# How wet must a wetland be to have federal protections? Estimating a range of potential impacts from Sackett v. EPA using wetland flooding frequency

Adam C. Gold[1]
[1]Environmental Defense Fund, Raleigh, NC, USA, agold@edf.org

## Abstract

In 2023, the Supreme Court's majority opinion in *Sackett v. EPA* created an unclear requirement that federally protected wetlands must have a "continuous surface connection" to federally protected waters. This study estimates the potential impact of interpretations of the ruling on federal wetlands protections, using wetland flooding frequency as a proxy for the new requirement. An estimated 17 million acres (19%) to nearly all 90 million acres of non-tidal wetlands in the conterminous US could be without federal protections, and variability in state protections creates hotspots of risk. The high-level estimates provided here represent a first step towards understanding the potential extent of the impact of *Sackett v. EPA* on federal wetlands protections and highlight the uncertainty introduced by the ruling.

## Main Text

The Clean Water Act (CWA) was passed in the United States in 1972 to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (*1*) by protecting select water bodies, streams, and wetlands. These federally protected, or federally jurisdictional, waters are defined as "waters of the United States" (WOTUS) by the US Environmental Protection Agency (EPA) and US Army Corps of Engineers (USACE). WOTUS generally includes large "navigable" water bodies and the streams and wetlands connected to them, but the specific definition of WOTUS and what "connected" means has shifted over the past 20 years and has had significant impacts on which waterbodies, streams, and wetlands are protected by the federal government (*2*, *3*).

The most recent change to the interpretation of what are WOTUS occurred in May 2023 after the US Supreme Court ruled in *Sackett v. EPA*. The majority opinion stated that federal protections under the CWA extend only to those wetlands that are "indistinguishable" from WOTUS, such that "the wetland has a continuous surface connection with that water, making it difficult to determine where the 'water' ends and the 'wetland' begins" (*4*). This narrower interpretation of federally protected wetlands has been characterized as "adjoinment"(*5*), but this requirement is neither science-based (*6*) nor well-defined by the Court. The majority opinion in Sackett v. EPA creates unclear federal jurisdiction requirements for wetlands, and this raises the question: how wet must a wetland be to have federal protections? Justice Kavanaugh noted this concept in his concurring opinion, writing "how difficult does it have to be to discern the boundary between a water and a wetland for the wetland to be covered by the Clean Water Act? How does that test apply to the many kinds of wetlands that typically do not have a surface water connection to a covered water year-round —for example, wetlands and waters that are connected for much of the year but not in the summer when they dry up to some extent?"(*4*).

To conform to the Supreme Court decision, the EPA released a final rule in August 2023 that revised the definition of WOTUS and narrowed the scope of protections under the Clean Water Act (*7*). The EPA's amended 2023 rule removed the significant nexus test (from *Rapanos v. United States*, 2006) which protected isolated wetlands that significantly affect downstream water quality and revised the definition of "adjacent" from "bordering, contiguous, or neighboring" to having a "continuous surface connection" (*9*). Highlighting the uncertainty introduced by the Supreme Court's language in its ruling in *Sackett v. EPA*, the EPA's conforming rule is already being challenged in court for allegedly defining the Supreme Court's requirement of a "continuous surface connection" to be too inclusive (*10*).

The Supreme Court opinion in *Sackett v. EPA* has potentially made a large portion of wetlands not federally jurisdictional (*5*, *11*), but there have been no large-scale, spatially-explicit estimates of the ruling's impact. Also, the lack of a science-based jurisdictional requirement for wetlands in the opinion means that there is no clear single interpretation that can be used for that estimation. Given the importance of wetland ecosystems and their myriad beneficial downstream impacts (*12*), there is a critical need to capture the full range of potential impacts of the Supreme Court's decision. While federal jurisdictional status of waters and wetlands can only be determined by the EPA and USACE, prior studies have demonstrated the utility of estimating federal jurisdictional status based on physical characteristics that align with definitions of WOTUS (*3*, *13*, *14*)

This study estimates the federal jurisdictional status of non-tidal wetlands in the conterminous US using a range of potential interpretations of the Supreme Court's *Sackett v. EPA* majority opinion. The potential interpretations presented here use different wetland flooding frequency thresholds as a proxy for a "continuous surface connection", so wetlands that are "drier" than a given flooding frequency threshold cannot be estimated jurisdictional. I use the best available national-scale data of wetlands extent (*15*) and hydrography (*16*) to estimate non-tidal wetlands as federally jurisdictional if they intersect estimated jurisdictional waters and meet or exceed a given flooding frequency (*17*). Finally, I use a national public lands dataset and state-level wetlands protections presence to determine which states may have the most unprotected wetland area.

## Most non-tidal wetlands could be federally non-jurisdictional

For the conterminous US, non-tidal wetland area estimated as non-jurisdictional ranged from 17.3 million acres (15– 25.9 million acres), or 19% of non-tidal wetland area, to nearly all 90 million acres of non-tidal wetland area (Figure 1). The low range of estimated non-jurisdictional non-tidal wetland area (17.3 million acres, 19%) does not exclude any wetlands based on flooding frequency, so the only requirement for estimated jurisdiction for a spatially contiguous group of wetland polygons is an intersection with estimated jurisdictional stream or water (*17*). More exclusive interpretations of the Sackett opinion where a flooding frequency threshold is used to filter out "drier" wetlands even if they intersect an estimated WOTUS leads to much larger wetland area estimated as non-jurisdictional. A seasonal flooding frequency threshold where wetlands typically have at least 1 month of surface inundation but are dry by the end of the growing season would exclude wetlands that have temporary surface inundation in response to storms and wetlands that have seasonally or continuously saturated soils but no regular surface water. A seasonal flooding frequency threshold interpretation results in an estimated 55 million acres (53.6 – 59.1 million acres), or 61%, of non-tidal wetlands as non-jurisdictional. A semi-permanently flooded threshold, where wetlands would need to almost always have surface water present to be jurisdictional, produces an estimated 81.9 million acres (81.4– 82.8 million acres), or 91%, of non-tidal wetlands without federal jurisdictional status. Finally, a potential interpretation that requires wetlands to be permanently flooded excludes practically all non-tidal wetlands from federal protections.

