



Waupaca County Forest Regeneration 2021 County Deer Advisory Report

Wisconsin Department of Natural Resources - Division of Forestry

March 08, 2022

Summary - Forest Regeneration

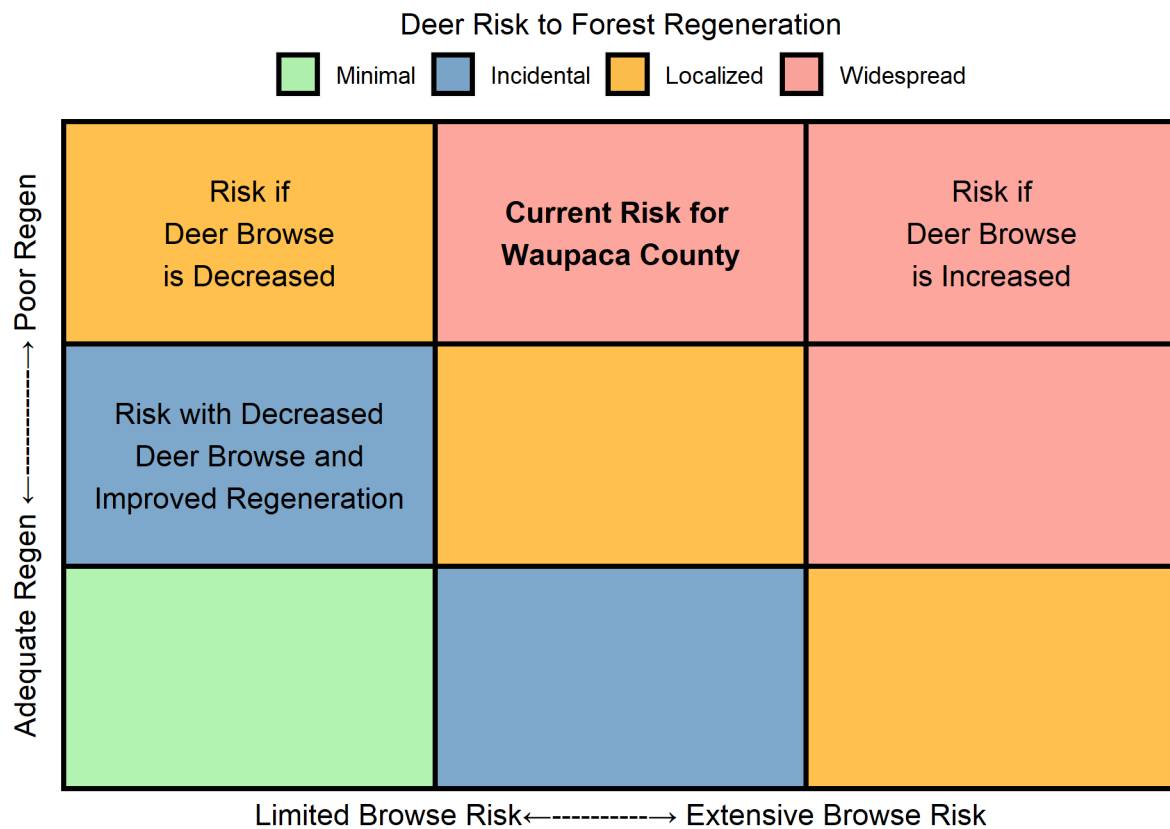
In Wisconsin, forest management relies on natural tree reproduction or regeneration to ensure the benefits of sustained outdoor recreation, wildlife habitat and timber production. Natural regeneration is the process when new tree seedlings become established through natural seeding, sprouting, suckering, or layering after trees are harvested or die from other causes. Successful regeneration is critical to sustainable forest management.

There are many factors that can affect forest regeneration such as the weather, interfering plant species and forest management practices. Animals browsing for food on seedlings and sapling can also pose a significant impediment to forest regeneration. In Wisconsin, white-tailed deer are the most common large animal that regularly eats tree leaves and stems. Research has regularly shown that high deer density often leads to increased browse impacts on forest regeneration.

Risk to Forest Regeneration in Waupaca County

Forest regeneration analysis conducted by the DNR Division of Forestry indicates that white-tailed deer browse currently poses a **widespread** risk to forest regeneration in Waupaca County. This result is derived from observations of significant regeneration difficulties and average deer browse.

The DNR Division of Forestry concludes that reducing the deer population in Waupaca County will likely reduce this risk and the severity of current regeneration impacts. Likewise, increasing the deer population will likely increase current risk and intensify current regeneration impacts.



