NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Vegetation-Related Transmission Outage Report

2016 Annual Report

May 9, 2017

RELIABILITY | ACCOUNTABILITY



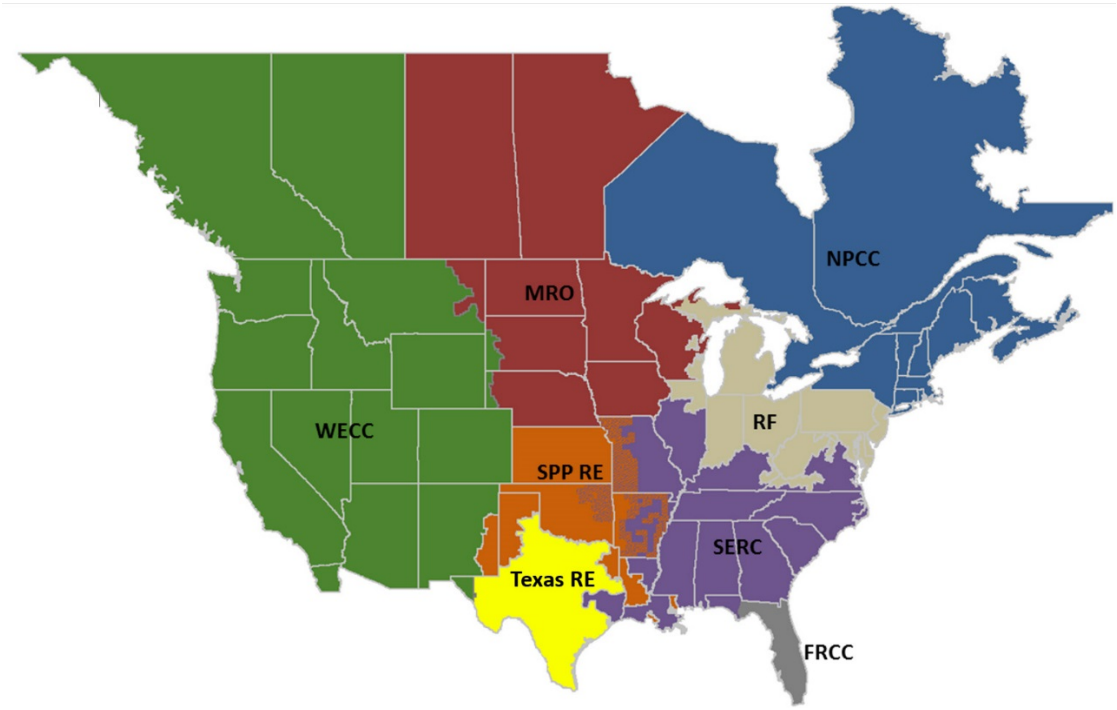

3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326
404-446-2560 | www.nerc.com

Table of Contents

Preface

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the reliability of the bulk power system (BPS) in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

The North American BPS is divided into several assessment areas within the eight Regional Entity (RE) boundaries, as shown in the map and corresponding table below.



The North American BPS is divided into eight RE boundaries. The highlighted areas denote overlap as some load-serving entities participate in one Region while associated transmission owners/operators participate in another.

FRCC	Florida Reliability Coordinating Council
MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
SPP RE	Southwest Power Pool Regional Entity
Texas RE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Executive Summary

This report provides a summary of 2016 vegetation-related reportable transmission outages. Reliability Standard FAC-003-4 requires that applicable Transmission Owners (TO) and Generator Owners (GO) submit a quarterly report to their RE identifying all Sustained Outages[1] determined by the applicable TO and GO to have been caused by vegetation. The RE in turn reports this outage information to NERC. The quarterly vegetation management outage reports are available on the NERC website.[2]

The REs reported 27 vegetation-related outages to NERC in 2016. Most of the 27 outages were caused by vegetation falling into applicable lines from outside the rights-of-way (ROWs) as the result of weather activities in the applicable region. The corrective and preventive actions that were reported appear appropriate. None of the 27 outages in 2016 involved a noncompliance with FAC-003.

[1] The de-energized condition of a transmission line resulting from a fault or disturbance following an unsuccessful automatic reclosing sequence or unsuccessful manual reclosing procedure. http://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf
[2] Vegetation Reports located at http://www.nerc.com/pa/comp/CE/Pages/vegetation-management-reports.aspx

Introduction

Background

Ineffective vegetation management was identified as a major cause of the August 14, 2003, blackout and was also cited as a major causal factor in other large-scale North American outages.[3] In response, NERC developed the FAC-003 vegetation management Reliability Standard, which formalized transmission vegetation management program and reporting requirements.

FAC-003-1 became mandatory and enforceable on June 18, 2007. The current version, FAC-003-4,[4] became effective on October 1, 2016. FAC-003-4 requirements are aimed at preventing vegetation-related outages that could lead to cascading outages. FAC-003-4 accomplishes this by requiring applicable registered entities to manage vegetation located on transmission ROWs and minimize encroachments from vegetation located adjacent to the ROW.

FAC-003-4 reflects revisions to the previous Minimum Vegetation Clearance Distances (MVCDs) in FAC-003-3 based on additional testing conducted by the Electric Power Research Institute (EPRI) in response to FERC's directive regarding the appropriate gap factor to be used to calculate clearance distances for vegetation.[5]

Similar to previous versions of the Reliability Standard, the current version continues to require all applicable TOs and GOs to report to their RE on a quarterly basis all Sustained Outages. These reports include pertinent information such as description of the cause of the outage, outage category, actions taken, and other details as described in the Reliability Standard.