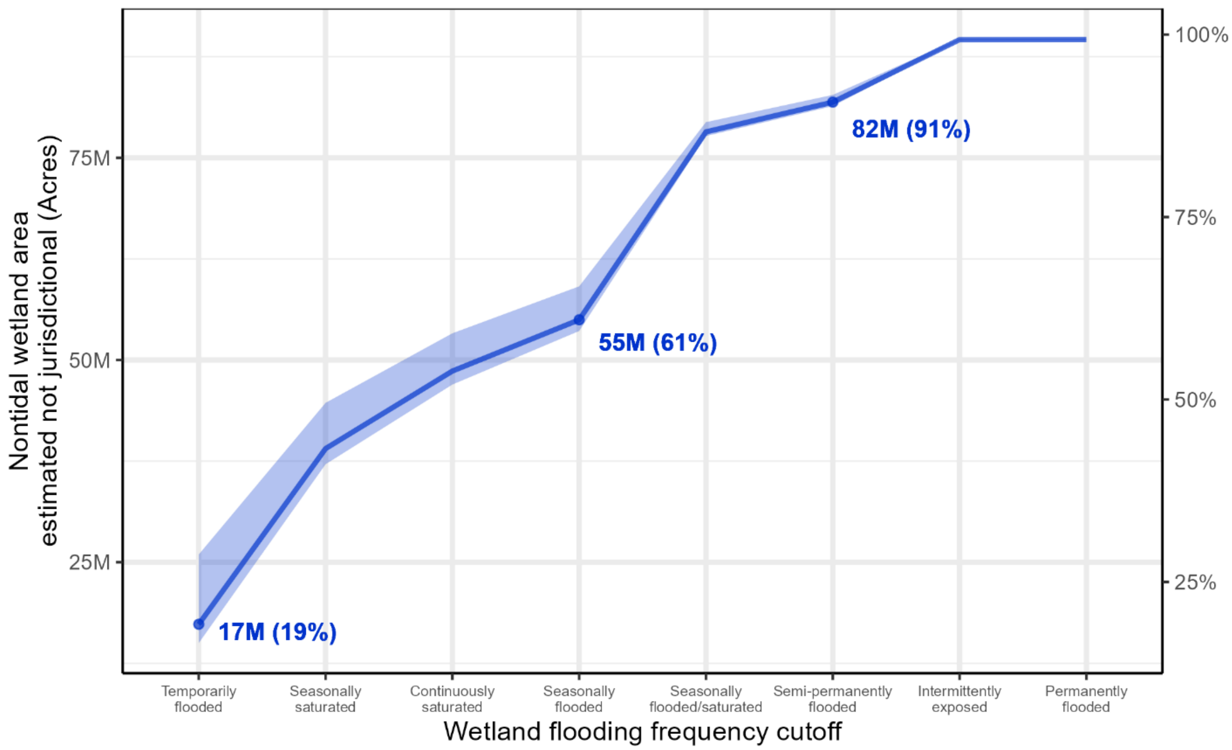


**Figure 1. Non-tidal wetland area estimated as not federally jurisdictional using different flooding frequency thresholds.** Large amounts of non-tidal wetland area in the conterminous US could be non-jurisdictional, depending on how the Supreme Court's *Sackett v. EPA* majority opinion is interpreted. The upper, mid-line, and lower bounds on the y-axis are defined by what types of streams and flowlines are considered WOTUS (*17*).

## Hotspots of at-risk wetland area

This analysis shows that a large proportion of each study state's non-tidal wetland area could be without federal jurisdictional status under higher flooding thresholds (Figure 2A), but there are geographic hotspots of at-risk wetland area due to variation in the presence of state protections. Non-tidal wetland area in the conterminous US is concentrated near the Gulf coast, Atlantic coast, and Great Lakes, and these locations also have the highest area of non-tidal wetlands without estimated federal protections under nearly every potential interpretation presented here (Figure 2B). Half of US states have some form of state-level protections beyond the CWA to protect their wetlands (*18*), and approximately half of non-tidal wetland area estimated as non-jurisdictional is in a state with some form of state-level protections (Figure 3). The four states with the most estimated non-jurisdictional wetland area using a seasonal flooding threshold– Minnesota, Michigan, Wisconsin, and Florida – have broad state-level protections in place (Figure 2B)(*18*). After Florida, the next 13 states with the largest amount of estimated non-jurisdictional wetland area have no state-level wetlands protections (Figure 2B, Table S5). These 13 states with high potential non-jurisdictional wetland area and no state protections are clustered in the Southern US and Great Plains region (Table S5).

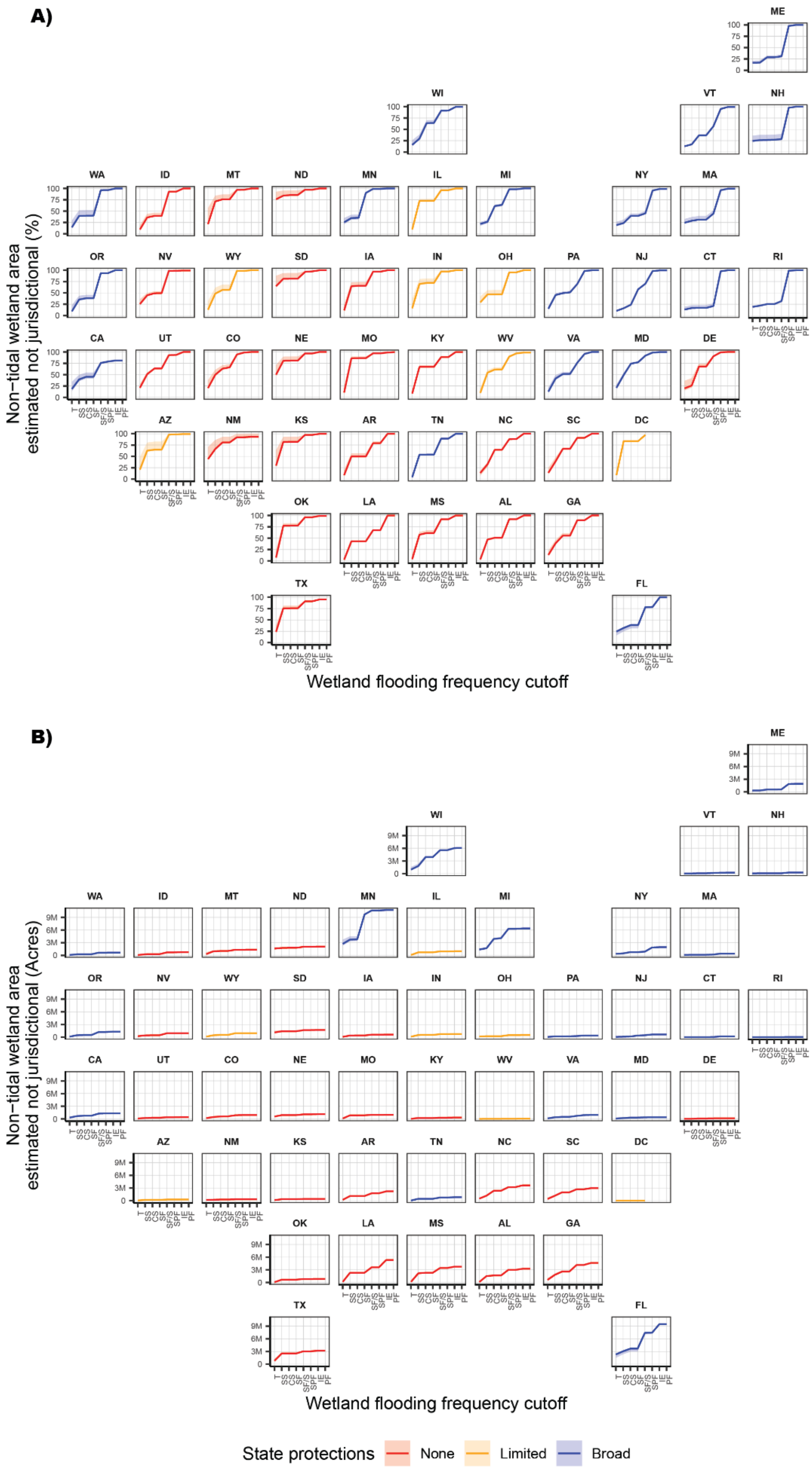
A)
ME
WI
VT
NH
WA
ID
MT
ND
MN
IL
MI
NY
MA
OR
NV
WY
SD
IA
IN
OH
PA
NJ
CT
RI
CA
UT
CO
NE
MO
KY
WV
VA
MD
DE
AZ
NM
KS
AR
TN
NC
SC
DC
OK
LA
MS
AL
GA
TX
FL
0
25
50
75
100
T
SS
CS
SF
SFS
SPF
IE
PF
Non−tidal wetland area estimated not jurisdictional (%)
Wetland flooding frequency cutoff
B)
0
3M
6M
9M
Non−tidal wetland area estimated not jurisdictional (Acres)
Wetland flooding frequency cutoff
State protections
None
Limited
Broad