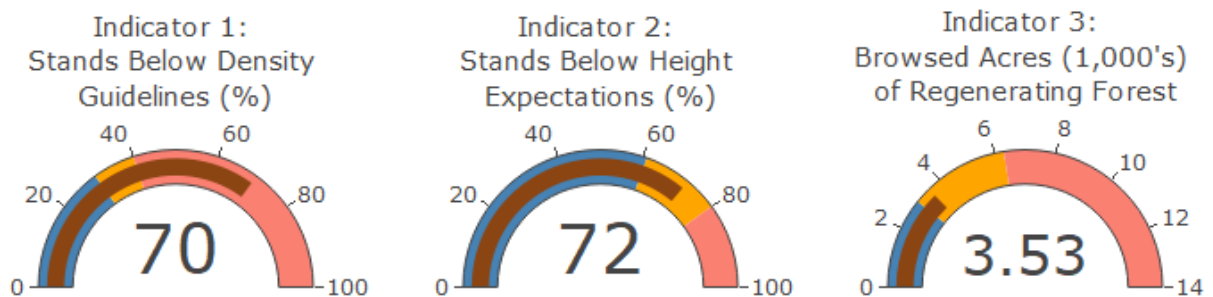
This risk table indicates the current risk that deer pose to forest regeneration in Waupaca County. It also demonstrates the likely consequences of increasing or decreasing deer browse. For example, an increase in deer browse will move the current risk right, whereas a decrease will move it left, unless already at the upper or lower limit. Over time, an increase in deer browse will likely worsen regeneration, moving risk up, where a decrease in browse will improve regeneration moving risk down. Find descriptions of the four risk categories in Appendix C at the end of this report.

Forest Risk Metrics for Waupaca County

The DNR Division of Forestry reports three metrics to identify risks to forest regeneration:

- Percentage of stands below density guidelines
- Percentage of stands below height expectations
- Acres of regenerating forest with deer browse present

These metrics contribute to our understanding of whether forest stands are meeting seedlings and sapling density guidelines, whether seedling and sapling heights are meeting growth rate expectations and whether observed browse and disturbance acreage is at level where regeneration impacts are more likely. The total number of indicators in the red or orange determine the current risk to deer regeneration.



The dark brown dial line and number represent Waupaca County's performance on each indicator. For Indicator 1, the color shaded areas reflect the stocking standards from the Wisconsin Silviculture Handbook. For indicators 2 and 3, the color shaded areas represent the 33rd, 66th and 100th percentiles for that value.

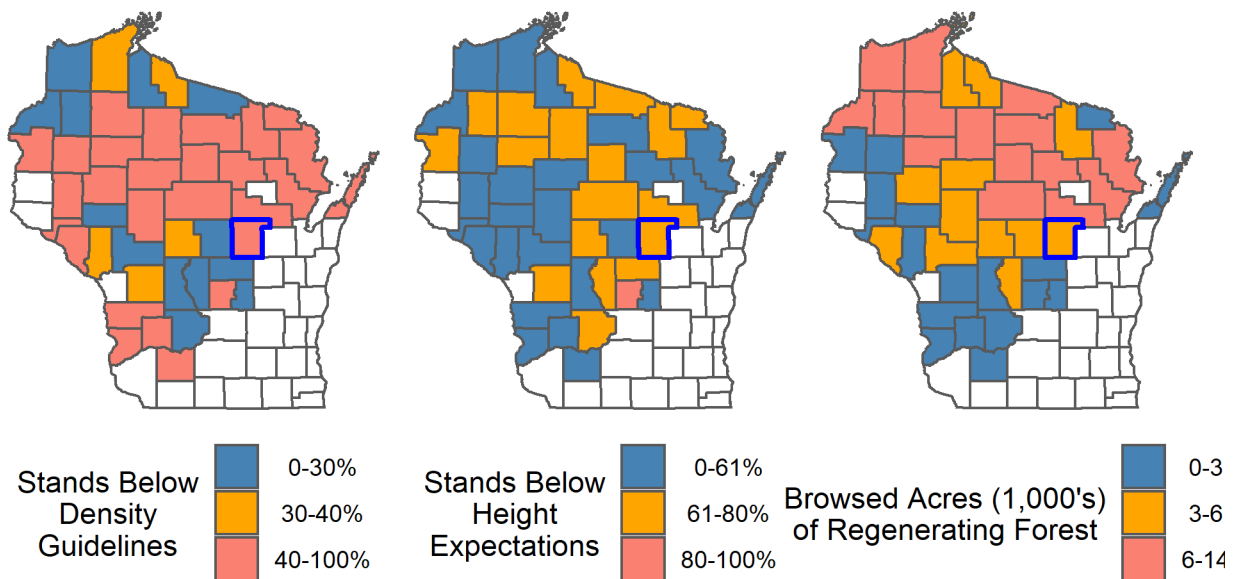
Indicator 1 - Forest regeneration monitoring from 2018-2021 indicates that **70%** of the recently harvested stands observed in Waupaca County are failing to meet regeneration guidelines. If a significant percentage of stands are failing to meet guidelines, this indicates that deer could be a factor impeding the overall regeneration of seedlings and saplings in Waupaca County.

