

# **Visualizing changes over time using dynamic hierarchies: TreeVesity2 and the StemView**

John Alexis Guerra Gómez, Michael L. Pack, Catherine  
Plaisant and Ben Shneiderman



Product					
Apples					
Oranges					
Milk					
Bread					
Butter					
Orange Juice					
Soda					

So you are collecting some data

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples					
Oranges					
Milk					
Bread					
Butter					
Orange Juice					
Soda					

and it has many attributes

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples				230	\$1.5
Oranges				210	\$5
Milk				93	\$2
Bread				105	\$3
Butter				10	\$10
Orange Juice				143	\$4
Soda				150	\$7

some numerical

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples	Fruit	No	No	230	\$1.5
Oranges	Fruit	No	No	210	\$5
Milk	Liquids	Yes	Yes	93	\$2
Bread	Staple	No	No	105	\$3
Butter	Staple	Yes	Yes	10	\$10
Orange Juice	Liquids	Yes	Yes	143	\$4
Soda	Liquids	Yes	Yes	150	\$7

some categorical

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples	Fruit	No	No	230	\$1.5
Oranges	Fruit	No	No	210	\$5
Milk	Liquids	Yes	Yes	93	\$2
Bread	Staple	No	No	105	\$3
Butter	Staple	Yes	Yes	10	\$10
Orange Juice	Liquids	Yes	Yes	143	\$4
Cheese	Liquids	Yes	Yes	150	\$7

And it changes over time...

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples	Fruit	No	No	245	\$2
Oranges	Fruit	No	No	201	\$4
Milk	Liquids	Yes	Yes	94	\$2
Bread	Staple	No	No	102	\$3.5
Butter	Staple	Yes	Yes	15	\$11
Orange Juice	Liquids	Yes	Yes	170	\$4
Cheese	Liquids	Yes	Yes	120	\$5

And it changes over time...

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples	Fruit	No	No	230	\$3
Oranges	Fruit	No	No	220	\$4
Milk	Liquids	Yes	Yes	110	\$4
Bread	Staple	No	No	92	\$2
Butter	Staple	Yes	Yes	10	\$8
Orange Juice	Liquids	Yes	Yes	160	\$3
Cheese	Liquids	Yes	Yes	150	\$7

And it changes over time...

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples	Fruit	No	No	220	\$2
Oranges	Fruit	No	No	110	\$3
Milk	Liquids	Yes	Yes	95	\$1
Bread	Staple	No	No	73	\$2
Cherries	Fruit	No	Yes	22	\$7.1
Orange Juice	Liquids	Yes	Yes	100	\$4
Soda	Liquids	Yes	Yes	190	\$7