**Figure 2. Non-tidal wetland area for each state estimated as non-jurisdictional using different flooding frequency thresholds. A)** Results presented as percent of total non-tidal wetland area in each state, and **B)** area in each state. State protections classifications from Kihslinger et al., 2023 (*18*).Values for the x-axis use the following acronyms: T = Temporarily flooded, SS = Seasonally saturated, CS = Continuously saturated, SF = Seasonally flooded, SF/S = Seasonally flooded/saturated, SPF = Semi-permanently flooded, IE = Intermittently exposed, PF = Permanently flooded.

Publicly owned or conserved land can serve as an important form of wetlands protection in the absence of federal or state protections, but only about a quarter of estimated non-jurisdictional wetland area is on protected lands in states without state-level protections (Figure 3). Further, land with a GAP (Gap Analysis Project)(*19*) status of 3 or 4 allows extractive uses and development, respectively, so wetlands in those areas could still be degraded. If GAP statuses 3 and 4 are classified as not protective, between 40 and 53.6% (across all scenarios) of all estimated non-jurisdictional wetland area also has no protection at the state or property level. Overall, state regulations protect much more potentially non-jurisdictional wetland area than protected lands.

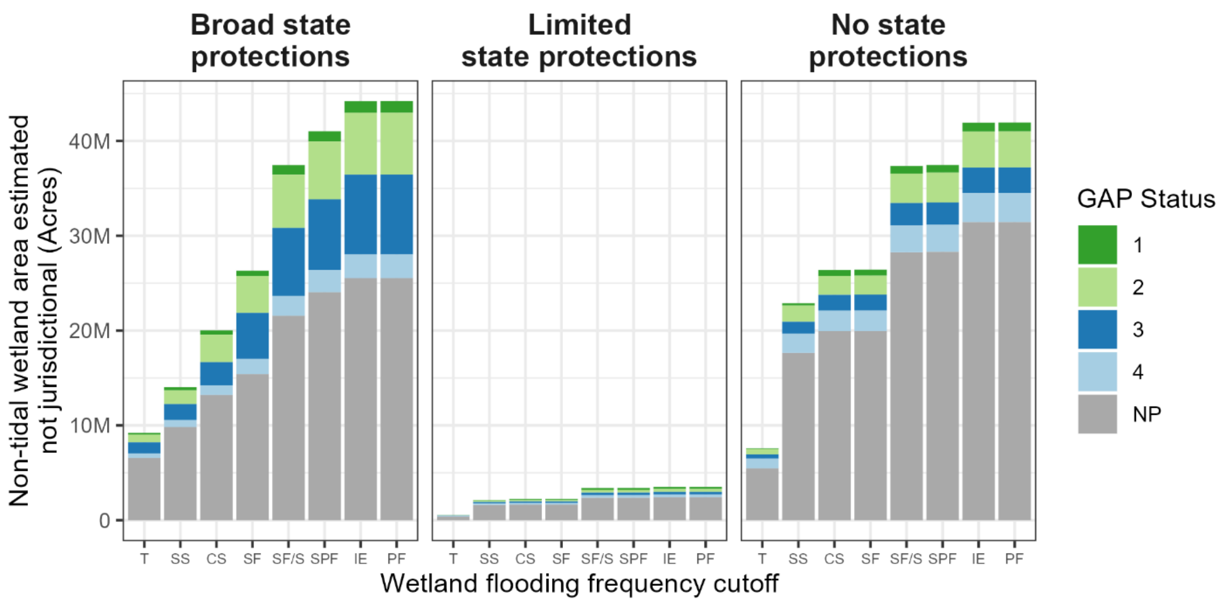


**Figure 3. Protected status of non-tidal wetland area estimated as non-jurisdictional.** Middle estimates of non-tidal wetland area estimated as not jurisdictional under different potential interpretations of Sackett v. EPA's majority opinion and organized by presence of state-level wetlands protections. GAP status is a measurement of conservation management, and a value of "NP" represents area that is "not protected" (i.e., No GAP status value). Values for the x-axis use the following acronyms: T = Temporarily flooded, SS = Seasonally saturated, CS = Continuously saturated, SF = Seasonally flooded, SF/S = Seasonally flooded/saturated, SPF = Semi-permanently flooded, IE = Intermittently exposed, PF = Permanently flooded.

## Smaller wetlands are more at risk and are underestimated

Under most modeled interpretations of the Supreme Court's majority opinion in this analysis, smaller wetlands were less likely than larger wetlands to be estimated as jurisdictional (Figure 4). This size trend was most apparent for the interpretation where no wetlands were excluded based on flooding frequency, meaning that smaller wetlands were generally less likely to intersect an estimated jurisdictional water than larger wetlands. Smaller wetlands are known to be less frequently connected to surface water than larger contiguous wetland areas, and this is why smaller wetlands, which are distributed throughout a landscape, can provide such large benefits to water quality and flooding (*20*, *21*).

