REBUTTAL EXPERT REPORT OF DR. ARI J. STERN

***Wise v. Missouri*, 2516-CV29597 (Circuit Court of Jackson County, Missouri)**

January 14, 2026

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I. Scope of Engagement

1. I have been asked by counsel to evaluate and respond to the Expert Report of Sean P. Trende, Ph.D. (the "Trende Report") and the Expert Report of M.V. Hood III (the "Hood Report"), with regard to the Missouri Congressional districts enacted in 2025 as H.B. 1 (the "Missouri FIRST Map"). In this response, I will also be referring to the contents of the Expert Report of Dr. Ari J. Stern (as amended on December 30, 2025) (the "Stern Report"), in which I previously presented my own analysis of the Missouri FIRST Map.

2. My qualifications and compensation are unchanged since the Stern Report. As before, my compensation does not depend in any way on the results of my analyses, the opinions I provide, or the outcome of this case.

II. Summary of Opinions

3. The Missouri FIRST Map is an extreme departure from historical Congressional maps in splitting the populations of Jackson County and of Kansas City. Maps going back decades kept over 87% of the Jackson County population and over 73% of the Kansas City population intact in a single district, CD5. The Missouri FIRST Map keeps under 52% of the Jackson County population and under 41% of the Kansas City population intact—and furthermore, places the largest intact populations of Jackson County and of Kansas City into separate districts.

4. The Trende Report and Hood Report compare the shapes of districts between different decades, different electoral offices, and different geographical regions, without regard for differences in natural boundaries, political subdivision boundaries, and other recognized redistricting criteria. These comparisons are incomplete at best and invalid at worst—especially so for Dr. Trende's comparison between the shapes of Congressional districts and those of

Missouri Senate and Missouri House districts, which differ in a variety of ways, including their number, size, population, and geography.

5. The ensemble used in the Stern Report contains a wide variety of both compact and non-compact maps, and is sufficiently diverse to include maps that resemble the Missouri FIRST Map. The algorithm I employ does not overweight compactness, nor does it have an adjustable compactness parameter as Dr. Trende claims. Nor do the conclusions of the Stern Report depend solely on the *proportion* of compact and non-compact maps in the ensemble; they also depend on the *magnitude* of compactness (and other) differences observed. Moreover, one may accept these conclusions without accepting Dr. Trende's straw-man standard that "requires the *most* compact map to be selected" (Trende Report at p. 27, emphasis original).

6. Additional ensemble analysis shows that the Missouri FIRST Map is extreme in the number of different counties it combines into CD5. Specifically, it combines portions of 15 different counties in CD5, compared to an ensemble median of 3, with less than 0.5% of ensemble maps being more extreme than this. The maps in the ensemble are much more likely to create a district that combines Jackson County only with neighboring counties, and much less likely to combine Jackson County with far-flung rural counties across the state. This rebuts Dr. Trende's claim that the ensemble "make[s] similar choices" to the Missouri FIRST Map in combining urban and rural counties in this manner (Trende Report at p. 30).

III. Extreme Splitting of Jackson County and Kansas City Compared to Previous Maps

7. The Trende and Hood Reports both employ an overly simplistic approach to measuring county and municipal splitting that understates the extreme splitting in the Missouri FIRST Map, especially in Jackson County and Kansas City. For instance, they note *whether* a county is split, and sometimes the *number* of splits—but fail to distinguish between splits that

keep the vast majority of the county population intact, versus those that fracture the population into much smaller pieces. As I emphasized in my previous report, "The latter is far more problematic from the perspective of maintaining the closely united territory that comprises a county and its residents." (Stern Report at p. 12).

8. Dr. Trende asserts: "The split of Jackson County is also not entirely *sui generis*. It was split three ways in the 2022 map…. [It] was also split three ways in 1992 and 2002." (Trende Report at p. 21). Although the *number* of splits has precedent in these historical maps, the severe cracking of Jackson County population by these splits is in fact "*sui generis*."