FAC-003-4 requires that all Sustained Outages of applicable lines be identified and reported quarterly through Periodic Data Submittals. Each of the Sustained Outages are categorized as one of the following:

- Category 1A — Grow-ins: Sustained Outages caused by vegetation growing into applicable lines, that are identified as an element of an IROL or Major WECC Transfer Path, by vegetation inside or outside of the ROW.
- Category 1B — Grow-ins: Sustained Outages caused by vegetation growing into applicable lines, but are not identified as an element of an IROL or Major WECC Transfer Path, by vegetation inside or outside of the ROW.
- Category 2A — Fall-ins: Sustained Outages caused by vegetation falling into applicable lines that are identified as an element of an IROL or Major WECC Transfer Path, from within the ROW.
- Category 2B — Fall-ins: Sustained Outages caused by vegetation falling into applicable lines, but are not identified as an element of an IROL or Major WECC Transfer Path, from within the ROW.
- Category 3 — Fall-ins: Sustained Outages caused by vegetation falling into applicable lines from outside the ROW.
- Category 4A — Blowing together: Sustained Outages caused by vegetation and applicable lines that are identified as an element of an IROL or Major WECC Transfer Path, blowing together from within the ROW.

[3] U.S.-Canada Power System Outage Task Force, August 14, 2003, Blackout: Causes and Recommendations (Apr. 2004), *available at* http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf.

[4] http://www.nerc.com/pa/Stand/Reliability%20Standards/FAC-003-4.pdf *General Requirements at the Transmission Interface*, Order No. 785, 144 FERC ¶61,221 (2013).

[5] When FERC approved Reliability Standard FAC-003-2, FERC stated that "it is important that NERC develop empirical evidence that either confirms assumptions used in calculating the MVCD values based on the Gallet equation, or gives reason to revisit the Reliability Standard." https://www.ferc.gov/whats-new/comm-meet/2013/032113/E-5.pdf *Revisions to Reliability Standard for Transmission Vegetation Management,* Order No. 777, 142 FERC ¶ 61,208 (2013).

- Category 4B — Blowing together: Sustained Outages caused by vegetation and applicable lines, but are not identified as an element of an IROL or Major WECC Transfer Path, blowing together from within the ROW.

The REs submit the aggregated report to NERC. Nearly all of the Sustained Outages reported under Periodic Data Submittals are Category 3 outages due to fall-ins from outside the ROW, which are not a violation of the vegetation management Reliability Standard.

Chapter 1: 2016 Sustained Outages

Registered entities reported a total of 27 Sustained Outages in 2016, all of which were caused by vegetation falling into lines from outside the ROW (Category 3). None of the 27 outages were violations of Reliability Standards. All but two were due to severe weather.

Five of the lines had experienced a previous vegetation-related Sustained Outage within the last eight reporting quarters. All of these previous outages were also Category 3 and weather-related.

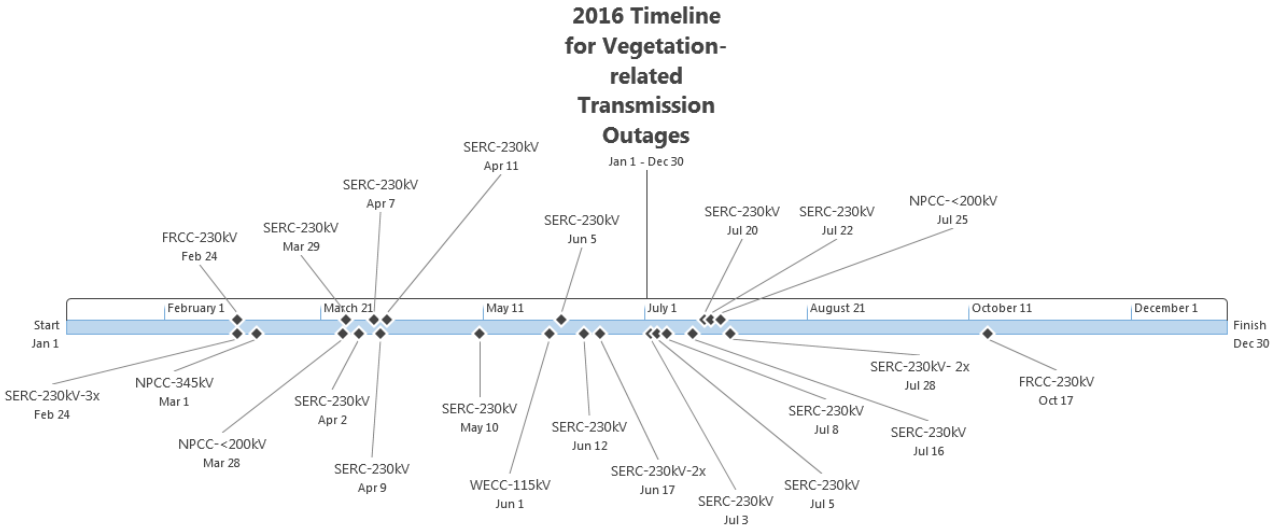


Figure 1.1: 2016 Timeline for Vegetation-related Transmission Outages

NERC staff's review indicated that the outages were isolated weather-related events that did not present a trend or pose a significant risk to the reliability of BPS.