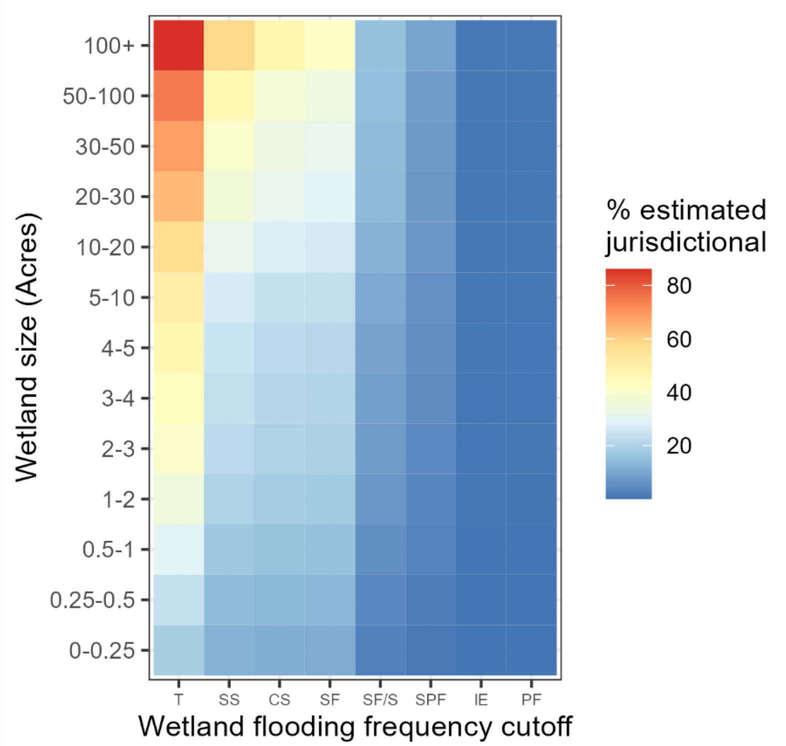


**Figure 4**. **Wetland size and estimated federal jurisdictional status.** Smaller wetlands are less likely to be estimated as jurisdictional using all potential interpretations of the Supreme Court's majority opinion in Sackett v. EPA. Color scale indicates the percentage of contiguous wetland groups in each size bin that are estimated to be federally jurisdictional. Values for the x-axis use the following acronyms: T = Temporarily flooded, SS = Seasonally saturated, CS = Continuously saturated, SF = Seasonally flooded, SF/S = Seasonally flooded/saturated, SPF = Semi-permanently flooded, IE = Intermittently exposed, PF = Permanently flooded.

Small wetlands are also less likely to be included in the underlying dataset used in this analysis, so the amount of estimated non-jurisdictional wetland area could be even higher than estimates provided here. This analysis uses the National Wetlands Inventory (NWI) to represent wetland area, and while the NWI is the best available national-scale sources of wetlands data for the US, it has well-known accuracy and resolution limitations (*22*). The main limitations relevant to this study are variable spatial accuracy, outdated data in some areas, and the omission of smaller wetlands (*22*, *23*). Some data limitations are partially addressed, by generously buffering streams and waters, for example (*17*), but future improvement of the NWI or the use of higher-resolution state-level datasets would improve the accuracy of future jurisdictional estimates.

## Conclusion

This study estimates potential impacts of the Supreme Court's ruling in *Sackett v. EPA* and highlights the extreme uncertainty and potentially devastating loss of federal wetlands protections as a result of the decision. The EPA's amended 2023 rule is now in effect in 23 states, DC, and US territories, but 27 states are implementing a pre-2015 regulatory regime consistent with the Sackett decision while litigation over the January 2023 rule is ongoing (*24*). Given this patchwork of implementation, multiple challenges to the amended 2023 rule, and the potential end of the "Chevron doctrine"(*25*), it is clear that the Supreme Court will eventually clarify its ruling in *Sackett v. EPA*. This high-level analysis is a first step towards understanding the long-term potential impacts of the Sackett decision, with the hope that an increased understanding of potential impacts will inform public discussion and response. There are still many questions around the Sackett decision that cannot be answered at the national scale with existing public data (*17*), and additional studies at different scales and higher resolution data are needed to understand the potential impacts in greater detail.

As many others in the scientific community have said before (*11*, *26*), lawmakers should act and implement robust federal wetlands protections that are based on sound science. States without wetlands protections should implement robust permitting programs, and all states with state-level protections should fully fund their agencies that enforce their regulatory protections. By creating or strengthening state protections to protect wetlands that are vulnerable post-Sackett, state governments can provide a level of certainty for wetlands permitting and protections.

## References


1. *33 U.S.C. §1251 et Seq.* (1972; https://www.govinfo.gov/content/pkg/USCODE-2022-title33/html/USCODE-2022-title33.htm).

2. S. Greenhill, H. Druckenmiller, S. Wang, D. A. Keiser, M. Girotto, J. K. Moore, N. Yamaguchi, A. Todeschini, J. S. Shapiro, Machine learning predicts which rivers, streams, and wetlands the Clean Water Act regulates. *Science* **383**, 406–412 (2024).

3. J. Wade, C. Kelleher, A. S. Ward, R. L. Schewe, The fluid definition of the 'waters of the United States': Non-uniform effects of regulation on US wetland protections. *Hydrological Processes* **36**, e14747 (2022).

4. *Sackett v. EPA* (2023; https://www.supremecourt.gov/opinions/22pdf/21-454_4g15.pdf).

5. A. S. Ward, A. Amos, The Supreme Court Is Bypassing Science—We Can't Ignore It. *Eos* (2023).

6. C. R. Lane, I. F. Creed, H. E. Golden, S. G. Leibowitz, D. M. Mushet, M. C. Rains, Q. Wu, E. D'Amico, L. C. Alexander, G. A. Ali, N. B. Basu, M. G. Bennett, J. R. Christensen, M. J. Cohen, T. P. Covino, B. DeVries, R. A. Hill, K. Jencso, M. W. Lang, D. L. McLaughlin, D. O. Rosenberry, J. Rover, M. K. Vanderhoof, Vulnerable Waters are Essential to Watershed Resilience. *Ecosystems* **26**, 1–28 (2023).

7. EPA, USACE, *Revised Definition of "Waters of the United States"; Conforming* (2023; https://www.federalregister.gov/d/2023-18929)vol. 88 FR 61964.

8. *Rapanos v. United States* (2006; https://www.epa.gov/sites/default/files/2016-04/documents/rapanos_decision_2006.pdf).

9. US EPA, Amendments to the 2023 Rule (2023). https://www.epa.gov/wotus/amendments-2023-rule.

10. *State of Texas v. EPA* (2024; https://subscriber.politicopro.com/eenews/f/eenews/?id=0000018d-6b7c-d66d-afed-effdea360000).