9. Table 1 shows the percentage of Jackson County population in each of CD4, CD5, and CD6, based on Census total population data for the 1992, 2002, 2012, and 2022 Congressional districts (103rd, 108th, 113th, and 118th Congresses, respectively), alongside the same data for the Missouri FIRST Map districts enacted in 2025. I make this comparison going back to 1992, since this is the range of time mentioned in Dr. Trende's claim above.

10. From 1992 until the adoption of the Missouri FIRST Map, between 87–90% of the population of Jackson County was assigned to CD5, keeping this portion of the county population intact. Even in those maps with a three-way split of Jackson County, only a small fraction of the county population was split off into CD4 and/or CD6. The Missouri FIRST Map is an extreme departure from the precedent set by these historical boundary lines, with less than 52% of the Jackson County population assigned to CD5 and over 46% assigned to CD4. In other words: historical maps going back decades have consistently kept nearly 90% of the Jackson County population intact, while the Missouri FIRST Map keeps less than 52% intact.

Table 1: Percentage of Jackson County population in each Congressional district by year.

District	1992	2002	2012	2022	2025
4	3.87%	2.89%	–	10.83%	46.05%
5	89.88%	88.36%	88.20%	87.32%	51.71%
6	6.26%	8.76%	11.80%	1.85%	2.24%

11. Likewise, Table 2 shows the percentage of Kansas City population in each of CD4, CD5, and CD6 by year, revealing a similarly extreme departure from the historical maps. From 1992 until the adoption of the Missouri FIRST Map, between 73%–84% of the population of Kansas City was assigned to CD5, keeping a majority of the population intact, with virtually all of the remainder assigned to CD6. By dramatic contrast, the Missouri FIRST Map cracks the Kansas City population into three comparably-sized pieces, with no district containing a majority of the population. The largest intact portion of population plunges by more than half from 2022 (83.55% of the population in CD5) to 2025 (40.85% of the population in CD6). Among the previous maps where Kansas City was split three ways, only a negligible number of residents was assigned to CD4: 42 persons in 1992, 197 in 2012, and 104 in 2022. The Missouri FIRST Map splits off 126,008 Kansas City residents into CD4, an over-thousandfold increase.

Table 2: Percentage of Kansas City population in each Congressional district by year.

District	1992	2002	2012	2022	2025
4	0.01%	–	0.04%	0.02%	24.80%
5	78.41%	73.13%	74.99%	83.55%	34.35%
6	21.58%	26.87%	24.97%	16.43%	40.85%

12. In the 1992, 2002, 2012, and 2022 Congressional districts, as shown above, the vast majority of the Jackson County population was kept intact in a single district, and likewise for the Kansas City population. In fact, these (overlapping) populations were kept intact in the *same* district, CD5, maintaining the closely united territory both within and between Jackson

County and Kansas City. In the Missouri FIRST Map, not only are the largest intact portions of Jackson County population and Kansas City population each reduced, but these largest portions are in *separate* districts. Specifically, the largest portion of Jackson County population (51.71%) is in CD5, which has only 34.35% of the Kansas City population; the largest portion of Kansas City population (40.85%) is in CD6, which has only 2.24% of the Jackson County population. Thus, the Missouri FIRST Map vastly reduces the extent to which the districts maintain the historical unity of Jackson County and Kansas City in their Congressional representation.

IV. Response to Compactness Comparisons Between Different Geographies and Maps

13. Compactness is highly context-dependent and cannot be reduced to a single score or threshold. A shape that is acceptable for a district in one part of the state may be unacceptable for a district in another part of the state due to differences in natural geographic boundaries, political subdivision boundaries (such as counties, municipalities, VTDs, and the boundary of the state itself), historical district boundaries, population density, and geographic distribution. Even within a particular part of the state, a district shape might be considered sufficiently compact if it maintains "closely united territory" and meets other recognized redistricting criteria, but insufficiently compact if it fails to do so. Comparing compactness scores between districts, without this context, is incomplete at best and invalid at worst.

