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Warnell School of Forestry & Natural Resources

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LEANING & UPROOTED PINE RECOVERY AFTER A MAJOR STORM EVENT

E. David Dickens – Forest Productivity Professor; David C. Clabo – Silviculture Assistant Professor;
C. Waldrop – Research Professional I, *Warnell School of Forestry and Natural Resources*
Andrew Sawyer, *Pecan Specialist;* and Sydni Ingram – *Thomas County ANR Agent - College of Ag. & Environmental Sciences, University of Georgia*

INTRODUCTION

Major weather events such as hurricanes, tornadoes, and ice storms impact portions of the southeastern United States annually. These events can inflict damage on both urban trees and rural forests. Severe storms often have major impacts on forests and can cause widespread tree breakage and uprooting. Less severe storms may leave scattered, individual trees damaged, leaning, or partially uprooted. These stems may live for a period of 2- to 5+ years after the event. Landowners are strongly encouraged to utilize professional foresters and arborists to help with decisions about timber management or potentially hazardous trees around homes and in urban environments. Seeking independent advice is a sound way to reduce hasty judgments and ensure all available options are considered. Storm damage within a given area can vary greatly, so careful evaluation of each damaged area should be the first step to recovery following a severe weather event. Management decisions are often based on the most damaged stands evaluated. However, damage across a storm path can vary greatly, and different areas should be considered independently.

This publication presents leaning and/or uprooted Southern pine (loblolly, longleaf and slash pine) recovery measurements, factors that impact degree lean and/or root damage, and management recommendations after major storm events. Recent storms in southern and middle Georgia include the 11 May 2008 Mother's Day EF2 tornado that went through parts of Emanuel and Johnson Counties, GA; the February 2014 ice storm that damaged trees in a 50+ mile radius around Augusta, GA; hurricanes Matthew (October 2016) (Figure 1), Irma (September 2017) (Figure 2), and Michael (October 2018) (Figure 3). The UGA Warnell School of Forestry & Natural Resources faculty, staff, County Agents and Specialist visited a number of sites after these storm events and estimated degree lean (from vertical or standing straight up) in young (1-10 years old), recently thinned (age 14 – 25 years old), older thinned (30-40 years old) and rather old (estimated at over 60 years old) natural stands of loblolly, longleaf and slash pine trees. The leaning and partially or fully uprooted pines in Figures 4 and 5 are from the aftermath of hurricane Michael in Florida illustrating severe to catastrophic damage. Figure 6 shows an example of an uneven-aged mixed stand that could be a management strategy to avoid severe or catastrophic wind damage. Starting with Figure 7 (page 9) through the end of the paper are examples of lightly damaged stands that had mostly tropical storm winds. These pine stands (loblolly, longleaf and slash pine) are the focus of the paper and are categorized into height classes and degree lean from vertical and uprooted trees along with their survival probability. Essentially most of the lean trees will survive as long as they are not partially or fully uprooted while partially or fully uprooted trees will die.

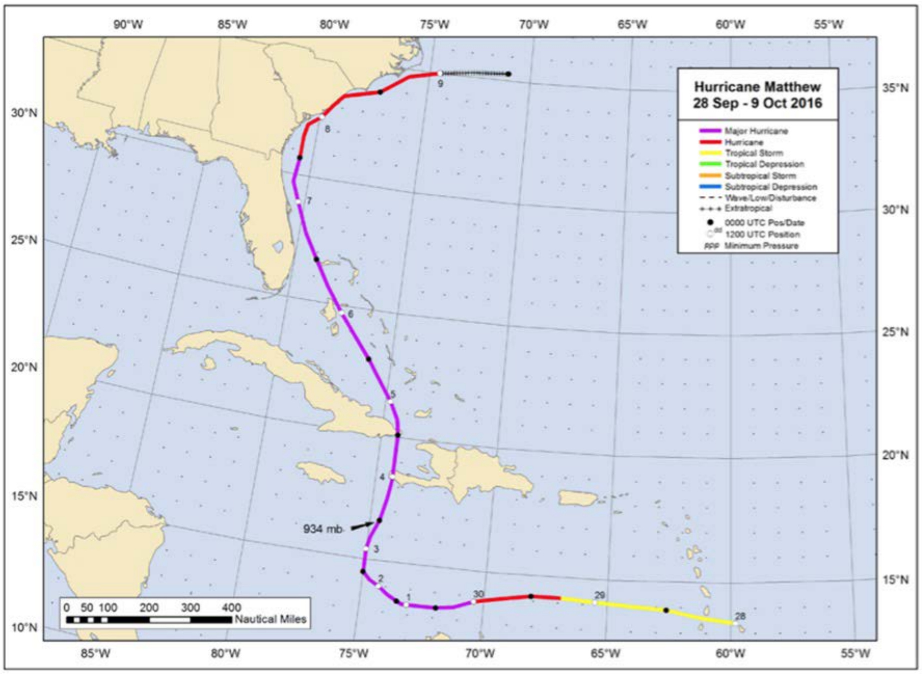


Figure 1: *Hurricane Matthew's path and intensity.*
Source: [*https://www.weather.gov/ilm/Matthew*](https://www.weather.gov/ilm/Matthew)

