observed in 2013 and 2014 and describes emerging forest health issues in relation to their effect on the sustainability and societal value of North Dakota's forested resources.

The term "forest health" does not denote the presence or absence of insect pests and diseases in the forest, nor is it equivalent to an arbitrary estimate of tree mortality. Forest health is more accurately portrayed as a depiction of forest sustainability, or the robustness of the forest's ability to provide social, economic and cultural benefits while maintaining its ecological functions.

All forests undergo succession, a natural change in vegetation through time. Forest succession is driven by biotic and abiotic pressures that influence the species composition of the forest and facilitate the death of weakened and less-fit individual trees. Abiotic pressures may include frost, snow, fire, wind, sun, drought, nutrient gradients and various human-caused injuries. Biotic pressures include fungi, insects, plants, animals, bacteria, phytoplasmas and nematodes that attack trees.

Such pressures are often a natural component of forest ecosystems, and the damage they cause should not be viewed as an imbalance of nature but rather a normal cycling and recycling of the forest. At times, however, the damage imposed by biotic and abiotic pressures may exceed our perception of what is normal or conflict with our management objectives. Additionally, pressures resulting from human activity and the introduction of non-native insects and pathogens may impair the long-term sustainability of forests substantially.

Report was compiled and written by Aaron Bergdahl, Forest Health Manager, North Dakota Forest Service and formatted by Dave Haasser, Graphic Designer, NDSU Agricultural Communications.

Cover photo of the Pembina Gorge: Aaron Bergdahl, NDFS

Forestland Ownership Distribution

Forests are an important part of North Dakota's natural resource heritage. Forests provide access to outdoor educational and recreational opportunities and managed wildlife habitat, and play an important role in protecting watersheds.

Roughly 68 percent (475,000 acres) of forestland in North Dakota is categorized as undifferentiated, privately owned (Figure 1). The federal government, primarily the U.S. Forest Service, is responsible for the management of roughly 167,000 acres, or 24 percent, while the state and local entities manage just more than 56,000 acres, or 8 percent, of the forestland. (Haugen et al. 2012).

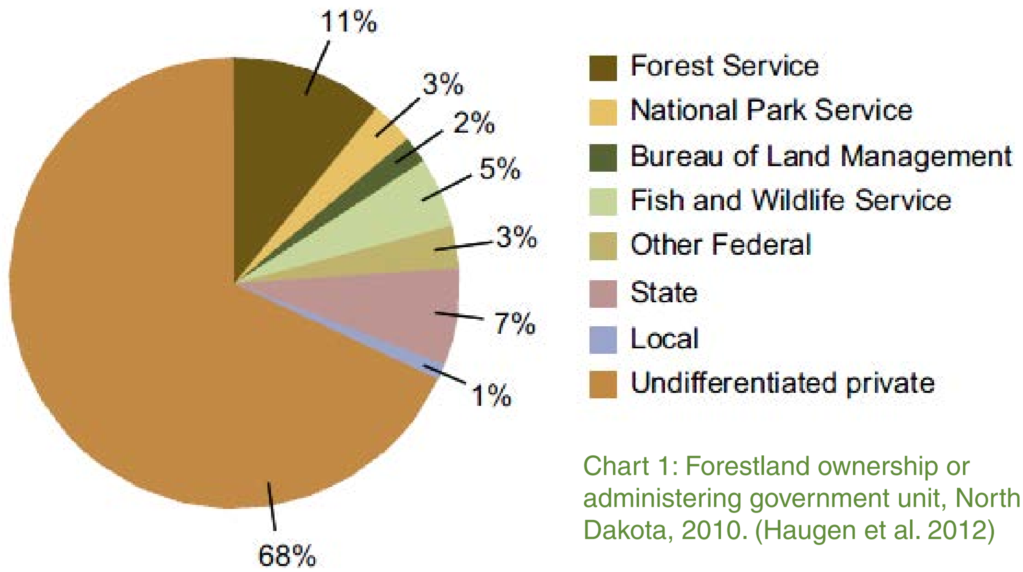


Chart 1: Forestland ownership or administering government unit, North Dakota, 2010. (Haugen et al. 2012)

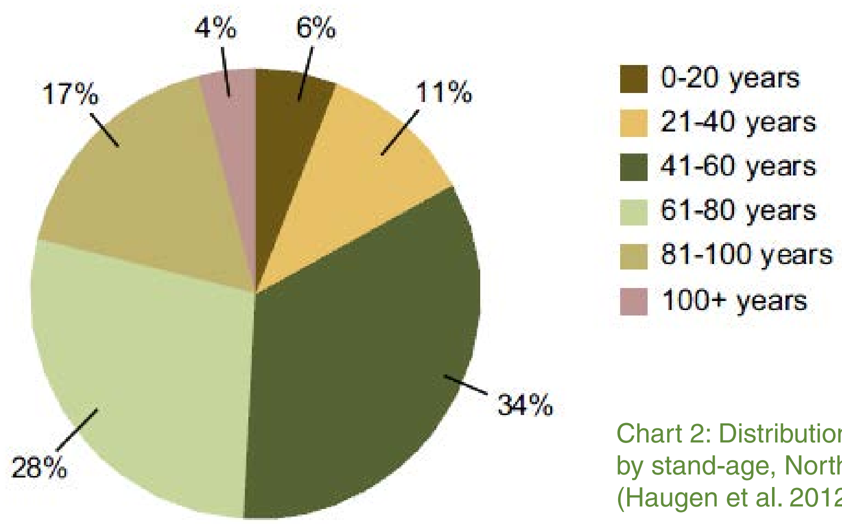


Chart 2: Distribution of forestland by stand-age, North Dakota. (Haugen et al. 2012)

Conditions of North Dakota's Forest Resources

North Dakota's forest resources can be separated into three categories: native forests, rural plantings and community forests. These resources provide numerous ecological, social and economic benefits to North Dakota residents. The following summaries describe the general conditions of each category of the state's forested resources. These narratives do not necessarily depict specific causal agents of tree/forest decline, but rather describe the factors that have led to the current condition of these resources.

Native Forests

Native forests and woodlands are distributed sparsely across the state and cover 753,600 acres, approximately 1.5 percent of North Dakota's total land area (Figure 1 and Appendix 2). Eastern deciduous and western coniferous forest types are found in North Dakota. This creates a unique ecological transition zone, with forest species, including forest pests, representing both forest types.

Deciduous forest types account for 98 percent of North Dakota's forests. Common deciduous forest types in North Dakota include elm/ash/cottonwood, aspen/birch and bur oak. These forest types are categorized by the dominance of one or a few tree species, although numerous species may be included in each forest type.

The elm/ash/cottonwood forest type is the most abundant and occurs along rivers, lakes and streams throughout the state. Bur oak and aspen/birch forests are common in the Turtle Mountains (north-central), Devils Lake Hills (center of northeastern quarter) and Pembina Gorge (northeastern corner).

Figure 1: North Dakota's largest native forests are found in the Turtle Mountains in Bottineau and Rolette counties.
(Aaron Bergdahl, NDFS)

Only 2 percent of the state's forestland is classified as western coniferous forests. These isolated stands consisting of ponderosa pine and Rocky Mountain juniper are in the southwestern counties of the state (Appendix 6).

Despite their limited acreage, native forests are important resources in North Dakota. These forests provide wildlife habitat and recreational opportunities, stabilize river banks, filter water runoff from adjacent agricultural lands, provide wood products, serve as seed sources for conservation tree production and increase the botanical diversity of the state.

The forests of North Dakota are generally resilient to damage imposed by endemic insects and diseases. However, damage caused by these agents, coupled with other underlying factors, may threaten the long-term sustainability of the state's forests. These factors include:

- Reduced species diversity due to damage caused by non-native forest pests
- Overmaturity of existing stands and suppression of natural disturbances essential to regenerate forests (Chart 2)
- Lack of forest regeneration due to heavy deer browsing pressure and alteration of natural flood plains along rivers (based on field observation and anecdotal information)

Riparian Forests

Nearly one-fifth of North Dakota's forests occur within 200 feet of a stream or lake (Haugen et al. 2011) (Figure 2). The majority of these forests consist of ash, elm and cottonwood. The health and sustainability of these plant communities have important implications for water quality, flood control, wildlife habitat and recreational opportunities.