Indicator 2 - Forest regeneration monitoring from 2018-2021 indicates that **72%** of recently harvested stands in Waupaca County are not meeting regeneration height expectations. When a forest stand is not progressing to maturity as quickly as expected, it indicates that deer browse may be restricting seedling and saplings growth, and the seedlings and saplings do not mature as expected. This impact can impede regeneration of forest stands even when minimum density guidelines are being met.

Indicator 3 - Forest regeneration monitoring from 2018-2021 recorded deer browse on **91%** of stands in Waupaca County. To estimate the overall risk that deer browse poses to regenerating forests, the percentage of stands with observed browse is scaled by the annual average **3,860** acres of forest disturbance in Waupaca County. Forest disturbance includes forest acres harvested or damaged by fire, wind, or flooding. In total there are **3,531** acres of browsed forest disturbance in Waupaca County. For this metric, a higher number indicates greater overall risk to forest regeneration, while a lower number indicates lower risk.

Taken alone, none of these indicators tell us for certain that deer browse is or is not having an impact on forest regeneration. When taken together, these indicators show the relative likelihood that deer browse is impacting forest regeneration and the ecological and economic risk it may pose to forests in Waupaca County.

The following maps show the regeneration metric status for counties in Wisconsin where we are monitoring forest regeneration.