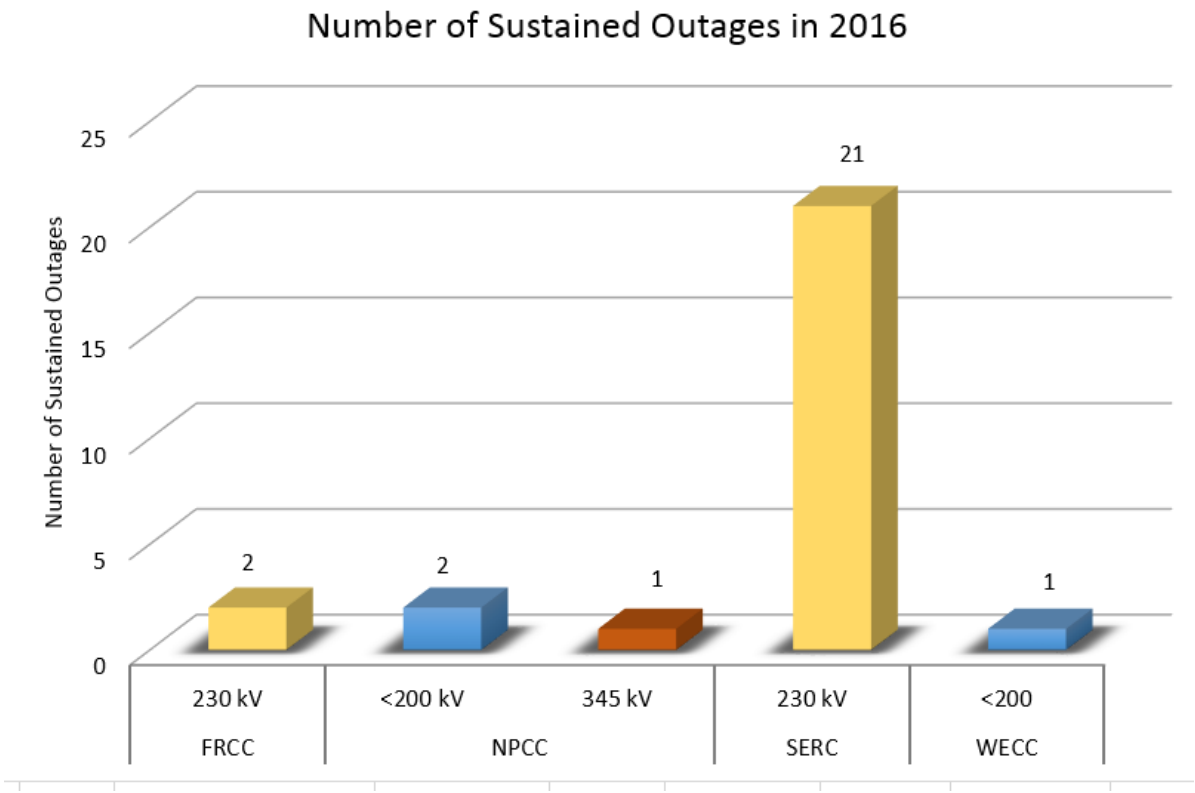


Figure 1.2: Vegetation-Related Outages by RE, Voltage Class, and Outage Category in 2016

In 2015, three Category 1B outages were reported in the United States. The three registered entities experiencing Category 1B occurrences also self-reported noncompliance with FAC-003. A fourth entity's outage did not meet the reporting criteria for periodic reporting due to the outage's real-time observable impact on the BPS, but it was self-reported as a possible noncompliance with the FAC-003 Reliability Standard. All noncompliance have been filed with FERC, as shown in Table 1.1.