14. The Trende Report and Hood Report both rely on such questionable comparisons. As an example of comparing district shapes covering different geographical areas, Dr. Trende compares CD5 in the Missouri FIRST Map to CD6 in the same map, as well as to CD2, CD3, CD4, and CD6 in previous maps (Trende Report at pp. 17–18). Prof. Hood also compares CD4 and CD6 in the Missouri FIRST Map to CD8 in the same map (Hood Report at pp. 6–7), and he groups completely different districts into a "zone of similarity" based on their compactness

scores alone (Hood Report at pp. 8–9). Yet, one cannot conclude—as they do—that if the challenged districts score similarly on some compactness metrics to other districts, in this or previous maps, then that alone is sufficient to judge the districts comparably compact without any additional context.

15. Even more questionable is Dr. Trende's comparison between the shapes of Congressional districts and those of Missouri Senate and Missouri House districts, which he applies to CD5 in the Missouri FIRST Map (Trende Report at p. 18). In addition to covering different geographic regions across the state, Missouri Senate and (especially) Missouri House districts are far smaller and more numerous than Congressional districts—making it hard to see how such a comparison could illuminate anything about the Congressional map in question.

V. Response to Dr. Trende's Claims About Compactness of the Ensemble Maps

16. The Stern Report is based on an ensemble of 100,000 alternative maps that change only the CD4–CD5 boundary in the Missouri FIRST Map, while leaving the other 6 districts untouched. Dr. Trende criticizes the ensemble methodology on the grounds that this ensemble might not contain sufficiently many "conceptually different maps" (Trende Report at pp. 27–28), and that the ReCom algorithm producing these maps might naturally *overweight* compactness to such a degree that the ensemble reflects only a narrow range of compactness possibilities among "the universe of plans that are available to the map drawer." (Trende Report at p. 29). In this section, I respond to these criticisms.

17. Within the region covered by CD4 and CD5, the ensemble contains a wide variety of maps across the spectrum of compactness. Figure 1 illustrates the wide range of compactness observed in the ensemble maps according to the number of cut edges along the CD4–CD5

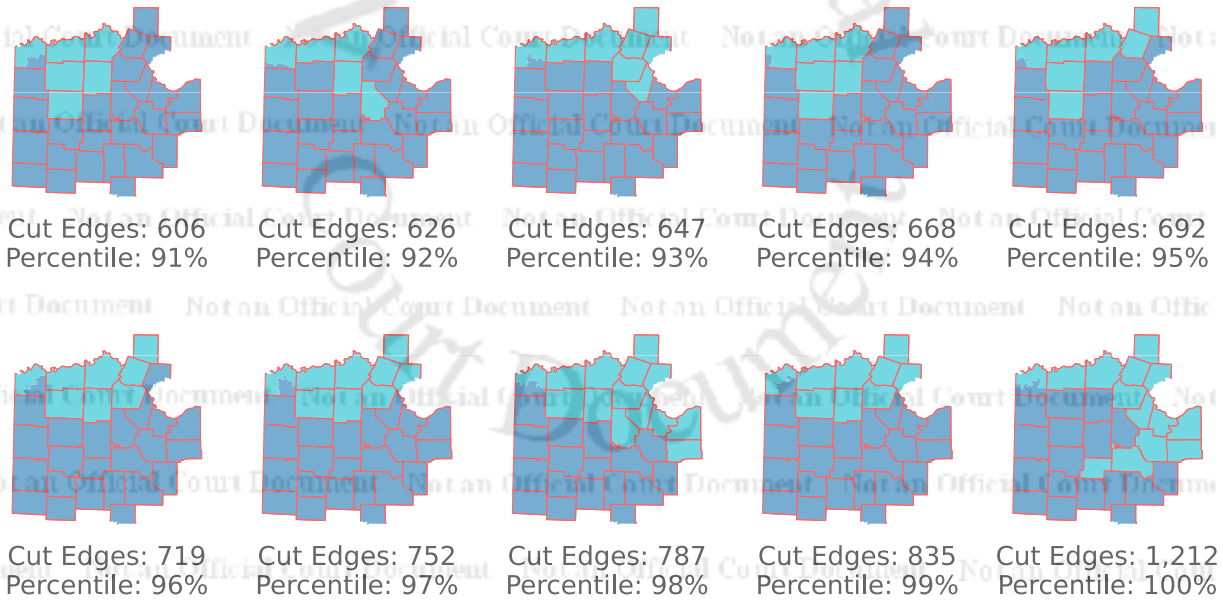
boundary.[1] The most compact maps with the fewest cut edges, starting in the top left, contain a district based tightly around Jackson County (shown in light blue). As the number of cut edges increases, compactness decreases, with the light blue district expanding further into neighboring counties. Eventually, in the least compact maps shown in the bottom row—and especially the bottom right—the districts sprawl and snake across numerous counties. For comparison, the Missouri FIRST Map cuts 792 edges along the CD4–CD5 boundary (percentile: 97.63%), placing it in between the least compact of the two maps in the bottom right of this figure (Stern Report at p. 22). Indeed, CD4 and CD5 in the Missouri FIRST Map visually resemble the districts in these last two maps more closely than the others.

