Visual Storytelling with Maps:
Update & Outlook from an Empirical Study

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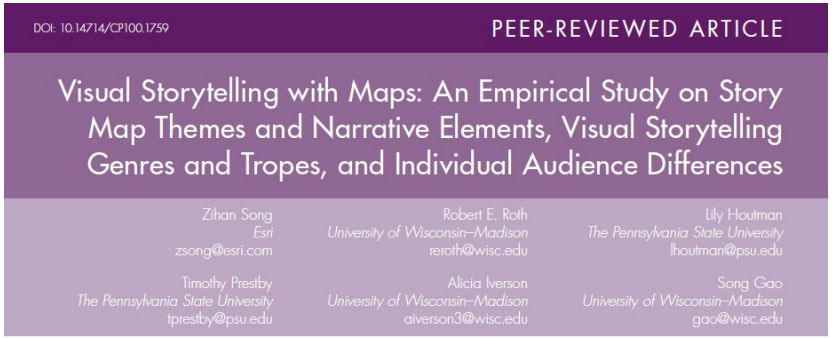

Full Paper:
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How can storytelling tropes help us
What other opportunities does new
How can we empower individuals to
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1. Three -Act Narrative Elements

recurring narrative components that can be visualized as unique symbols within a single graphic or separate frames within a larger, multiscene story

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Cartographic Design as Visual Storytelling: Synthesis and Review of Map-Based Narratives, Genres, and Tropes

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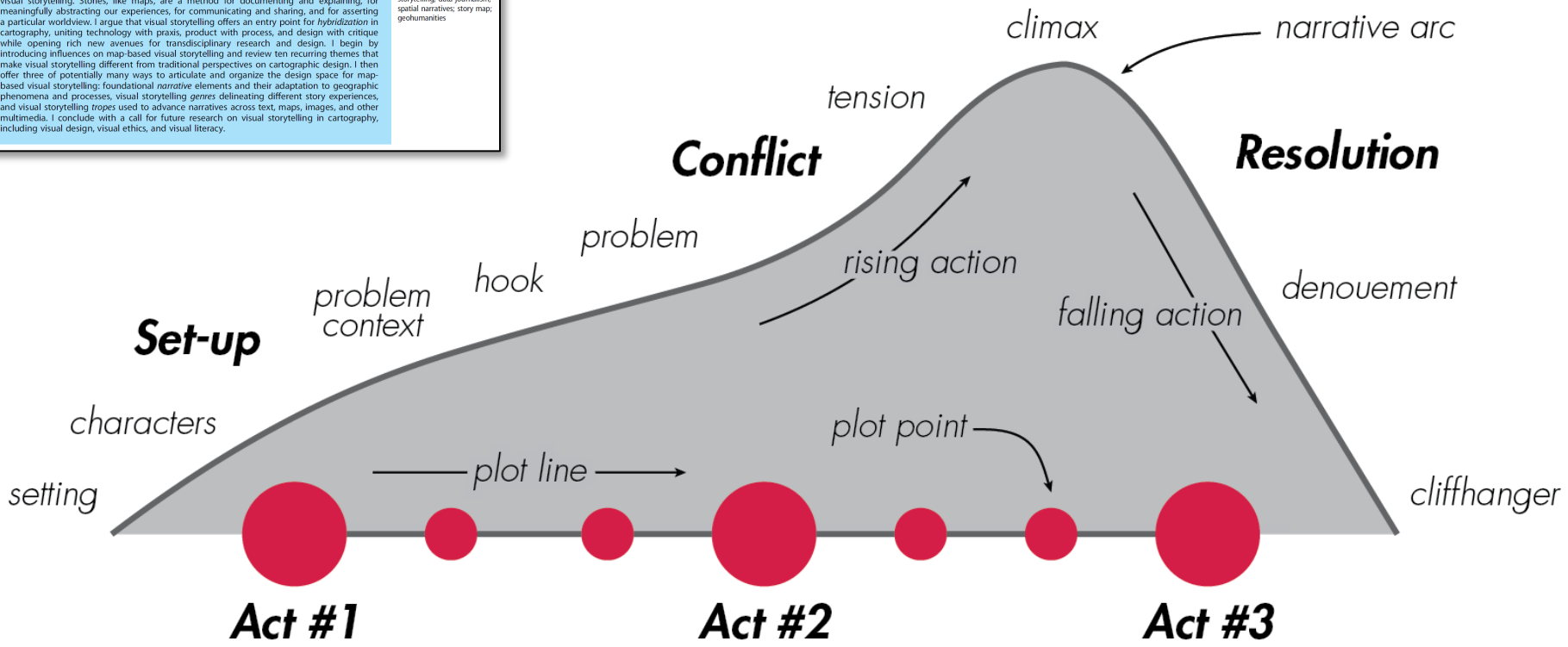
ABSTRACT

In this article, I review considerations and techniques for approaching cartographic design as visual storytelling. Stories, like maps, are a method for documenting and explaining, for meaningfully abstracting our experiences, for communicating and sharing, and for asserting a particular worldview. I argue that visual storytelling offers an entry point for *hybridization* in cartography, uniting technology with praxis, product with process, and design with critique while opening rich new avenues for transdisciplinary research and design. I begin by introducing influences on map-based visual storytelling and review ten recurring themes that make visual storytelling different from traditional perspectives on cartographic design. I then offer three of potentially many ways to articulate and organize the design space for map-based visual storytelling: foundational *narrative* elements and their adaptation to geographic phenomena and processes, visual storytelling *genres* delineating different story experiences, and visual storytelling *tropes* used to advance narratives across text, maps, images, and other multimedia. I conclude with a call for future research on visual storytelling in cartography, including visual design, visual ethics, and visual literacy.

KEYWORDS

Cartographic design; visual storytelling; data journalism; spatial narratives; story map; geohumanities

Roth (2021)



2. Genres

the visual or interactive technique used to enforce linearity in the narrative sequence

Kraak MJ, RE Roth, B Ricker, A Kagawa, & G Le Sourd (2020)

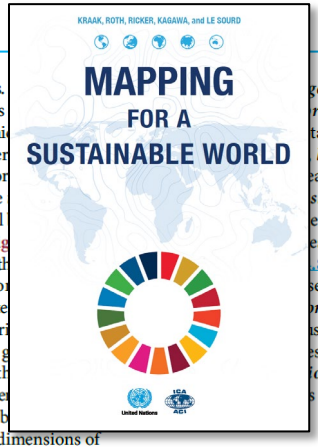
4.7 Storytelling with Maps

Storytelling is a method of documenting or explaining a sequence of events and, thus, is an important social and cultural tool for sharing and remembering individual experiences. From journalism to science communication, there is growing interest in how maps can organize and enhance storytelling. Accordingly, map-based storytelling offers a valuable opportunity to engage both Member States and individual citizens in communicating the aims of the SDGs. A "story map" could be a key advocacy communication tool for the SDGs across partners.

Maps are inherently two-dimensional (see Section 1.3), but a story map differs from other maps by leading the audience through a primarily one-dimensional, linear narrative. Here, ***story*** describes information about specific events, places, and people while ***narrative*** describes the structure and presentation of this content to shape the story's meaning. The broadest definition of a ***story map***, therefore, is any cartographic representation that exhibits narrative elements. ***storytelling*** refers to stories cated through maps, graphi and videos along with other oral, written, and audio stor

While often adapted, the ***narrative*** provides a useful designing a visual story (Fig The narrative begins with th introducing background co the setting and key characte ple, presenting and compari countries or SDG regional g The narrative proceeds to th emphasizing the key proble ing the story, which might b maps explaining different dimensions of an SDG. The narrative concludes with the ***resolution***, reaching the climactic issue facing the characters and presenting one or several resolutions, such as recommendations for action on the SDGs.

In practice, there are a number of ways for enforcing linear continuity across a narrative arc, described as visual sto-



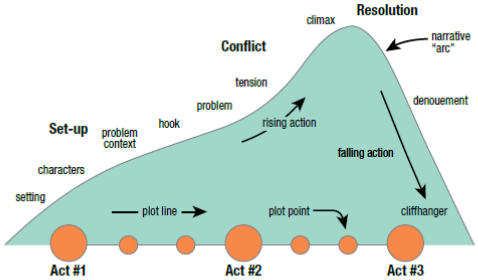
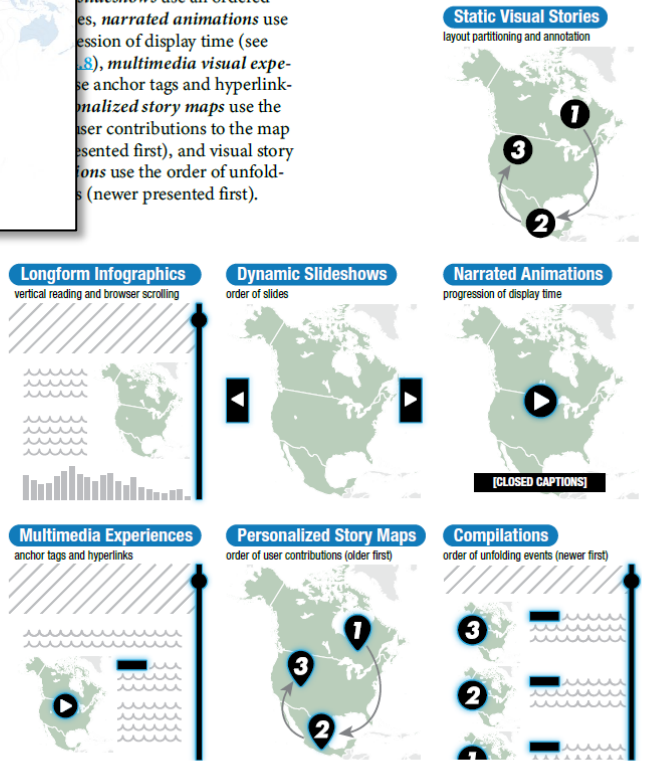


Figure 4.7-1: Three-act narrative. While many narrative structures exist, beginning with a traditional three-act narrative helps to plan and organize content for a visual story or story map.

genres (Figure 4.7-2). ***Static ries*** use layout partitioning tation to advance the linear ***longform infographics*** use eading and browser scrolling, ***slideshows*** use an ordered es, ***narrated animations*** use ession of display time (see .8), ***multimedia visual expe-*** se anchor tags and hyperlink- ***nalized story maps*** use the ser contributions to the map esented first), and visual story ***ions*** use the order of unfold- s (newer presented first).