The elm/ash forest type is the most abundant of all native riparian forestland in the state. These forests have experienced significant alterations during the past decades due to damage caused by Dutch elm disease (*Ophiostoma ulmi and O. nova-ulmi*), overgrazing, altered water flows and conversion to nonforestland. The threat of the emerald ash borer is another significant issue with the potential to drastically affecting the elm/ash forest type along riparian areas due to the overall abundance of ash. Emerald ash borer has not been detected in North Dakota.

The cottonwood (*Populus deltoides*) forests that occur within the Missouri River flood plain are in poor condition, which has resulted from progressive mortality of mature trees and the absence of natural regeneration to replace those that have died. Prior to flood mitigation, the Missouri River flood plain experienced periodic inundation as high spring water flows deposited sand in low-lying areas. These moist sandbars serve as seedbeds for cottonwood and are critical for natural regeneration of the species.

In the absence of flooding and subsequent sandbar formation, riparian cottonwood forest acres will continue to decline because no young cottonwoods will be available to replace the overmature trees that have succumbed to old age and senescence. While historic flooding along the Missouri and Souris rivers during the 2011 growing season has re-created a situation that would benefit the regeneration of cottonwood, the extent of regeneration is yet to be seen. Due to the infrequency of flooding events such as that in 2011, sustainability of cottonwood regeneration on the Missouri River is not likely without direct management.

Figure 2: Riparian forest resources, such as the pictured area on the Missouri River forming the border between Burleigh and Oliver counties, are the most common type of forest land in North Dakota. (*Aaron Bergdahl, NDFS*)

Aspen Forests

Figure 3: Native, predominantly aspen forests in the Killdeer Mountains of Dunn County, N.D. (*Aaron Bergdahl, NDFS*)

Nearly 17 percent of North Dakota's forestland is classified as the aspen/birch forest type (Figure 3). The majority of this forest type is in the Turtle Mountains, where the state's largest concentration of forestland is represented. Lack of fire disturbance and/or harvesting has resulted in older stands with minimal natural regeneration within these forests. The current condition of many stands is characterized by extensive stem decay caused by *Phellinus tremulae* and large stem mortality caused by hypoxylon canker (*Hypoxylon mammatum*).

In addition, the Turtle Mountains are prone to periodic defoliation caused by the forest tent caterpillar FTC (*Malacosoma disstria*) and, more recently, large aspen tortrix (LAT) (*Choristoneura conflictana*). Defoliation reduces growth, predisposes trees to other damaging agents and exacerbates the senescence of aging aspen stands. The declining aspen overstory may succeed to hazel (*Corylus spp.*) shrub land, in part due to the absence of shade-tolerant conifers in North Dakota.

Forestland owners have not actively pursued the harvest of aspen in the past two years. The vigorous regeneration of aspen that follows harvesting is important for the long-term perpetuation of this unique forested resource. Unfortunately, future opportunities to harvest North Dakota's timber likely will decrease due to the scarcity of sawmills, increasing mill production costs and decreasing demand for aspen wood products from local sources.

Rural Plantings

North Dakota is largely a rural state with an economy that is deeply rooted in agriculture. Rural tree plantings are an important component of many agricultural systems and improve the quality of rural living in the Northern Plains (Figure 4). Rural tree plantings generally refer to field windbreaks, farmstead shelterbelts, living snow fences, wildlife plantings and other plantings that are designed to achieve conservation, economic and societal goals. For example, field windbreaks reduce soil erosion during years of drought, reduce water evaporation from adjacent cropland and increase crop yields.

Similarly, some plantings are designed to stabilize riverbanks, filter water runoff from adjacent agricultural lands, provide wildlife habitat, protect stretches of highways prone to severe snow accumulation, provide wind protection and increased gains for livestock, or protect farmsteads and rural homes from snow and wind, therefore saving energy while beautifying the homestead and surrounding area.

Figure 4: Farmstead and shelterbelt plantings in Pembina County, N.D. (*Aaron Bergdahl, NDFS*)

Although many conservation tree plantings occur in areas where the historical vegetation type was prairie, these resources are critical for the present needs of rural residents who live in the current agricultural landscape.

Tree plantings of the northern Plains are exposed to numerous pests and environmental conditions that reduce their effectiveness, hinder planting success and limit long-term survival. Deterioration of tree plantings often is incited by drought, flooding, wildland fire, early or late frosts, inadequate spacing, weed competition, herbicide exposure, defoliating insects and foliar diseases. As trees become weakened, canker diseases and wood-boring insects may cause further damage to these plantings.

The damage to rural plantings caused by these interacting factors are more effectively prevented than treated. Incorporating various weed-control techniques, manipulating planting density and arrangement, or selecting species most suitable for the site have been effective approaches to prevent the decline of tree plantings.

Limited species diversity is an underlying factor in the decline of many rural plantings. Plantings composed of one or few species often experience episodes of elevated tree mortality simply because all trees are equally vulnerable to the same damaging agents.

Some examples of planting failure associated with limited species diversity include the decline of single-row Siberian elm field windbreaks due to herbicide exposure, marginal cold hardiness and canker diseases, and the decline of Colorado blue spruce plantings due to yellowheaded spruce sawfly (*Pikonema alaskensis*) (predominantly in the western half of the state), Stigmina needlecast (*Stigmina lautii*) and, less commonly, Rhizosphaera needlecast (*Rhizosphaera kalkhoffii*) (both predominantly in the eastern half of the state), and Cytospora canker (*Cytospora kunzei*), which commonly occurs statewide. The impacts of these damaging factors could have been reduced greatly had additional species been incorporated into these plantings.

Community Forests

Community forests include boulevard trees, trees planted in city parks and trees that naturally occur in city limits or public rights of way. The management of such tree resources may fall under the responsibility of city foresters, public works departments and/or community tree boards. The community forest also includes trees that are planted on private or commercial properties (Figure 5).

As a whole, these tree resources provide many benefits to the community's residents, including reduced winter heating and summer cooling costs, wind and snow protection, beautification, recreational opportunities and enhanced quality of life.

Trees planted in residential areas are exposed to numerous insects and diseases. The frequency and severity of pest damage often reflects the composition and abundance of host species in the community's forest. In addition, trees growing in residential areas are exposed to many environmental stressors, such as compacted soils, turf herbicides, lack of (or too much) watering, nutrient deficiency and mechanical injuries. Such stresses compound the damage caused by insects and disease.

Above all other insects, diseases and abiotic stresses, Dutch elm disease continues to be the most damaging to community tree resources. This disease has eliminated many of the stately elms that once graced North Dakota communities. Several of North Dakota's larger communities have developed management programs to combat Dutch elm disease with notable success. However, many smaller communities lacking the financial resources to support a forestry staff have been and continue to be severely impacted by this disease.

Ash species and cultivated ash varieties have been the most common replacements for elms killed by Dutch elm disease. As a result, many community forests that once were dominated by elm now have an overabundance of ash. Although ash performs well on a variety of sites and conditions, the overreliance on this species has raised concerns since the recent discovery of the emerald ash borer (*Agrilus planipennis*, an exotic ash-killing beetle) that is found as nearby as Minneapolis, Minn., and Superior, Wis. Many North Dakota communities are realizing the vulnerability of their community tree resource and are beginning to embrace the concept of species diversification.

Figure 5: Aerial view of the community forest resources of Velva, ND.
(*Aaron Bergdahl, NDFS*)

Section | Weather-Related Trends

Weather trends in 2013 and 2014 presented a unique set of tree health problems, starting with a late spring in both years keeping soil temperatures lower for a longer duration than usual across most of the state (Figures 6, 7). The amount of precipitation in both years was higher than usual in the early spring in most areas, with an extremely wet May 2013 (Figure 6) and a wetter than normal June 2014 (Figure 7). This led to a higher incidence of tree disorders related to these conditions, such as a higher than normal incidence of chlorosis in trees, especially maples (see section on this later in this report).

Reports of chlorosis were most common around Bismarck, where environmental conditions (cool and wet soils) certainly favored the disorder. Also, ample spring moisture favored the early development of various fungal diseases in 2013 and 2014. This included the development of some diseases that seldom have been recorded as causing notable damage.