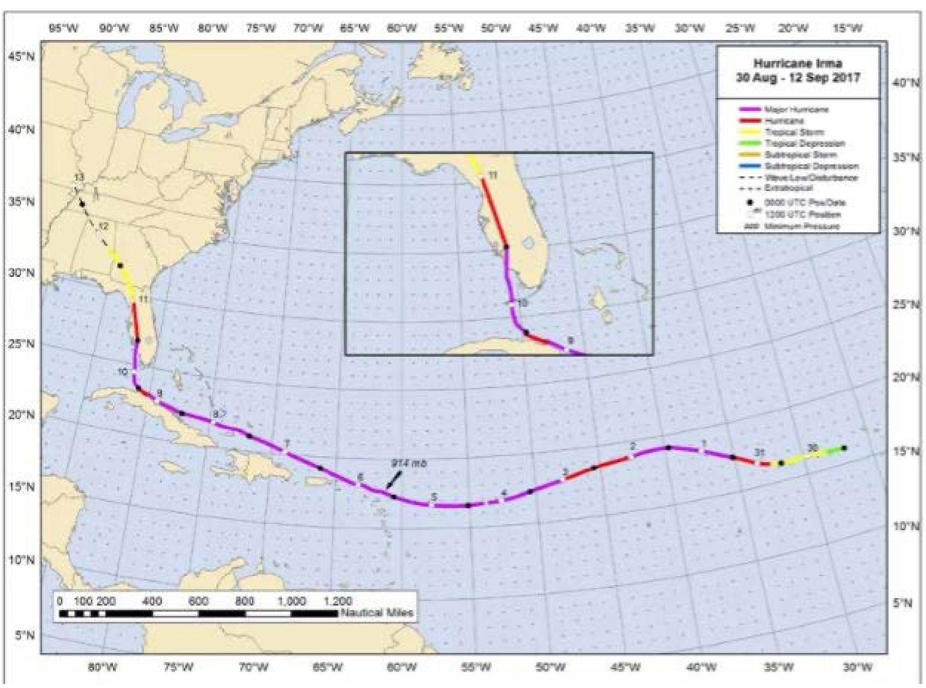


Figure 2: *Hurricane Irma's path and intensity.*
Source: [*https://www.weather.gov/ffc/2017_Irma*](https://www.weather.gov/ffc/2017_Irma)

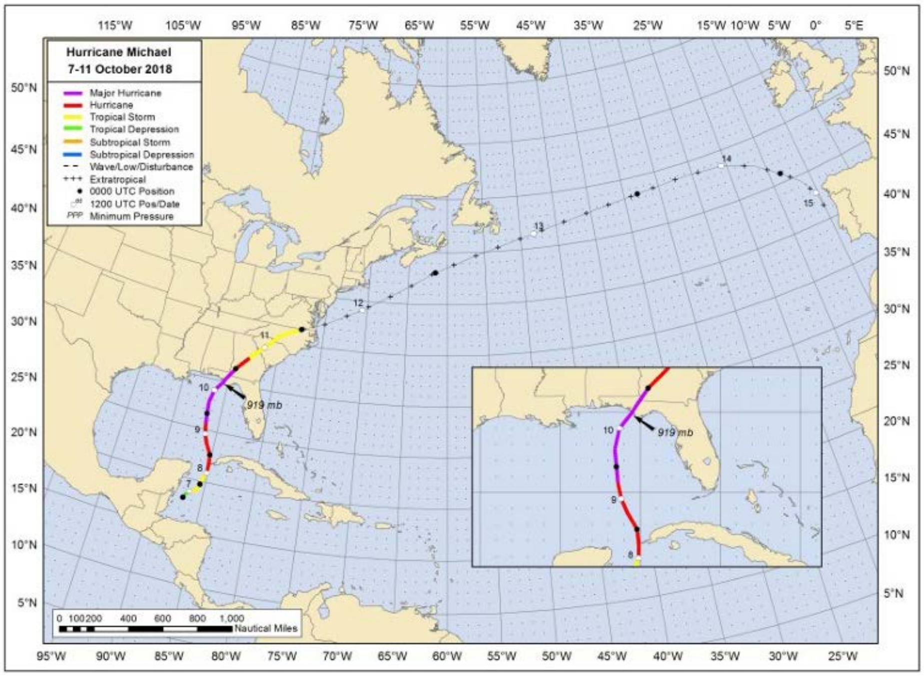


Figure 3: ***Hurricane Michael's path and intensity.***
Source: [*https://www.weather.gov/mob/michael*](https://www.weather.gov/mob/michael)