Figure 4.7-2: Visual storytelling genres. The elements highlighted in blue indicate the typical interactive features used to enforce linearity for the genre. Static visual stories do not require interactive map use environments. Example maps and diagrams do not depict SDG indicator.

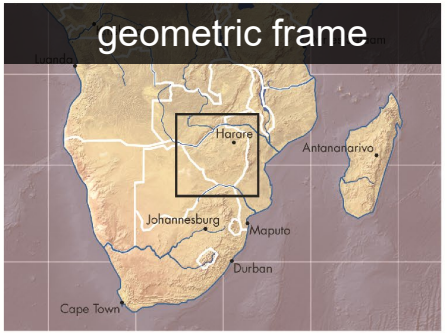


3. Tropes

design techniques used not to represent data, but to enhance the narrative

3a. Attention

emphasizing important or unusual information that cannot be missed in the story



Roth (2021)

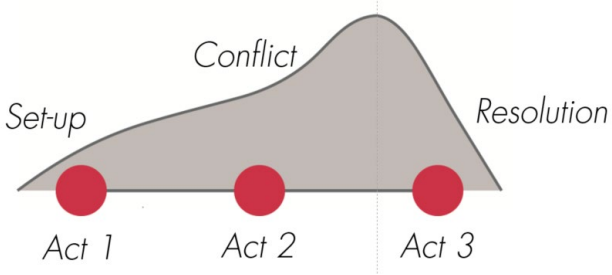
Research Questions

1. What is the influence of **story map themes** and their constituent **narrative elements** on the audience's retention, comprehension, and reaction?

2. What is the influence of visual storytelling **genres** on the audience's retention, comprehension, and reaction?

3. What is the influence of visual storytelling **tropes** on the audience's retention, comprehension, and reaction?

4. What is the influence of **individual audience differences** on their retention, comprehension, and reaction?



Narrative Elements

Song Z, RE Roth, LHoutman, T Prestby, A Iverson, & S Gao (2022)

Narrative Element	Description	Story 1: US Presidential Campaign Donations	Story 2: US Sea-level Rise Vulnerability
Theme	The general thematic category of the visual story (Vujakovic 2014)	A. Politics: internal; I. Government	D. Environment and Science; 8. Environmental problems/ impacts
Topic	The specific geographic phenomenon or process covered in the visual story	US presidential campaign donations	US sea-level rise
Title **(Panel 1)**	A condensed, engaging headline for the visual story	The Presidency's Price Tag: Campaign Donations and the 2012 Presidential Election	Soaking in Water: Sea-Level Rise and Vulnerable Coastal Properties Since 2012
Summary	A brief introduction to the visual story following a three-act narrative structure	***Purpose:*** *This story follows two swing states—Colorado and Ohio—to explain the impact of campaign donations on the US presidential election results.* ***Problem:*** *Differences in party campaign donations influenced voting results in many swing states during the 2012 Presidential Election.* ***Resolution:*** *Colorado and Ohio represent different alternatives for addressing campaign donations.*	***Purpose:*** *This story follows two coastal states—New York and North Carolina—to explain the impact of sea-level rise on the vulnerability of coastal properties in the US.* ***Problem:*** *Rising sea levels have increased the vulnerability of properties on the East Coast of US since 2012.* ***Resolution:*** *New York and North Carolina represent different alternatives for addressing sea-level rise.*
Act 1: Set-up			
Setting	The specific place, time, and social context, giving the story a geography		
Space	Where the story takes place	US Swing States	US Eastern Coastal States
Time	When the story occurred	The 2012 US Presidential Election	The 2012 Hurricane Season
Characters	The people or places who embody the narrative and act-out the plot		
Protagonist (accented)	The main character in the story	Colorado: A swing state whose voting support increased for the Democratic candidate as Democrats gained an advantage in campaign donations	New York: A coastal state whose vulnerability increased as sea level rose
Antagonist (accented)	The character in opposition to the protagonist	Ohio: A swing state whose voting support was largely not influenced by an advantage in campaign donations by either party	North Carolina: A coastal state whose vulnerability was largely not influenced by rising sea levels
The Hook (Panel 1)	An exciting early scene that captures the audience's interest and encourages them to continue reading	Private donations, not public discourse, shape the outcome of the presidential election	Even small rises in sea-level dramatically increase coastal vulnerability to storms
Problem Context (Panel 2)	Additional background information needed to interpret the story later in the narrative sequence	**Title**: What Is Happening with Our Elections? It Starts with Rising Campaign Costs. **Fact:** US presidential campaign costs have increased nearly 800% in the past 40 years. **Accent:** Campaign costs peaked at $1.74 billion in the 2008 presidential election. **Graph:** *Y value:* Presidential Election Costs ($ Billion); *X value:* Year.	**Title:** What is Happening with Our Coasts? It Starts with Rising Temperatures. **Fact:** US average temperatures have increased almost 3 °F in the past 40 years. **Accent:** US average temperatures peaked at 54.3 °F in 2015. **Graph:** *Y value:* Average Temperature (°F); *X value:* Year.
Problem Context (Panel 3)	Additional background information needed to interpret the story later in the narrative sequence	**Title:** Why Do Costs Matter? More than 50% of Campaign Funds were from Donations in 2012. **Colorado:** The average person in Colorado donated $3.30 during the 2012 presidential election. **Ohio:** The average person in Ohio donated only $1.50 during the 2012 presidential election. **Legend:** *title:* Presidential Campaign Donations; *description:* Average donations per person ($), 2012 presidential election.	**Title:** Why Do Coasts Matter? More than 50% of US Citizens Lived in Coastal Areas by 2012. **New York:** 3,081 people live in an average square mile of New York coasts. **North Carolina:** Only 73 people live in an average square mile of North Carolina coasts. **Legend:** *title:* Coastal Population Density; *description:* Average people per square mile of coastal area, 2012.

Table 1. Elements of a Three-act Narrative. A linear, three-act narrative comprises a set-up (Act 1), conflict/confrontation (Act 2), and resolution (Act 3). This table describes how we applied the constituent elements of a linear, three-act narrative to the pair of visual stories used in this study. Continued on next page.

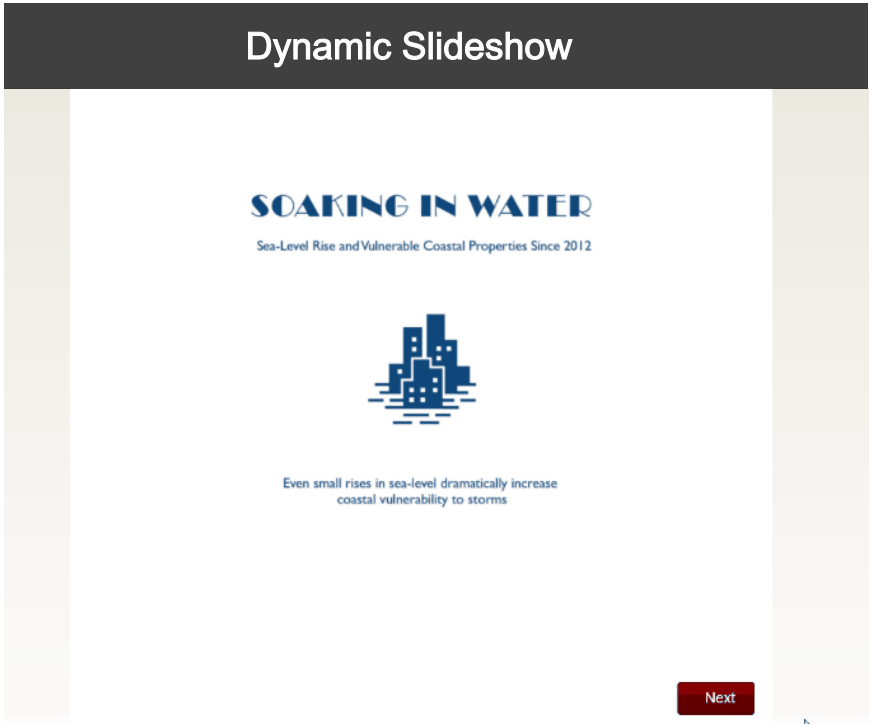
Act 2: Conflict/Confrontation			
Problem/ Catalyst (Panel 4)	The central confrontation, obstacle, or setback driving the story	**Title:** So What? Increasing Donations Pose A Problem… **Fact:** The Democrat advantage in campaign donations reached $253 million for the 2012 presidential election. **Accent:** Democrats received $51 million more donations than Republicans in September, the largest donations advantage during the 2012 president election. **Graph:** *Y value:* Cumulative Donation Gap ($ Million); *X value:* Month	**Title:** So What? Rising Sea Levels Pose a Problem… **Fact**: The US average sea levels in 2012 reached 47.8 millimeters above the 2002 average. **Accent:** Global sea levels rose 8.4 millimeters in 2012, the largest sea-level rise from 2002-2012. **Graph:** *Y value:* Cumulative Sea Level Change (Millimeters); *X value:* Year.
Tension (Panel 5)	The impact of the problem on the protagonist versus the antagonist	**Title:** …Particularly for Swing States. **Colorado:** Democrats increased their support by 6.5% in the swing state of Colorado. **Ohio**: Democrats only increased their support by 0.7% in the swing state of Ohio. **Legend:** *title:* Increase in Voting Lead; *description:* Change in Democratic lead (% total), July 2012 poll to Nov 2012 election.	**Title:** …Particularly for States on the East Coast. **New York:** The average value of vulnerable properties in coastal areas is $24,800 in New York. **North Carolina**: The average value of vulnerable properties in coastal areas is only $7,730 in North Carolina. **Legend:** *title:* Property Vulnerability; *description:* Average value of vulnerable coastal properties ($), 2012
Plot Points (Panel 6)	One in a sequence of events motivated by the problem that impacts the characters (Cause)	**Title:** A Deeper Look: Democrats Gained their Largest Donation Advantage in Major Cities. **Fact:** Democrats drew 140% more urban-based donations per person in Colorado than Ohio, largely attributed to the progressive Denver metro area. **Accent:** The Democrat's gained an advantage of $4,400,000 in Denver, the highest urban lead in swing states; **Legend:** *title:* Donation Gap *description:* Democrat advantage in campaign donations ($), 2012	**Title:** A Deeper Look: Sea Levels Rose the Most in Major Stations. **Fact:** Sea-level rose 50% more in urban-centers in New York compared to North Carolina, particularly due to the dense infrastructure in New York City and Long Island. **Accent:** Sea-level annual rate in Bergen Point is 4.4 millimeters, the highest rate among stations in coastal states. **Legend:** *title:* Average Sea-Level Rise *description:* Average annual sea-level rise (millimeters/ year), 1992–2012.
Act 3: Resolution			
Climax (Panel 7)	The final plot point bringing characters together to face their tension and consider competing solutions (Effect)	**Title:** As a Result, Campaign Donations Have a Different Influence on Election Results in Swing States like Colorado versus Ohio. **Colorado:** Every $100 advantage for the Democrats bought 7.5 votes in Colorado. **Ohio:** Every $100 advantage for the Democrats bought only 2.8 votes in Ohio.	**Title:** As a Result, Sea-level Rise Has a Different Impact on Vulnerability in Coastal States like New York versus North Carolina. **New York:** Every inch in sea-level rise exposes $3,900 of property in New York. **North Carolina**: Every inch in sea-level rise only exposes $1,400 of property in North Carolina.
Resolution & Denoue-ment (Panel 8)	Falling action in which all remaining matters with the setting, characters, and problem context are explained or resolved	**Title:** What's Next? Colorado and Ohio Represent Different Alternatives for Addressing Campaign Donations. **Colorado:** Colorado has imposed new regulations to limit campaign funding since the 2012 presidential election. **Ohio:** At the same time, Ohio has failed to act on campaign funding.	**Title:** What's Next? New York and North Carolina Represent Different Alternatives for Addressing Sea-level Rise. **New York:** New York has invested considerable public funds to prevent sea-level rise related crises. **North Carolina:** At the same time, North Carolina has failed to act on sea-level rise.
Cliffhanger (Panel 9)	The dramatic ending, leaving open strands for the audience to ponder	**Title:** What Do You Think We Should Do As a Nation? **Colorado:** The Democrats are predicted to make only a 2.3% gain in Colorado in the 2020 presidential election if campaign funding remains consistent from 2016. **Ohio:** The Republicans are predicted to make a whopping 12.5% gain in Ohio in the 2020 presidential election if campaign funding remains consistent from the 2016. **Legend:** *title:* Voting Results Predictions, 2020 Presidential Election; *description:* Predicted Republican voting lead; Predicted Democratic voting lead	**Title:** What Do You Think We Should Do as a Nation? **New York:** The value of vulnerable properties per person in New York only is predicted to increase to $290 by 2020 if sea levels continue to increase at a consistent rate. **North Carolina:** The value of vulnerable properties per person in North Carolina is predicted to increase a surprising $325 by 2020 if sea levels continue to increase at a consistent rate. **Legend:** *title:* Predicted Property Vulnerability; *description:* Increased value of vulnerable coastal properties per person ($), 2020 Prediction