Figure 1: A sample of maps across the compactness range observed in the ensemble, according to the number of cut edges along the CD4–CD5 boundary, from the 0th percentile (fewest cut edges, most compact) in the top left to the 100th percentile (most cut edges, least compact) in the bottom right. Only the region covering CD4 and CD5 in the Missouri FIRST Map is shown, since the ensemble does not make changes to any other districts. County lines are shown in red.

[1] This metric, and its usefulness in measuring compactness, are described in paragraph 46 of the Stern Report.

18. Figure 2 focuses on the least compact 10% of maps in the ensemble, according to the cut edges metric, this time showing a sample map at every whole-number percentile level rather than every five. Again, we see considerable variety and range among these non-compact maps, which become less compact as the number of cut edges and percentile rank increase. CD4 and CD5 in the Missouri FIRST Map bear a close visual resemblance to the 98th percentile ensemble map shown here, which has a similar number of cut edges.[2] Clearly, the range of compactness is sufficiently broad to include maps as non-compact as the Missouri FIRST Map.

Figure 2: A sample of maps from the 91st–100th percentile in cut edges along the CD4–CD5 boundary, representing the least compact 10% of ensemble maps according to this metric.



19. Dr. Trende suggests that the ensemble may be giving excess weight to compactness (Trende Report at pp. 28–30), but it is impossible to overweight one redistricting factor without underweighting another, where there is some trade-off between the two. If the ensemble truly overweighted compactness, we would expect to see better compactness among

[2] More precisely, this "98th percentile" map has a percentile score of 97.51%, rounded to the nearest whole-number percentile for display in the figure, which is slightly more compact than the Missouri FIRST Map at 97.63%.

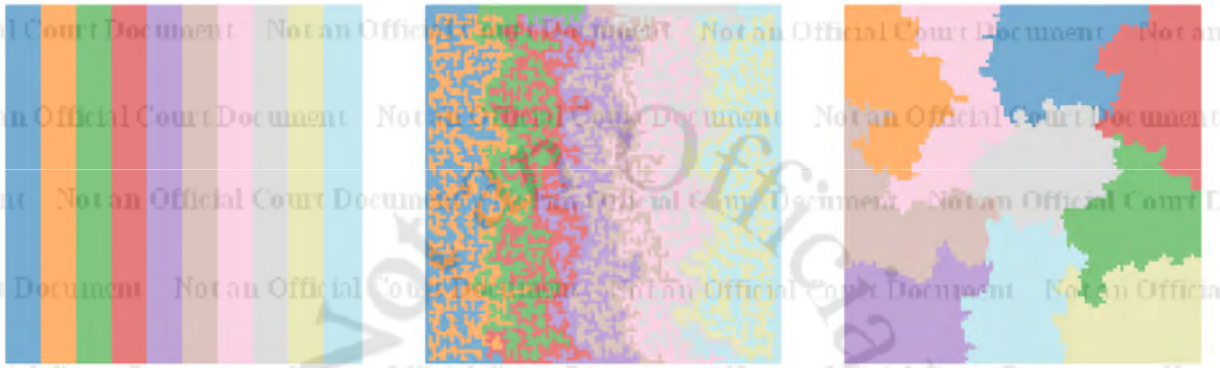
the ensemble maps, but at the expense of *worse* performance on some other recognized redistricting criteria for which deviations from compactness are permissible. Yet, the Stern Report demonstrates that this is not the case: the Missouri FIRST Map is worse than the ensemble on compactness *and* other criteria that might explain deviations from compactness. These criteria include preservation of counties, municipalities, and VTDs; preservation of previous Congressional districts and current Missouri Senate districts; and allocation of Black Voting Age Population between CD4 and CD5.