DRIVING FACTORS THAT CAUSE LEANING AND/OR UPROOTED PINE DAMAGE

1. The amount of rainfall that occurred with the storm and overall soil moisture status prior to the wind event impacting the pine stand can be a major factor. Precipitation and temporary increases in soil moisture during hurricanes on better drained soils may actually help support trees by increasing root system weight and increase tree stability during wind drag and oscillation. This can be especially important for larger individual trees.
2. Certain soil textures, soil drainage classes, and restrictive layers or horizons can result in greater root damage and increase the likelihood of stems bending during a wind event. Southern pines growing on somewhat poorly, poorly and very poorly drained soils tend to have a higher incidence of tree damage during wind events due to less root development and mass contributed to more anaerobic soil conditions. Similarly, soils with a hardpan (natural or human-caused) that limits root and water penetration into deeper soil horizons can increase the likelihood of tree blowdown and damage during wind events.
3. More topographically exposed stands (low ridges, upper slope positions, etc.) as might be found in parts of the Upper Coastal Plain or Red Hills/Tallahassee Hills region of southwestern Georgia and the Florida Panhandle are likely to receive greater damage than stands in areas with less prominent topography though storm characteristics and intensity can greatly impact damage levels.
4. Wind speed directions and duration (time) in the stand heavily impact damage levels. It is possible to have two or more wind directions with rotating storms as more intense and longer duration storms are more likely to cause greater amounts of damage. As an example, the high wind speeds of Hurricane Michael (a Category 5 hurricane when it came ashore in Mexico Beach, FL) caused more widespread severe to catastrophic (on average 75% or more of the trees within a stand are damaged) damage than did weaker hurricanes Matthew or Irma when making US landfall in 2016 and 2017, respectively.

5. Tree height class, crown size, and stem taper are important factors as taller trees with larger crowns catch more wind or hold more ice than shorter/smaller trees (crowns act like a sail on a sailboat) – young stands with tree heights less than 20 feet tend to have less damage than taller stands. Damage tends to be less in trees with a lower stem taper, or larger stem diameters for a given height. Managing at low stem densities during stand development could potentially increase taper lessening impacts from extreme wind events. More varied crown structure (stands with mixtures of short and tall trees as well as varying crown sizes) of trees throughout a stand or collection of stands in a forest can also decrease wind speeds thus reducing individual tree and overall stand damage during storms. These conditions might occur when multiple age classes (i.e., uneven-aged management) occur in a stand (Figure 6), species mixtures occur within the stand, or when stands with differing ages and average tree sizes are located adjacent to one another.
6. Years since thinning is also important for stand windfirmness. Pine stands thinned within two years of a tornado, hurricane or ice storm tend to have much more damage and are less windfirm than stands thinned 3 – 5+ years ago or unthinned stands.

GENERAL RULES OF THUMB after hurricane, tornado, and ice storm events are as follows for stands in varying circumstances:

1. Unthinned, fully stocked young pine stands less than five to eight years old with heights less than 20 feet generally have the least damage. Damage may include some stem breakage, lean, or uprooting, but typically the number of trees damaged per acre is less compared to older, taller stands. The lean, uprooting, and stem damage in these young, unthinned stands tend to be on the edges of the stands, where the winds were the strongest. Larger acreages of adjacent, unfragmented forested areas nearby result in lower canopy wind speeds. The age, height, stem taper, crown size and position in the stand, stand density, and species composition can also affect damage levels. The windward stand size, species composition, heights and crown size can also affect the damage level in younger adjacent pine stands. Pine stands with tree heights in the >20 through 40 feet tend to have low damage levels, but the percentage of lean trees is higher than in stands 20 feet tall or less.
2. Recently thinned (within the last two years) pine stands tend to have the most damage, with leaning and uprooted trees and greater stem breakage rates (usually at the 8-20 feet stem height range) (Figure 4).
3. Pines with heights greater than 40 feet tall and lean greater than 30 to 45 degrees (from vertical) do not typically straighten and recover (Figure 5). Trees less than this height threshold and lean range tend to recover more often.
4. Older, larger pines (diameters greater than 12-14 inches and greater than 60 – 100 feet tall) that are leaning less than 30-45 degrees will usually not return to a straight position, but tend to live for a number of years (at least two to three years following the storm) as long as the root system is intact with little to no evidence of mounding, uprooting, or exposed roots.
5. Partially uprooted pines that have most of their root system intact in the ground can survive for some time, but may not be a long-term viable (would be cut in next timber harvest) part of the stand. Uprooted pines with exposed roots and leaning more than 60 degrees or crowns laying on the ground tend to have delayed mortality that may not be evident for one or more growing seasons after the tree is damaged (Figure 7).