Table 1 (continued). Elements of a Three-act Narrative. A linear, three-act narrative comprises a set-up (Act 1), conflict/confrontation (Act 2), and resolution (Act 3). This table describes how we applied the constituent elements of a linear, three-act narrative to the pair of visual stories used in this study.

each genre by the number and order of frames within the story: magazine style, annotated chart, partitioned poster, flow chart, comic strip, slide show, and film/video/animation. While foundational, the original Segel and Heer taxonomy primarily drew upon printed news maps and passive television news reporting, thus preceding many emerging design practices made possible by pervasive computing, new media, and geoweb technologies (Kosara and Mackinlay 2013). Further, the number of frames is less relevant with these emerging technologies, where page space is unlimited. In response, we previously proposed a revised taxonomy of visual storytelling *genres* based only on the visual or interactive technique used to enforce continuity of elements in the narrative sequence:

Genres

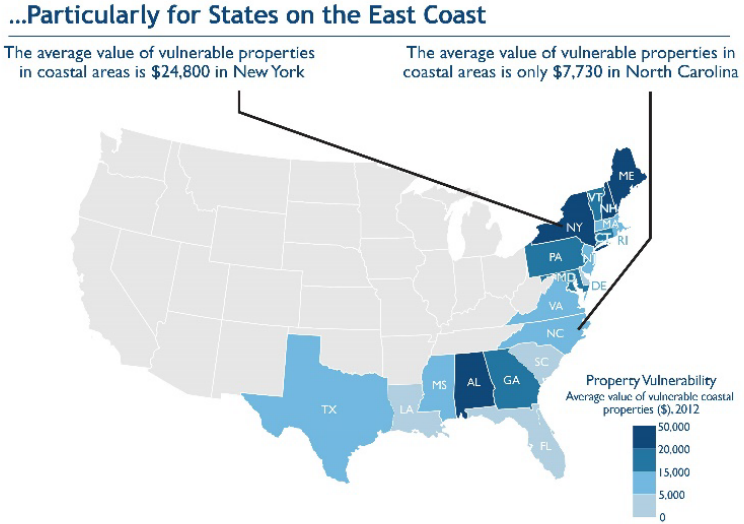
Longform Infographic



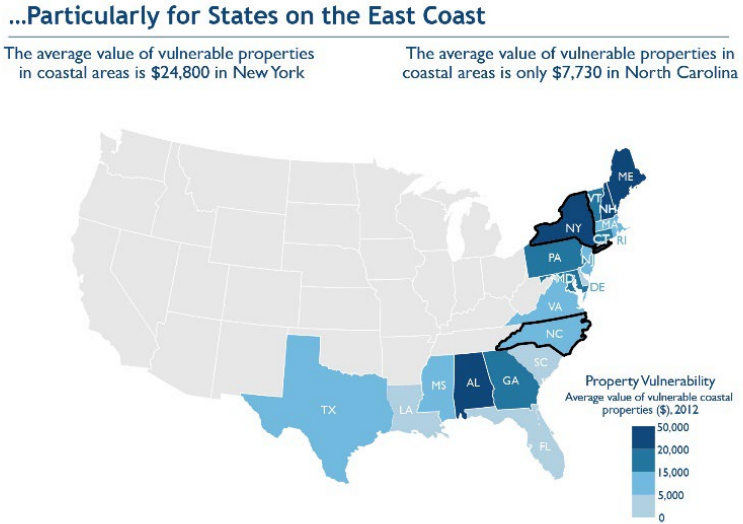
Dynamic Slideshow

Tropes

Leader Lines



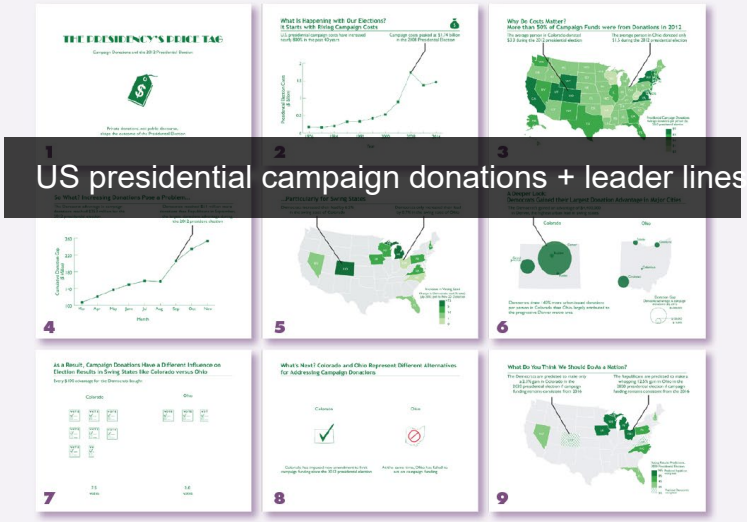
Color Highlighting

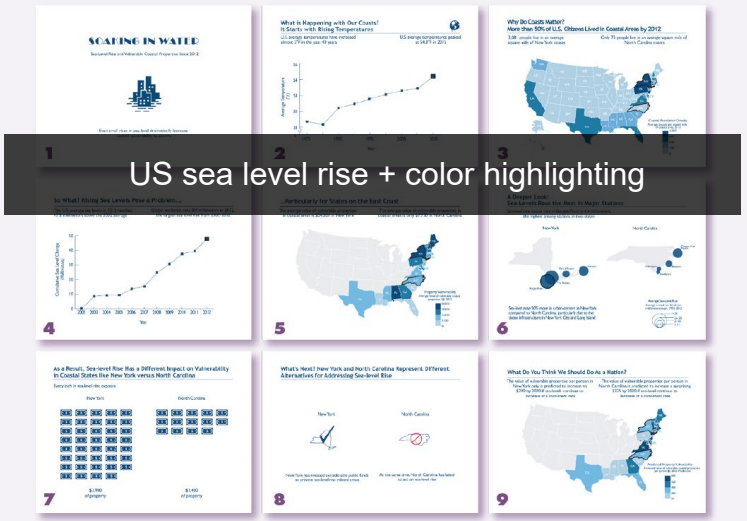


2x2x2 Factorial Design

Story	Theme (Factor 1)	Genre (Factor 2)	Trope (Factor 3)
Story 1	US sea-level rise	Longform Infographic	Color highlighting
Story 2	US presidential campaign donations	Longform Infographic	Leader lines
Story 3	US presidential campaign donations	Longform Infographic	Color highlighting
Story 4	US sea-level rise	Longform Infographic	Leader lines
Story 5	US presidential campaign donations	Dynamic Slideshow	Leader lines
Story 6	US sea-level rise	Dynamic Slideshow	Color highlighting
Story 7	US sea-level rise	Dynamic Slideshow	Leader lines
Story 8	US presidential campaign donations	Dynamic Slideshow	Color highlighting

Table 4. Factorial Design. The study followed a 2×2×2 factorial design, resulting in eight unique visual stories.





Dependent Variables

Retention

What was the largest amount of sea level rise exhibited in a single year from 2002-2012?

- 8.4 millimeters
- 10.4 millimeters
- 12.4 millimeters
- Not Sure

What was the largest rate of sea-level rise at a single New York station in 2012?