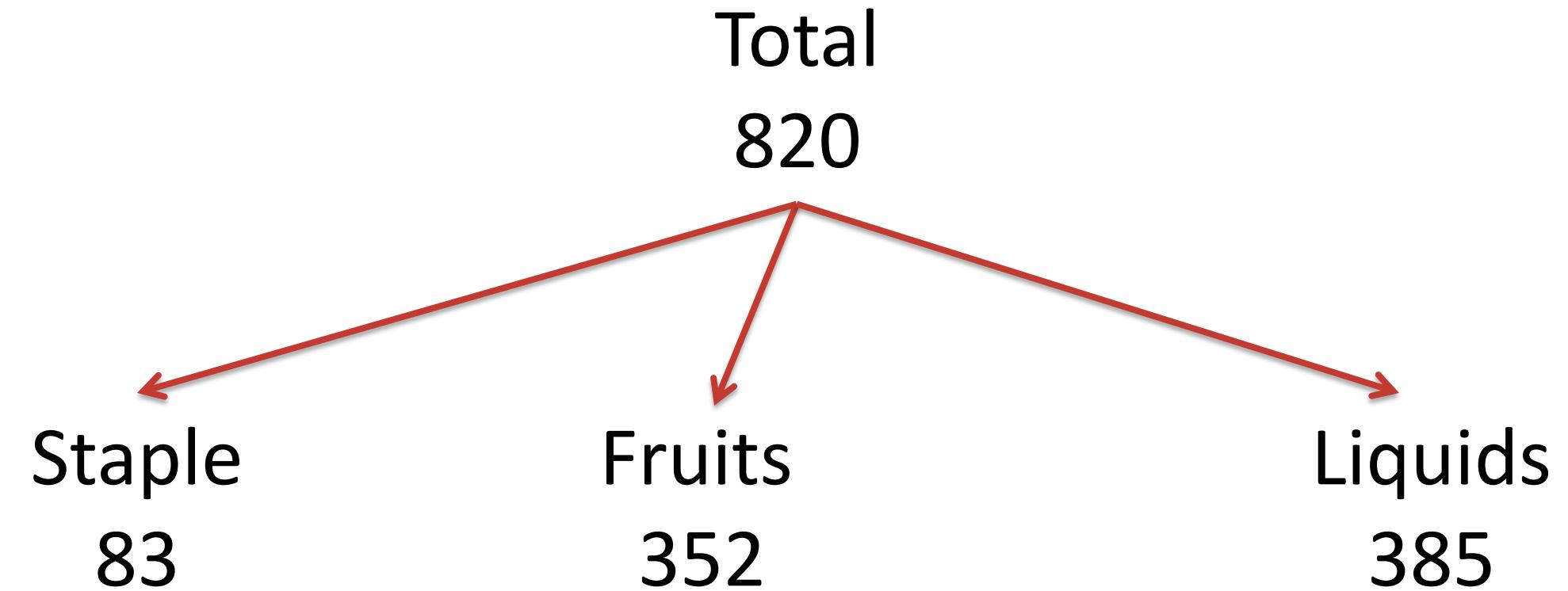
And it changes over time...

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Cherries	Fruit	No	Yes	22	\$7.1
