Visual Blending as Cartographic Design Practice for Multivariate Natural Hazard Mapping

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Introduction

Natural hazards are spatially heterogeneous, and mapping them often requires balancing overall spatial pattern recognition with the retrieval of individual hazard attributes. Composite indices can provide a useful overview, but they reduce the visibility of individual variables; small multiples preserve variable-level detail, but the comprehensive pattern becomes less immediate. This creates a design problem for multivariate mapping: how can one map support both attribute-level retrieval and overall pattern recognition? This lightning talk presents four cartographic prototypes that explore visual blending as one possible strategy. Inspired by pointillism and CMYK halftone printing, the project treats discrete symbol components not only as separate variable encodings, but also as elements that can combine through color, size, transparency, and overlap. Rather than presenting these maps as empirical validation, this submission uses practice-based cartographic design to examine how visual form, data structure, and human judgment work together in multivariate hazard mapping.

Method

In this project, four iterative cartographic prototypes (Table 1) were developed to examine different design conditions, including data source, variable count, aggregation unit, form, color mode, and prototype role. Map 1 (*United States of Natural Disasters*) uses 1,000-square-mile hexagon bins and overlapping circular sub-symbols to test whether 7 disaster variables can form a coherent blended visual field. Map 2 (*United States of Blooming Risks*) extends the approach with FEMA National Risk Index (NRI) data for 18 hazards, proportionally aggregated from counties to the same hexagonal framework. To systemtically organize these hazards in the complex symbol, AI-assisted similarity matrices among hazards were used as exploratory aids, followed by manual review and cartographic refinement. Map 3 (*United States of Rising Hazards*), translates the method into an interactive ArcGIS JavaScript-based web map with layer toggles, search, and pop-up values, under dark color mode. Map 4 (*Multi-Hazard Map Quilt Tile*), applies the approach to the Louisville area using census tract-level data.

	Map 1	Map 2	Map 3	Map 4
Name	United States of Natural Disasters	United States of Blooming Risks	United States of Rising Hazards	Multi-Hazard Map Quilt Tile
Data Source	FEMA, NOAA, USGS, Esri, etc.	FEMA NRI (County)	FEMA NRI (County)	FEMA NRI (Census Tract)
Number of Variables	7	18	18	18
Aggregation Unit	1,000-sq-mi hexagon, U.S.	1,000-sq-mi hexagon, U.S.	1,000-sq-mi hexagon, U.S.	200-acre hexagon, Louisville, U.S.
Form	Static (w/ small multiples)	Static (w/ small multiples)	Interactive (w/ layer control and query)	Static
Color Mode	Light	Light	Dark	Light
Visual Variables	Color hue, value, transparency, arrangement	Color hue, size, transparency, arrangement	Color hue, transparency, arrangement	Color hue, transparency, arrangement
Prototype Role	Initial visual blending	Systematic symbolization	Interactive exploration	Local-scale adaptation

Table 1: Summary of the four cartographic prototypes.

Results

The primary outcomes of this practice-based inquiry are the four cartographic products shown in Figures 1–4.

Figure 1 (*United States of Natural Disasters*) showed that overlapping sub-symbols can create a strong halftone-like pattern at the national scale, while also revealing problems of subjective variable selection, inconsistent data sources, and simple aggregation.

Figure 2 (*United States of Blooming Risks*) produced a more systematic and information-rich map, but the inclusion of 18 hazards increased cognitive load and made individual variable retrieval more difficult.

Figure 3 (*United States of Rising Hazards*) transformed the static design into an dark-mode web map, using color blending to improve the on-screen visibility of overlapping symbols. It demonstrated how interaction can support map reading and data retrieval through layer isolation and pop-up values, but it also introduced rendering constraints and highlighted the need for more refined interaction design.

Figure 4 (*Multi-Hazard Map Quilt Tile*) showed that the visual blending strategy can be transferred to a local urban context, but it also revealed that some hazard variables have limited spatial variation at finer scales, making the design more useful as a cartographic exploration than as a strict comparative analysis.