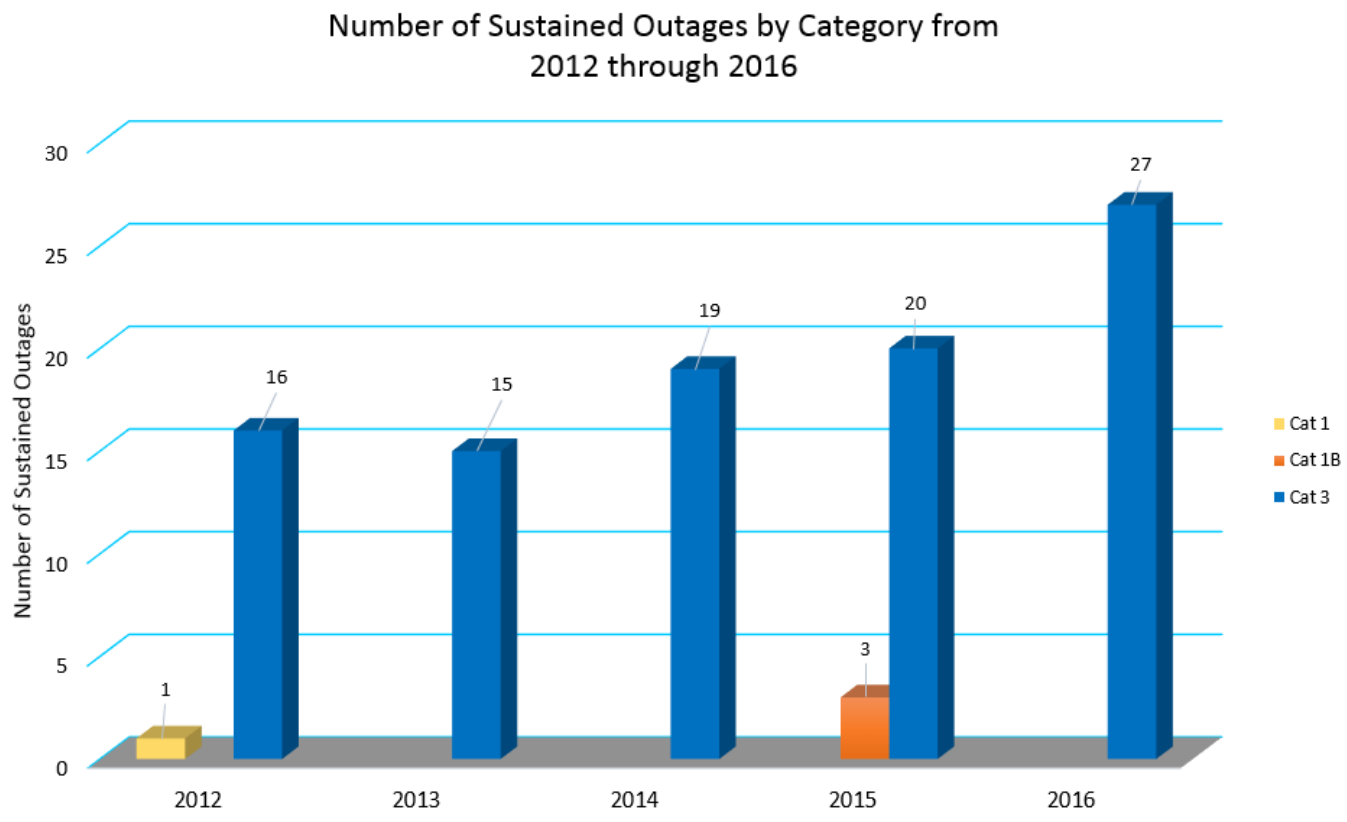


Figure 1.3: Vegetation-Related Outages by Outage Category from 2012 to 2016

Table 1.1: Status of Violations with Observed Real-time Impact Due to Vegetation-related Outages			
Violation ID	**Entity Name**	**Final Risk Assessment**	**Regulatory Filing ID**
WECC2015015138	Black Hills Corporation	Moderate	NP17-6-000
FRCC2015015004	Florida Power & Light Co.	Serious	NP16-19-000
SERC2016015498	Alabama Power Company	Serious	NP17-19-000[6]
SERC2015015011	Mississippi Power Company	Moderate	NP17-15-000

[6] Filing also included a violation of FAC-009

Chapter 2: Conclusion

There has been a slight rise in Sustained Outages. The ERO Enterprise will continue to monitor these outages and noncompliance related to FAC-003 and engage industry, forums, and technical committees in identifying and mitigating risks, including reducing vegetation-related outages.[7]

[7] To review the 2017-2020 ERO Enterprise Strategic Plan and Metrics, please visit: http://www.nerc.com/gov/Annual%20Reports/ERO%20Enterprise%20Strategic%20Plan%20and%20Metrics%202017-2020_Clean.pdf

Appendix A

The information in this appendix is intended to provide helpful context behind some observed trends in the past five years within the three US electric interconnections.

Increase in Number of Category 3 Outages

There has been a slight increase in Category 3 outages reported from 2012 through the end of 2016. The majority of these outages were from entities in the Eastern interconnect (EI) compared with the Western Interconnect (WI) or Texas Interconnect (TI). SERC had the most Category 3 outages.

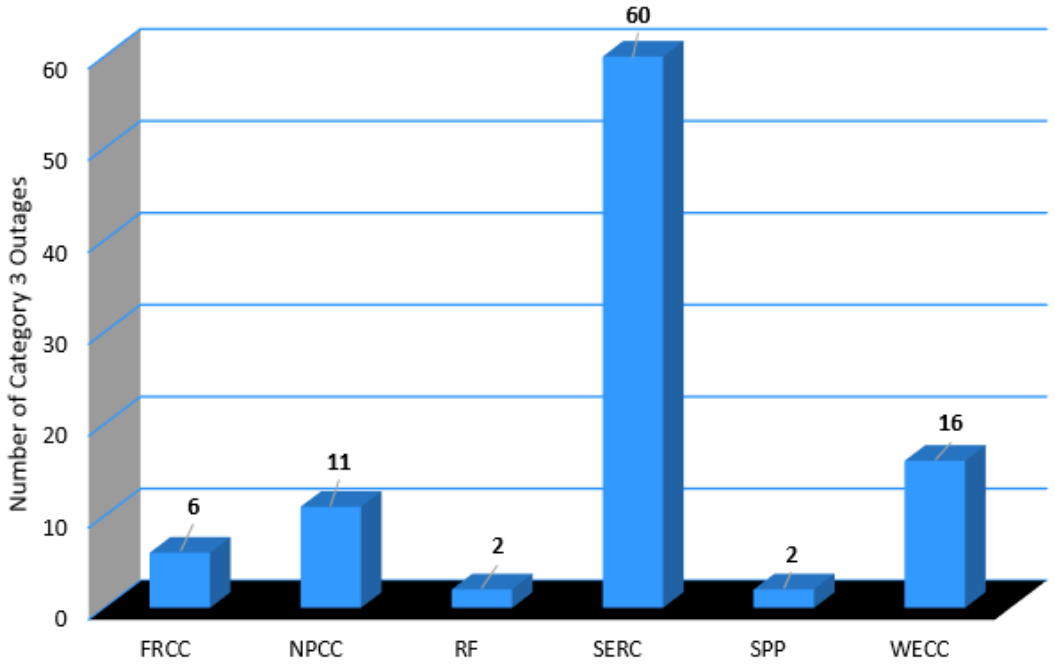


Figure A.1: Vegetation-Related Category 3 Outages by RE from 2012 to 2016

Climate and vegetation concentration are two of the major contributing factors in the observed trends.

Climate

High winds and heavy precipitation, particularly those from seasonal storms, could cause damage to the electric grid and result in interruption in transmission and distribution of power. In many cases, the service interruptions are due to debris from fallen trees and other vegetation.[8]

The majority of outages reported from 2012 to 2016 as part of FAC-003 periodic data reporting were due to inclement weather such as rain or snow storms, high winds, tornadoes, or hurricanes. The average duration of the outages was about 361 minutes.[9]

[8]Weather-Related Power Outages and Electric System Resiliency (2012) https://fas.org/sgp/crs/misc/R42696.pdf.

[9] NERC does not have information regarding the impact of these outages on end-user customers. US utilities collect and report indices related to the distribution system such as System Average Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI), and System Average Interruption Frequency Index (SAIFI) to the applicable Public Utility Commission (PUC). Also, the duration of the outage depends on a variety of factors, such as accessibility of the area requiring inspection and repair, crew safety, and work urgency.