Orange Juice	Liquids	Yes	Yes	100	\$4
Soda	Liquids	Yes	Yes	190	\$7

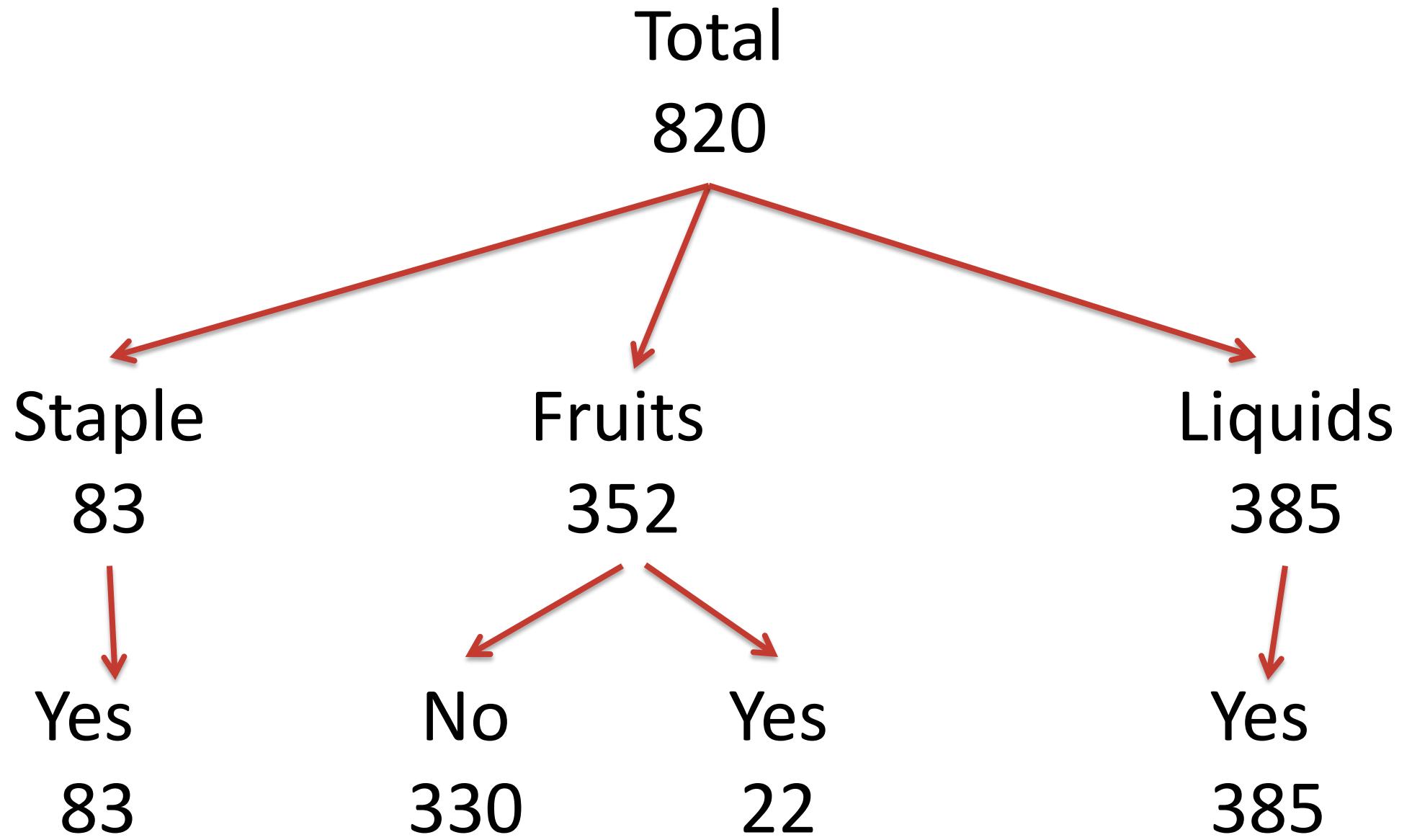
What Changed?