- 2.4 millimeters/year
- 4.4 millimeters/year
- 6.4 millimeters/year
- Not Sure

Comprehension

In your own words, please summarize the visual story you just reviewed:

Reaction

Rate the degree to which you agree with the following statements about the visual story on sea-level rise in the U.S. (1=strongly disagree, 7=strongly agree)

	Strongly disagree						Strong agree
	1	2	3	4	5	6	7
The visual story ***bored*** me	○	○	○	○	○	○	○
The visual story ***concerned*** me	○	○	○	○	○	○	○
The visual story ***excited*** me	○	○	○	○	○	○	○
I ***agree*** with the visual story	○	○	○	○	○	○	○

Individual Differences

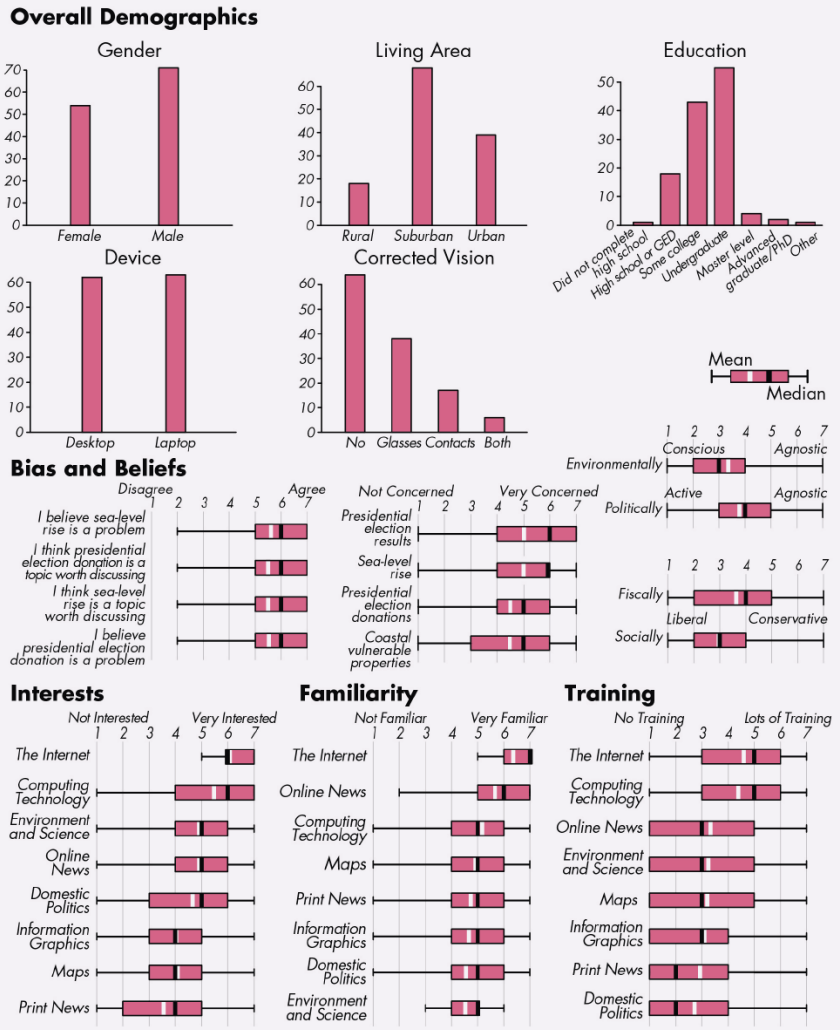


Figure 1. Participant Background.

Retention Results

Factor / Interactions		Compare (Ordinal)			Rank (Ordinal)			Identify (Numerical)			Total Retention		
Descriptive Statistics	n		Mean	SD		Mean	SD		Mean	SD		Mean	sd
Total	3000		81.9%	24.5%		71.7%	27.4%		66.2%	26.8%		71.4%	20.7%
US presidential campaign donations	1500		84.3%	27.0%		63.5%	27.6%		65.3%	27.2%		69.6%	21.6%
US sea-level rise	1500		79.5%	21.5%		80.0%	24.7%		67.1%	26.5%		73.3%	19.6%
Longform infographics	1512		84.9%	21.3%		70.9%	27.6%		71.0%	24.4%		74.5%	18.2%
Dynamic slideshows	1488		78.8%	27.0%		72.6%	27.2%		61.3%	28.3%		68.3%	22.6%
Leader lines	1500		84.0%	24.5%		73.3%	27.4%		69.2%	26.8%		73.8%	20.7%
Color highlighting	1500		79.7%	25.4%		70.1%	27.4%		63.2%	27.1%		69.1%	20.9%
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Theme	1	1.30	2.44	0.12	15.38	25.12	0.00	0.68	0.27	0.60	12.10	2.03	0.16
Genre	1	2.13	4.01	0.05	0.16	0.26	0.61	21.35	8.52	0.00	33.75	5.67	0.02
Trope	1	0.97	1.83	0.18	0.73	1.19	0.28	8.22	3.28	0.07	20.93	3.51	0.06
Theme : Genre	1	0.05	0.09	0.76	0.77	1.25	0.26	1.30	0.52	0.47	0.13	0.02	0.88
Theme : Trope	1	0.21	0.40	0.53	2.46	4.01	0.05	3.74	1.49	0.22	14.72	2.47	0.12
Genre : Trope	1	0.18	0.33	0.57	0.02	0.03	0.85	0.63	0.25	0.62	0.13	0.02	0.88
Residuals	243	0.53			0.61			2.51			5.96		

Table 6. Participant Retention Results. The table shows descriptive statistics (top) and factorial ANOVA (bottom) for retention. The table includes main effects by factor (theme, genre, and trope) as well as interaction effects between factors. The table includes four separate factorial ANOVA models on retention for compare (ordinal), rank (ordinal), identify (numerical), and total retention. Color indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$, $p < 0.001$.

Retention Results

Factor / Interactions		Compare (Ordinal)			Rank (Ordinal)			Identify (Numerical)			Total Retention		
Descriptive Statistics	n		Mean	SD		Mean	SD		Mean	SD		Mean	sd
Total	3000		81.9%	24.5%		71.7%	27.4%		66.2%	26.8%		71.4%	20.7%
US presidential campaign donations	1500		84.3%	27.0%		63.5%	27.6%		65.3%	27.2%		69.6%	21.6%
US sea-level rise	1500		79.5%	21.5%		80.0%	24.7%		67.1%	26.5%		73.3%	19.6%
Longform infographics	1512		84.9%	21.3%		70.9%	27.6%		71.0%	24.4%		74.5%	18.2%
Dynamic slideshows	1488		78.8%	27.0%		72.6%	27.2%		61.3%	28.3%		68.3%	22.6%
Leader lines	1500		84.0%	24.5%									
Color highlighting	1500		79.7%	25.4%									
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Theme	1	1.30	2.44	0.12	15.38	25.12	0.00	0.68	0.27	0.60	12.10	2.03	0.16
Genre	1	2.13	4.01	0.05	0.16	0.26	0.61	21.35	8.52	0.00	33.75	5.67	0.02
Trope	1	0.97	1.83	0.18	0.73	1.19	0.28	8.22	3.28	0.07	20.93	3.51	0.06
Theme : Genre	1	0.05	0.09	0.76	0.77	1.25	0.26	1.30	0.52	0.47	0.13	0.02	0.88
Theme : Trope	1	0.21	0.40	0.53	2.46								
Genre : Trope	1	0.18	0.33	0.57	0.02								
Residuals	243	0.53			0.61								

1. Performance declined with task difficulty (expected)

2. No significant difference in overall retention by theme (design not topic matters for recall!)

3. Significant differences in overall retention by genres & (to a weaker degree) tropes. Longform infographics & leader lines improved recall.

Table 6. Participant Retention Results. The table shows descriptive statistics (top) and factorial ANOVA (bottom) for retention. The table includes main effects by factor (theme, genre, and trope) as well as interaction effects between factors. The table includes four separate factorial ANOVA models on retention for compare (ordinal), rank (ordinal), identify (numerical), and total retention. Color indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$, $p < 0.001$.

Comprehension

1. Relatively rich discussion (48% of all elements) with relatively few mistakes (12.4%; unexpected)

Factor / Interactions		Space			Time			Protagonist			Antagonist			Problem		
Descriptive	n		mean	sd		mean	sd		mean	sd		mean	sd		mean	sd
Total	250		26.5%	44.2%		18.0%	38.5%		59.6%	49.2%		52.4%	50.0%		96.0%	19.6%
US presidential campaign donations	125		35.2%	48.0%		24.0%	42.9%		52.0%	50.2%		48.8%	50.2%		96.0%	19.7%
US sea-level rise	125		17.7%	38.4%		12.0%	32.6%		67.2%	47.1%		56.0%	49.8%		96.0%	19.7%
Longform infographics	126		32.5%	47.0%		18.3%	38.8%		60.3%	49.1%		50.8%	50.2%		99.2%	8.9%
Dynamic slideshows	124		20.3%	40.4%		17.7%	38.4%		58.9%	49.4%		54.0%	50.0%		92.7%	26.0%
Leader lines	125		24.0%	42.9%		19.2%	39.5%		60.8%	49.0%		52.0%	50.2%		95.2%	21.5%
Color highlighting	125		29.0%	45.6%		16.8%	37.5%		58.4%	49.5%		52.8%	50.1%		96.8%	17.7%
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Theme	1	1.94	10.49	0.00	0.90	6.23	0.01	1.44	6.02	0.01	0.32	1.27	0.26	0.00	0.00	1.00
Genre	1	0.96	5.19	0.02	0.00	0.01	0.92	0.01	0.06	0.82	0.07	0.26	0.61	0.26	6.82	0.01
Trope	1	0.17	0.92	0.34	0.03	0.19	0.66	0.05	0.20	0.66	0.00	0.01	0.92	0.02	0.42	0.52
Theme : Genre	1	0.58	3.13	0.08	0.47	3.24	0.07	0.20	0.83	0.36	0.00	0.02	0.89	0.02	0.40	0.53
Theme : Trope	1	0.06	0.34	0.56	0.26	1.82	0.18	0.05	0.19	0.66	0.00	0.00	1.00	0.00	0.00	0.99
Genre : Trope	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.98
Residuals	[illegible]	[illegible]			[illegible]			[illegible]			[illegible]			[illegible]		

3. Nearly all participants discussed the main problem with longforminfographics. A small but significant set missed the problem with dynamic slideshows.