Due to an unusually fast warmup following a longer than usual and harsh 2014 winter, severe conifer winterburn was reported across the state (see section on this later in this report). Additionally, with temperatures staying unusually cool into June in 2014, leaf disease development was delayed. With June also being the wettest month of the growing season (Figure 6) and the 16th wettest in 120 years, conditions perpetuated several leaf diseases in 2014 that were prevalent in 2013 (Aküz et al. 2014).

The 2014 growing season appears wetter than normal overall (Figure 7). However, the percent of normal rainfall for July showed levels falling to roughly 50 percent of the norm across most of the state. In fact, July was rated as the 19th driest in the past 120 years (Aküz et al. 2014). Thus, the leaf diseases characterized by cyclical infection that benefitted from a wetter June were halted in July when dry conditions prevailed.

Drought stress to trees was reported from several areas in the state after July. What followed was an extremely wet August (fourth wettest in 120 years; as a specific example, 795 percent of normal rainfall in the southwestern part of the state) and a very dry September across most of the eastern part of the state (below half normal precipitation in many areas).

In summary, many diseases developed due to wet weather in 2013 but never gained significant momentum due to the wet/dry pattern of 2014. These highly fluctuating weather statistics typified conditions during the 2014 growing season.

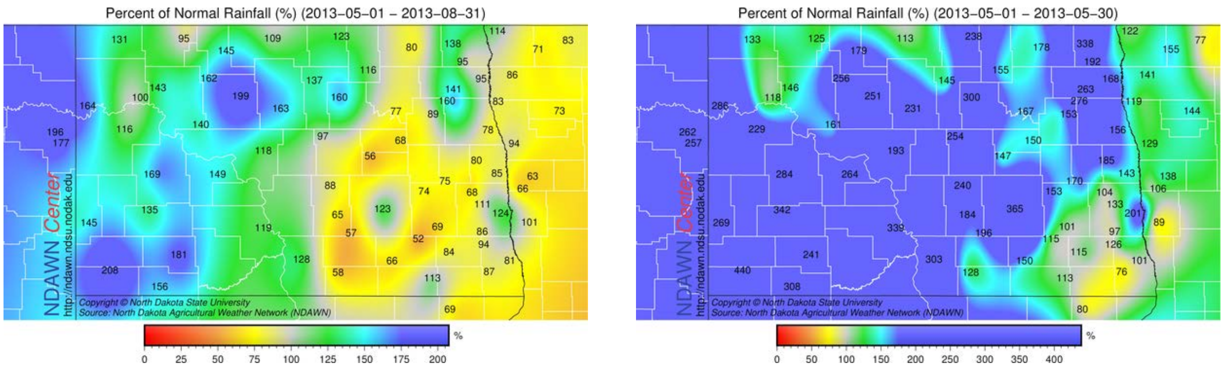


Figure 6: (left) Percentages of normal rainfall in 2013 highlight the patchiness of moisture conditions and, therefore, possible pathogen incidence; (right) a very wet May 2013 is depicted.

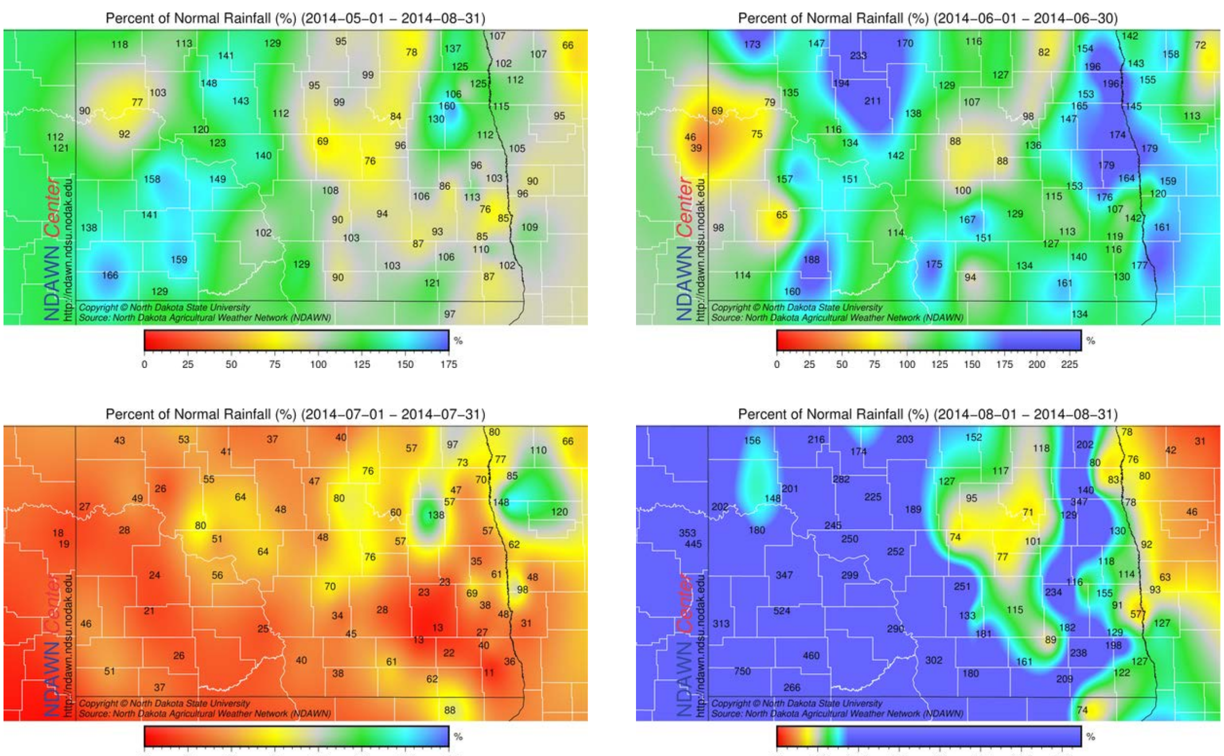


Figure 7: (top left) Percent of normal rainfall for the 2014 growing season; (top right) percent of normal precipitation for June 2014; (bottom left) percent of normal rainfall for a very dry July; (bottom right) percent normal rainfall for August 2014. (NDAWN)

Section II

Cooperative Forest Pest Surveys

Gypsy Moth *(Lymantria dispar)*

In 2013, a cooperative trapping effort was conducted by the North Dakota Department of Agriculture (NDDA), U.S. Department of Agriculture Animal and Plant Health Inspection Service Plant Protection and Quarantine (APHIS PPQ) and the North Dakota Forest Service (NDFS). NDFS Forest Health placed 157 of 380 traps in the state (Figure 8).

Figure 8: A weathered gypsy moth trap at Towner State Nursery. (*Aaron Bergdahl, NDFS*)

In 2014, the North Dakota Forest Service Forest Health Program again cooperated with the NDDA and APHIS PPQ and placed 147 of a total of 339 traps. No gypsy moths were detected in 2013 or 2014. No positive finds of gypsy moth have occurred in North Dakota since 2005 (Mike Kangas, personal contact).

Emerald Ash Borer *(Agrilus planipennis)* (EAB)

In 2013, in a cooperative trapping effort, the NDDA, APHIS PPQ and the NDFS Forest Health placed a total of 364 "purple sticky prism" EAB monitoring traps throughout North Dakota (Figure 9). NDFS Forest Health was responsible for roughly 100 of these traps. In 2014, NDFS Forest Health placed roughly 80 EAB monitoring traps. No EAB were detected in 2013 or 2014.

Figure 9: An emerald ash borer trap. (*Aaron Bergdahl, NDFS*)

In 2013, a new EAB pheromone lure was tested in 25 traps placed in selected sites across the state. The lure, (3Z)-lactone (aPhinity EAB, Sylvar Technologies Inc., New Brunswick, Canada) is a synthesized copy of a female EAB-produced pheromone that has shown higher trapping rates in low-density EAB populations. This new lure was used in combination with the 3(Z)-Hexanol and manuca oil lures. No EAB were detected with the new pheromone lure, and no distinguishable differences were discovered in the collateral insects that were collected (no native *Agrilus* spp., such as the two-lined chestnut borer, *Agrilus bilineatus*, were found in the traps when inspected at the conclusion of the trapping season). The use of this pheromone for EAB trapping was discontinued in 2014.