Figure 4: *Example of a recently thinned slash pine stand near the Gulf Coast following hurricane Michael.*

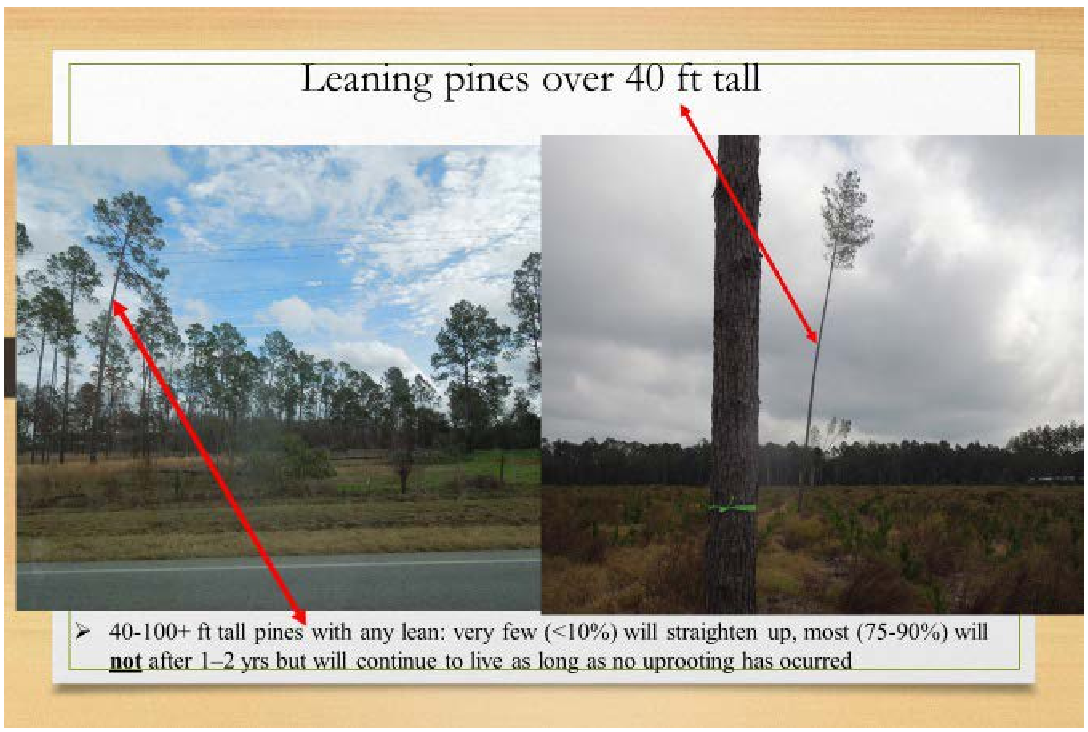
Figure 5: *Note the pine trees in the above photo after Hurricane Michael. Trees taller than 40 ft with lean greater than 30-45 degrees from vertical tend to not straighten (less than 2-10% of the time) but may live for 2- to 5+ years. Logging operations in these stands are difficult.*

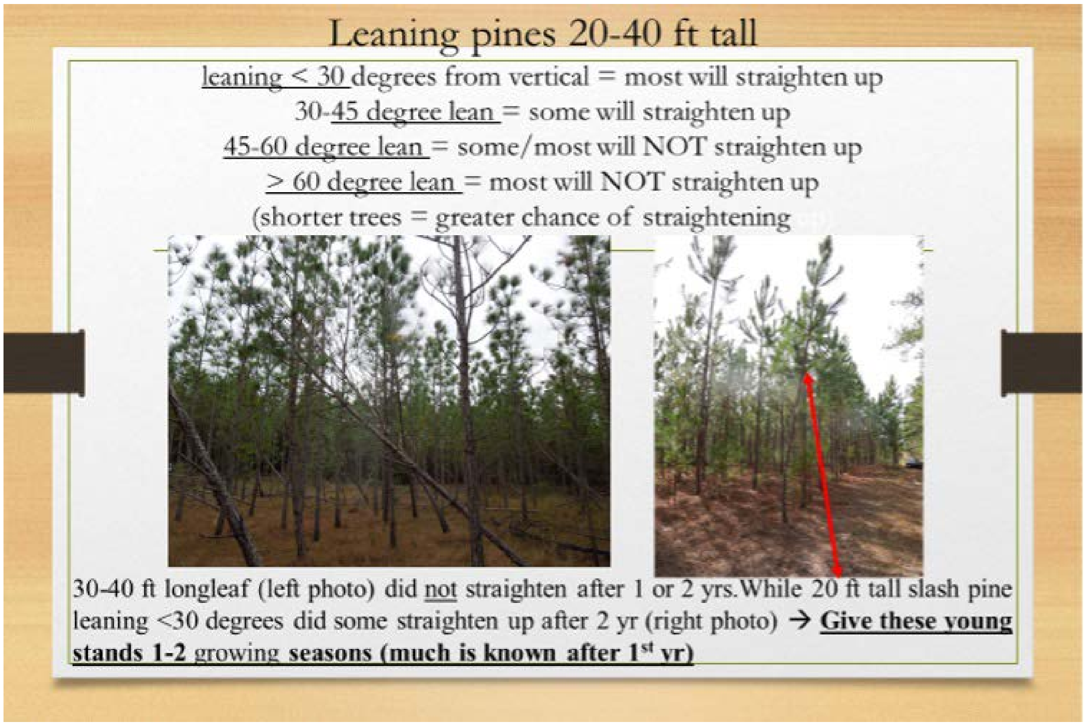
Figure 6: *Example of an uneven-aged slash-loblolly pine stand in the Upper Coastal Plain region of Georgia. Managing for mixed species stands with three or more age classes can be a strategy to reduce storm wind damage.*