The Department of Energy collects the Electric Emergency Incident and Disturbance Report (Form OE-417) on electric incidents and emergencies from the electric utilities that operate as Control Area Operators or Reliability Authorities, as well as other electric utilities, as appropriate. The form is a mandatory filing whenever an electrical incident or disturbance is sufficiently large enough to cross the reporting thresholds.[10] Over 36% of the reported incidents from 2012 to 2016 were weather-related. Nearly 80% of the weather related OE-417 reports were from utilities in the EI (11% from WI and 7% were from TI).

As noted in the figure below, states within the EI have experienced a greater number of weather and climate disasters from 2012 to 2016. While this figure only shows the climate-related disasters, it still provides a reasonable account for the differences in reported Category 3 outages at the interconnection level. Though Texas is the most highlighted section of the figure, the entire southeastern section of the country has had significant climate disaster spending during the last several years.

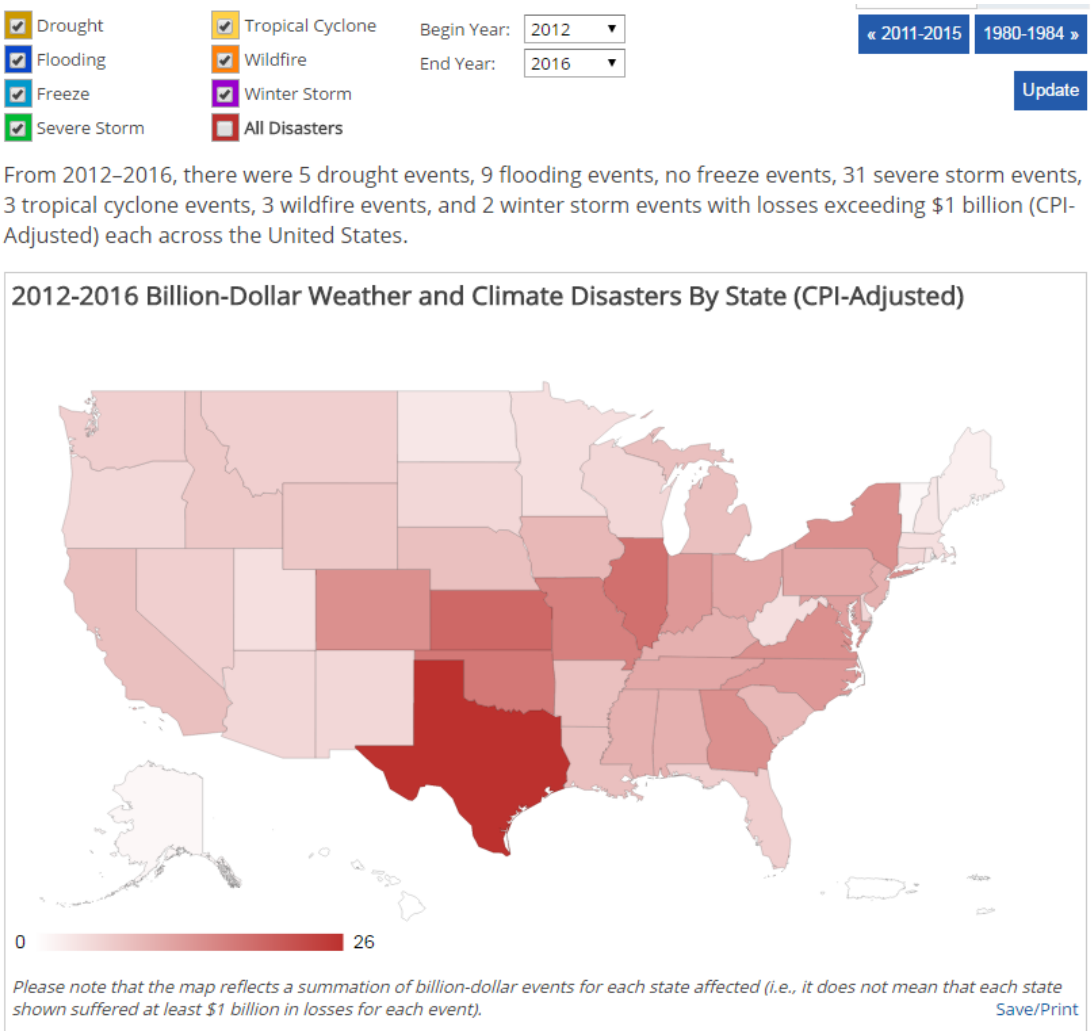


Figure A.2: 2012-2016 Billion Dollar Weather and Climate Disaster by State[11]

[10] Reporting coverage for the Form OE-417 includes all 50 States, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and the U.S. Trust Territories. Visit https://www.oe.netl.doe.gov/oe417.aspx for additional information.

[11] National Oceanic and Atmospheric Administration; Nation Center for Environmental Information: https://www.ncdc.noaa.gov/billions/mapping.

Although the outages in this report are not directly correlated with specific disasters, and despite a slight increase, the overall low number of Category 3 outages could speak to the industry's disaster preparedness and recovery activities that also include management of the vegetation that could cause power interruptions.

Forested Land and Aboveground Woody Biomass[12]

Various images below from US agencies such as the National Aeronautics and Space Administration and the United States Forest Service[13] show the tree population, density, and tree type in the US.[14] The images depict that the EI has a heavier tree population than the WI and the TI. This greater tree population potentially increases the likelihood of vegetation-related outages in the EI.