11. S. M. P. Sulliván, "Testimony for the U.S. Senate Committee on Environment and Public Works: Examining the Implications of Sackett v. U.S. Environmental Protection Agency for Clean Water Act Protections of Wetlands and Streams" (2023); https://www.epw.senate.gov/public/_cache/files/5/7/575e4e70-4e50-40ce-8ee9-def9c46f757b/6791ADF26116D5CFB2B14A514886238C.10-18-2023-sulliv-n-testimony.pdf.

12. U.S. EPA, "Connectivity of Streams and Wetlands To Downstream Waters: A Review and Synthesis of the Scientific Evidence (Final Report)" (Reports & Assessments EPA/600/R-14/475F, U.S. Environmental Protection Agency, Washington, DC, 2015); https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=296414.

13. R. Walsh, A. S. Ward, Redefining Clean Water Regulations Reduces Protections for Wetlands and Jurisdictional Uncertainty. *Frontiers in Water* **1** (2019).

14. R. Walsh, A. S. Ward, An overview of the evolving jurisdictional scope of the U.S. Clean Water Act for hydrologists. *WIREs Water* **9**, e1603 (2022).

15. US FWS, "National Wetlands Inventory" (U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C., 2023); https://www.fws.gov/wetlands.

16. U.S. Geological Survey, "National Hydrography Dataset Plus High Resolution (NHDPlus HR) - USGS National Map Downloadable Data Collection" (2023); https://www.sciencebase.gov/catalog/item/57645ff2e4b07657d19ba8e8.

17. Materials and methods are available as supplementary materials.

18. R. Kihslinger, J. M. McElfish, H. Luedke, Jr., G. Ray, "Filling the gaps: Strategies for States/Tribes for Protection of non-WOTUS waters: A Taxonomy" (Environmental Law Institute, Washington, D.C., 2023); https://www.eli.org/sites/default/files/files-pdf/Strategies%20for%20States-Tribes%20for%20Protection%20of%20non-WOTUS%20waters%201.2.pdf.

19. U.S. Geological Survey, Gap Analysis Project. https://www.usgs.gov/programs/gap-analysis-project.

20. J. M. Marton, I. F. Creed, D. B. Lewis, C. R. Lane, N. B. Basu, M. J. Cohen, C. B. Craft, Geographically Isolated Wetlands are Important Biogeochemical Reactors on the Landscape. *BioScience* **65**, 408–418 (2015).

21. H. E. Golden, H. A. Sander, C. R. Lane, C. Zhao, K. Price, E. D'Amico, J. R. Christensen, Relative effects of geographically isolated wetlands on streamflow: a watershed-scale analysis. *Ecohydrology* **9**, 21–38 (2016).

22. J. R. Christensen, H. E. Golden, L. C. Alexander, B. R. Pickard, K. M. Fritz, C. R. Lane, M. H. Weber, R. M. Kwok, M. N. Keefer, Headwater streams and inland wetlands: Status and advancements of geospatial datasets and maps across the United States. *Earth-Science Reviews* **235**, 104230 (2022).

23. S. Gale, "National Wetlands Inventory (NWI) accuracy in North Carolina" (NC Department of Environmental Quality, 2021); https://www.ncwetlands.org/wp-content/uploads/NWI_Accuracy_In_NC_NCDWR-Final_Report_8-10-2021.pdf.

24. EPA, Definition of "Waters of the United States": Rule Status and Litigation Update (2023). https://www.epa.gov/wotus/definition-waters-united-states-rule-status-and-litigation-update.

25. A. Liptak, Conservative Justices Appear Skeptical of Agencies' Regulatory Power, *The New York Times* (2024). https://www.nytimes.com/2024/01/17/us/supreme-court-chevron-case.html.

26. A. S. Ward, J. Wade, C. Kelleher, R. L. Schewe, Clarify jurisdiction of US Clean Water Act. *Science* **379**, 148–148 (2023).

27. E. Gage, D. J. Cooper, R. Lichvar, Comparison of USACE Three-Factor Wetland Delineations to National Wetland Inventory Maps. *Wetlands* **40**, 1097–1105 (2020).

28. US FWS, Derivation of Wetland Difference Products by Comparing the NWI Geospatial Dataset with C-CAP (10-m) and NLCD (2019) Data | FWS.gov (2022). https://www.fws.gov/media/derivation-wetland-difference-products-comparing-nwi-geospatial-dataset-c-cap-10-m-and-nlcd.

29. Federal Geographic Data Committee, "Classification of Wetlands and Deepwater Habitats of the United States. Second Edition" (FGDC-STD-004-2013, Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service, Washington, DC, 2013); https://www.fws.gov/sites/default/files/documents/Classification-of-Wetlands-and-Deepwater-Habitats-of-the-United-States-2013.pdf.

30. U. C. Bureau, TIGER/Line Geodatabases, *Census.gov*. https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-geodatabase-file.html.

31. U.S. Geological Survey (USGS) Gap Analysis Project (GAP), Protected Areas Database of the United States (PAD-US) 3.0 Spatial Analysis and Statistics, [object Object] (2022); https://doi.org/10.5066/P9KLBB5D.

32. J. A. Villines, C. T. Agouridis, R. C. Warner, C. D. Barton, Using GIS to Delineate Headwater Stream Origins in the Appalachian Coalfields of Kentucky. *JAWRA Journal of the American Water Resources Association* **51**, 1667–1687 (2015).

33. K. M. Fritz, B. R. Johnson, D. M. Walters, Physical indicators of hydrologic permanence in forested headwater streams. *Journal of the North American Benthological Society* **27**, 690–704 (2008).

## Acknowledgements

EDF is solely responsible for the methods and outputs of this work. I thank my colleagues at EDF for their comments and discussion of this work, especially K. Boicourt and I. Steinberg-McElroy. Thank you also to Environmental Law Institute for their review of portions of this work.

## List of supplementary materials

Materials and Methods
Tables S1 and S5
References (27–33)

# Supplementary Materials

## Materials and Methods

To determine the federal jurisdictional status of wetlands, this study estimates the hydrologic connection of wetlands in the contiguous United States and uses the Cowardin water regime modifier of NWI wetland polygons to explore potential interpretations of a "continuous surface connection". This analysis consisted of 3 major steps: 1) processing NWI polygons to better align with the USACE 3-factor wetland definition, 2) calculating the connectivity of National Hydrography Dataset Plus High Resolution (NHDPlus HR) features - streams and select water bodies - to wetlands, and 3) estimating jurisdictional status based on range of interpretations of a "continuous surface connection" using wetland flooding frequency (i.e., Cowardin water regime) as a proxy. After the federal jurisdictional status of wetlands was estimated, state protections and national protected lands datasets were overlaid with this study's wetlands dataset to inform potential vulnerability of wetlands.