Factor / Interactions		Tension			Cause			Effect			Cliffhanger			Total			Mistakes		
Descriptive	n		mean	sd		mean	sd		mean	sd		mean	sd		mean	sd		mean	sd
Total	250		69.2%	46.3%		32.4%	46.9%		50.8%	50.1%		26.8%	44.4%		48.0%	22.9%		12.4%	33.0%
US Presidential campaign donations	125		71.2%	45.5%		20.8%	40.8%		44.0%	49.8%		25.6%	43.8%		46.4%	22.7%		16.0%	36.8%
US sea-level rise	125		67.2%	47.1%		44.0%	49.8%		57.6%	49.6%		28.0%	45.1%		49.6%	23.0%		8.8%	28.4%
Longform infographics	126		69.8%	46.1%		35.7%	48.1%		50.8%	[illegible]		27.0%	44.6%		[illegible]	21.7%		11.1%	[illegible]
Dynamic slideshows	124		68.5%	46.6%		29.0%	45.6%		50.8%	50.2%		26.6%	44.4%		46.6%	24.0%		13.7%	[illegible]
Leader lines	125		[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]
Color highlighting	125		64.8%	48.0%		29.6%	45.8%		51.2%	50.2%		28.0%	45.1%		47.6%	[illegible]		11.2%	31.6%
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Theme	1	0.10	0.46	0.50	3.36	16.36	0.00	1.16	4.63	0.03	0.04	0.18	0.67	5.18	1.21	0.27	0.32	2.98	0.09
Genre	1	0.01	0.05	0.83	0.28	1.36	0.25	0.00	0.00	1.00	0.00	0.00	0.95	3.93	0.92	0.34	0.04	0.39	0.53
Trope	1	0.47	2.19	0.14	0.24	1.15	0.28	0.00	0.01	0.94	0.03	0.17	0.68	0.47	0.11	0.74	0.03	0.29	0.59
Theme:Genre	1	0.11	0.52	0.47	0.32	1.56	0.21	0.11	0.43	0.51	0.10	0.48	0.49	0.25	0.06	0.81	0.03	0.30	0.58
Theme:Trope	1	0.11	0.50	0.48	0.34	1.63	0.20	0.57	2.29	0.13	0.12	0.58	0.45	0.09	0.02	0.89	0.08	0.69	0.41
Genre:Trope	1	0.00	0.02	0.90	0.25	1.20	0.27	[illegible]	0.12	0.73	0.31	1.55	0.21	0.68	0.16	0.69	0.21	1.96	[illegible]
Residuals	243	0.22			[illegible]			0.25			0.20			4.30			0.11		

2. No significant difference in total elements discussed by theme, but a weak difference in mistakes

4. No significant differences in total elements or mistakes by genres or tropes (unexpected), pointing to the difficulty of quantitatively measuring comprehension

Table 7. Participant C[illegible] ANOVA (bottom half) [illegible] between factors. The [illegible] elements and two additional models for total comprehension across all elements and mistakes in comprehension. Color indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$, $p < 0.001$.

Reaction

Factor / Interactions		Interest+ (Interest)			Interest- (Concern)			Belief+ (Agree)			Belief- (No Influence)		
Descriptive	n		mean	sd		mean	sd		mean	sd		mean	sd
Total	2000		5.0	1.7		4.5	1.9		5.0	1.6		3.8	1.9
US presidential campaign donations	1000		5.1	1.6		4.9	1.8						
US sea-level rise	1000		4.8	1.8		4.0	1.9						
Longform infographics	1008		5.1	1.6		4.4	1.9						
Dynamic slideshows	992		4.9	1.8		4.5	1.9						
Leader lines	1000		5.2	1.7		4.6	1.8		5.1	1.6		3.6	1.9
Color highlighting	1000		4.8	1.7		4.3	1.9		4.9	1.5		3.9	1.9
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Theme	1	4.62	1.62	0.21	46.66	14.01	0.00	10.82	4.57	0.03	7.40	2.10	0.15
Genre	1	1.61	0.56	0.45	0.48	0.14	0.71	7.74	3.27	0.07	11.05	3.14	0.08
Trope	1	12.19	4.26	0.04	5.60	1.68	0.20	3.79	1.60	0.21	5.77	1.64	0.20
Theme : Genre	1	0.08	0.03	0.87	2.35	0.71	0.40	0.00	0.00	0.97	7.66	2.17	0.14
Theme : Trope	1	1.87	0.65	0.42	8.28	2.49	0.12	4.34	1.83	0.18	0.62	0.18	0.67
Genre : Trope	1	13.79	4.81	0.03	3.74	1.12	0.29	0.08	0.03	0.85	2.06	0.58	0.45
Residuals	243	2.86			3.33			2.37			3.52		

Factor / Interactions		Arousal+ (Excite)			Arousal- (Bore)			Hedonic+ (Enjoy)			Hedonic- (Upset)		
Descriptive	n		mean	sd		mean	sd		mean	sd		mean	sd
Total	2000		3.5	1.7		3.1	1.9		4.4	1.8		3.2	1.8
US presidential campaign donations	1000								4.4	1.7		3.5	2.0
US sea-level rise	1000								4.3	1.8		2.9	1.7
Longform infographics	1008								4.4	1.7		2.9	1.8
Dynamic slideshows	992								4.3	1.8		3.5	1.9
Leader lines	1000		3.6	1.7		2.9	1.8		4.5	1.7		3.2	1.9
Color highlighting	1000		3.4	1.6		3.2	1.9			1.8		3.1	1.8
Factorial ANOVA	df	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p	Mean Sq	F	p
Theme	1	0.04	0.01	0.91	0.48	0.14	0.71	0.58	0.19	0.67	23.72	7.24	0.01
Genre	1	7.73	2.76	0.10	9.67	2.78	0.10	0.34	0.11	0.74	21.52	6.57	0.01
Trope	1	3.83	1.37	0.24	6.01	1.72	0.19	4.55	1.47	0.23	0.92	0.28	0.60
Theme : Genre	1	0.16	0.06	0.81	2.30	0.66	0.42	0.19	0.06	0.80	1.60	0.49	0.49
Theme : Trope	1	0.50	0.18	0.67	4.72	1.35	0.25	2.21	0.72	0.40	0.99	0.30	0.58
Genre : Trope	1										0.63	0.19	0.66

1. Strongest differences in reaction in “concern” and “upset” by theme. Greater valence for US Presidential Campaign Donations and general neutrality for US Sea Level Rise story (unfortunate)

2. Significant difference in “upset” with dynamic slideshows, which could be used in design for emotional congruence.

3. Significantly more “interest” with leader lines, a key measure for focusing attention

Table 8. Participant Reaction Results (in two parts). The table shows descriptive statistics (top half of each part) and factorial ANOVA (bottom half) for reaction. Likert ratings are out of 7 points. The table includes main effects by factor (theme, genre, and trope) as well as interaction effects between factors. The table includes eight separate factorial ANOVA models on reaction, one for each of the evaluated reaction measures. Color indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$, $p < 0.001$.

Individual Differences

1. For retention, familiarity & interest in *digital* technology and design was a greater driver than prior beliefs related to the theme.

2. Stronger beliefs and more training regarding US Sea Level Rise negatively influenced comprehension

3. Individual differences had the overall greatest impact on participant reaction, particularly related to the theme.

Individual Difference		A: Influence on Retention						B: Influence on Comprehension					
		Sea-level rise		Presidential campaign donations		Both		Sea-level rise		Presidential campaign donations		Both	
Relation to Visual Story Theme		β	p	β	p	β	p	β	p	β	p	β	p
Expertise: Familiarity	Environment and Science	-0.28	0.24					0.08	0.68				
	Domestic Politics			0.38	0.13					-0.09	0.69		
Expertise: Training	Environment and Science	-0.15	0.39					-0.42	0.01				
	Domestic Politics			-0.06	0.77					-0.12	0.52		
Motivation: Prior Interest	Environment and Science	0.04	0.84					-0.18	0.29				
	Domestic Politics			-0.28	0.24					0.20	0.33		
	Socially liberal-v-conservative	0.26	0.08					-0.18	0.15				
	Fiscally liberal-v-conservative			0.20	0.19					0.00	0.98		
	Environmentally conscious-v-agnostic	-0.37	0.03					-0.34	0.02				
	Politically active-v-agnostic			-0.22	0.24					-0.05	0.76		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			-0.44	0.01				
	Concern about coastal vulnerable properties	[illegible]	[illegible]	[illegible]	[illegible]								
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]69								
	Concern about the presidential election results	[illegible]	[illegible]	[illegible]	[illegible]					-0.12	[illegible]40		
	I believe presidential campaign donation is a topic wo[illegible] discussing			0.10	0.62			0.41	0.03				
	I believe sea-level rise is a problem									0.29	0.10		
	I believe presidential election campaign donation is a problem												
Relation to Design and Technology		β	p	β	p	β	p	β	p	β	p	β	p
Expertise: Familiarity	Print News Sources	0.23	0.11	0.31	0.11	0.57	0.01	-0.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Online News Sources	-0.65	0.01	-0.77	0.01	-1.20	0.00	-0.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Maps	-0.35	0.27	-0.26	0.27	-0.51	0.04	0.02	0.92	-0.12	[illegible]	[illegible]	[illegible]
	Computing Technology	-0.00	0.59	-0.13	0.59	-0.37	0.17	-0.22	0.25	-0.21	[illegible]	[illegible]	[illegible]
	The Internet	0.56	0.00	0.96	0.00	1.51	0.00	0.18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Information Graphics	0.34	0.72	0.08	0.72	0.45	0.09	0.24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Expertise: Training	Print News Sources	-0.13	0.43	0.23	0.26	-0.05	0.82	-0.02	0.89	0.22	0.20	0.04	
	Online News Sources												0.826
	Maps	-0.13	0.47	-0.47	0.02	-0.63	0.00	0.12	0.44	-0.09	0.63	-0.25	
	Computing Technology												0.20
	The Internet	0.26	0.07	-0.13	0.42	0.06	0.71	0.25	0.04	0.11	0.41	0.16	
	Information Graphics												0.304
Motivation: Prior Interest	Print News Sources	-0.32	0.09	-0.53	0.01	-0.80	0.00	-0.27	0.09	-0.31	0.09	-0.37	0.07
	Online News Sources	0.55	0.01	0.58	0.01	1.07	0.00	0.63	0.00	0.39	0.05	1.05	0.00
	Maps	0.08	0.67	0.22	0.26	0.28	0.20	0.04	0.81	0.03	0.85	-0.04	0.86
	Computing Technology	-0.07	0.74	-0.01	0.97	0.16	0.55	-0.11	0.54	-0.04	0.85	0.06	0.81
	The Internet	0.14	0.59	0.26	0.37	0.37	0.26	0.12	0.57	0.13	0.60	0.31	0.29
	Information Graphics	0.22	0.29	0.23	0.31	0.32	0.20	-0.27	0.12	-0.21	0.27	-0.48	0.03

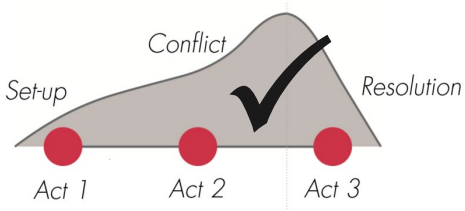
Table 9. Influence of Individual Differences on Retention and Comprehension. The table shows the results of multiple linear regression between individual differences and retention and comprehension. Color indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$, $p < 0.001$. Yellow indicates an individual difference measure that we removed.