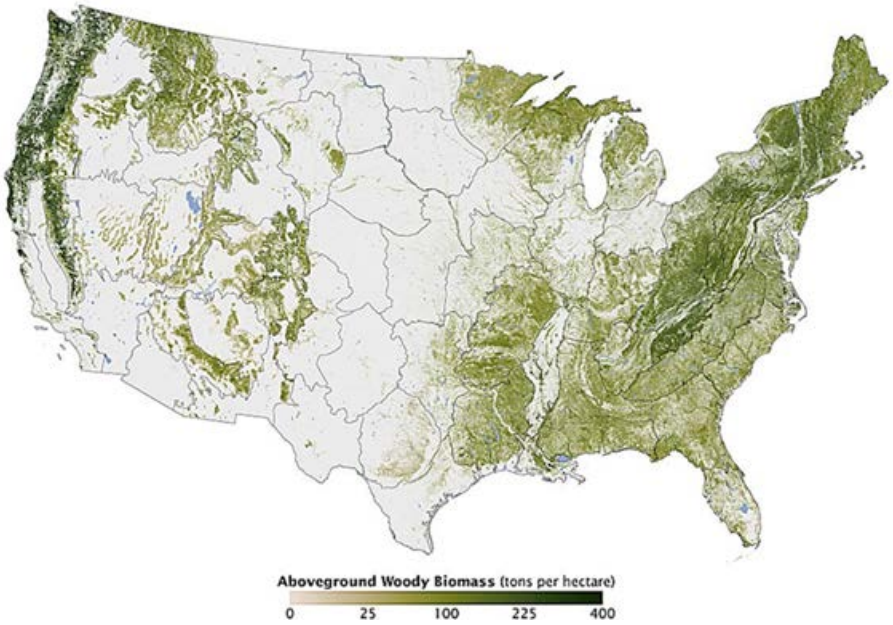


Figure A.3: Tree Topography[15]

[12] The trees and woody plants, including limbs, tops, needles, leaves, and other woody parts, grown in a forest, woodland, or rangeland environment, that are the by-products of forest management. Source: https://www.fs.fed.us/woodybiomass/whatis.shtml.
[13] An agency of the US Department of Agriculture.
[14] These images also show the approximate US States borderlines.
[15] NASA: http://earthobservatory.nasa.gov/Features/ForestCarbon/page4.php.

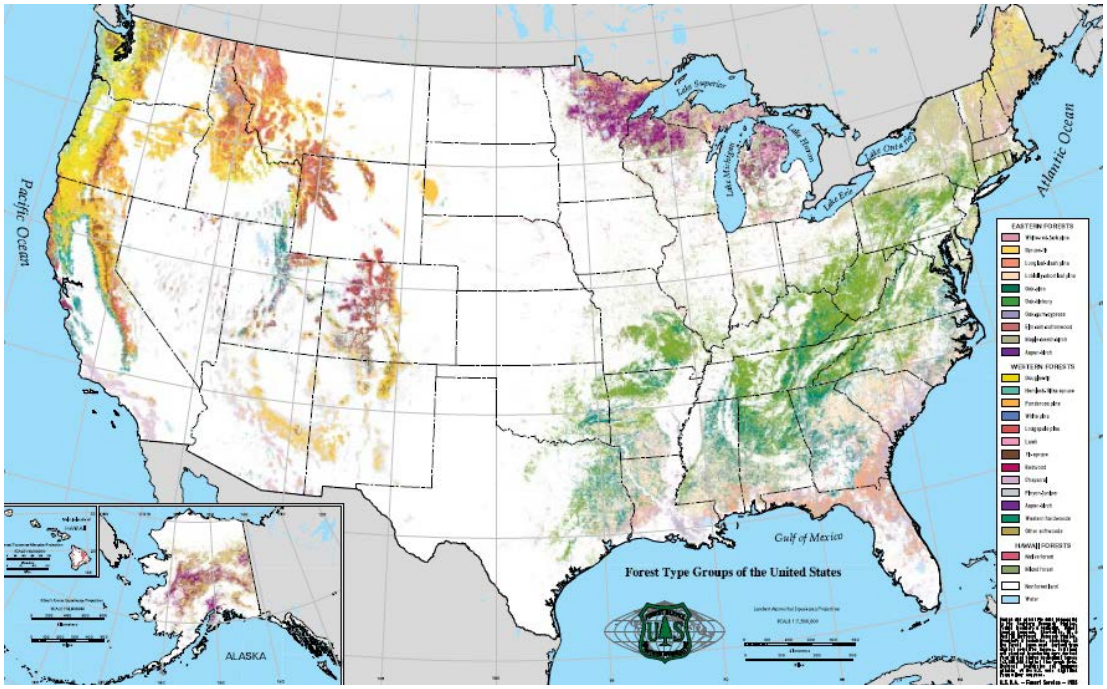


Figure A.4: Forest Types Groups[16]