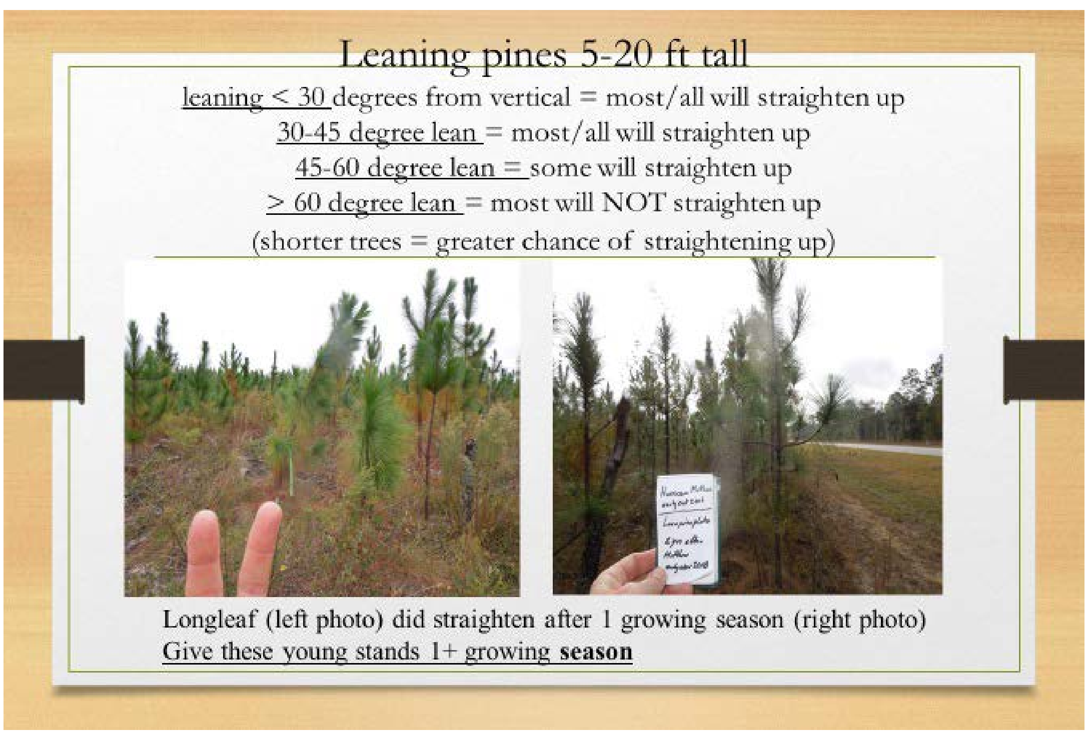
Figure 7: *This longleaf pine had greater than 60 degree lean during the January after hurricane Michael toppled it the previous October. The following winter this tree was dead.*