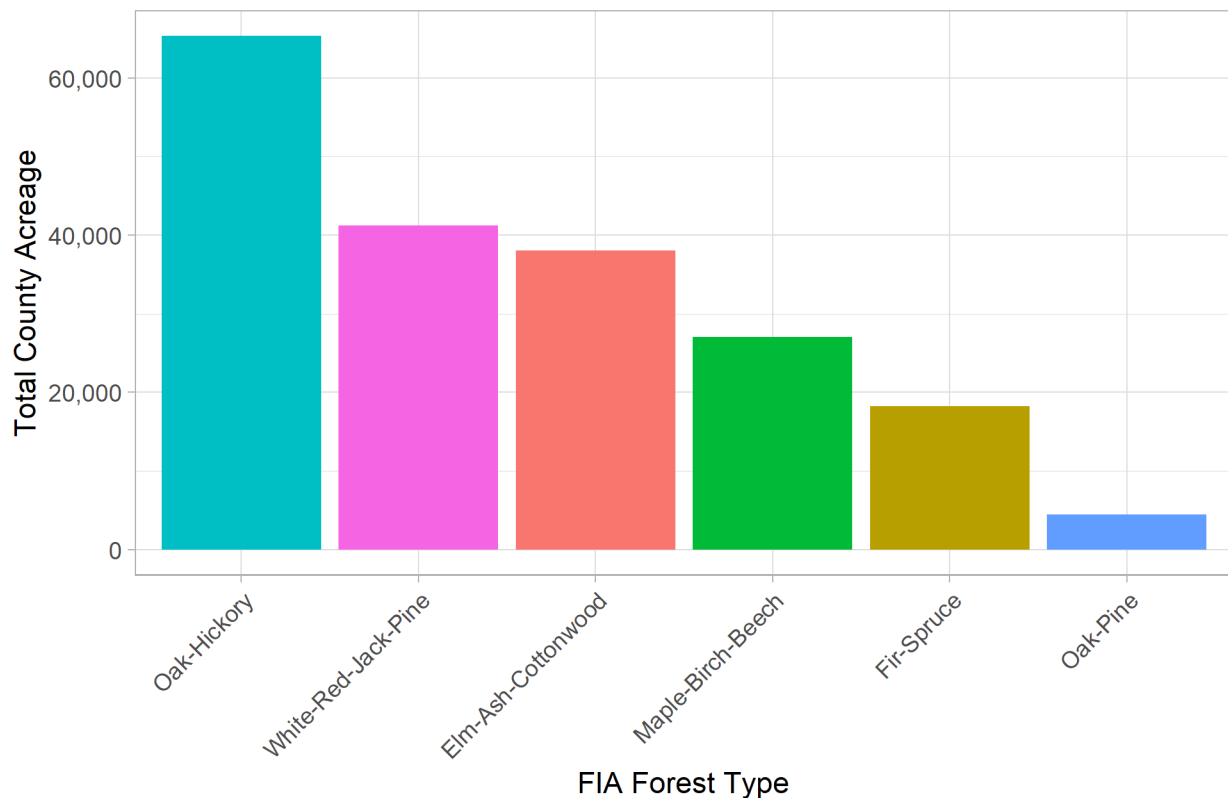


Report Detail for Waupaca County

County Overview

Waupaca County has a total of 489,504.2 acres of which 217,984 are forested. In terms of forested land cover, Waupaca County ranks #32 in Wisconsin at 45% forested. Forestry in Waupaca County yields approximately \$4.56 million per year in economic output.

FIA Forest Type Acres in Waupaca



Note - Forest Inventory Analysis (FIA) forest types are slightly different from the DNR forest cover types discussed in the remainder of this analysis.

Since forest regeneration monitoring began in Waupaca County, 2 stands with 13 plots were surveyed in 2018, 19 stands with 108 plots were surveyed in 2019, 14 stands with 66 plots were surveyed in 2020 and 12 stands with 63 plots were surveyed in 2021.

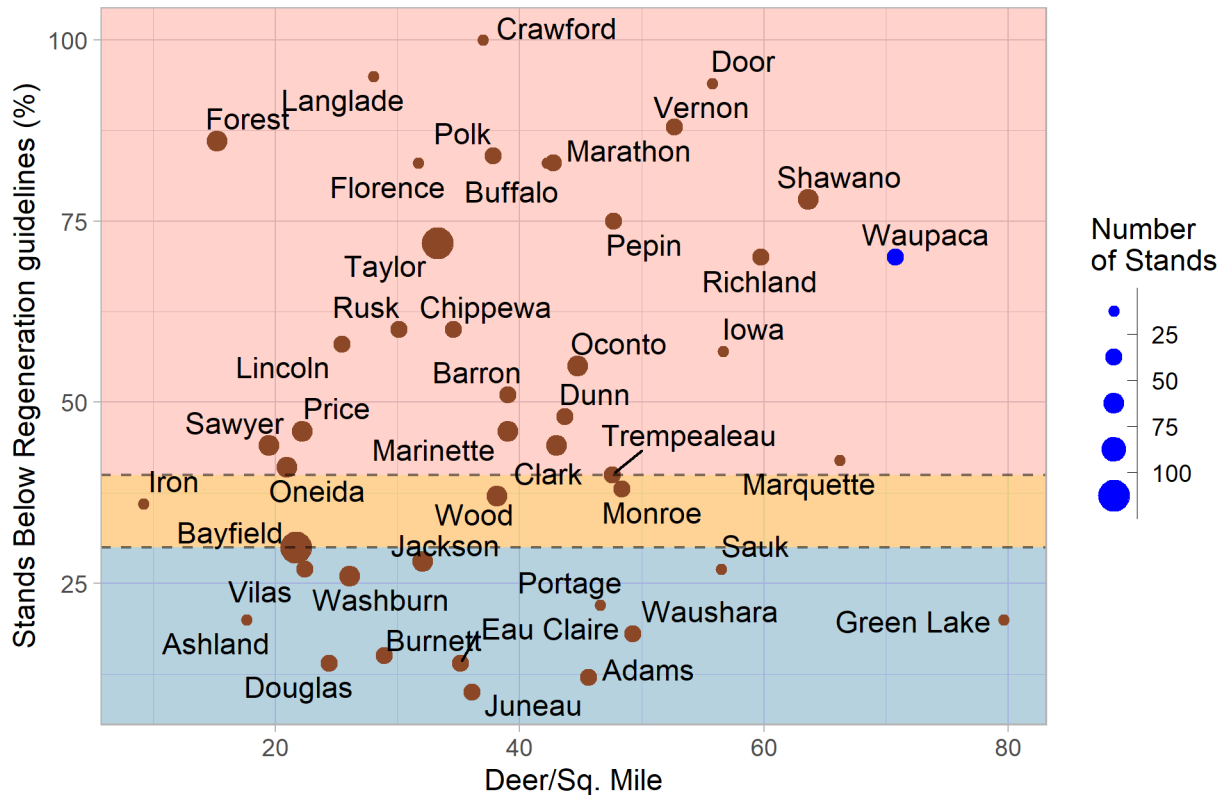
Deer Browse and Forest Disturbance in Waupaca County