Individual Difference		Arousal+ The visual story excited me.		Arousal- The visual story bored me.		Hedonic+ I enjoyed the visual story.		Hedonic- I was upset by the visual story.		Interest+ The visual story interested me.		Interest- The visual story concern me.		Belief+ I agree with the visual story.		Belief- The visual story did not influence my views.	
Relation to Visual Story Theme		θ	p	θ	p	θ	p	θ	p	θ	p	θ	p	θ	p	θ	p
Expertise: Familiarity	Environment and Science OR Domestic Politics	0.93	0.60	1.33	0.03	0.80	0.09	0.76	0.03	0.71	0.01	0.73	0.02	0.81	0.11	1.39	0.01
Expertise: Training	Environment and Science OR Domestic Politics	1.15	0.19	1.25	0.03	1.07	0.49	1.08	0.50	0.98	0.85	1.10	0.33	1.09	0.40	1.12	0.28
Motivation: Prior Interest	Environment and Science OR Domestic Politics	1.11	0.38	0.89	0.29	1.02	0.85	1.37	0.01	1.15	0.24	1.09	0.46	0.92	0.46	0.94	0.59
Prior Beliefs	Socially liberal-v-conservative OR Fiscally liberal-v-conservative	0.99	0.92	1.06	0.47	1.15	0.08	1.18	0.03	1.04	0.59	1.10	0.26	0.93	0.35	0.97	0.67
	Environmentally conscious-v-agnostic OR Politically active-v-agnostic	1.10	0.33	1.14	0.18	1.25	0.02	0.98	0.80	1.09	0.37	1.07	0.53	1.14	0.11	1.06	0.56
	Concern about sea-level rise OR Concern about presidential campaign donations	1.07	0.48	1.13	0.20	1.10	0.32	1.18	0.09	1.05	0.60	1.33	0.00	1.24	0.03	0.91	0.33
	Concern about coastal vulnerable properties																
	Concern about the presidential election results																
	I believe sea-level rise is a topic worth discussing OR I believe presidential campaign donation is a topic worth discussing	1.16	0.20	0.77	0.02	1.26	0.04	1.14	0.22	1.41	0.00	1.23	0.07	1.20	0.11	0.78	0.03
	I believe sea-level rise is a problem																
	I believe Presidential election campaign donation is a problem																
Relation to Design and Technology		θ	p	θ	p	θ	p	θ	p	θ	p	θ	p	θ	p	θ	p
Expertise: Familiarity	[illegible]	[illegible]	[illegible]	[illegible]	0.58	0.99	0.90	1.02	0.90	1.10	0.34	0.94	0.55	0.93	0.50	1.06	0.61
	Online News Sources	1.02	0.91	[illegible]	0.57	1.50	0.01	1.00	0.98	1.15	0.36	0.81	0.15	1.16	0.30	1.19	0.24
	Maps	[illegible]	0.00	[illegible]	0.23	0.73	0.02	1.24	[illegible]	0.81	0.11	1.11	0.41	0.92	0.53	1.12	0.40
	[illegible]	[illegible]	[illegible]	[illegible]	0.11	0.94	0.64	1.25	[illegible]	1.00	0.99	1.03	0.85	0.79	0.07	1.21	0.12
	The Internet	0.91	0.57	[illegible]	0.77	0.77	0.13	0.88	0.42	0.80	0.19	1.05	0.76	0.96	0.82	0.84	0.29
	Information Graphics	1.20	0.15	0.94	0.56	0.90	0.44	0.89	0.34	1.01	0.95	1.15	0.25	1.33	0.02	0.69	0.00
Expertise: Training	Print News Sources	0.86	0.15	1.01	0.90	0.87	0.16	[illegible]	0.24	0.94	0.53	1.03	0.77	0.93	0.48	1.01	0.89
	Online News Sources																
	Maps	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.89	0.26
	Computing Technology																
	The Internet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.21
	Information Graphics																
Motivation: Prior Interest	Print News Sources	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.20
	Online News Sources	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.54
	Maps	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.47
	Computing Technology	1.02	0.88	0.78	0.04	1.00	1.00	0.84	0.16	1.14	0.30	1.16	0.23	1.18	0.20	0.81	0.09
	The Internet	0.89	0.48	0.96	0.74	1.04	0.80	0.87	0.36	1.15	0.39	0.95	0.77	1.56	0.01	0.85	0.32
	Information Graphics	1.35	0.01	0.96	0.70	1.40	0.01	1.06	0.65	0.96	0.76	0.96	0.76	0.80	0.06	1.04	0.77

Table 10. Influence of Individual Differences on Reaction. The table shows the results of multiple linear regression between individual differences and reaction. Color indicates significance: $p < 0.10$, $p < 0.05$, $p < 0.01$, $p < 0.001$. Yellow indicates an individual difference measure that we removed.

Take-home Points

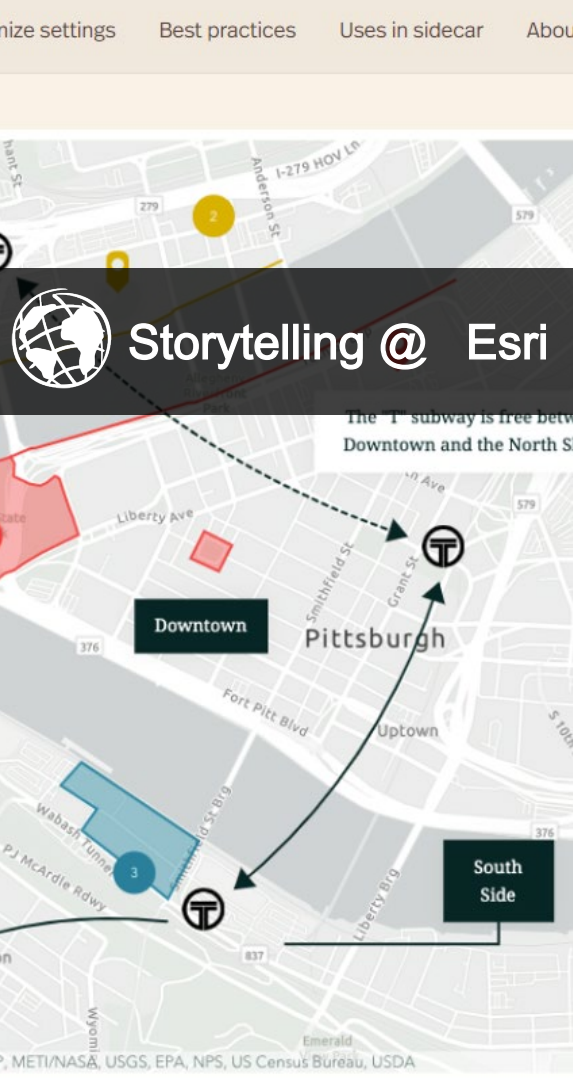
- Consider **three-act narrative elements** in your visual stories! Our examples serve as a template to plan your designs!

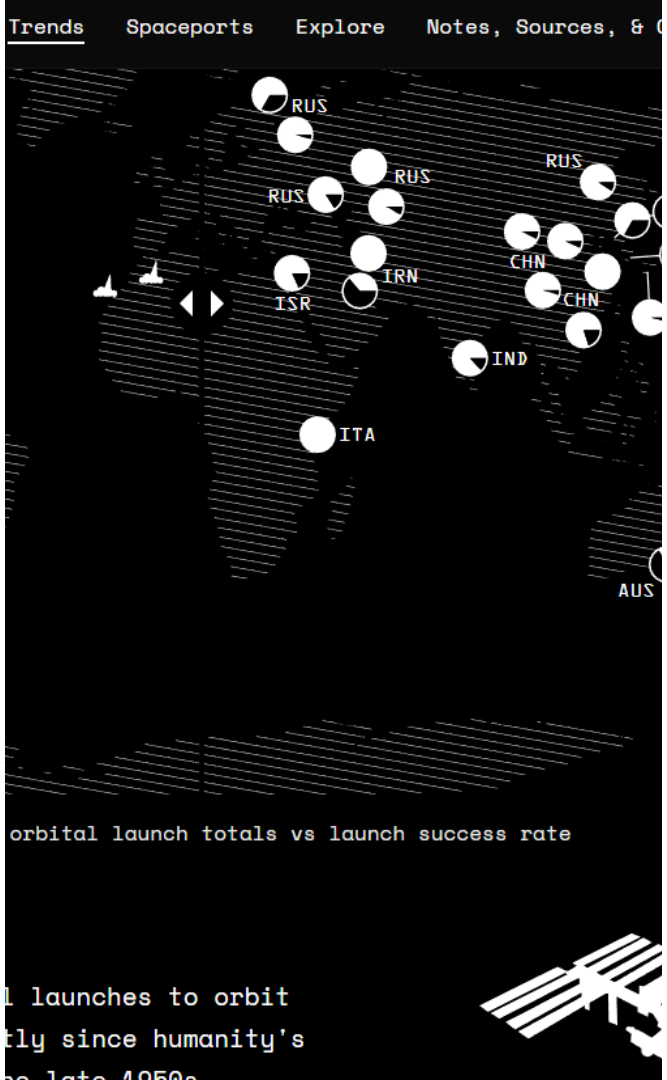


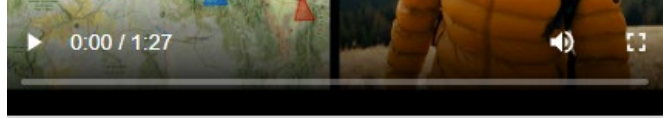
- Embrace the scroll and **use longform infographics**! Consider using Esri Story Maps instead of PPT Slides for your next presentation!

- Insert **leader lines** to focus attention on key points. Visual accenting is important to enforce linearity in an otherwise non-linear story map!

- Story theme and individual differences do impact the user's reaction. Future research is needed on **individual differences** to better understand how our designs influence diverse audiences!