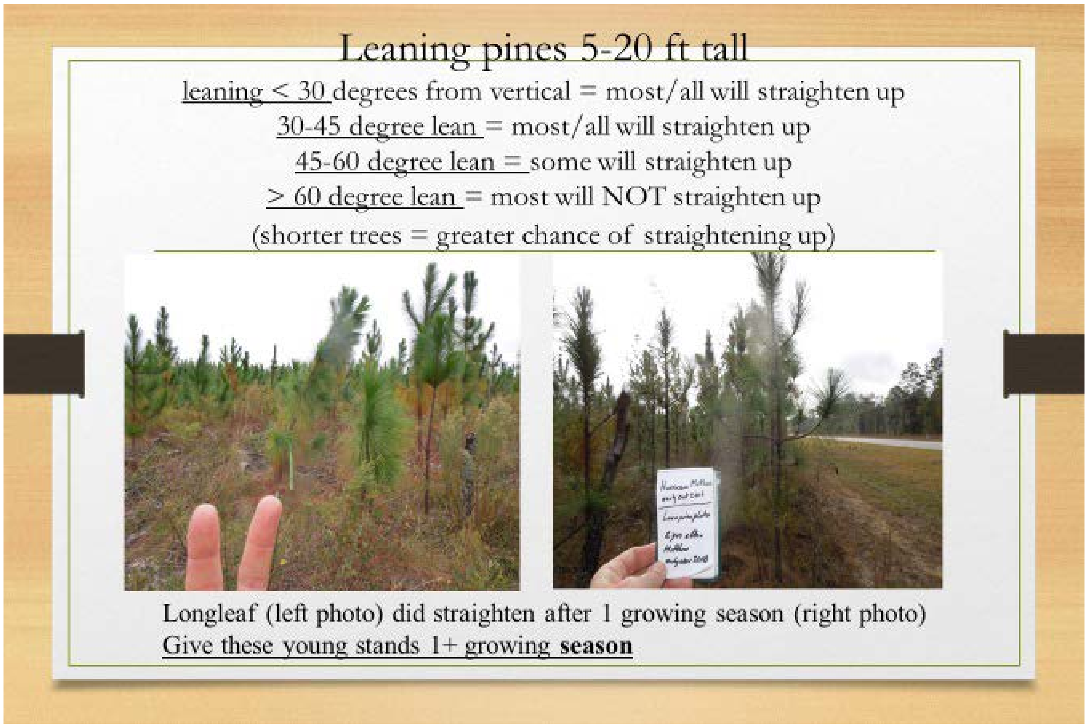
SUMMARY

During the first 30 days to 12+ months after a storm event, pine stands with leaning leaning and uprooted (fully or partially) stems should be visited every 3-4 weeks to remain vigilant of mortality and possible beetle activity. Our observations in several pine stands, over time, gave us some general rules of thumb. There may be some situations (stand circumstances) that may not follow the general rules of thumb we have found after following these stands over the 2008 through 2021 time-frame. The following photo series is a breakdown of leaning and/or uprooted loblolly, longleaf and slash pine recovery. If a small portion of a merchantable (trees greater than 45-50 feet and diameters at 4.5 feet; dbh greater than 4.5 inches) pine stand has major damage but the vast majority of the stand has minor damage then the stand could can be carried to a thinning or clearcut 2- to 5- years after the storm event. This waiting time can be advantageous as pine stumpage prices tend to rebound 2- to 5- years after the storm event.




Leaning pines 20-40 ft tall
leaning < 30 degrees from vertical = most will straighten up
30-45 degree lean = some will straighten up
45-60 degree lean = some/most will NOT straighten up
> 60 degree lean = most will NOT straighten up
(shorter trees = greater chance of straightening
30-40 ft longleaf (left photo) did not straighten after 1 or 2 yrs. While 20 ft tall slash pine leaning <30 degrees did some straighten up after 2 yr (right photo) → Give these young stands 1-2 growing seasons (much is known after 1st yr)


Leaning pines 5-20 ft tall
leaning < 30 degrees from vertical = most/all will straighten up
30-45 degree lean = most/all will straighten up
45-60 degree lean = some will straighten up
> 60 degree lean = most will NOT straighten up
(shorter trees = greater chance of straightening up)
Longleaf (left photo) did straighten after 1 growing season (right photo)
Give these young stands 1+ growing season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> 60 degree lean = most will NOT straighten up
(shorter trees = greater chance of straightening up)
Longleaf (left photo) did straighten after 1 growing season (right photo)
Give these young stands 1+ growing season


Leaning pines <5 ft tall → rules of thumb
leaning < 30-45 degrees from vertical = most/all will straighten up
45-60 degree lean = most/all will straighten up
60-80 degree lean = most will straighten up
shorter trees = greater chance of straightening up)
1 yr old loblolly leaning >45- 60 deg that straightened back up after 1 yr (left photo).
Rt photo 1-yr old loblolly with hole at base from hurricane Matthew tree straightened up after 1 yr.
Give these young stands 1+ growing season