Following a disturbance, such as timber harvest, fire, flood, or blow-down, tree seedlings that will eventually recruit into the forest canopy are established or released. In the early stages of regeneration after any of these five types of disturbances, young seedlings and saplings are the most vulnerable to deer browse, which slow or prevents the forest from reaching a stage of maturity where it can provide ecological and economic benefits to wildlife habitat, outdoor recreation, and timber production. Furthermore, regeneration problems associated with deer will have a relatively larger impact in areas where more acreage is disturbed, even when deer browse is less common. By comparison, where deer browse is very common but disturbances are not widespread, deer browse poses a smaller total risk to future ecological and economic health of forests. In these areas, deer browse still presents a significant risk to the few stands that are disturbed, but in absolute terms, the overall effect of these impacts will be less than in areas where disturbance is more common.

Regeneration Minimum Density Guidelines in Waupaca County

Statewide, there is a strong linear relationship between deer densities and the likelihood that recently harvested forest stands are meeting tree count guidelines for regeneration. The following graph compares the deer population in each county (x axis) to the percentage of forest stands that are below minimum density guidelines (y axis). A deer density increase of 2 deer per square mile is related to about a 1% increase in the likelihood that forest stands in that county will not meet regeneration minimum density guidelines. On the graph, an increase in deer densities would be expected to move the county up and to the right. Conversely, a decrease in deer densities would be expected to move the county down and to the left. The brown points represent the other counties in Wisconsin with forest regeneration monitoring. The size of each point is proportional to the total number of monitored stands in that county.

Deer Density and Stand Regeneration



The Wisconsin Silviculture Handbook indicates that all forest cover types are fully stocked if 70% of sample plots are meeting regeneration guidelines, and are inadequately stocked if fewer than 60% are meeting guidelines. These 60% and 70% thresholds are used here as a rough guide to identify counties that are systematically not meeting minimum density guidelines.

Forest regeneration monitoring indicates that recently harvested stands in Waupaca County are not meeting seedling and sapling regeneration guidelines on **70%** of the observed stands. In addition, the DNR Bureau of Wildlife Management staff estimate there were **71** deer per square mile of deer range in Waupaca County.

Minimum Density Guidelines by Forest Cover Type in Waupaca County

Different forest types regenerate differently in response to deer browsing preference and seedling and sapling growth patterns. In some cases, deer browse may prevent seedlings and saplings from reaching the minimum density needed for that forest ecosystem to develop into a mature, self-sustaining forest with marketable timber. This analysis is capable of determining the proportion of stands that are not meeting these minimum seedling and sapling counts. Statewide, regeneration of pine (Red, White and