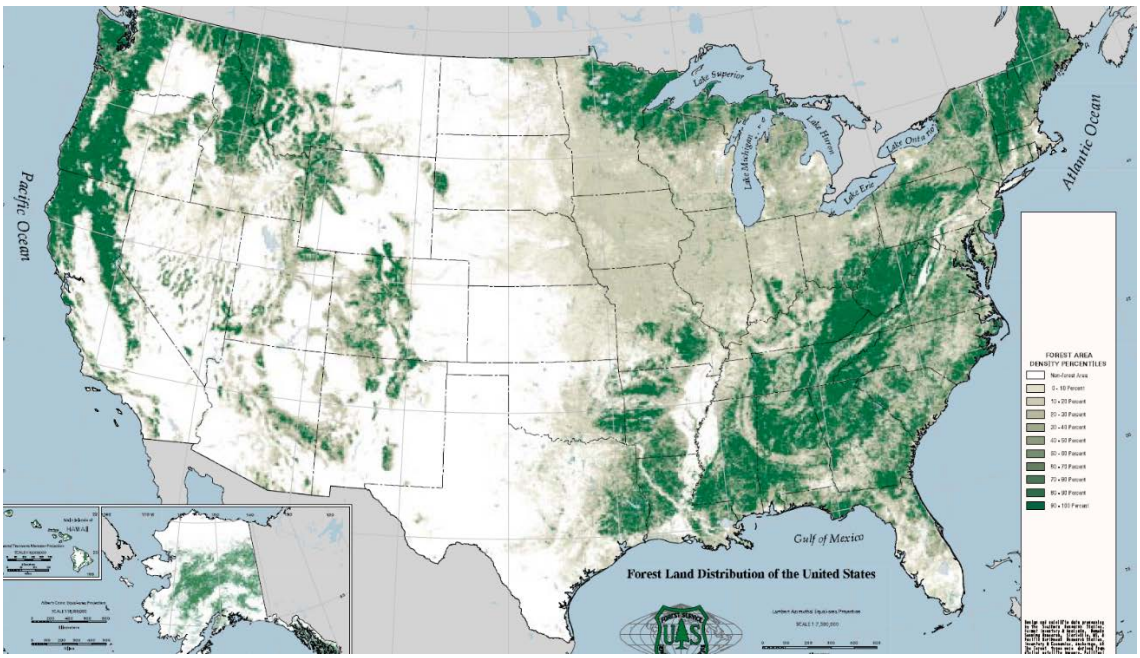


Figure A.5: Forest Area Density[17]

Within the EI, SERC had the most Category 3 outages. SERC is responsible for monitoring NERC registered entities in the states of Missouri, Alabama, Tennessee, North Carolina, South Carolina, Georgia, Mississippi, and portions of Iowa, Illinois, Kentucky, Virginia, Oklahoma, Arkansas, Louisiana, Texas, and Florida.

[16] Higher resolution is available at https://0.tqn.com/z/g/forestry/library/graphics/ustype.pdf.
[17] Higher resolution is available at https://0.tqn.com/z/g/forestry/library/graphics/usdensity.pdf.

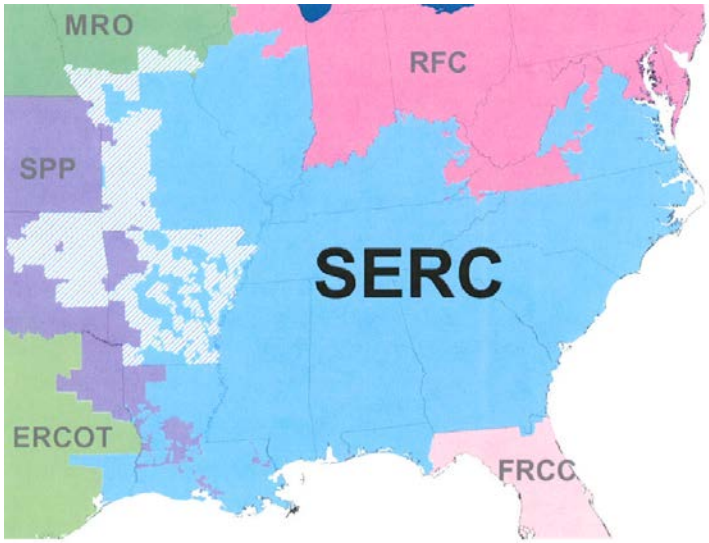


Figure A.6: SERC Regional Map[18]

Superimposing the SERC region over the US Forest Area Density map, it appears that a large portion of SERC territory is covered by trees and woody biomass.