General Health of Spruce Plantings Across North Dakota

In 2014, Jim Walla of Northern Tree Specialties, a retired NDSU forest pathologist, was contracted to conduct a general health assessment of spruce plantings across North Dakota. The survey was designed as a resurvey of a long-term spruce health monitoring project started at NDSU and was supported by the NDFS in 1987. The most recent resurvey was conducted in 2006.

Spruce plantings were sampled along two east-west transects, one across southern North Dakota and one across northern North Dakota. Five counties distributed along each of those transects were selected, and between 10 and 15 plantings of various types were examined in each county. The counties were Cass, Stutsman, Burleigh, Stark and Golden Valley along the southern transect and Grand Forks, Ramsey, Pierce, Ward and Williams along the northern transect.

Examined plantings were selected in two ways. First, at least five spruce plantings at sites no closer than five miles from other sampled sites were selected in each county in a manner without known bias for the presence of specific needle diseases. Multiple planting types (e.g., single-row field windbreak, multi-row farmstead windbreak, wildlife habitat, urban park, cemetery plantings) were represented in the sample. Results of the study are expected in early 2015.

Meyer Spruce Needle Disease Survey

Spruce needle cast diseases are a significant threat to spruce tree health in North Dakota, often having a significant negative effect on the aesthetics of landscape plantings and reduced function in conservation plantings and living snow fences. That is why the Meyer spruce (*Picea meyeri*), a species native to China that is purported to be resistant to needle cast disease, was selected for a needle disease survey. To the author's knowledge, no formal evaluations of this in the Great Plains previously were conducted.

Because Meyer spruce is available at Towner State Nursery, sales records were available and indicated where Meyer spruce plantings might be found. Additionally, Lundeby's Evergreens in Tolna, N.D., and Big Sioux Nursery in Watertown, S.D., also have a longer history of growing this tree species and gladly offered their assistance and allowed access to their plantings for evaluations. In all, 94 trees from five different sites were evaluated in 2014.

Meyer spruce is most easily identified by the cones (Figure 10, top), although the mild pubescence on newer growth (Figure10, middle) proved to be a valuable characteristic for identification. Also, the growing form (Figure 10, bottom) is somewhat useful for identification when paired with the other characteristics. Meyer spruce has been described as looking like (and feeling like, due to the sharper needles) a Colorado blue spruce but with the more upright growth form of a Black Hills spruce (as opposed to the more planar branch structure of the Colorado blue spruce).

Needles from the oldest persisting needle age class were sampled from the northern, southern, eastern and western portions of the lower crown. Average growth was recorded for the previous three years, and an overall evaluation of health, growth and form was conducted. In several cases, needle cast disease was verified on Colorado blue spruce and Black Hills spruce in the immediate area. Meyer spruce trees were evaluated in random increments at each site depending on the size of the planting (every fifth or third, or every other tree in a row).

Figure 10: (top) Twig and cone comparison of (left to right) Black Hills spruce, Colorado blue spruce and Meyer spruce; (middle) a close-up image of a Meyer spruce twig showing a light pubescence that is not seen on Black Hills or Colorado blue spruce; (bottom) forest health intern Alec Miller standing next to a Black Hills spruce (center) and (further to the right) a Meyer spruce tree. (*Aaron Bergdahl, NDFS*)

Overall growth of this species was noticed to be slow in the earlier years (the youngest evaluated plantings); however, accounts from Lundeby's Nursery and Big Sioux Nursery indicated that this was normal for the species prior to a growth spurt that eventually catches up to the average growth rate of other spruce species that grow in our region.

The slowest growing spruce were 7 years old and were growing about 3 inches per year in an establishing shelterbelt with weed barrier fabric and no irrigation in Rolette County, N.D. The trees growing the best were in a nursery setting with tilled soil and no irrigation in Nelson County, N.D. An almost identical growth rate was measured from 7-year-old trees on a site in Ransom County, N.D., with drip irrigation and weed fabric. Trees on these sites had an average growth of approximately 5.3 inches over three years. On the Ransom County site, where at least 300 Meyer spruce were incorporated in a series of wildlife plantings, some trees had 2014 leaders in excess of 1 foot.

Some have questioned Meyer spruce's drought tolerance. At Big Sioux Nursery, a severe drought was experienced in 2012. The Meyer spruce that did not receive supplemental water suffered considerable dieback and reduced needle retention, while the Meyer spruce were not damaged in another area of the nursery where irrigation was provided. The trees that suffered drought grew about 1 inch less per year on average; however, the sample size was only 15 trees.

Needle cast fungi fruiting bodies were found on needles from several trees, and the spores were observed microscopically to verify whether the disease was Rhizosphaera needle cast, Stigmina needle cast or saprophytic fungi. Both needle cast fungi species were verified from samples; however, no fruiting bodies were found on needles less than 5 years old in any sampled trees. What was assumed to be saprophytic fungi, because the spores did not match Rhizosphaera or Stigmina, was observed growing on a few persisting dead needles from two samples and was thus not considered to be a threat to tree health.

The trees with the highest rate of needle cast fungi (Rhizosphaera) were previously severely drought-stressed trees that were within 40 feet of a row of Colorado blue spruce trees very severely infected with Rhizosphaera needle cast. At one site, fruiting bodies were found on 44 percent of the trees. Stigmina needle cast was confirmed on one tree, with the rest of the samples verified as Rhizosphaera needle cast. Fruiting bodies of Rhizosphaera needle cast were confirmed on 75 percent of the trees in the drought-stressed samples, compared with 15 percent on the nondrought-stressed trees at the same location but in a different area.

In conclusion, what is interesting is that in all cases, even the drought-stressed trees with a heavy inoculum load nearby, signs of needle cast were not found on any needles younger than 5 years old, and in most cases, needles were retained and disease-free for more than seven years. These preliminary observations from this initial effort may indicate a potential level of resistance to Rhizosphaera and Stigmina needle cast diseases, with subtle symptoms only shown in the oldest needle age classes of some trees. However, this information should not be considered as anything more than anecdotal at this stage.

This effort to evaluate needle cast disease resistance in Meyer spruce is in its very first stages, and assessments will expand and continue in coming years. Further, this assessment only focuses on a few parameters (growth and disease resistance), and several other factors must be considered when evaluating the suitability of Meyer spruce for planting in greater numbers in North Dakota.

Section III Recent Insect Trends of Concern

Elm Bark Beetles: Population Changes

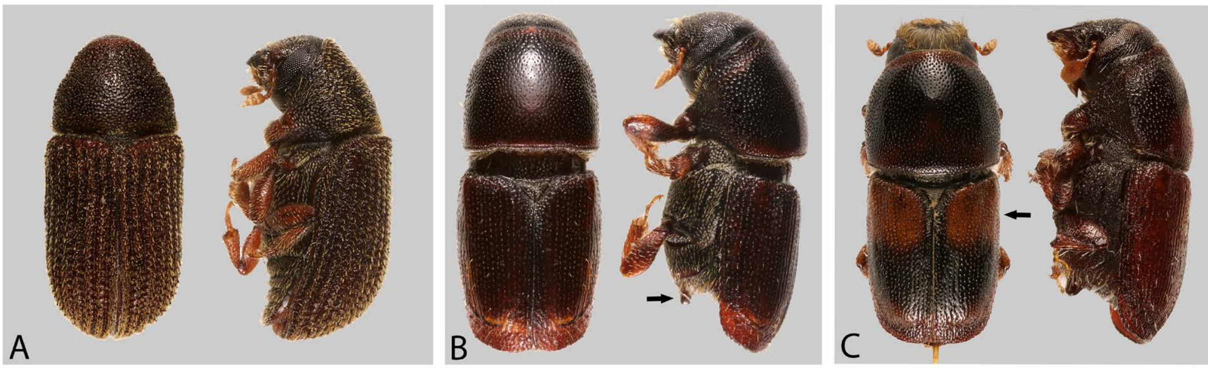


Figure 11: A) Native elm bark beetle; B) European elm bark beetle, arrow indicating distinguishing feature; C) banded elm bark beetle, arrow indicating distinguishing feature (A composite of *images taken separately by Guy Hanley, Minot State University, Minot, N.D.).*

An apparent shift in populations of elm bark beetles that vector the Dutch elm disease (DED) fungus (Figure 11) has been occurring during the past few years, with the smaller European elm bark beetle (*Scolytus multistriatus*) all but disappearing in results from insect trapping carried out by the North Dakota State University Entomology Department in eight locations around North Dakota. Native elm bark beetle (*Hylurgopinus rufipes*) and banded elm bark beetle (*Scolytus shevyrewi*) were trapped in roughly equal frequency. Only one European elm bark beetle was recorded in traps in 2013 (Gerald Fauske, personal communication).