20. Dr. Trende correctly notes that the ReCom algorithm used in *Gerrychain* has a natural preference for compact maps: it "does not *enforce* compactness, but it tends to avoid extreme or pathological district shapes." (Trende Report at p. 29, emphasis original). However, some context is needed to understand what this means and its bearing on the maps in question. Figure 3, reproduced from the original paper introducing ReCom,[3] shows what maps look like when produced by an algorithm that does not have this preference. The map shown at center, produced by an earlier algorithm called Flip that does not share ReCom's compactness properties, looks noisy and fractured—almost like television static. There is no meaningful sense in which such a map should be considered "available to the map drawer" (Trende Report at p. 29) in a redistricting context. Yet, perhaps counterintuitively, there is a far larger variety of such wild-looking maps than ordinary-looking maps resembling those a human map drawer might produce, so if one were to simply pick maps out of a hat uniformly, nearly all of them would contain extremely unusual districts like the Flip example below (DeFord, Duchin, and Solomon at p. 7). *These* are the "extreme or pathological" maps that ReCom naturally avoids, and by reducing their likelihood of being drawn, the ensemble actually better resembles the

[3] DeFord, D., Duchin, M., & Solomon, J. (2021). Recombination: A Family of Markov Chains for Redistricting. *Harvard Data Science Review*, *3*(1).

options available to a map drawer. As shown above, ReCom is plenty capable of drawing maps that resemble the Missouri FIRST Map.

Figure 3: A comparison between the pathological maps produced by the non-compactness-favoring Flip algorithm (center) and the more ordinary-looking maps produced by ReCom (right). Reproduced from DeFord, Duchin, and Solomon, Figure 1.



(a) Initial Partition (b) 1,000,000 Flip steps (c) 100 ReCom steps

21. Dr. Trende's statements about the compactness of ReCom ensembles (Trende Report at pp. 28–30) rely on work characterizing the original version of the algorithm, which draws maps using random spanning trees without regard to county lines. My ensemble does not use this plain-vanilla ReCom algorithm; it uses a "region-aware" variant of ReCom configured to avoid splitting counties. This means that it does not simply prefer geometrically compact plans in the spanning-tree sense; it gives additional weight to plans that keep counties together. There are surely geometrically-compact maps that split several counties between CD4 and CD5; the fact that the ensemble contains *no* such maps clearly shows that this factor is given sufficient weight, and that the algorithm is not simply valuing compactness above all. Indeed, my ensemble matches the Missouri FIRST Map in splitting only one county between CD4 and CD5 (Stern Report at p. 12), showing that the avoidance of county splits was weighed appropriately.

22. Dr. Trende states that "one *may* adjust the compactness parameter in ReCom upward or downward, so as to favor more- or less- compact districts." (Trende Report at p. 30,

emphasis original). This is incorrect: there is no such parameter. While there has been some recent research on so-called "Metropolized" variants of ReCom[4] that can target a more- or less-compact distribution of maps than the natural one, these variants essentially work by drawing ReCom maps as usual, then keeping or discarding them according to their compactness score. This is not part of the ReCom algorithm itself, however: it is an extra processing step that "weeds out" maps according to their compactness in order to hit an externally-imposed target. I do no such weeding-out and impose no such target. Interpreted literally, Dr. Trende's statement is false. Interpreted charitably, through the lens of recent research, it merely says that the Missouri FIRST Map might look better if I deliberately threw away the ensemble maps that make it look bad.[5]