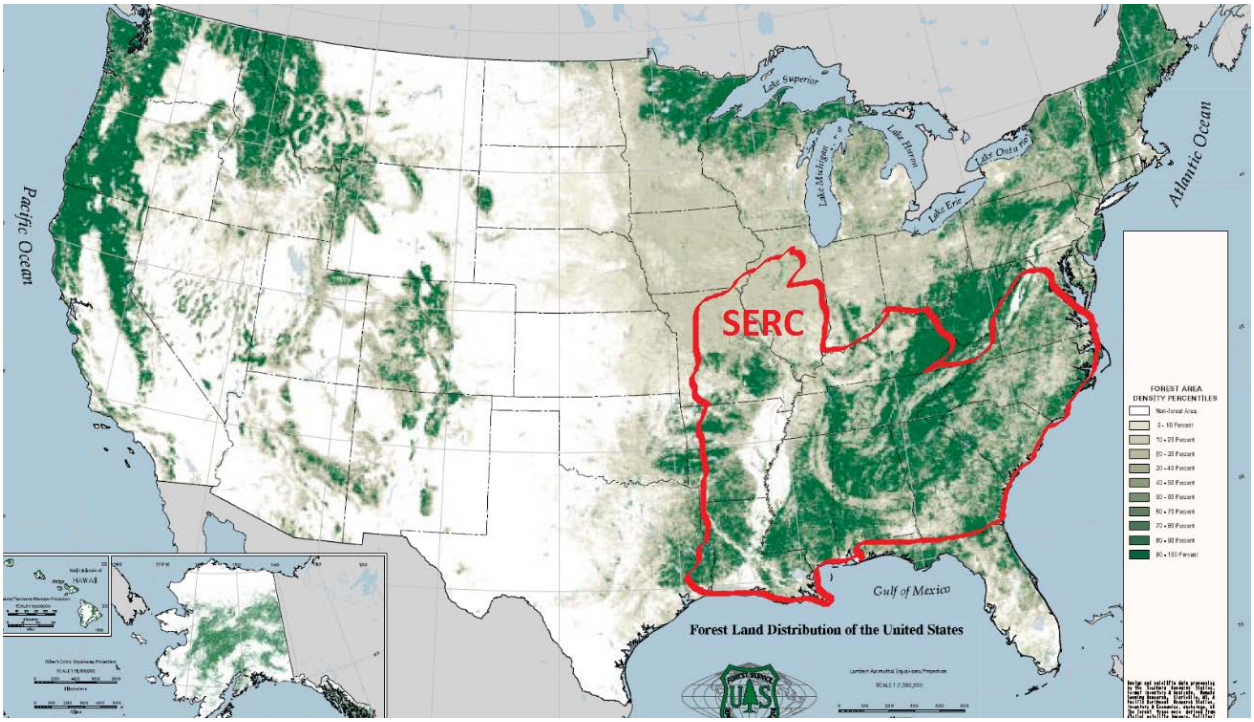


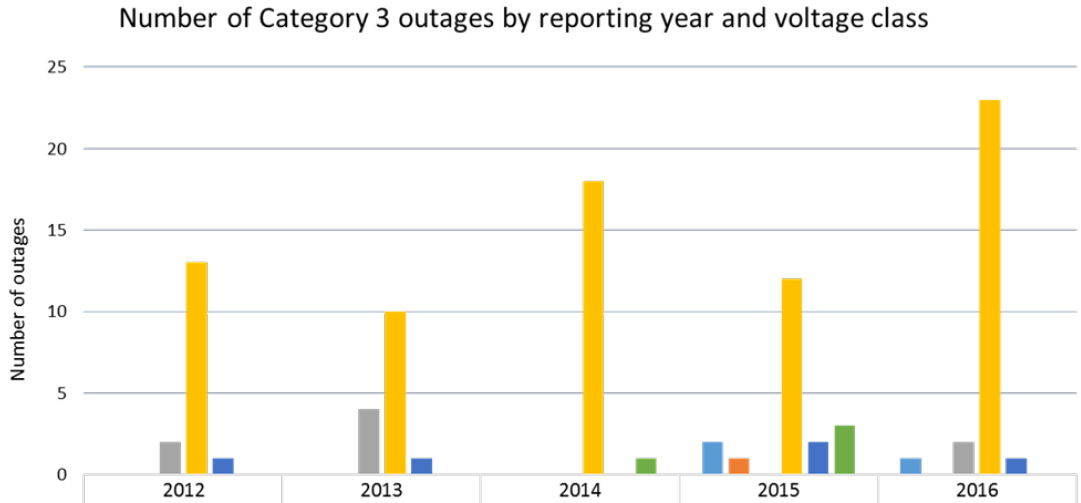
Figure A.7: SERC Over Forest Area Density Map[19]

[18]SERC Regional Map; https://www.serc1.org/docs/default-source/about-serc/landing-page/serc-regional-boundaries.pdf?sfvrsn=6
[19] SERC Regional boundaries may not be exact.

Various environmental factors such as precipitation and growth season,[20] vegetation type,[21] and, as mentioned before, the extreme weather and climates in the majority of southern states within the SERC territory could be among the reasons that the majority of Category 3 outage reports are from entities in SERC.

230 kV Lines Experience More Sustained Outages

230 kV lines experienced most outages and the majority of the outages.



	2012	2013	2014	2015	2016
115				2	1
138				1	
<200 kV	2	4			2
230 kV	13	10	18	12	23
345 kV	1	1		2	1
500 kV			1	3	

Figure A.8: Category 3 Outages by Voltage Class

As shown in the table and figure below, 230 kV is the voltage class with the most transmission miles in the US, representing nearly 40% of the high-voltage transmission line miles.

Table A.1: Miles of High-voltage Transmission Lines in the United States
Source: ABB velocity suite data

Voltage	Miles of Transmission line (In service and proposed)
AC	182,739
230-300	77,832
345	64,814
500	34,076
735 and Above	6,016
DC	10,473

[20] The south has longer growing seasons than can include sudden changes in soil moisture due to climate changes such as drought followed by extreme rainfalls, which could cause dramatic growth.

[21] For example, loblolly pine is one of the fastest growing southern pines. It is also an important American timber tree. It grows to a height of 60-90 feet with a spread of 25 to 35 feet at maturity. It can grow more than two feet per year. Source: https://www.arborday.org/trees/treeguide/TreeDetail.cfm?ItemID=899.

Table A.1: Miles of High-voltage Transmission Lines in the United States *Source: ABB velocity suite data*	
DC Line	10,473
Grand Total	193,212

Figure A.9: US Transmission Map by Voltage Class[22]

While the width of a ROW depends on a variety of factors (conductor type, terrain, etc.), as shown in the table below, higher voltage classes in general require a wider ROW.[23]

Given the total length of the 230 kV lines and the width of the associated ROWs, it is reasonable to observe more outages for the 230 kV voltage class than the others.

[22] Source: ABB Transmission Map in US

[23] Capital Costs for Transmission and Substation, Recommendations for WECC Transmission Expansion Planning, dated October 2012: https://www.wecc.biz/Reliability/1210_BV_WECC_TransCostReport_Final.pdf.

SOURCE	230-KV SINGLE CIRCUIT	230-KV DOUBLE CIRCUIT	345-KV SINGLE CIRCUIT	345-KV DOUBLE CIRCUIT	500-KV SINGLE CIRCUIT	500-KV DOUBLE CIRCUIT	500-KV DC BI-POLE
FERC Nation-wide Utility Survey	100 ft.	-	125 ft.	-	175 ft.	-	-
DRECP (SCE/LADWP)	100 ft.	-	-	-	200 ft.	-	-
SDG&E	-	300 ft.	-	-	200 ft.	-	-
PG&E	75 ft.	-	-	-	-	-	-
PacifiCorp	125/150 ft.	-	150 ft.	-	250/300 ft.	300	-
BPA	125/225 ft.	-	-	-	150 ft.	-	-
Idaho Power	-	-	-	-	250 ft.	-	-
Xcel Energy	-	-	-	225/250 ft.	-	-	-
WREZ	150 ft.	150 ft.	160 ft.	160 ft.	175 ft.	175 ft.	200 ft.
WECC Assumption	125 ft.	150 ft.	175 ft.	200 ft.	200 ft.	250 ft.	200 ft.
Acres/mile*	**15.14**	**18.17**	**21.20**	**24.23**	**24.23**	**30.29**	**24.23**

***Acres/mile values were calculated by multiplying the right of way width by 5,280 feet per mile and dividing by 43,560 sq. ft. per acre.**

Figure A.10: ROW Widths by Voltage Class and Data Source