### Processing wetlands data

NWI data are available for public download as state-level files, so these state-level files required assembly into a seamless multi-state dataset. State-level NWI data were downloaded as a geodatabase for each US state and territory from the NWI webpage (https://www.fws.gov/program/national-wetlands-inventory/download-state-wetlands-data) using R. An ArcPy script then modified each selected state's feature class denoting current wetland polygons by converting geometries from multipart to singlepart, repairing geometries using the ESRI validation method, and clipping the state dataset to corresponding state boundaries from 2022 US Census state boundaries (TIGER geodatabase). The clipped and repaired state-level feature classes were combined into a single feature class covering the entire study area.

The definition of wetlands differs between the NWI and the criteria used by the USACE for jurisdictional determinations (*27*), so NWI Cowardin wetland types that do not align the USACE 3-factor criteria were removed following similar methods from previous studies (*3*, *27*)(Table S1). Most of the removed wetland types were associated with either deepwater, non-vegetated, or anthropogenically influenced features. Of note, "impounded" vegetated wetlands were not removed because they can be jurisdictional if the impoundment they are connected to is a WOTUS. After isolating non-deepwater wetlands by removing lake, riverine, and estuarine and marine deepwater wetlands, the average percentage of non-deepwater NWI area removed by the 3-factor filter for each state was 12.9% and ranged from 3 – 32.5% (Table S2). Remaining wetlands were classified as either "tidal" or "non-tidal" based on their Cowardin classifications, with wetlands classified as tidal if they contained "Saltwater tidal" or "Freshwater tidal" water regime modifiers. All other wetlands were considered "non-tidal". The processed NWI polygons were then spatially joined to a national-scale NWI Difference polygon product (*28*) which added National Land Cover Database (30 meter resolution) or Coastal Change Analysis Program (10 meter resolution) impervious surface coverage within each NWI polygon that had impervious surface area increase between their delineation date and 2015-2019. Wetland polygons with greater than 5% impervious surface coverage based on the NWI Difference product were removed so that polygons with a high likelihood of development would not be counted. The 5% impervious surface coverage threshold was picked after visual inspection to remove wetland polygons with larger amounts of development and keep wetlands with minimal impacts such as development around the perimeter of a polygon or a single road through large wetland polygons. The amount of wetland area removed due to the impervious surface filter was 322,432 acres, or 0.36% of total nontidal wetland area.

## Estimating jurisdictional streams and waters

Flowlines and water bodies within the NHDPlus HR dataset were used to create three versions of the estimated jurisdictional network to create a lower, middle, and upper bounds of estimated jurisdictional features. Each flowline was assigned a hydrographic classification derived from either its “fcode” attribute or the “fcode” attribute of flowlines connected to it (Table S3). Water bodies were assigned either a perennial classification based its “ftype” attribute (Table S3) or the minimum hydrographic classification value of a flowline that intersected it (Lakes, ponds, impoundments: 46000, 43613, 43615, 43617, 390 [LakePond]). Additional criteria for inclusion in the jurisdictional stream network differed by flowline type (Table S4). The three versions of the estimated jurisdictional network were created by selecting flowlines with only perennial hydrographic classification (value of 1), perennial or intermittent hydrographic classifications (value of 1 or 2), and perennial, intermittent, or ditch hydrographic classifications (value of 1,2, or 3). All features in the estimated jurisdictional networks were buffered by 20m, except water bodies with a hydrographic classification greater than 1, which were buffered by 5m. To be jurisdictional under the Clean Water Act, relatively permanent waters must be connected without interruption to “navigable waters”, but stream permanence and flowline type classification errors in the NHDPlusHR made this criterion impractical to implement. In assessing connectivity of flowlines to downstream waters, small, misclassified flowlines essentially “blocked” the upstream propagation of connectivity based on hydrographic classification (i.e., perennial and connected), leading to underestimates of perennial and intermittent stream lengths. Additionally, some NHDPlusHR flowlines terminate into wetlands rather than other flowlines or water bodies. This study assumes that all flowlines with an “InNetwork” flag eventually flow to traditionally navigable waters, which is likely an overestimation of jurisdictional extent.

## Estimating federal jurisdictional status of wetlands

The estimated jurisdictional status of NWI wetland polygons was determined based on their connections to jurisdictional streams and water bodies and if they exceeded a specific wetland flooding frequency threshold (Cowardin water regime modifier). The boundaries of NWI polygons are determined by Cowardin codes (*29*) that describe wetland type and attributes such as vegetation type, anthropogenic impacts, and flooding frequency. Given that the latest interpretation of WOTUS focuses on “a continuous surface connection” to jurisdictional waters, a range of interpretations of “continuous surface connection” were modeled by spatially grouping wetlands based on their flooding frequency rather than full Cowardin code. The Cowardin code water regime modifier that represents wetland flooding frequency was extracted for each polygon and using a range of water regime thresholds spanning from “temporarily flooded” to “permanently flooded” wetlands, NWI polygons were selected if they met or flooded more frequently than the water regime threshold. Wetland polygons with the same or more frequent flooding class were then spatially grouped and assigned as jurisdictional if at least one wetland polygon in the group was estimated jurisdictional based on its intersection with estimated jurisdictional streams and water bodies.

### Overlaying wetlands with state and land protections

A shapefile representing state wetlands protections was created using the Census Bureau TIGER feature class representing US state boundaries (*30*) and categories of state wetlands protections (*18*). The attribute table of state wetlands protections shapefile was joined to the wetland polygons by state abbreviation using RStudio. Wetland polygons were intersected with a vector spatial analysis product from the PAD-US dataset (*31*) representing GAP status to determine wetland area on protected lands. GAP status is a measurement of conservation management. The area of each wetland polygon was recalculated after the intersection with the GAP status feature class.

## Tables

**Table S1.** NWI wetland types removed to better align with USACE 3-factor delineation criteria.

| Cowardin wetland type | Cowardin wetland attribute/modifier | Cowardin description |
|---|---|---|
| Lake | - | - |
| Riverine | - | - |
| Estuarine and Marine Deepwater | - | - |
| Any | x | Excavated |
| | K | Artificially flooded |
| | s | Spoil |
| | RB | Rock bottom |
| | UB | Unconsolidated bottom |
| | RF | Reef |
| | AB | Aquatic bed |
| | RS | Rocky shore |
| | SB | Streambed |
| | US | Unconsolidated shore |

**Table S2.** Area of non-deepwater NWI polygons before and after a filter to better align with the USACE's 3-factor definition of a wetland. Pre-3 factor area is the area of NWI polygons, excluding "Lake", "Riverine", and "Estuarine and Marine Deepwater" wetland types. Post-3 factor area is the area of NWI polygons after removing wetlands with the attributes listed in Table S1.