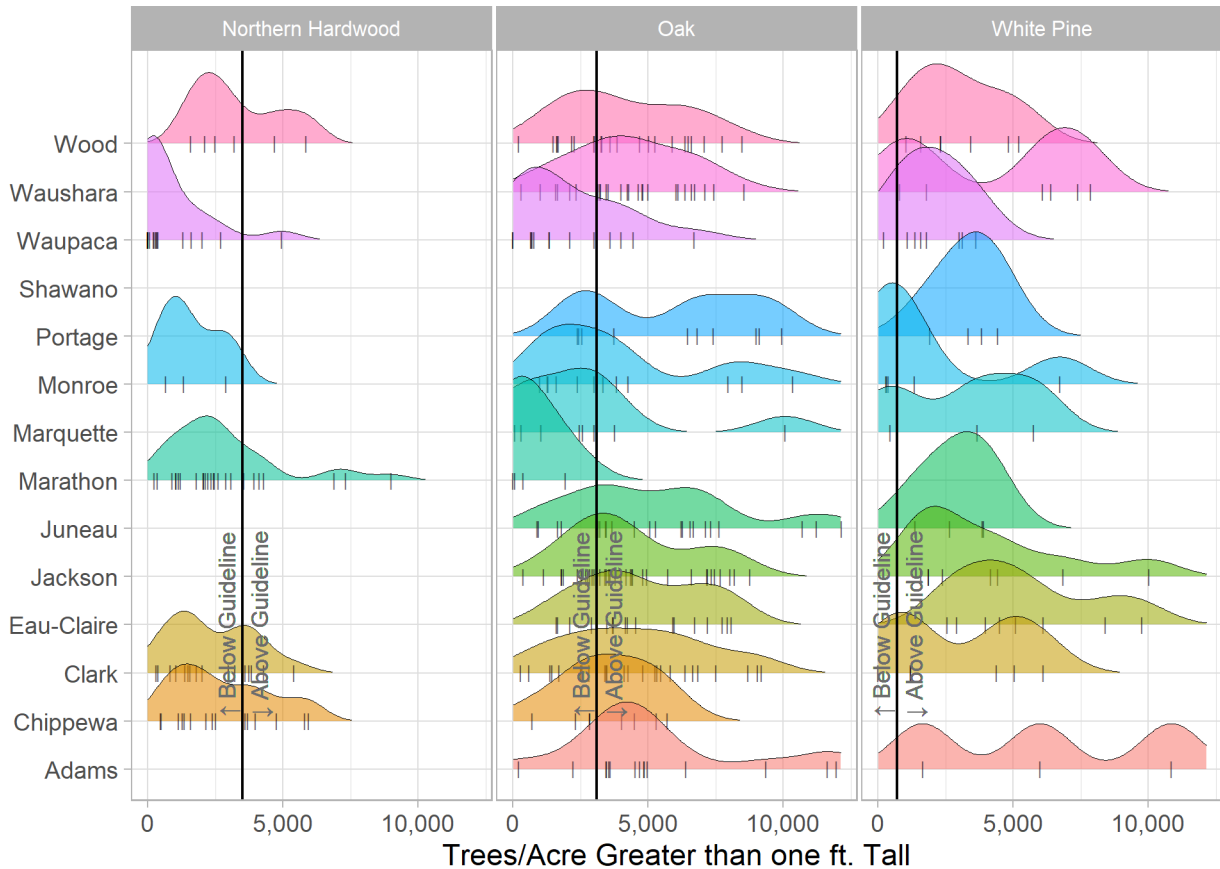
Jack) is doing well in most counties. By comparison, a larger proportion of hardwood stands such as oak and maple are falling short of the regeneration guidelines in most counties.

There are 3 forest types in Waupaca County that have been surveyed more than three times since forest regeneration monitoring began. The below table compares regeneration between Waupaca County and the regional average for these forest types.

Table 1: Forest Regeneration in Waupaca County by Forest Cover Type Compared to Region (types with less than 3 stands excluded)

Forest Type	County				Region			
	Total Stands	Seedlings per Acre	Stands Browsed (%)	Below Guideline (%)	Total Stands	Seedlings per Acre	Stands Browsed (%)	Below Guideline (%)
Northern Hardwood	17	849	94	100	87	2,735	94	78
Oak	14	2,100	93	71	243	5,552	97	34
White Pine	9	3,377	100	11	69	3,996	88	7

The plot below compares the seedlings and saplings per acre greater than one foot tall observed for different forest cover types in counties within the Forest Inventory Analysis region.



On the above plot, each shaded area represents the tree densities on monitored stands for each county. The vertical line represents the regeneration guideline for that forest cover type. The more shaded area there is to the right of the line, the more stands are meeting regeneration guidelines.