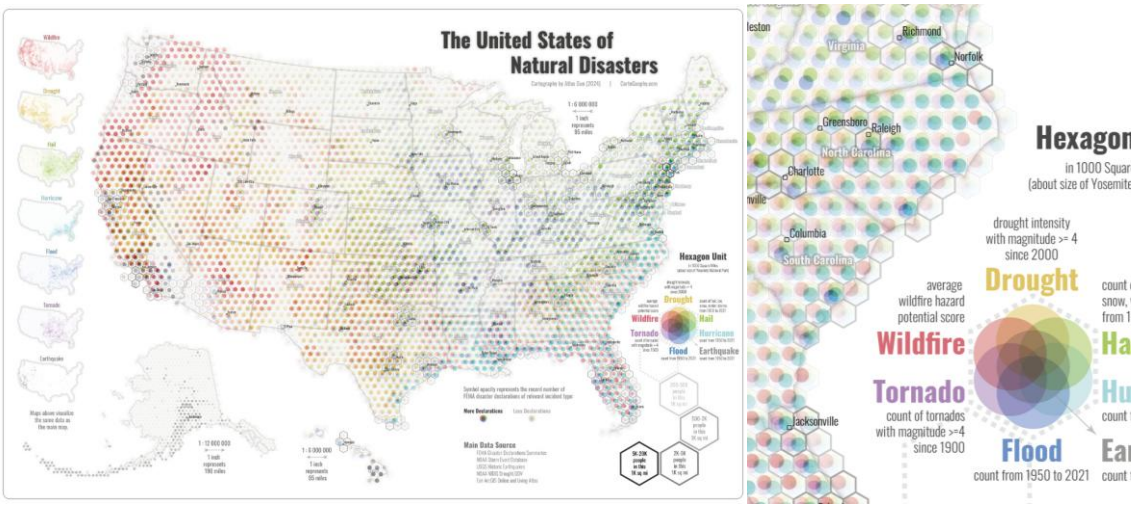

Figure 1: United States of Natural Disasters

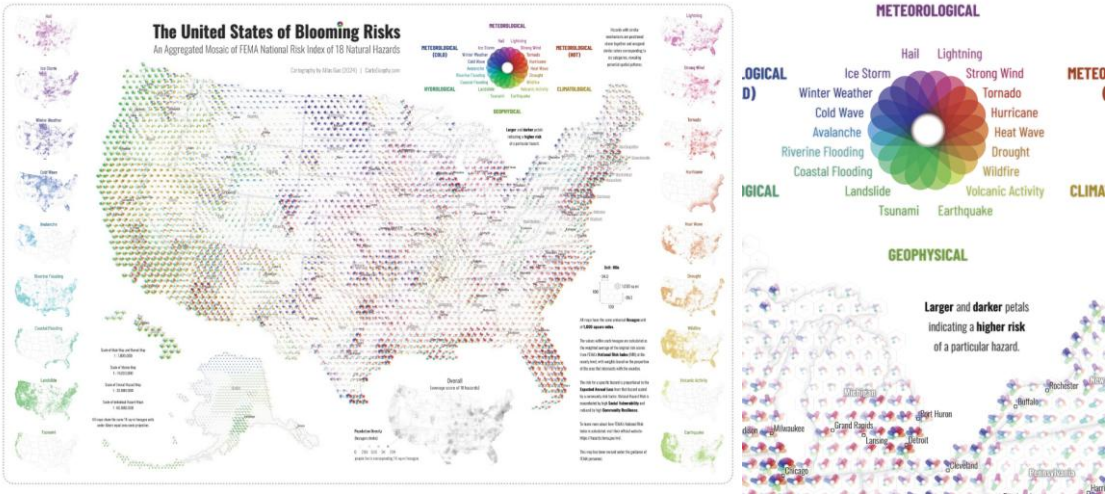

Figure 2: United States of Blooming Risks

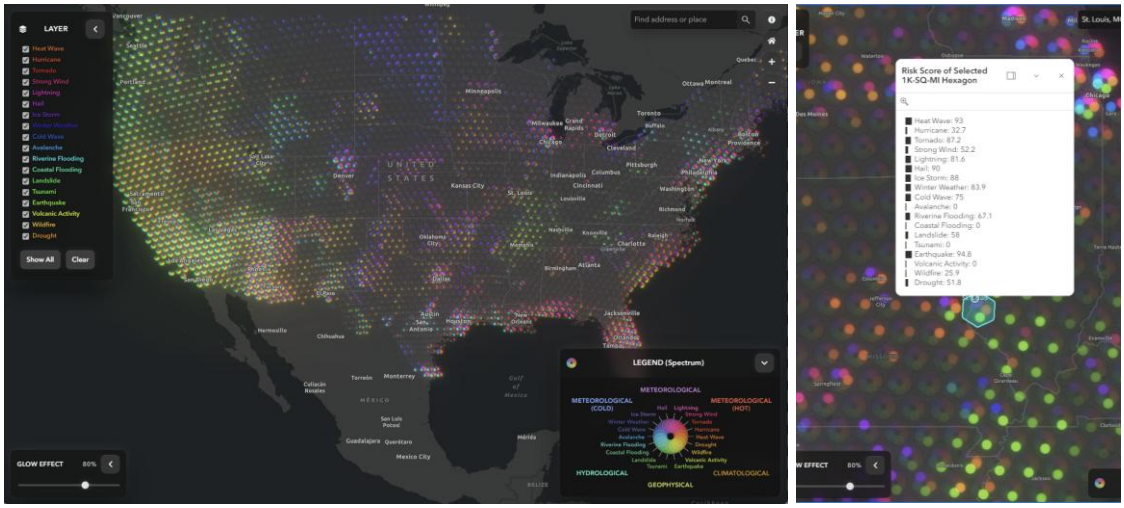

Figure 3: United States of Rising Hazards

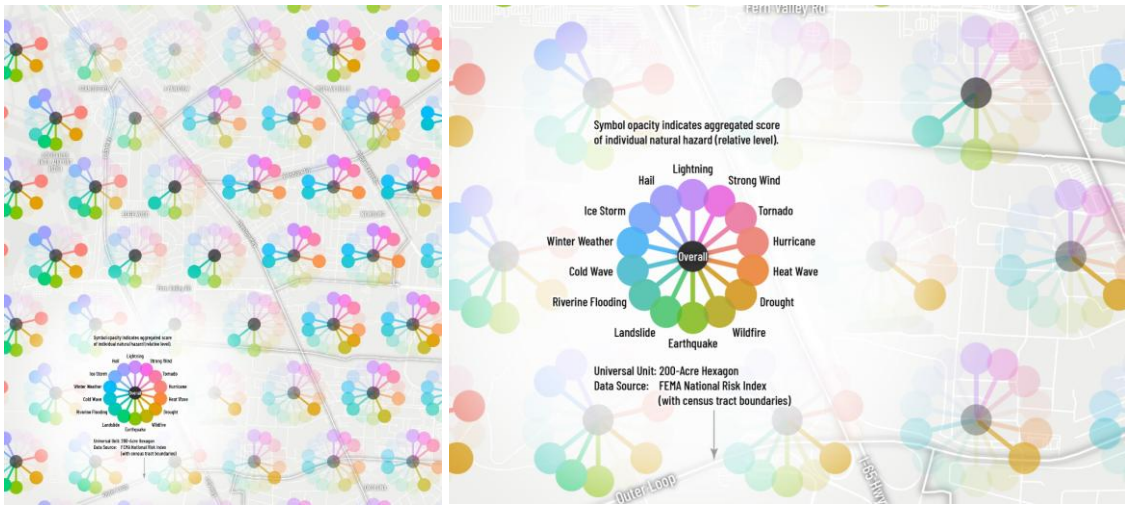

Figure 4: Multi-Hazard Map Quilt Tile

Discussion and Conclusion

These prototypes suggest that visual blending is a promising but demanding strategy for multivariate symbol mapping. Its value lies in creating a map that can be read both as an overall spatial texture and as a collection of variable-specific symbols. Its limitations lie in the trade-offs among visual richness, legibility, data consistency, scale, and interaction.

Accessibility is also a key concern, especially for readers with color vision deficiency. Because hue is used for categorical hazard types, the prototypes reduce reliance on color alone by pairing hue with internal arrangement. Maps 1 and 2 further support reading through small multiples, Map 3 through layer control and query-based interaction, and Map 4 through larger, more legible symbols.

The project therefore emphasizes the cartographer's role in the loop: AI and automation can assist with organization and implementation, but human judgment remains central to variable grouping, symbol structure, color balance, and interpretive responsibility. More broadly, the work proposes the idea of a *reference thematic map*: an information-rich thematic map that is visually engaging, structured for repeated reference, and capable of supporting exploration, comparison, and public learning.

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