Leaning pines <5 ft tall → rules of thumb

<u>leaning < 30-45</u> degrees from vertical = most/all will straighten up

<u>45-60 degree lean</u> = most/all will straighten up

<u>60-80 degree lean</u> = most (>60-75%) will straighten up

<u>shorter trees</u> = greater chance of straightening up

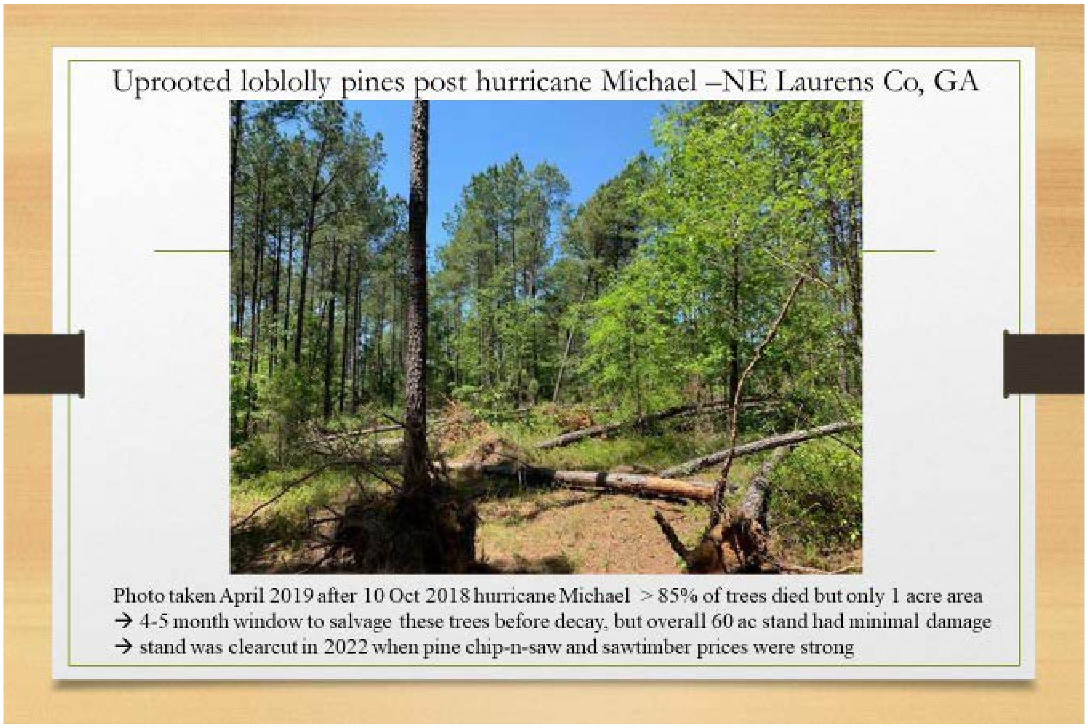
<u>Left photo</u>: 1-yr old loblolly w/ 45 deg lean from vertical post Matthew (Nov 2016 photo) that straightened back up after 2 yrs <u>Right photo</u>: 2 yrs post Matthew in Effingham Co, GA

Uprooted large pines

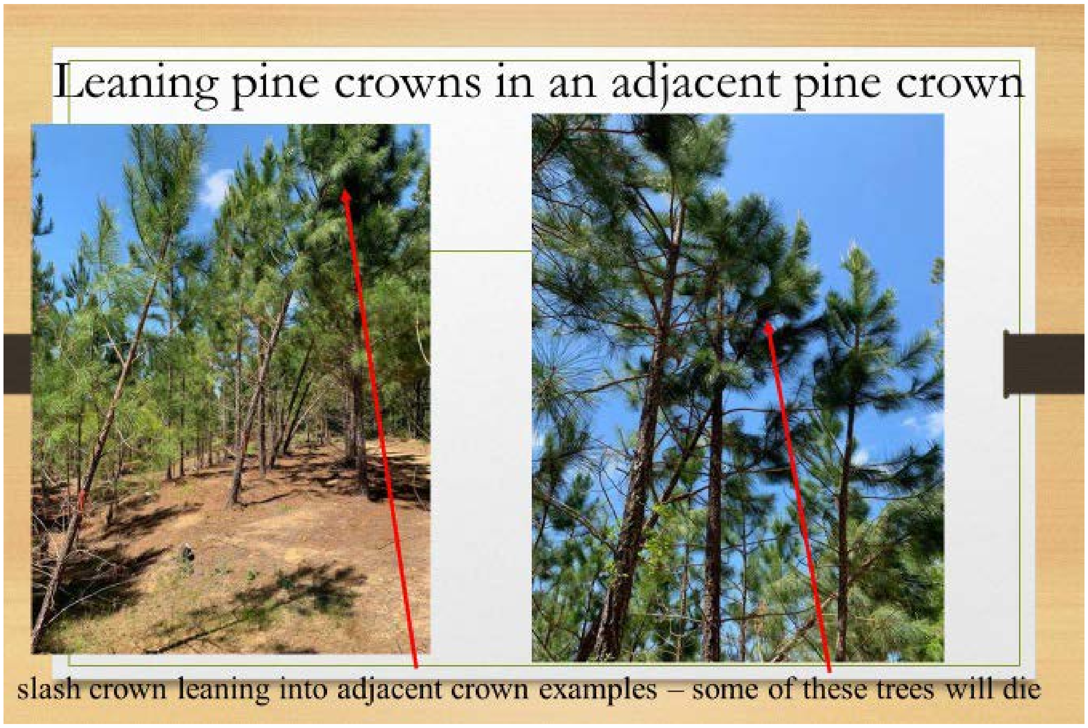
tops tended to stay green until spring (March-April) of following year