Total  
820

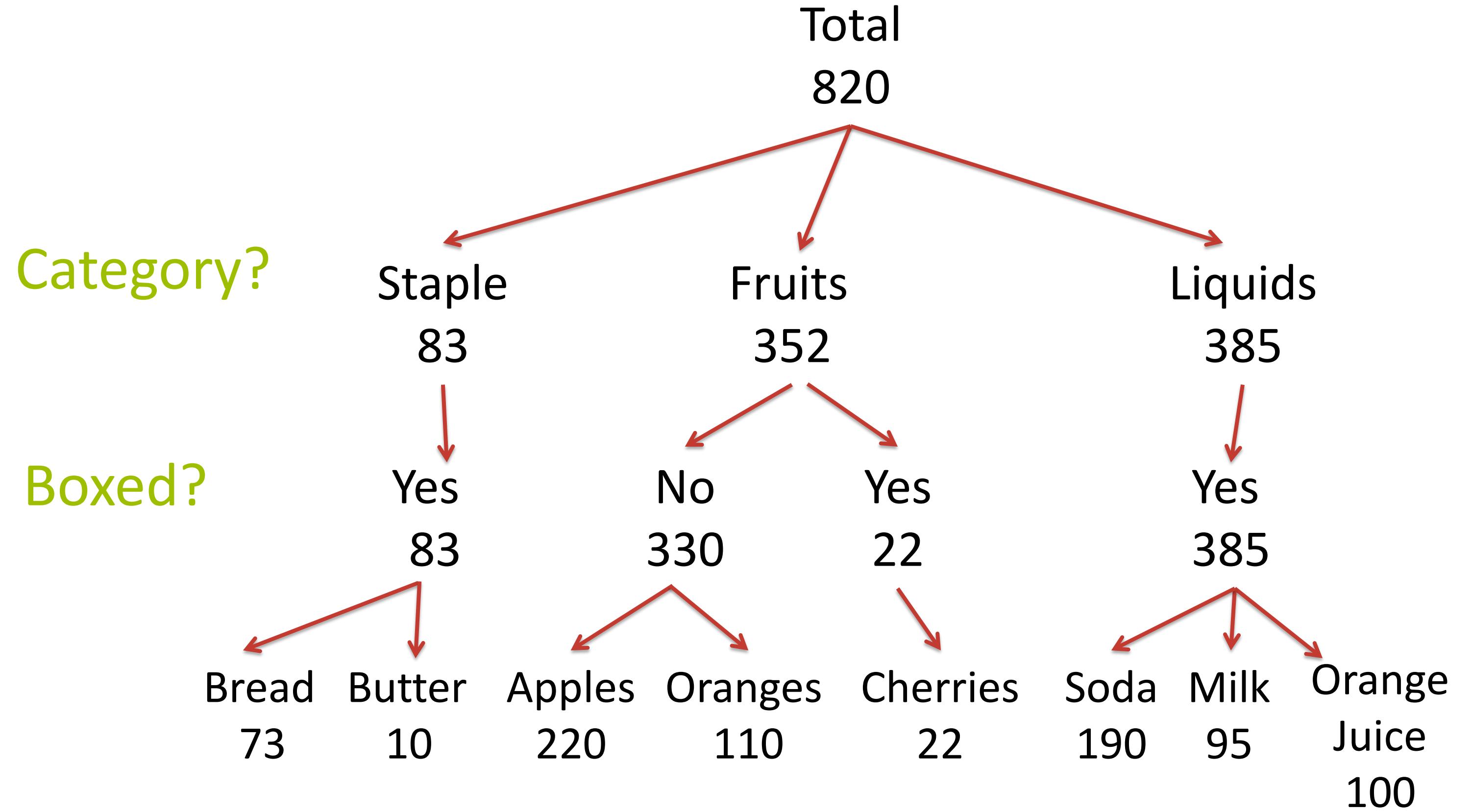
**Category?**



Category?



Boxed?



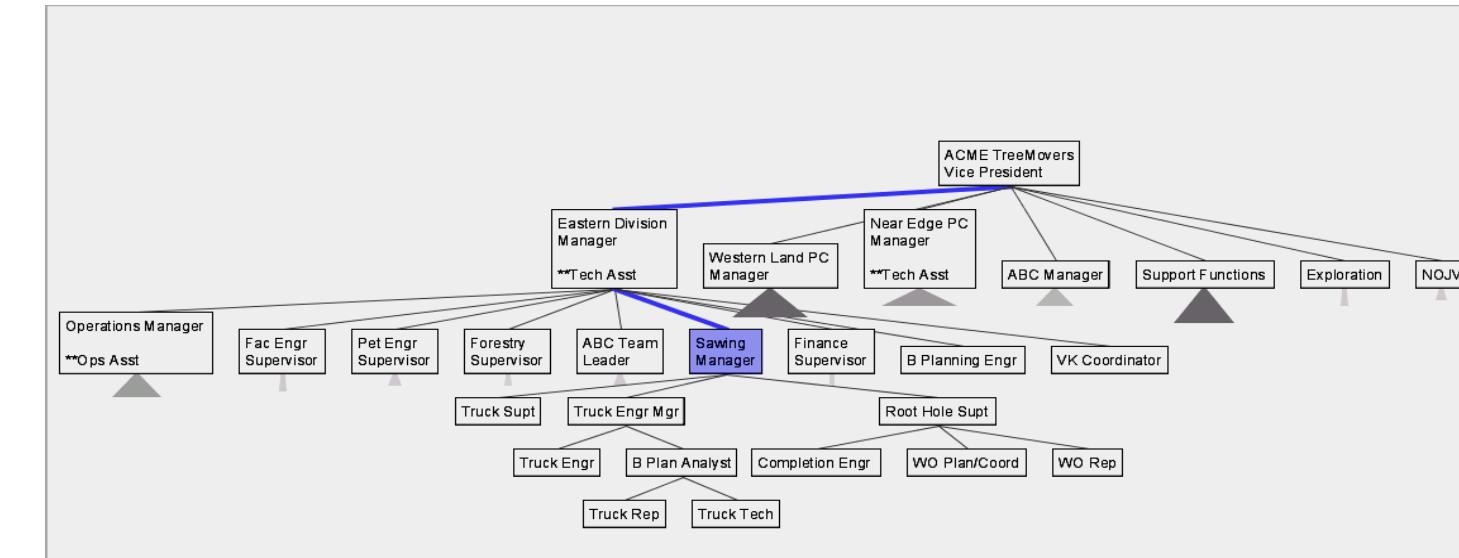
# ...and we are really good with them



TreeMaps [Johnson & Shneiderman 1991]

## Visualizing

Storing, Computing, etc...