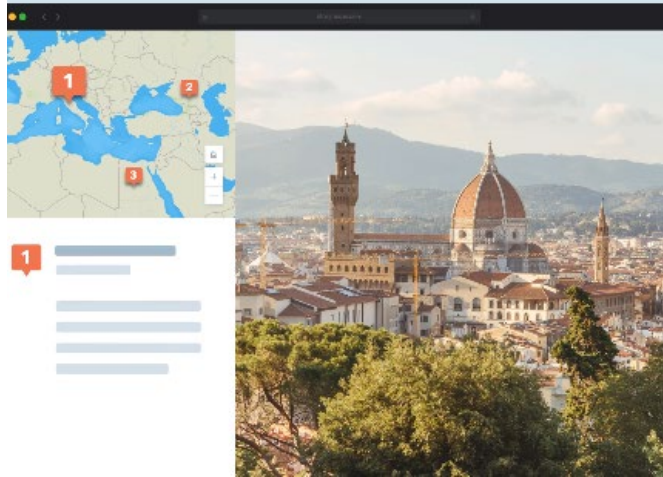






Everyone has a story to tell

From epic road trips to your favorite local restaurants, your experiences can inspire and engage people everywhere. Everyone loves a good story, and your stories are waiting to be told. Let us help you share them with the world.



Visual Storytelling with Maps:
Update & Outlook from an Empirical Study

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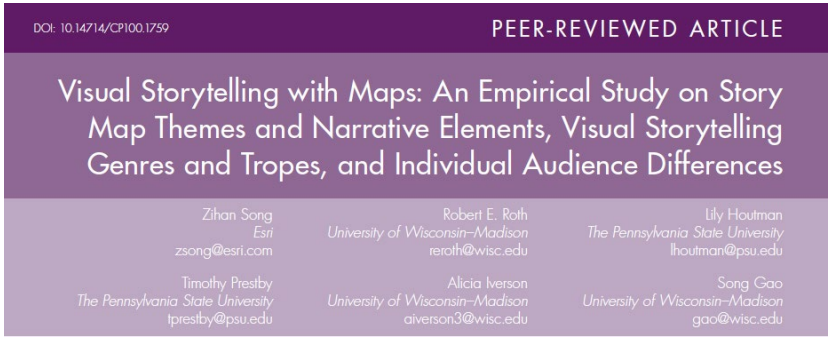


Full Paper:
Song Z, RE Roth, L Houtman, T Prestby, A Iverson, & S Gao. 2022. Visual storytelling with maps: An empirical study on story map themes and narrative elements, visual storytelling genres and tropes, and individual audience differences. Cartographic Perspectives. #100. DOI: 10.14714/ CP100.1759

Conclusions

1. What is the influence of **story map themes** and their constituent **narrative elements** on the audience's retention, comprehension, and reaction?

- The three-act narrative and constituent narrative elements is an effective way to structure visual storytelling w map.
- Story map themes did not impact retention or comprehension but influenced audience reaction.

2. What is the influence of visual storytelling **genres** on the audience's retention, comprehension, and reaction?

- Longform infographics outperformed dynamic slideshows for on overall retention.
- Longform infographics were more effective for comprehending the main problem of the story.
- Participants were more upset with stories presented as dynamic slideshows.

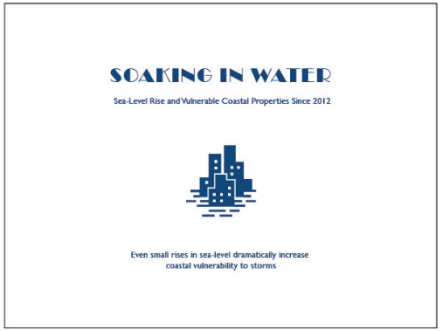
Conclusions

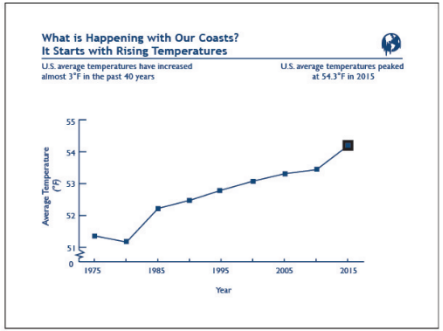
3. What is the influence of visual storytelling **tropes** on the audience's retention, comprehension, and reaction?

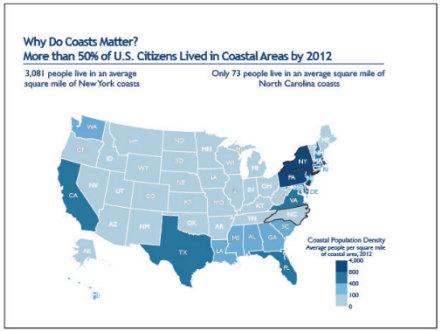
- Retention significantly improved when narrative elements were accented by leader lines instead of color highlighting.
- Leader lines better focus audience attention on important or unusual information in the story, likely because they employ the visual variable location.

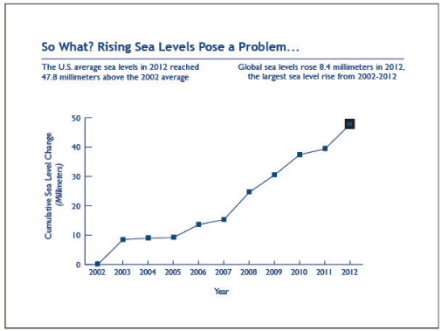
4. What is the influence of **individual audience differences** on their retention, comprehension, and reaction?

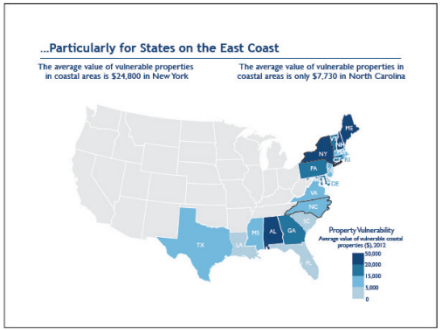
- Familiarity with digital technology and design improves retention. Preference for print actually inhibits retention.
- Prior beliefs and training about the story theme has a greater influence on comprehension and reaction.

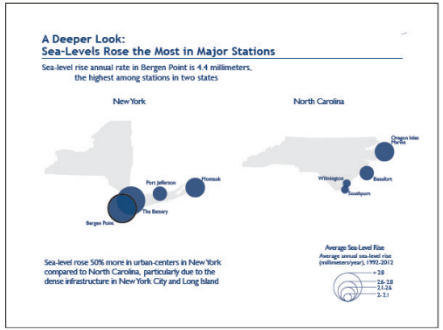


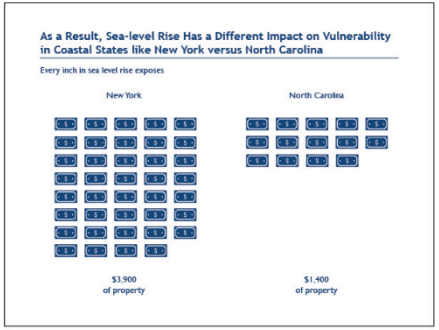


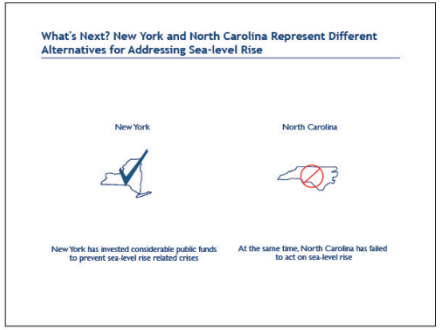


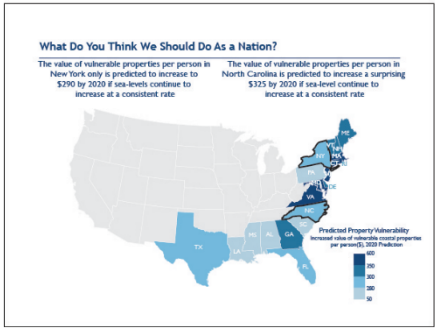




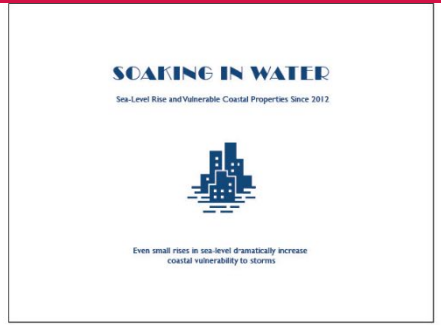


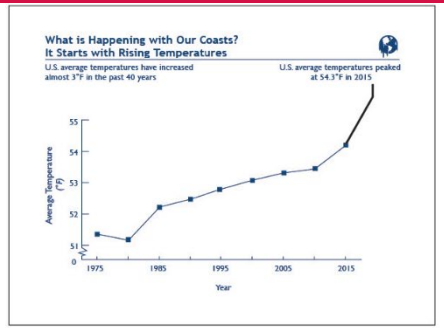


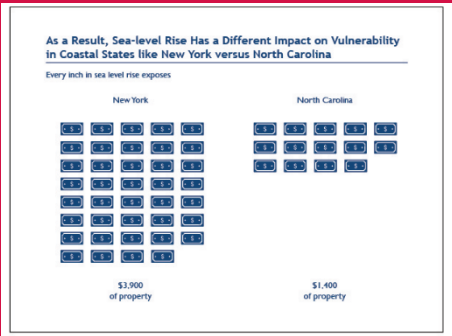


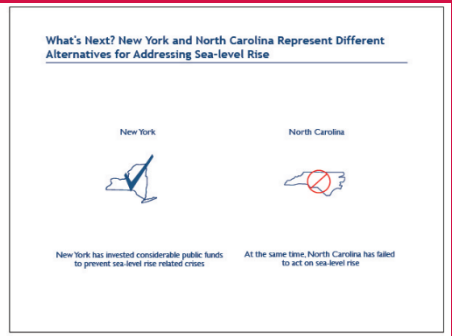


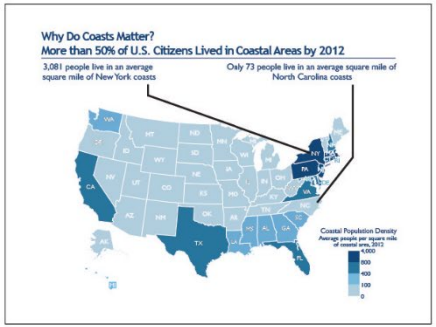
US Sealevel Rise Vulnerability + Color highlighting