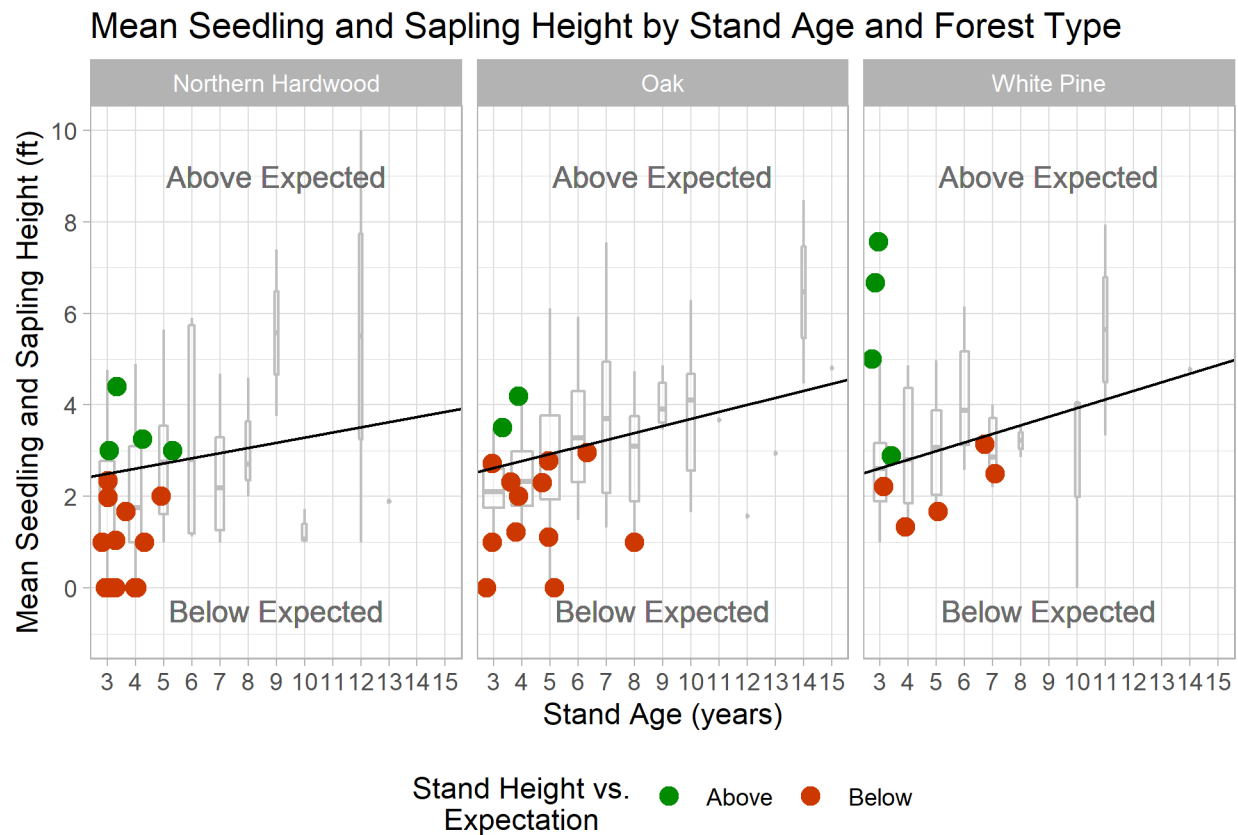
The small vertical tick marks are the observed tree density values for individual stands. More tick marks mean the shaded area is more accurately represented. If a county does not have a shaded area for a forest type, it indicates that no monitoring was done for that type in that county.

Regeneration Height Expectations in Waupaca County

In addition to affecting the total amount of trees per acre, deer browse can also affect the height distribution of a regenerating forest. For example, deer may repeatedly browse on seedlings and saplings in a manner that does not kill them but slows or stalls their growth. In this case, the minimum density guideline may be met according to the total seedling and sapling count, but over time the seedlings and saplings may never become established trees.

Forest regeneration monitoring began in 2018 and revisits stands every three years. Therefore, this analysis cannot at this time identify individual stands that are failing to mature.

However, some forest cover types (Northern Hardwood, Oak, Red Maple, Central Hardwood and Pine) can be compared to a modeled expected growth rate using statewide data for each forest type. Compared to the expected mean height for the stand's age, forest regeneration monitoring indicates that **72%** of recently harvested stands in Waupaca County are below growth rate expectations.



The above graph shows each stand in the county as a point representing average seedling and sapling heights relative to expectations for different forest cover types. The

x-axis represents the age of the stand in the number of years since its last harvest. The y-axis is the mean height of seedlings and saplings in that stand. The black line represents expected mean height at that age. Green points above the black line represent tree stands that are above expectations at that age. Red points below the black line represent stands below the expected growth rate that may be failing to adequately develop into mature forest stands. Boxplots of the regional distribution are shown behind the points to reference Waupaca County against other counties in the Central FIA region.

Note that this metric is only used as a rough guide to determine growth rate expectation. Closer investigation of the data for individual stands is needed to assess that stand's actual progression as would be expected for its age and harvest type.

Appendices

Appendix A - Forest Regeneration Monitoring Methods

Forest regeneration monitoring on recently harvested stands began in 2018 in Wisconsin. This effort is limited to the 45 (out of 72) counties with more than 30% forest cover. The goal of this monitoring is to determine if forest stands are regenerating at a rate that will support ecological purposes such as wildlife habitat and future economic benefits such as timber harvest. In addition, this monitoring attempts to identify factors that might be preventing or slowing regeneration of the forest. This is done by recording the count, height, species of all seedlings and saplings that have not grown large enough where they are free to grow without interference from other plants or animals browsing on them. In addition, other measures are recorded such as visible deer browse, canopy coverage, ground cover and the type of recent harvest that was conducted.