23. Furthermore, the conclusions in the Stern Report are not based solely on the *proportion* of ensemble maps that outperform the Missouri FIRST Map on compactness (and population splitting, and other factors), but on the *magnitude* of this outperformance. For example, the CD4–CD5 boundary in the Missouri FIRST Map is over twice as long as the ensemble median, whether measured in miles or in cut edges (Stern Report at pp. 21–22). If one were to adjust the *relative* proportion of compact and non-compact maps, it would change the percentile scores—but it would not make the CD4–CD5 boundary in the Missouri FIRST Map any shorter in an *absolute* sense. There would still be many thousands of maps that are more compact in this regard than the Missouri FIRST Map by at least a factor of two.

24. Finally, Dr. Trende frequently resorts to a straw-man argument against a compactness standard no one is advancing: that the State is obligated to find *the* most compact map possible out of "millions or even billions of maps," and to change it the moment "more

[4] Autry, E., Carter, D., Herschlag, G. J., Hunter, Z., & Mattingly, J. C. (2023). Metropolized forest recombination for Monte Carlo sampling of graph partitions. *SIAM Journal on Applied Mathematics, 83*(4), 1366-1391.

[5] Calibrating an ensemble to match the enacted map's compactness *can* be useful for analyzing other properties of the map, such as race or partisanship, but is not useful if one is interested in analyzing compactness itself.

simulations and exploration … discover a more compact map" (Trende Report at p. 17); that "the Missouri Constitution requires the *most* compact map to be selected" (Trende Report at p. 27, emphasis original); that "to demonstrate that it is possible to generate a map that is even *more* compact than the Enacted Map" is invalidating (Trende Report at p. 27). Again, no one to my knowledge is making these claims—I certainly am not. The ensemble analysis does not merely show that a more compact map exists: it shows that there is an *abundance* of maps that are *substantially* more compact (both geometrically and in the "closely united territory" sense), and which also outperform the Missouri FIRST Map (often dramatically) on recognized redistricting criteria that would permit deviations from compactness. Within the ensemble, it is not merely possible to do better than the Missouri FIRST Map; it is difficult to do worse.

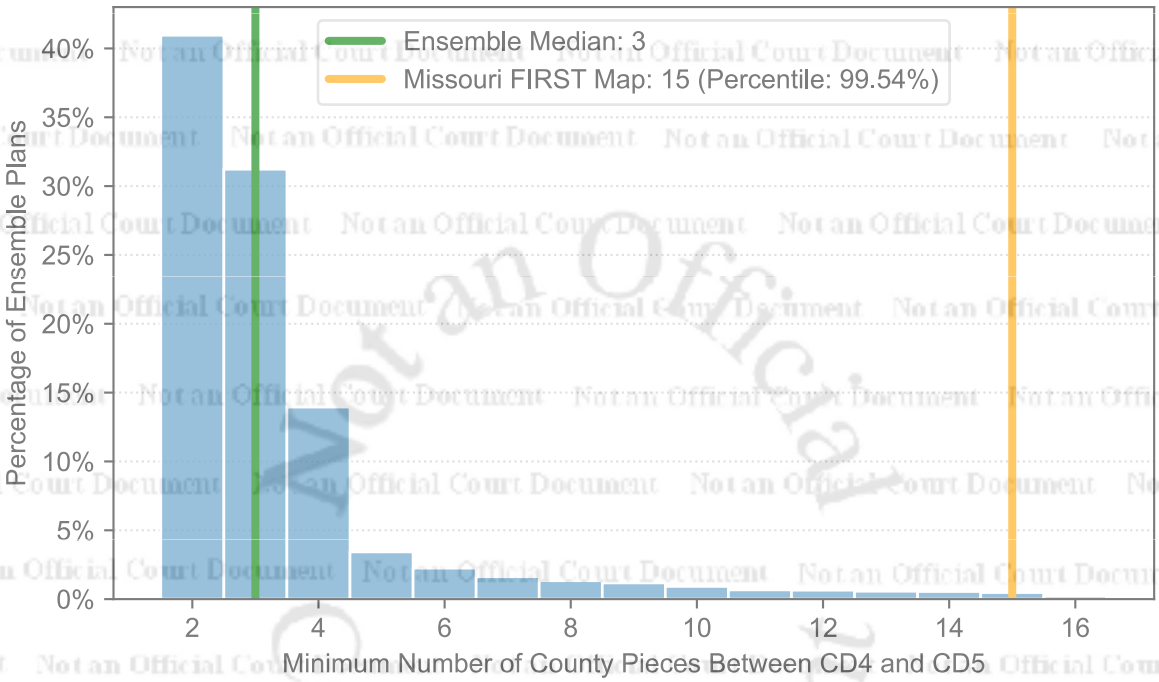
VI. Ensemble Analysis of Districts Combining Many Different Counties