| State | Pre-3 factor area (Acres) | Post-3 factor area (Acres) | % kept |
|---|---|---|---|
| AL | 3,440,357 | 3,286,474 | 95.53 |
| AR | 2,503,087 | 2,220,386 | 88.71 |
| AZ | 322,016 | 282,555 | 87.75 |
| CA | 2,293,955 | 1,745,616 | 76.10 |
| CO | 1,035,143 | 920,020 | 88.88 |
| CT | 222,624 | 195,511 | 87.82 |
| DC | 249 | 222 | 89.14 |
| DE | 245,677 | 228,953 | 93.19 |
| FL | 11,696,801 | 10,666,937 | 91.20 |
| GA | 5,329,164 | 5,043,036 | 94.63 |

| | | | |
|---|---|---|---|
| IA | 759,653 | 612,449 | 80.62 |
| ID | 817,097 | 769,055 | 94.12 |
| IL | 1,161,718 | 999,228 | 86.01 |
| IN | 888,205 | 731,774 | 82.39 |
| KS | 633,521 | 427,942 | 67.55 |
| KY | 444,524 | 325,520 | 73.23 |
| LA | 7,645,972 | 7,326,850 | 95.83 |
| MA | 564,471 | 493,073 | 87.35 |
| MD | 698,973 | 665,529 | 95.22 |
| ME | 2,142,605 | 1,955,708 | 91.28 |
| MI | 6,585,970 | 6,387,625 | 96.99 |
| MN | 11,081,974 | 10,677,198 | 96.35 |
| MO | 1,323,633 | 991,461 | 74.90 |
| MS | 4,060,909 | 3,818,226 | 94.02 |
| MT | 1,557,337 | 1,372,751 | 88.15 |
| NC | 4,120,166 | 3,941,043 | 95.65 |
| ND | 2,556,512 | 2,093,046 | 81.87 |
| NE | 1,253,295 | 1,116,707 | 89.10 |
| NH | 312,762 | 277,049 | 88.58 |
| NJ | 910,907 | 869,556 | 95.46 |
| NM | 439,173 | 348,809 | 79.42 |
| NV | 1,011,338 | 941,910 | 93.14 |
| NY | 2,187,500 | 2,011,386 | 91.95 |
| OH | 648,164 | 499,971 | 77.14 |
| OK | 1,132,257 | 851,527 | 75.21 |
| OR | 1,467,269 | 1,337,905 | 91.18 |
| PA | 455,042 | 386,272 | 84.89 |
| RI | 70,011 | 60,566 | 86.51 |
| SC | 3,667,664 | 3,485,291 | 95.03 |
| SD | 2,092,333 | 1,717,083 | 82.07 |
| TN | 928,402 | 834,345 | 89.87 |
| TX | 4,763,329 | 3,756,699 | 78.87 |
| UT | 543,854 | 437,577 | 80.46 |
| VA | 1,414,166 | 1,211,780 | 85.69 |
| VT | 253,295 | 232,730 | 91.88 |
| WA | 1,001,975 | 719,694 | 71.83 |
| WI | 6,286,730 | 6,086,353 | 96.81 |
| WV | 85,535 | 65,555 | 76.64 |
| WY | 1,051,553 | 940,545 | 89.44 |

**Table S3.** Hydrographic classification scale and associated values from NHDPlus HR datasets.

| Value | Category | Details | Fcode | Ftype | |
|---|---|---|---|---|---|
| | | | *NHDFlowlines* | *NHDArea* | *NHDWaterbody* |
| 1 | Perennial | Connected to streams that flow year-round and large water bodies that approximate traditionally "navigable" waters | 46006 (Perennial stream) | • 445 (SeaOcean)<br>• 312 (BayInlet)<br>• 460 (StreamRiver) | • 493 (Estuaries) |
| 2 | Intermittent | Connected to streams that flow seasonally | 46003 (Intermittent stream) | - | - |
| 5 | Ditch | Connected to a canal/ditch drainage feature | 336* (Canal/Ditch) | - | - |
| 4 | Ephemeral | Connected to streams classified as "ephemeral" | 46007 (Ephemeral stream) | - | - |
| 5 | Unknown | Connected to a stream with unknown stream permanence classification | 46000 | - | - |
| 6 | Isolated | Not connected to any flowlines or water bodies | - | - | - |

**Table S4.** Flowlines included in the estimated jurisdictional stream network and their criteria for inclusion. Multiple criteria for inclusion should be interpreted as "AND" statements.

| Description | FType | FCode | Additional criteria for inclusion | Hydrographic classification | Justification |
|---|---|---|---|---|---|
| Perennial streams | 460 | 46006 | | 1 - perennial | Perennial streams are considered a relatively permanent water. |
| Intermittent streams | 460 | 46003 | | 2 - intermittent | Intermittent streams are considered a relatively permanent water if they flow seasonally, typically for more than 3 months every year. |
| Canal/Ditch | 336 | | | 3 - canal/ditch | Canals and ditches can be jurisdictional if they are a relatively permanent water. They were included with a flow hydrographic classification of "3" unless they met additional criteria in this table for hydrographic classification re-assignment. |

| | | | | | |
|---|---|---|---|---|---|
| Unknown streams | 460 | 46000 | • Total upstream drainage area > 0.259 km$^2$ (0.1 mi$^2$) | • 1 – perennial. Total upstream drainage area > 2.59 km$^2$ (1 mi$^2$)<br>• 2 – Intermittent. Total upstream drainage area > 0.259 km$^2$ (0.1 mi$^2$) and < 2.59 km$^2$ | Some areas with higher resolution streams did not have flow permanence classifications, so a conservative upstream drainage area threshold was used to select a subset of unknown streams and make results more comparable across the entire study area (*13*, *32*, *33*). |
| Connector | 334 | - | | • 1 – perennial. Connectors that intersected rivers, oceans, estuaries, and bays/inlets.<br>• Other | Connectors often represented outlets of permanent water bodies. They were assigned a perennial hydrographic classification if they intersected large perennial waters, or they were assigned the minimum hydrographic classification of flowlines they intersected. |
| Artificial flowpath | 558 | - | | • 1 – perennial. Connectors that intersected rivers, oceans, estuaries, and bays/inlets.<br>• Other | Artificial flowpaths represent flowpaths through water bodies to maintain connectivity in the NHD network. They were assigned a perennial hydrographic classification if they intersected large perennial waters, or they were assigned the minimum hydrographic classification of flowlines they intersected. |
| Canal/Ditch | 336 | - | • gnis_name is NOT NULL | Other | Heavily ditched areas may have replaced natural stream channels with ditched, or there may be large canals that permanently hold and convey water. If the canal/ditch is large enough to have a name, it may be permanent enough to be included as a feature. These features were assigned the minimum hydrographic classification of flowlines they intersected. |

| | | | | | |
|---|---|---|---|---|---|
| Canal/Ditch | 336 | - | • Total upstream drainage area > 25 $km^2$ | Other | Some areas had stream networks drain to a ditch and then transitioned back to a stream. Note this uses a much larger threshold than the unknown stream flow permanence classification. These features were assigned the minimum hydrographic classification of flowlines they intersected. |
| Any | - | - | • InNetwork == 0<br>• Within 60m of an "in network" flowline or 20m of a water body | • Classified based on FCode or hydrographic classification of connected flowlines, if not a stream or canal/ditch | Some out-of-network flowlines terminated into wetlands rather than a body of water or another flowline, but they could still have significant upstream area and stream length. These would be included in the jurisdictional stream network if they were reasonably close to another in-network feature. |