This may have implications affecting the rate of mortality in DED-infected trees and the rate of spread of the DED fungus. This inference is based on literature that states the banded elm bark beetle (BEBB) prefers feeding on larger-diameter branches and more frequently utilizes the main stem. This translates to the introduction of the DED fungus lower in the canopy (closer to the main stem) and in the main stem, which would lead to rapid decline and death of elms infected in this way.

Further, BEBB life history information indicates that the insect is capable of multiple life cycles in a growing season, increasing the potential for vectoring the DED fungus.

Redheaded Ash Borer (RHAB) (*Neoclytus acuminatus*)
Found in Unusually Large Numbers throughout N.D. in 2013

In yearly beetle trapping results carried out and compiled by the NDSU Entomology Department, RHAB (Figure 12) was collected in record numbers in 2013. The amount of RHAB found in 2013 was several hundred percent higher than has been found on average in previous years of the survey using the same trapping protocol (same traps, lures, locations, etc.) (Gerald Fauske, personal contact). Researchers do not know why this indicated population surge has occurred. Interestingly, in 2014 the number of RHAB found in traps was back to the pre-2013 average.

Figure 12 (left) Redheaded ash borer larva; (middle) their quarter-inch, round exit holes; (right) the adult life stage. (left to right: Dan Herms, Ohio State University; James Solomon, USFS; Kansas Department of Agriculture)

Zimmerman Pine Moth

Cooperative efforts to manage Zimmerman pine moth *(Dioryctria zimmermani)* at Icelandic State Park will continue in 2015. NDFS Forest Health has been partnering with the North Dakota Parks and Recreation Department to develop effective management strategies to reduce damage from Zimmerman pine moth in plantings in high-use areas of the park (Figure 13). Last year's effort to use a granular systemic insecticide was reviewed in 2014 and a new approach will be used in 2015.

Zimmerman pine moth is a very challenging pest to manage in the northern Plains, and little current information has been published on this topic. Ideas for control strategies have been communicated by members of the forest health community in the Plains.

Figure 13: (left) Pitch masses at branch whorls are typical symptoms of Zimmerman pine moth infestation that can lead to stem breakage, especially in smaller-diameter trees (right). (*Aaron Bergdahl, NDFS*)

Japanese Beetle

Japanese beetle (*Popillia japonica*) (Figure 14) was detected in a few locations in North Dakota in 2013. The highest number trapped in the 2013 survey was in Bismarck. In 2014, following a record-cold winter, Japanese beetle was trapped in 13 locations in the Fargo metro area, Bismarck and one location in Grand Forks.

Six trap locations were in parks that were not near tree nurseries. This is significant because the suspected source of the introduction of Japanese beetle was infested nursery stock from an out-of-state supplier. The pest has not been verified to be established in North Dakota, but this information is certainly an indication that the pest may overwinter here.

Japanese beetle is of concern to tree health due to its strong feeding preference for the foliage of American basswood (*Tilia americana*) and little-leaf linden (*Tilia cordata*). It also is a serious pest of many other trees and woody horticultural plants, and is able to feed on more than 300 different species.

Figure 14: Japanese beetle adults from a 2014 NDDA monitoring trap. (*Aaron Bergdahl, NDFS*)

Section IV Recent Diseases of Concern

Apple Diseases: Fire Blight, Black Rot and Apple Scab

Figure 15: Fire blight of crabapple in Valley City, N.D. (*Aaron Bergdahl, NDFS*)

Fire blight (*Erwinia amylovora*) (Figure 15) continues to be a commonly encountered problem on apple trees, caragana and pear trees in North Dakota. This was especially true in 2013 in areas experiencing higher than normal precipitation. The opposite was seen in areas such as Carrington that experienced a very dry growing season in 2013.

The same was true for other common diseases of apple in 2014, such as black rot (*Botryosphaeria obtusa*) (Figure 16) and apple scab (*Venturia inaequalis*) (Figure 17). These diseases remained significant in areas receiving normal to above-normal precipitation. Foresters suspect that the level of these diseases still was encountered in the driest regions due to homeowner irrigation practices.

Homeowners who do not take measures to avoid spraying water directly on the crown of trees and unintentionally prolong periods of leaf wetness unknowingly create favorable conditions for the development of these diseases. Efforts continue to encourage homeowners to irrigate at night, when relative humidity is at its highest, and avoid spraying irrigation water directly on tree foliage.

Figure 16: Black rot canker in Cass County, N.D. (*Aaron Bergdahl, NDFS*)

Figure 17: Heavy summer defoliation due to severe apple scab infection in Pembina County, N.D. (*Aaron Bergdahl, NDFS*)

Cottonwood Canker Fungi

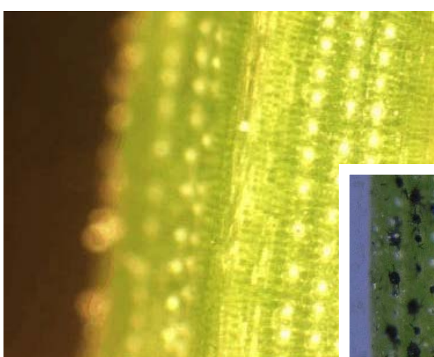
Cankers of cottonwood were recognized as a significant problem throughout North Dakota in 2014 with several calls for assistance in towns as well as shelterbelt plantings (Figure 18). The canker fungi involved were determined to be Phomopsis canker of cottonwood *Phomopsis macrospora* and a *Cytospora* spp. In several cases, the most severe cankering was seen on cottonless hybrids of cottonwood. In most cases, these trees were at the end of their service life or were otherwise stressed for unclear reasons.

No effective management strategies for these cankers are available. Foresters have observed that in our region, hybrids of the genus *Populus* typically accrue tree health issues after about 25 years of growth and quickly decline thereafter. This should be considered when using these hybrids as shelterbelt and landscape plantings.

Figure 18: A canker believed to be caused by the fungal pathogen *Phomopsis macrospora* in Cavalier County. N.D. (*Aaron Bergdahl, NDFS*)

Spruce Health Issues: Needle Diseases and a Possible New Phytoplasma Disease

Stigmina needle cast (Figure 19, top) appears to have replaced Rhizosphaera needle cast (Figure 19, bottom) throughout North Dakota, but many people are not aware of any change because the symptoms of both diseases are quite similar. Management recommendations for Rhizosphaera are not adequate for Stigmina management, but until the actual extent of the two pathogens is determined, recommendations for both diseases need to be provided. The spruce health survey mentioned earlier in this report should provide a clearer picture of the occurrence of these diseases when final results are made available.



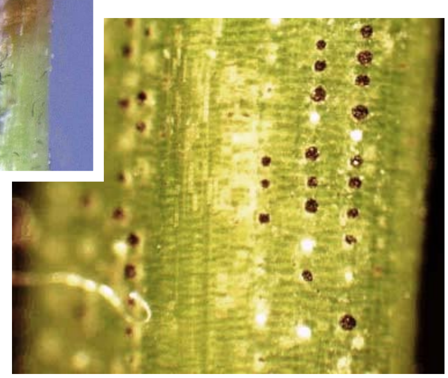


Figure 19: (top) A healthy needle; (middle) a needle with the fuzzy-appearing tendriled fruiting bodies of Stigmina needle cast fungus; (bottom) a needle with characteristically smooth-margined Rhizosphaera fruiting bodies. (*Kasia Kinzer, NDSU*)

Several reports of deformed spruce needles, as pictured in Figure 20, have emerged in isolated areas of North Dakota. In these cases, the use of herbicides in the area has been eliminated and questions have been raised about possible agents.

Figure 20: Deformed current-year growth of spruce possibly due to infection by a phytoplasma has been reported in several locations in North Dakota (*Aaron Bergdahl, NDFS*).