The forest regeneration monitoring program will attempt to revisit most stands every three years. With repeated measurement, DNR Forestry staff will be able to identify specific stands that are not progressing toward maturity and determine what factors are impacting its growth. However, since the forest regeneration monitoring program is only four years and just completed the first year of remeasurements in 2021, this analysis will not be possible for several years. For now, DNR Forestry staff have compiled indicators based on statewide statistical analysis to identify potential problems. These indicators are not capable of definitively connecting deer browse to impacts on forest regeneration, but instead indicate the level of risk deer pose to forest regeneration in a county.

The first forest regeneration indicator identifies the percentage of stands in a county meeting regeneration guidelines. When regeneration monitoring measurements are

completed on a stand, DNR staff calculate the number of desirable seedlings and saplings per acre taller than one foot and compare them to regeneration guidelines for that forest type as defined in the Wisconsin Silviculture Handbook. If the tree density is above the minimum density in the handbook, the stand is considered to be meeting the regeneration standard. If the tree density is below the minimum density in the handbook, the stand is considered not meeting the standard. This calculation is done when the forest is in the regeneration period for its forest cover type. These periods are 1-2 years after harvest for aspen and birch and three or more years for all other forests. Eventually, DNR Forestry staff will be able to use regeneration monitoring to refine the current guidelines.

The second forest regeneration indicator identifies the percentage of stands that are meeting expected growth rates. Expected growth rate curves were determined from the forest regeneration monitoring dataset by calculating the mean seedling and sapling height for each forest cover type at each year post harvest. Linear regression models were then used to calculate the annual expected growth for the forest cover types had a statistically significant relationship between year and height. Notably, this modeling likely includes forest stands that have substantial regeneration problems. Therefore, the growth rate curves are likely too low for what would be expected from a healthy stand.

At this time there is little to no research that prescribes a target growth rate for different forest cover types. However, DNR Forestry staff will use forest regeneration monitoring data to calculate growth rate curves that can be used by forestry staff, the timber industry and landowners to assess the health of their stands as they regenerate after harvest.

Appendix B - Risk Category Assignments

Risk categories were assigned to each county based on the number of regeneration metric indicators it has. For each indicator, a value of 1 was assigned if the county was in the 25th percentile, a value of 2 was assigned if it was in the 25-50th percentile and a value of 3 was assigned if the county was in the 50-100th percentile. Deer indicators were placed on the x-axis of the risk matrix. The two regeneration metrics were summed and placed on the y-axis. A result of this is that a county could be assigned to the category of poor regeneration if it had one regeneration indicator in the 50-100th percentile or two in the 25-50th percentile.

A limitation of this current approach is that the indicator assignments are based on how a county compares to all other counties in Wisconsin. It would be preferable to compare each county to a static performance standard. Although, those static standards do not yet exist, further research and continued analysis of these data will be used to eventually create these static standards.

Appendix C - Risk Category Descriptions

Widespread Risk - Widespread risk is the most severe risk category. It indicates that there are currently multiple or severe regeneration problems coupled with moderate to high deer browse by disturbance. There are likely to be county-wide impacts from deer browse or severe impacts where deer browse is the highest. Reducing deer browse county-wide will likely decrease risk and improve forest regeneration in the long-term.

Localized Risk - Localized risk indicates either a) severe or multiple regeneration problems have been identified in the county or b) that deer browse is high enough to represent a potential risk to forest regeneration. This risk may be focused on specific tree species, specific forest cover types, or specific parts of the county where deer browse is highest. Reducing deer browse, especially where browse is the highest would likely reduce this risk.

Incidental Risk - Incidental risk indicates that either a) some regeneration problems have been observed but that deer browse is low enough that do not pose a widespread risk, or b) regeneration is adequate but deer browse is high enough that they represent an increased risk. It is likely that deer will still periodically impact forest regeneration to some degree, particularly in areas with the densest population. Reducing deer browse will likely have limited impact on reducing risk, whereas increased deer browse could dramatically increase the risk to forest regeneration.

Minimal Risk - Minimal risk is the lowest risk category and indicates that deer browse is low and few if any regeneration problems have been observed. Reduction of deer browse is unlikely to reduce risk significantly whereas an increase might increase risk, especially in the long-term.