25. Dr. Trende uses my ensemble to challenge a claim in Dr. Cromartie's report about "districts combining very different types of counties and extending into different metropolitan areas…. Dr. Stern demonstrates that even a computer drawing blindly to such considerations can make similar choices." (Trende Report at p. 30). As evidence, he points to one of my demonstration maps in which CD5 contains parts of 6 different counties. Setting aside the apparent contradiction between this statement of Dr. Trende's, and his previous claim that the ensemble maps are too laser-focused on compactness and thus insufficiently diverse, I will use ensemble analysis to examine the degree to which the Missouri FIRST Map is extreme in its combining of Jackson County with many different counties. As in the Stern Report, I will confine my attention to the region covered by CD4 and CD5, since that is the geography on which the ensemble is constructed.

26. For context, the Missouri FIRST Map contains 32 "county pieces" between CD4 and CD5: (i) two pieces of Jackson County, one in each district; (ii) pieces of two counties (Boone and Webster) that are not split between CD4 and CD5 but are split with other districts in the map; and (iii) 28 whole counties that are not split at all and lie entirely within CD4 or CD5. Of these 32 county pieces, there are 17 in CD4 and 15 in CD5 of the Missouri FIRST Map. By comparison, my demonstration map that Dr. Trende cites has 26 county pieces in CD4, with only 6 in CD5 (Stern Report at p. 57). In other words, the Missouri FIRST Map combines parts of more than twice as many counties in CD5 compared with my demonstration map. If these are "similar choices" in kind, then they are hardly similar in magnitude.

27. Figure 4 contains a histogram showing the number of county pieces in whichever district contains fewer of them, which would typically be labeled CD5. The ensemble median is only three counties, typically Jackson County and neighboring counties; over 40% of ensemble maps have just two, Jackson County and Cass County. *That* is the typical result of "a computer drawing blindly" (Trende Report at p. 30), i.e., without expressly distinguishing between rural and metro counties. Compared to the ensemble, the Missouri FIRST Map is especially extreme with 15 county pieces in CD5, corresponding to a percentile rank of 99.54%. Less than 0.5% of the ensemble maps are more extreme than this with a perfect 16–16 split of the 32 county pieces.

Figure 4: Histogram of the number of county pieces in whichever of the districts has fewer. In the ensemble, this typically consists only of Jackson County and neighboring counties, forming a compact district based around Jackson County and the Kansas City metro area. In the Missouri FIRST Map, CD5 combines Jackson County with 14 other counties across a sprawling territory.



VII. Response to Dr. Trende's Claims About Splitting of Missouri Senate Districts

28. My previous report showed that the Missouri FIRST Map "splits state senate districts between CD4 and CD5 a greater number of times, and more severely, than about 90% of ensemble maps … and thus it does not resemble a map for which 'align[ing] closely with the existing Missouri Senate Map' was indeed a priority." (Stern Report at p. 33). Indeed, the supposed goal of following Missouri Senate district lines appears to have been applied selectively in splitting Jackson County, but not elsewhere along the CD4–CD5 boundary.