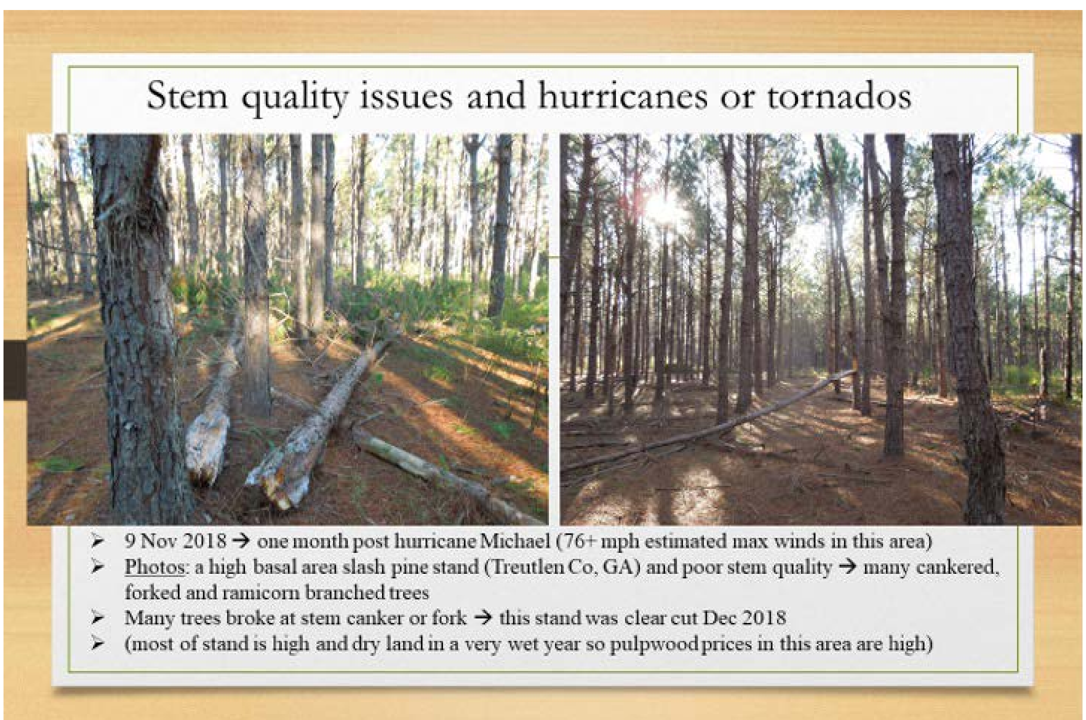
5-6 month salvage window for high value uprooted wood

Late Oct 2016 after Matthew Bulloch Co GA


Uprooted loblolly pines post hurricane Michael –NE Laurens Co, GA
Photo taken April 2019 after 10 Oct 2018 hurricane Michael > 85% of trees died but only 1 acre area
→ 4-5 month window to salvage these trees before decay, but overall 60 ac stand had minimal damage
→ stand was clearcut in 2022 when pine chip-n-saw and sawtimber prices were strong


Uprooted longleaf with > 60 degree lean
Post hurricane Michael, unthinned longleaf planted on a poorly drained Pelham soil with greater than 60 degree lean and uprooted – these trees died 4 months after Michael


Leaning pine crowns in an adjacent pine crown
slash crown leaning into adjacent crown examples – some of these trees will die


Stem quality issues and hurricanes or tornados
9 Nov 2018 → one month post hurricane Michael (76+ mph estimated max winds in this area)
Photos: a high basal area slash pine stand (Treutlen Co, GA) and poor stem quality → many cankered, forked and ramicorn branched trees
Many trees broke at stem canker or fork → this stand was clear cut Dec 2018
(most of stand is high and dry land in a very wet year so pulpwood prices in this area are high)

A UGA Warnell School Extension paper published in 2020 can assist forest landowners with decision-making in their major storm damaged stands: https://bugwoodcloud.org/bugwood/productivity/pdfs/Outreach_Assessing_Storm_Damage_Sept2020.pdf. This paper has storm damage categorized into catastrophic-severe, moderate and light levels and goes into detail on management options and timelines for each category.

Citation: Dickens, E.D., D.C. Clabo, C. Waldrop, S. Ingram, and A. Sawyer. 2024. Leaning and uprooted pine recovery after a major storm event. www.bugwood.org 13 p.