Efforts utilizing molecular analysis at the NDSU Plant Sciences Department to verify the possible presence of a phytoplasma, *'Candidatus* Phytoplasma *pini,*' that may be responsible for this type of deformation. Although results were inconclusive for the sample pictured in Figure 20, as well as a few others, a sample from western ND tested positive. This is not currently a major threat to general spruce health; however, it has been seen to spread in conservation plantings and stunts tree growth, and could reduce windbreak effectiveness. If this type of deformation is not the result of a phytoplasma, researchers have suggested that the agent of damage may be some kind of eriophyid mite.

Chlorosis

Chlorosis is a perennial problem in North Dakota, especially when weather conditions are favorable for development of this common disorder of predominantly maple and birch species (Figure 21). The amount of precipitation in both years covered in this report was higher than usual in the early spring in most areas, with an extremely wet May 2013 and a wetter than normal June 2014 (Reference Figures 6,7). This, in connection with prolonged cool soil temperatures, led to a higher than normal incidence of chlorosis in trees, especially maples.

Figure 21: Chlorosis of maple. (*Aaron Bergdahl, NDFS*)

Section V

Other General Tree Health Trends of 2013-2014

Ponderosa Pine Windbreak Decline in Burleigh, Kidder and Stutsman Counties

The decline of mature ponderosa pine windbreaks has been seen increasingly in the past years in Burleigh, Kidder and Stutsman counties. Decline, such as that pictured in Figure 22, has been reported to be quite rapid and has been associated with damage that appears to be of a "wilting" type. No signs of root pathogens were discovered following digging around the base of several trees, and soil test results have been within normal range.

Figure 22: A mature ponderosa pine windbreak in Burleigh County, N.D., showing rapid decline in July 2013. Most of these trees died and have since been removed (*Aaron Bergdahl, NDFS*).

Closer observation of these conservation plantings revealed the presence of ips engraver beetles that seem to have taken advantage of stressed trees. In many cases, the trees were originally planted to meet past cost-share specifications or in line with the recommendations of that time, which meant they were placed too close together.

Today, in situations where shelterbelts and plantings have not been thinned, the mature trees are in heavy competition with neighboring trees for resources. Additionally, trees may be affected by other stressors such as herbicide exposure and competition with heavy bromegrass and other vegetation. These factors together clearly represent significant stressors leading to tree decline and making them attractive and susceptible to mass attack by ips beetles.

A similar, large-scale example of this was observed at the North Beulah Mine Wildlife Management Area in Mercer County, where most pines in that area were suffering dieback and mortality due to heavy ips infestation. (Figure 23) Multiple insects were collected from infested trees and determined to be *Ips grandicollis* by the entomology lab at NDSU. This was the first time that the insect species was reported in Mercer County.

Figure 23: (top) Symptoms of ips infestation at North Beulah Mine Wildlife Management Area in Mercer County, N.D.; (bottom) insect galleries, larvae, pupae, adult ips beetles and blue-stained wood were evidence of ips infestation at the location. (*Aaron Bergdahl, NDFS*).

Porcupine Damage in the Native Ponderosa Pine Forest Resources of Slope County, N.D.

On several visits to the native ponderosa pine stands in Slope County, extensive damage from porcupine feeding was seen (Figure 24). The original reason for visiting this area was to evaluate the possibility of ips bark beetle damage to the unique resource there resulting from accumulation of slash piles from ongoing fuels-reduction activities in the area. Information from an aerial survey of the area also indicated a need to do some ground-truthing for a potential forest health issue.

While ips beetles were present in the area and were causing a limited amount of damage in a few specific areas where trees had been stressed for various reasons like fire or porcupine damage, bark beetles did not appear to be the primary forest health issue. This was somewhat surprising considering the large amount of slash piles throughout the area that could have served as prime beetle breeding material and subsequently could have led to epidemic levels of ips damage. The reason this did not occur is likely due to wetter weather in southwest N.D. in the past few years. High moisture weather patterns have been shown to keep ips beetle populations in check in western states, as it results in high ips beetle mortality.

Insects collected from slash piles were identified by NDSU entomologists, leading to two new county reports for *Ips pini*, a more serious, mostly secondary pest of pine trees, and a less aggressive tertiary beetle, *Pityogenes carinulatus*. While slash management best management practices have been addressed, extensive porcupine feeding damage remains an issue of concern.

Figure 24: Examples of porcupine feeding damage on ponderosa pine in Slope County, N.D. (*Aaron Bergdahl, NDFS*).

Winterburn of Conifers

The number of reports of winterburn of conifers was typical for 2013, while the prolonged, harsh winter of 2014 resulted in a major spike in reports. In urban settings, conifers with winterburn symptoms were so abundant, they just about outnumbered those without symptoms (Figure 25).

Rural plantings also were injured at higher-than-normal levels. This phenomenon was not so much a factor of poor soil moisture conditions going into the fall of 2013 or the very cold, harsh winter, but rather a consequence of a rather fast warmup period following a delayed spring.

Figure 25: Winter injury was seen statewide due to the winter of 2013-14 that was longer and colder than usual. (*Aaron Bergdahl, NDFS*)

Herbicide Injury

Herbicide damage (Figure 26) continues to be a commonly encountered abiotic agent of damage to trees and shrubs in urban and rural environments. Improper or careless selection and/or application of pesticides constitute a substantial percentage of homeowner inquiries regarding tree and shrub health in North Dakota.

Cultural practices, such as improper planting, mulching, pruning, watering, fertilization practices and failure to remove landscape fabric, mostly by private homeowners, constitute a major proportion of tree health issues responded to by the forest health specialist in North Dakota. Continued efforts to educate the public about species and site selection (right tree for the right place) and proper tree care continue to be a priority of the North Dakota Forest Service, North Dakota State University, and state and municipal entities involved in the care of tree resources.

Figure 26: Severe chemical injury to the leaves of a hackberry in Bottineau County, N.D. (*Aaron Bergdahl, NDFS*)

Section VI Aerial Survey 2013 and 2014

Overview of 2013 Aerial Survey Results

In 2013, the NDFS's Forest Health Program contracted with the Minnesota Department of Natural Resources' resource assessment group from Grand Rapids, Minn., to do an aerial forest health survey of forest resources in the Red River (Appendix 2) corridor along the North Dakota/Minnesota border and the Pembina Gorge in northeastern North Dakota (Figure 27). The survey did not take place until July due to the late phenology of trees resulting from the longer cool spring.

The survey focused on a 300-meter buffer zone along the Red River from Wahpeton, N.D., north to the Canadian border. Roughly 90,000 acres were surveyed. In addition, the Pembina Gorge, comprising roughly 40,000 acres of forestland, was surveyed.

The purpose of the survey was to identify forest health threats in specific areas for later ground truthing. Ground truthing for this particular survey began in the fall of 2013 and continued during the 2014 field season. This process allows confirmation of the presence/absence of forest pests/disorders and quantifies the extent of impact on the forest resource. Management options will be outlined for forestland owners/managers if needed or requested.

The main deliverables of the project were aerial mapping of the identified forest resources via a geographical information system (GIS). GIS shapefiles containing polygons coded according to damage type were given to the NDFS for use in reports and mapping. Pictures also were taken from the air by the forest health specialist for use in NDFS publications.

The main findings of the survey were:

- Approximately 2,000 acres of forest tent caterpillar (FTC) (Malacosoma disstrium) defoliation and roughly 1,300 acres of flooding mortality was recorded along along the Red River.
- Dutch elm disease (DED) (Ophiostoma ulmi/ O.novo-ulmi) was seen scattered throughout the Pembina Gorge and along the Red River.
- Several hundred acres of uncategorized "decline" were reported in the Pembina Gorge area. These sites will be visited to determine the actual agents of decline. From the air, these areas appeared to be predominantly aspen.

Overview of 2014 Aerial Survey Results

In summer 2014, the NDFS conducted aerial surveys of forest resources along the Souris (Mouse) River and in the Turtle Mountains, ponderosa pine forests in the southwestern region of North Dakota, the Killdeer Mountains region, a portion of the Little Missouri River and riparian forests along the Missouri River west of Fort Berthold, N.D., to the Montana border (Figure 27). The purpose of the survey was to identify forest health threats in specific areas for later ground truthing.