**Table S5.** Non-tidal wetland area estimated not jurisdictional in each study state using a seasonal flooding jurisdictional requirement and ranked by middle estimate. State protections classifications from Kihslinger et al., 2023 (*18*).

| State | State Protections | Acres - Low | % - Low | Acres - Mid | % - Mid | Acres - Upper | % - Upper |
|---|---|---|---|---|---|---|---|
| MN | Broad | 9,589,211 | 89.31 | 9,670,909 | 90.07 | 9,891,390 | 92.13 |
| MI | Broad | 3,890,861 | 60.96 | 4,073,460 | 63.82 | 4,242,648 | 66.47 |
| WI | Broad | 3,865,056 | 63.54 | 3,900,478 | 64.12 | 4,285,592 | 70.45 |
| FL | Broad | 2,981,569 | 31.47 | 3,678,402 | 38.83 | 3,859,339 | 40.74 |
| GA | None | 2,557,841 | 55.33 | 2,565,477 | 55.49 | 2,830,749 | 61.23 |
| TX | None | 2,471,392 | 73.54 | 2,541,986 | 75.64 | 2,736,212 | 81.42 |
| NC | None | 2,307,241 | 63.41 | 2,351,620 | 64.63 | 2,393,933 | 65.80 |
| LA | None | 2,280,804 | 42.81 | 2,299,006 | 43.15 | 2,397,372 | 44.99 |
| MS | None | 2,289,978 | 61.30 | 2,292,552 | 61.37 | 2,505,027 | 67.05 |
| SC | None | 1,961,174 | 66.12 | 1,977,077 | 66.65 | 2,050,637 | 69.13 |
| ND | None | 1,789,449 | 85.50 | 1,789,629 | 85.51 | 2,000,386 | 95.58 |
| AL | None | 1,649,979 | 50.88 | 1,650,803 | 50.91 | 1,718,886 | 53.01 |
| SD | None | 1,391,911 | 81.11 | 1,394,977 | 81.29 | 1,610,836 | 93.87 |
| AR | None | 1,087,370 | 49.04 | 1,102,533 | 49.72 | 1,251,588 | 56.45 |
| MT | None | 1,036,666 | 75.54 | 1,043,525 | 76.04 | 1,191,984 | 86.86 |
| NE | None | 888,487 | 79.60 | 901,645 | 80.78 | 1,004,767 | 90.02 |
| MO | None | 848,789 | 85.81 | 853,915 | 86.32 | 890,655 | 90.04 |
| NY | Broad | 771,106 | 39.18 | 777,159 | 39.49 | 880,718 | 44.75 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CA | Broad | 690,415 | 41.53 | 754,875 | 45.40 | 907,345 | 54.57 |
| IL | Limited | 717,092 | 72.52 | 718,688 | 72.68 | 759,130 | 76.77 |
| OK | None | 657,670 | 77.42 | 658,464 | 77.51 | 702,409 | 82.69 |
| CO | None | 602,217 | 65.67 | 606,121 | 66.09 | 668,039 | 72.84 |
| ME | Broad | 546,883 | 28.50 | 547,017 | 28.51 | 622,666 | 32.45 |
| WY | Limited | 522,697 | 55.63 | 531,586 | 56.58 | 639,318 | 68.05 |
| IN | Limited | 516,721 | 70.78 | 524,875 | 71.90 | 596,001 | 81.64 |
| OR | Broad | 481,405 | 37.03 | 496,407 | 38.18 | 593,513 | 45.65 |
| VA | Broad | 459,611 | 48.98 | 484,119 | 51.59 | 524,263 | 55.87 |
| NV | None | 455,405 | 48.62 | 462,450 | 49.37 | 502,732 | 53.67 |
| TN | Broad | 447,107 | 53.91 | 447,330 | 53.93 | 464,782 | 56.04 |
| IA | None | 401,232 | 65.60 | 401,664 | 65.67 | 451,470 | 73.82 |
| NJ | Broad | 371,816 | 57.46 | 374,314 | 57.85 | 382,010 | 59.04 |
| KS | None | 349,748 | 81.85 | 351,157 | 82.18 | 397,671 | 93.07 |
| MD | Broad | 308,327 | 76.30 | 312,384 | 77.30 | 319,652 | 79.10 |
| ID | None | 296,916 | 38.67 | 302,726 | 39.42 | 354,866 | 46.21 |
| NM | None | 281,315 | 80.70 | 281,685 | 80.80 | 324,043 | 92.95 |
| UT | None | 267,703 | 61.80 | 275,097 | 63.51 | 282,874 | 65.30 |
| WA | Broad | 262,096 | 39.43 | 266,117 | 40.03 | 348,307 | 52.40 |
| OH | Limited | 229,014 | 46.09 | 232,793 | 46.85 | 278,819 | 56.11 |
| KY | None | 216,378 | 66.74 | 217,358 | 67.04 | 230,575 | 71.11 |
| PA | Broad | 195,581 | 51.14 | 195,668 | 51.16 | 208,387 | 54.49 |
| AZ | Limited | 180,579 | 64.07 | 182,779 | 64.85 | 232,570 | 82.51 |
| MA | Broad | 134,004 | 30.55 | 137,369 | 31.32 | 172,100 | 39.23 |
| DE | None | 95,607 | 65.79 | 98,659 | 67.90 | 107,794 | 74.18 |
| VT | Broad | 85,368 | 36.71 | 85,767 | 36.88 | 85,768 | 36.88 |
| NH | Broad | 73,029 | 26.98 | 73,169 | 27.03 | 103,793 | 38.34 |
| WV | Limited | 40,173 | 61.41 | 40,176 | 61.42 | 43,387 | 66.32 |
| CT | Broad | 30,172 | 16.73 | 30,398 | 16.86 | 41,386 | 22.95 |
| RI | Broad | 14,280 | 25.26 | 14,281 | 25.26 | 15,076 | 26.67 |
| DC | Limited | 114 | 83.69 | 114 | 83.69 | 114 | 83.69 |