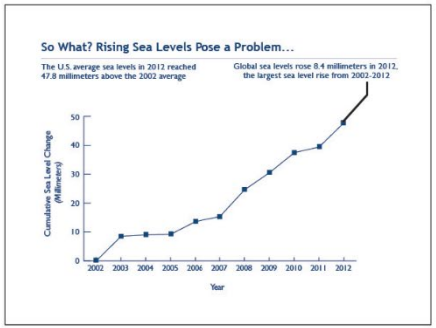


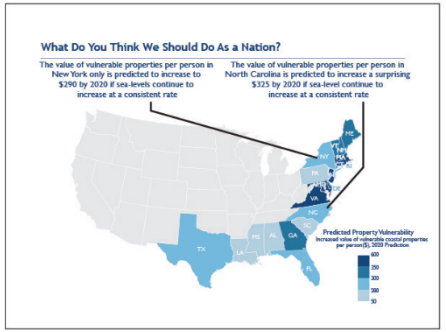


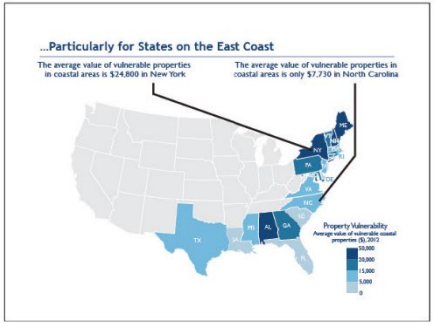


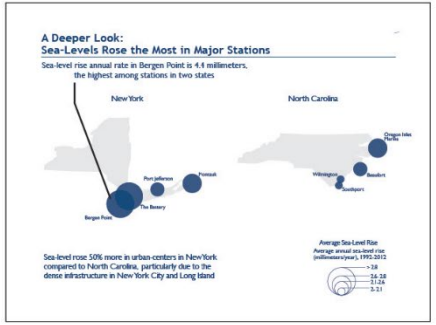




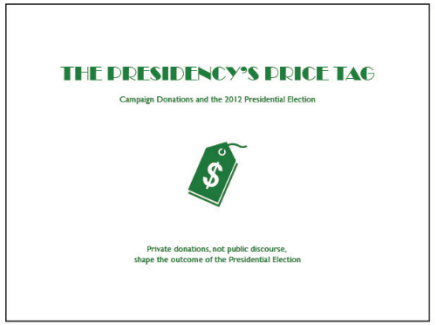


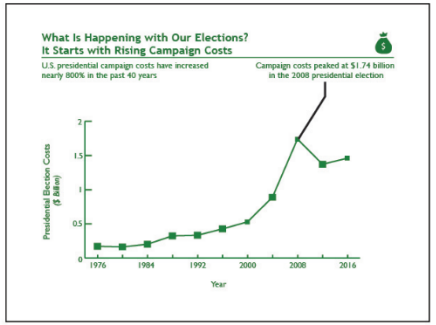


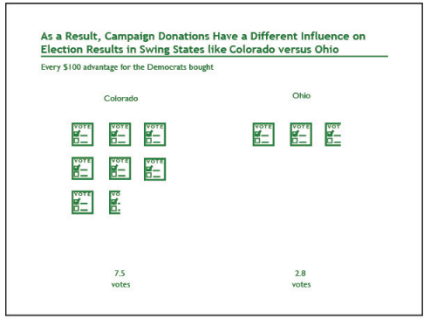


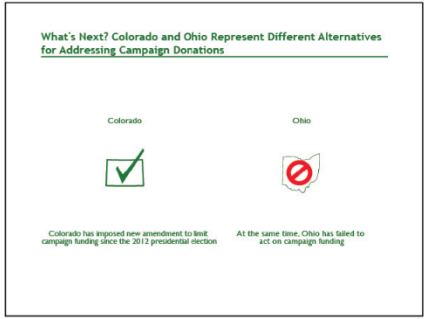


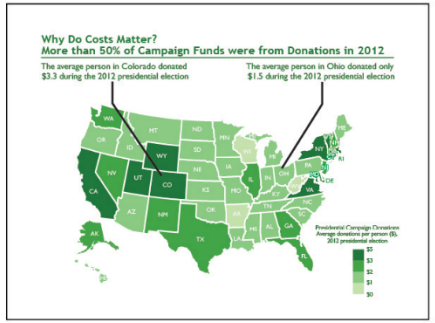
US Sea level Rise Vulnerability + Leader lines

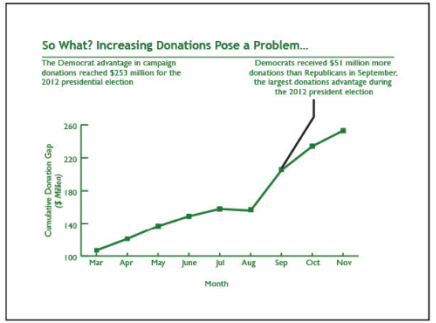


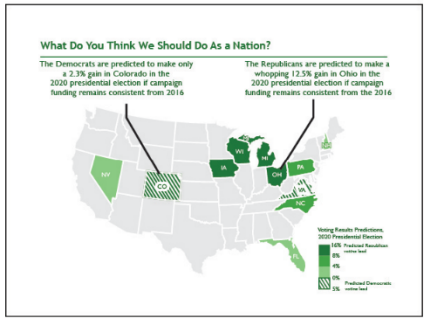


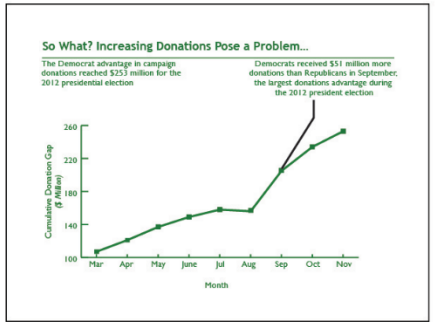


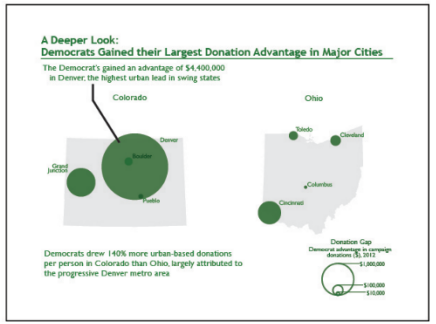






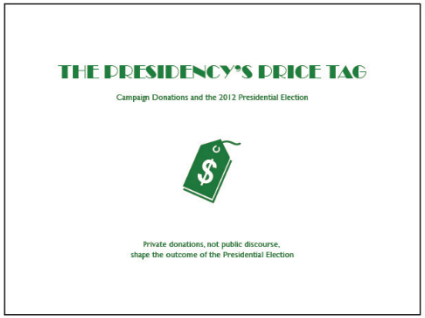


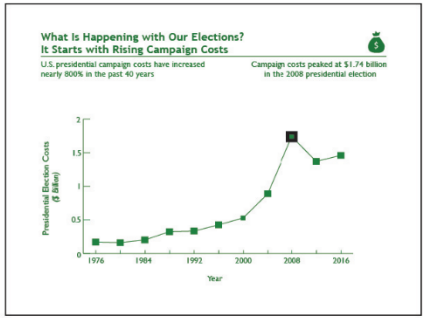


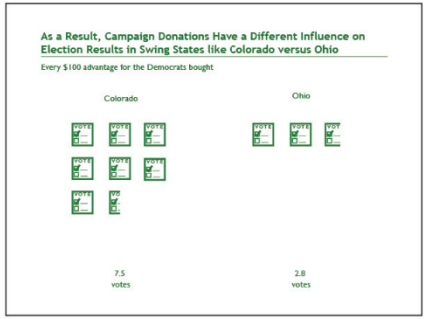


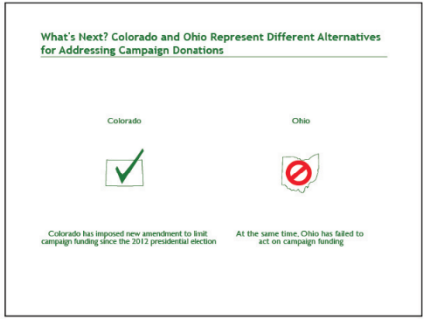
US Presidential Campaign Donations

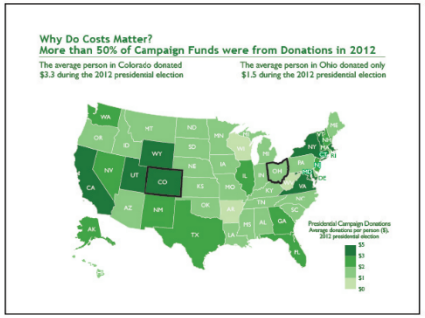
+ Leader lines

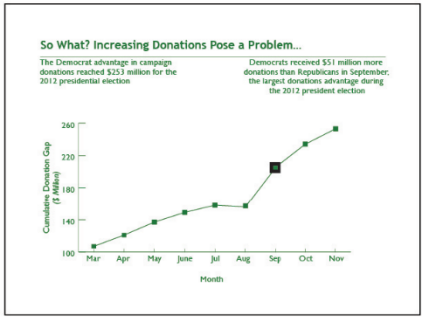


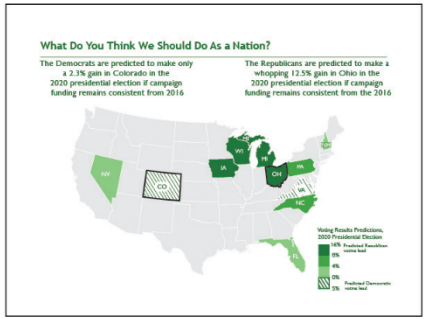


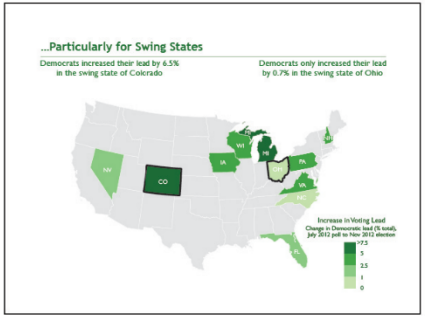


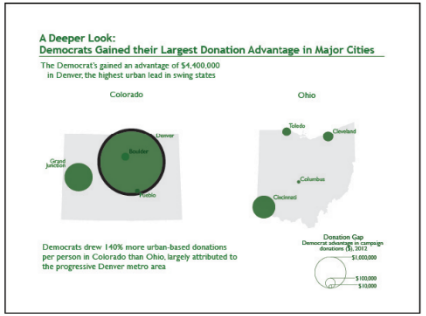












US Presidential Campaign Donations
+ Color highlighting