The NDFS Forest Stewardship program participated in the Turtle Mountains and Souris River portion of the survey to gain perspective on overmaturity of aspen resources in parts of the Turtle Mountains and riparian forest resources impacted by past flooding events.

The U.S. Forest Service's Forest Health Management Program Aerial Survey Team from Missoula, Mont., assisted in the survey of the ponderosa pine resources and riparian forests along the Little Missouri River and in the northwestern-most part of the Missouri River in North Dakota in June.

For the July survey of the Turtle Mountains, Souris River and Missouri River (from Garrison Dam to Cannonball, N.D.), the forest health program contracted an aerial survey crew from the Minnesota Department of Natural Resources' resource assessment group from Grand Rapids, Minn. Both survey groups used geographical positioning systems on board the aircraft and aerial imagery on specialized tablet computers to record information about forest health.

The collected data was given to NDFS Forest Health for input into ArcMap, a geographical information system computer program enabling closer analysis, acreage calculations and mapping of forest health issues of concern. Aerial photos of areas of concern and healthy forests also were taken (see the Appendix).

Notable findings of the 2014 aerial survey include:

- Roughly 4,500 acres of forest tent caterpillar/large aspen tortrix defoliation occurred in the Turtle Mountains (Appendix 4). This number is down from about 20,000 acres from the previous survey in 2011. Also, approximately 4,000 acres of aspen decline (undefined) was recorded in the Turtle Mountains. Overmaturity, meaning aspen stands are old and have accumulated various health problems such as stem and root rots, has been determined to be the main cause of this issue.
- In the Souris River basin (Appendix 5), roughly 20,000 acres of standing dead trees were recorded due to flooding during the growing season (2011 flood).
- The state's only native ponderosa pine forests in Slope County (Appendix 6) comprise roughly 10,000 acres. Overall, these forests were in good health and no mountain pine beetle, an insect that has strongly impacted pine forests in the Black Hills, was observed. Damage to trees by porcupine feeding and other bark beetles was seen in several areas.
- Killdeer Mountain (Appendix 7) forest resources were overall in good health, although several defoliated areas were identified. These areas will be revisited in 2015 to determine the actual defoliator and determine the extent of the phenomenon.
- Forest resources along the Missouri River (Appendix 8) and Little Missouri River (Appendix 9) were in good health overall and no major forest health threats or trends were seen from the air.

Plans are being made to conduct future aerial surveys focusing on riparian forests on the Sheyenne River and Devils Lake Hills.

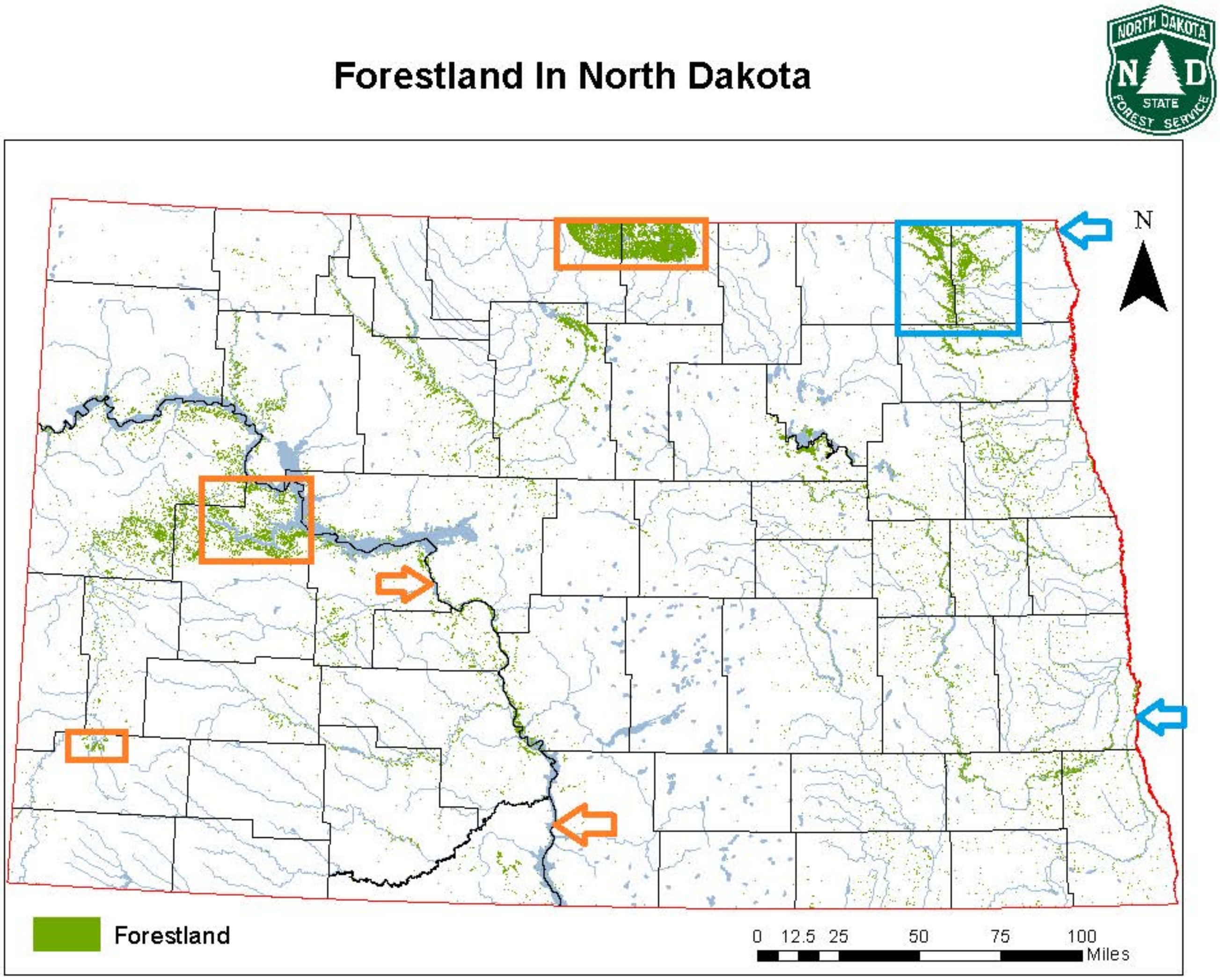


Figure 27: Aerial survey locations from 2013 (blue) and 2014 (orange). Arrows indicate the start and end point of the survey of riparian forest resources (NDFS).

Forest Health Program Activities

Emerald Ash Borer First Detector Training

Emerald Ash Borer First Detector Training in 2013 was held during the joint meeting of the North Dakota Urban and Community Forestry Association (NDUCFA) and North Dakota Nursery and Greenhouse Association in Fargo, N.D. This earlier-than-usual January training included an informational session, an indoor hands-on ash log-peeling session and firewood identification session.

In 2014, EAB First Detectors training events again were held in Fargo and Mandan and included the Master Gardeners program training for the first time (Figure 28). More than 50 people attended the training, elevating the number of North Dakota EAB first detectors to more than 300.

Figure 28: Emerald Ash Borer First Detector Training at the Mandan, N.D., USDA Agricultural Research Station (*Aaron Bergdahl, NDFS*).

Emerald Ash Borer Awareness Week

EAB Awareness Week 2013 was observed during May 19-25. Activities included a governor's proclamation of the event and cooperation with 16 communities and several state parks. Those participating hung weatherproof fliers on ash trees to highlight information about EAB, its potential to change local tree resources and other messages, such as "Don't Move Firewood" and increase tree diversity in tree resources (Figure 29).