29. Dr. Trende explains this selective following of Missouri Senate district lines within Jackson County, but not outside it, as follows:

> While the 2022 Map might split fewer districts *outside* of Jackson County, rural Missouri has large state senate districts that sprawl multiple counties; keeping

> counties whole will often be at odds with avoiding senate district splits. (Trende Report at p. 31, emphasis original).

This last point is false, as the results in my previous report show. The ensemble maps avoid splitting counties along the CD4–CD5 boundary to the same extent the Missouri FIRST Map does—i.e., no more than one county split between CD4 and CD5—*and* 90% of them split fewer Missouri Senate districts (Stern Report at pp. 33–34). This is incompatible with the two factors being "at odds" (Trende Report at p. 31).

VIII. Additional Responses to the Hood Report

30. Prof. Hood mischaracterizes a law review article by Pildes and Niemi,[6] stating:

> There is also at least one academic article of note that suggests a cutoff point by which a district may be judged to be non-compact…. On two measures of compactness, Reock and Polsby-Popper, these scholars suggest numerical values whereby a district might be judged to be non-compact. For the Reock measure this value is less than .16 and for the Polsby-Popper measure this value is less than .06…. Using these specific metrics there is no evidence to categorize the challenged congressional districts as being non-compact. (Hood Report at p. 8).

In fact, Pildes and Niemi explicitly and repeatedly caution against such a misinterpretation and misuse of their work. These cutoffs are not a proposed legal standard, but merely a threshold for inclusion in a short table "listing the congressional districts whose [Reock] or [Polsby–Popper] score (or both) is relatively low. *In choosing the cutoff points used in Table 3, we do not imply that all districts below those points, or only those districts, are vulnerable …. The cutoff points in Table 3 are somewhat arbitrary*." (Pildes and Niemi at p. 564, emphasis added). They later repeat

[6] Pildes, R. H., & Niemi, R. G. (1993). Expressive Harms, "Bizarre Districts," and Voting Rights: Evaluating Election-District Appearances After Shaw v. Reno. *Michigan Law Review*, *92*(3), 483–587.

this statement about arbitrariness and adopt different cutoffs for a subsequent table (*id.* at p. 568). Elsewhere, Pildes and Niemi emphasize that "there is no bright line between compact and noncompact districts" and that comparisons between scores must be evaluated with additional context, including geographic differences (*id.* at p. 563 n.223).

31. The Hood Report employs three compactness metrics: Reock, Polsby–Popper, and (Alternate) Schwartzberg. However, it should be noted that the latter two scores measure the exact same relationship between a district's area and its perimeter: "Schwartzberg and Polsby–Popper assessments must rank districts from best to worst in precisely the same way."[7] (This is the "mathematical relationship between the Schwartzberg and Polsby–Popper scores" alluded to on p. 28 of the Stern Report.) As a (literal) reflection of this relationship, note that Figure 3 in the Hood Report is basically just Figure 2 turned upside down. Using both Polsby–Popper and Schwartzberg provides no additional analytical power over using just one of them, so the Hood Report really contains only two independent compactness metrics rather than three.

32. Finally, Prof. Hood makes a small error about my methodology when he states: "Professor Stern's expert report … also relies on Maptitude" (Hood Report at p. 5 n.9). Although my choice of compactness metrics was informed by those included in the *Maptitude* reports appearing in the Kincaid Memo,[8] I did not use the *Maptitude* software for any of my analysis. All of the compactness metrics appearing in the Stern Report were calculated using my own Python code, employing the *GeoPandas* geospatial-computing library.

[7] Duchin, M. (2022). Explainer: Compactness, by the Numbers. In *Political Geometry*, eds. Duchin, M., & Walch, O., Birkhäuser/Springer, Cham, at p. 30.
[8] Adam Kincaid, *Memo to Representative Dirk Deaton, HB 1 Sponsor, re: The Missouri First Map* (Sept. 10, 2025).

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I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge. I reserve the right to revise, update, or supplement my opinions as new information becomes available to me.

Date: January 14, 2026

Dr. Ari J. Stern