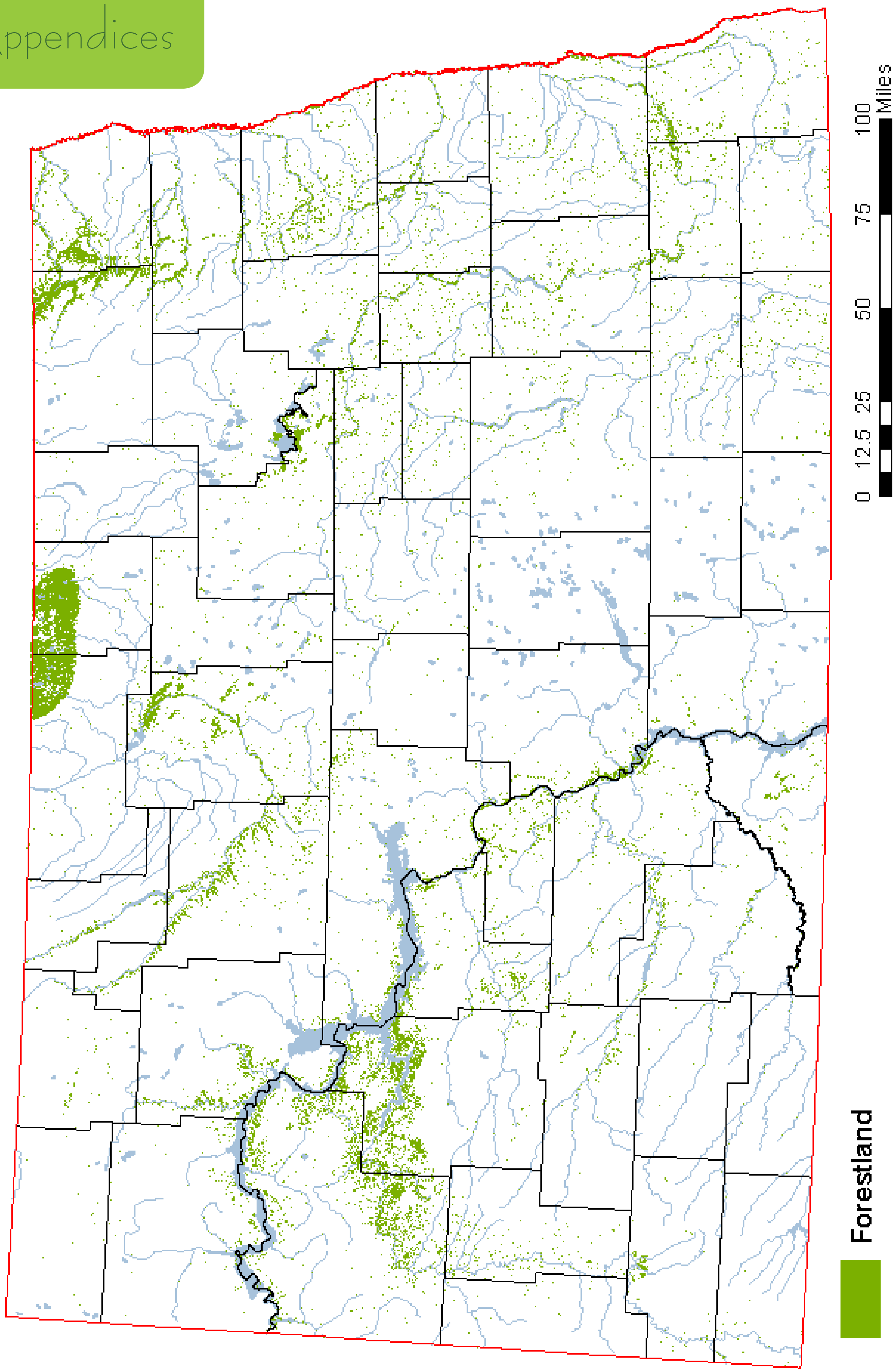
EAB Awareness Week 2014 was preceded by a governor's proclamation declaring May 18-24 a week to increase awareness of the potential threat of EAB to North Dakota's tree resources.

By partnering with the North Dakota Forest Service's Community Forestry Program, EAB Awareness Week took an important, large step forward in 2014. Utilizing community forestry's expertise and community contacts, the number of communities that participated doubled from the previous year to 32 towns of varying sizes across North Dakota. Again, several state parks also participated.

Weatherproof fliers were hung on ash trees to highlight information about EAB and its potential to drastically alter tree resources. Messages focused on issues including the danger of transporting invasive tree pests such as EAB in firewood and increasing species diversity of community tree resources. Fact sheets and EAB talking points for use when addressing the news media also were provided to community contacts on flash drives.

Future Awareness Week efforts will continue to involve cooperation among North Dakota Forest Service, Forest Health and Community Forestry programs, the North Dakota Department of Agriculture and North Dakota State University Extension Forestry.

Figure 29: EAB Awareness Week fliers at a Bottineau, N.D., park; flash drives used to provide communities with EAB Awareness Week information. (*Aaron Bergdahl, NDFS*)



Appendix 1: Forestland coverage in North Dakota (NDFS).

Appendix 2: Riparian forest on the Red River in North Dakota from the 2013 aerial survey. (*Aaron Bergdahl, NDFS*)

Appendix 3: Forest resources of the Pembina Gorge in northeastern North Dakota. (*Aaron Bergdahl, NDFS*)

Appendix 4: Native, predominantly aspen forests in the Turtle Mountains in north-central North Dakota experienced relatively little pressure from defoliating insects, compared with last year. (*Aaron Bergdahl, NDFS*).

Appendix 5: Dead, mature trees still standing in the Souris River basin in north-central North Dakota due to long-duration flooding in 2011. (*Aaron Bergdahl, NDFS*).

Appendix 6: Ponderosa pine forests in the southwestern region of North Dakota. (*Aaron Bergdahl, NDFS*)

Appendix 7: Forested areas of the Killdeer Mountains in Dunn County, N.D., showing evidence of defoliation by a yet unidentified defoliating agent. (*Aaron Bergdahl, NDFS*)

Appendix 8: Riparian forests along the Missouri River were generally in excellent health, although concerns about limited cottonwood regeneration remain. (*Aaron Bergdahl, NDFS*)

Appendix 9: The riparian forests on the banks of the Little Missouri River. (*Aaron Bergdahl, NDFS*)

References and Sources of Supplemental Information

- Akyüz, A., Ritchison, D., Shlag, A., Gust, G., and Mullins, B.A. 2014 North Dakota Climate Bulletin, North Dakota State University, Department of Soil Science, Summer, 2014.
- Akyüz, A., Ritchison, D., Shlag, A., Gust, G., and Mullins, B.A. 2013 North Dakota Climate Bulletin, North Dakota State University, Department of Soil Science, Summer, 2013.
- Cranshaw, W. 2004 Garden insects of North America: The Ultimate Guide to Backyard Bugs. Princeton University Press, New Jersey
- Haugen, David E.; Harsel, Robert; Bergdahl, Aaron; Claeys, Tom; Woodall, Christopher W.; et al. 2012. North Dakota's forests 2010. Resour. Bull. NRS-76 Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 52 p.
- Johnson, W., and Lyon, H. 1991. Insects that Feed on Trees and Shrubs, 2nd Edition. Cornell University Press, Ithaca. 560 p.
- North Dakota Gypsy Moth Detection Survey Trapping Schedule, North Dakota Gypsy Moth Survey Committee, USDA PPQ. Version Jan. 12, 2011.
- Riffle, J., and Peterson, G., technical coordinators. 1986. Diseases of Trees in the Great Plains. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service. GTR RM-129. 149 p.
- Sinclair, W.A., and Lyon, H.H. 2005 Diseases of Trees and Shrubs (Ed. 2). Comstock Publishing Associates
- North Dakota Agricultural Network: http://ndawn.ndsu.nodak.edu/

Thanks to Dr. Jim Walla, Dr. Joe Zeleznik, Tom Nowatzki, Steven Burdick, Larry Kotchman, Tom Claeys, Mike Kangas, Gerri Makay, Scott Liudahl, Mike Fugazzi, Brian Johnson and Bruce Johnson for contributing anecdotal information about regional tree health trends in North Dakota.

Also, the following organizations deserve thanks for their contribution to this document: Region 1Forest Health Management USDA US Forest Service, North Dakota State University, North Dakota Department of Agriculture, North Dakota Game and Fish, North Dakota Parks and Recreation, North Dakota Association of Soil Conservation Districts and Minnesota Department of Natural Resources Resource Assessment Group.

Partial funding for this report is made available through support from the USDA Forest Service State and Private Forestry Program.

Any inquiries about the North Dakota Forest Service insect trapping or the Forest Health Program in general can be directed to Aaron.D.Bergdahl@ndsu.edu or (701) 231-5138. This publication is available in alternative formats by calling (701) 231-5138.