SpaceTree [Plaisant, Grosjean & Bederson 1998]

## Navigating



A photograph of a large evergreen tree with dense green needles and a smaller tree with bright yellow-green leaves growing next to it. The background shows a forested area.

What about comparing them?

# Definitions

# Tree

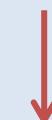
- Set of nodes and links that express the parent-to-child relationship.
- Where each node:
  - Is uniquely labeled in the tree.
  - Contains one or more numeric variables with values over time.
  - Contains one or more categorical attributes that may have more than one value.

# Types of Trees

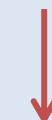
# Types of Trees

**Fixed**

State



County

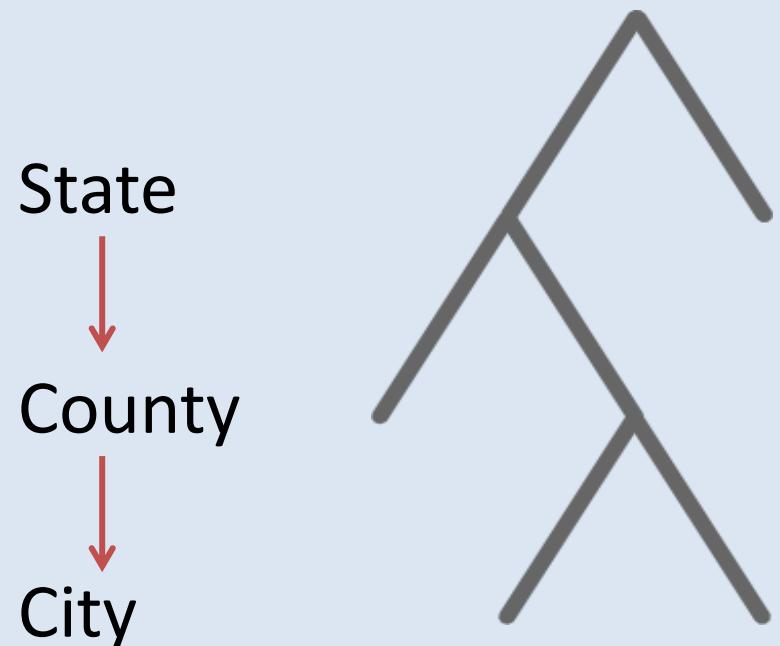


City

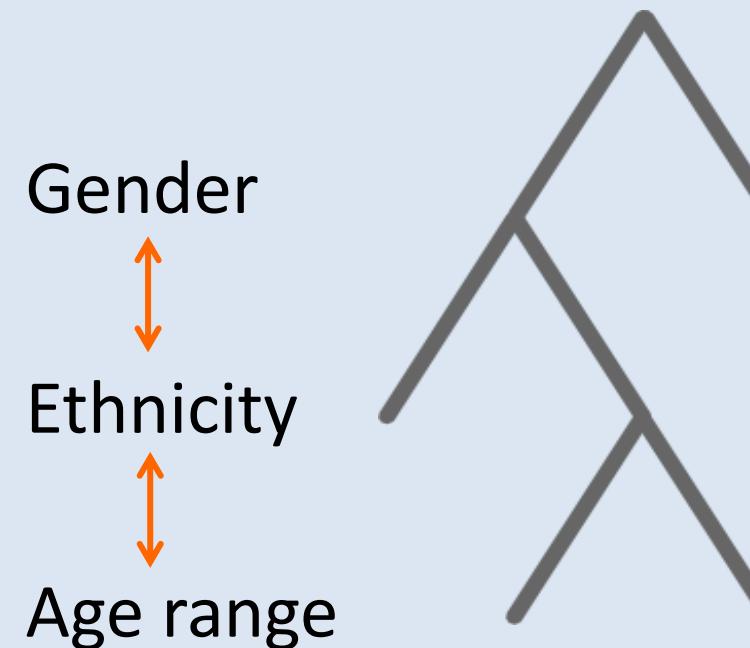


# Types of Trees

# Fixed



# Dynamic



# Types of Trees

**Fixed**

State  
↓  
County  
↓  
City



**Dynamic**

Gender  
↔  
Ethnicity  
↔  
Age range

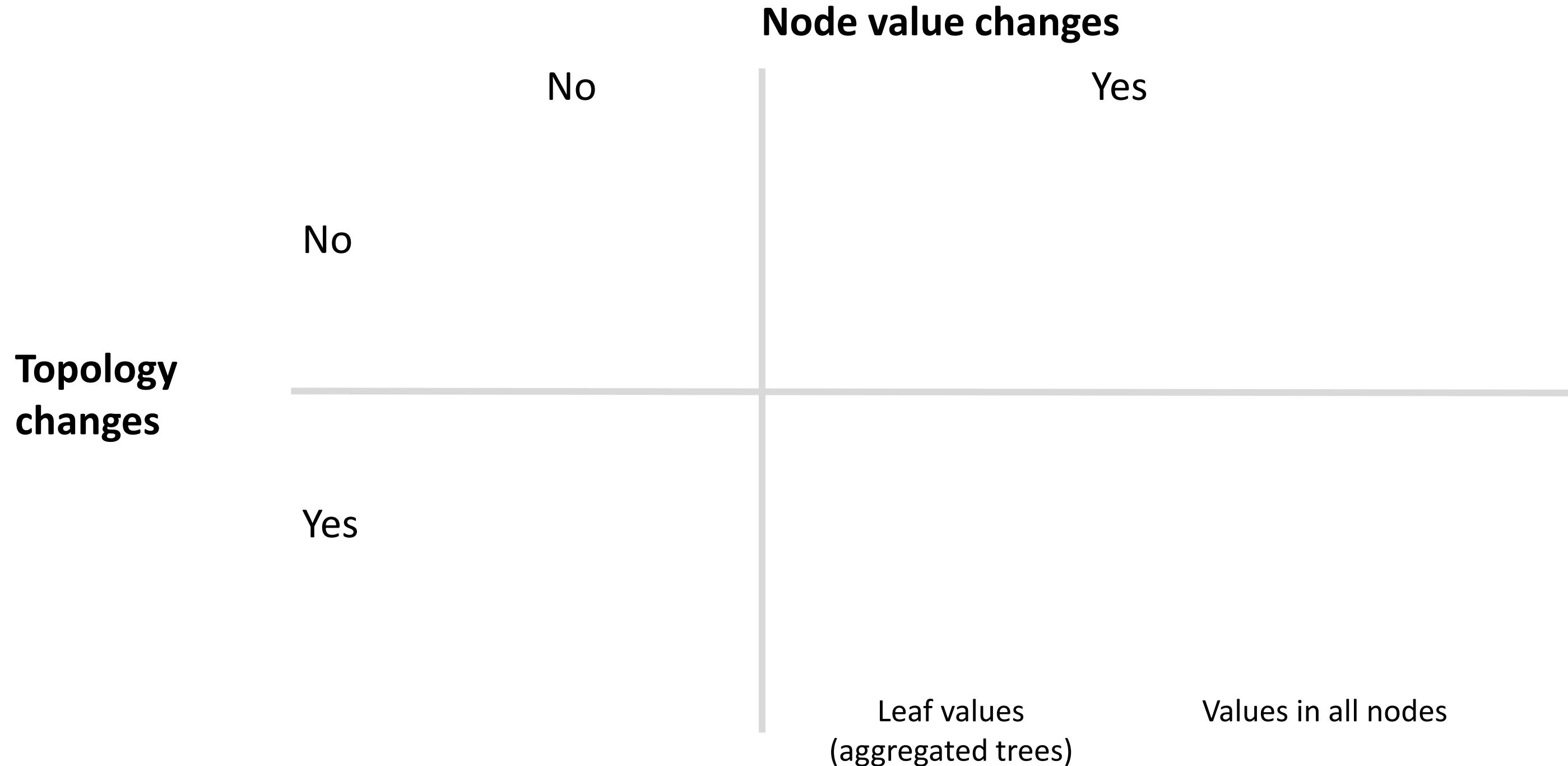


**Mixed**

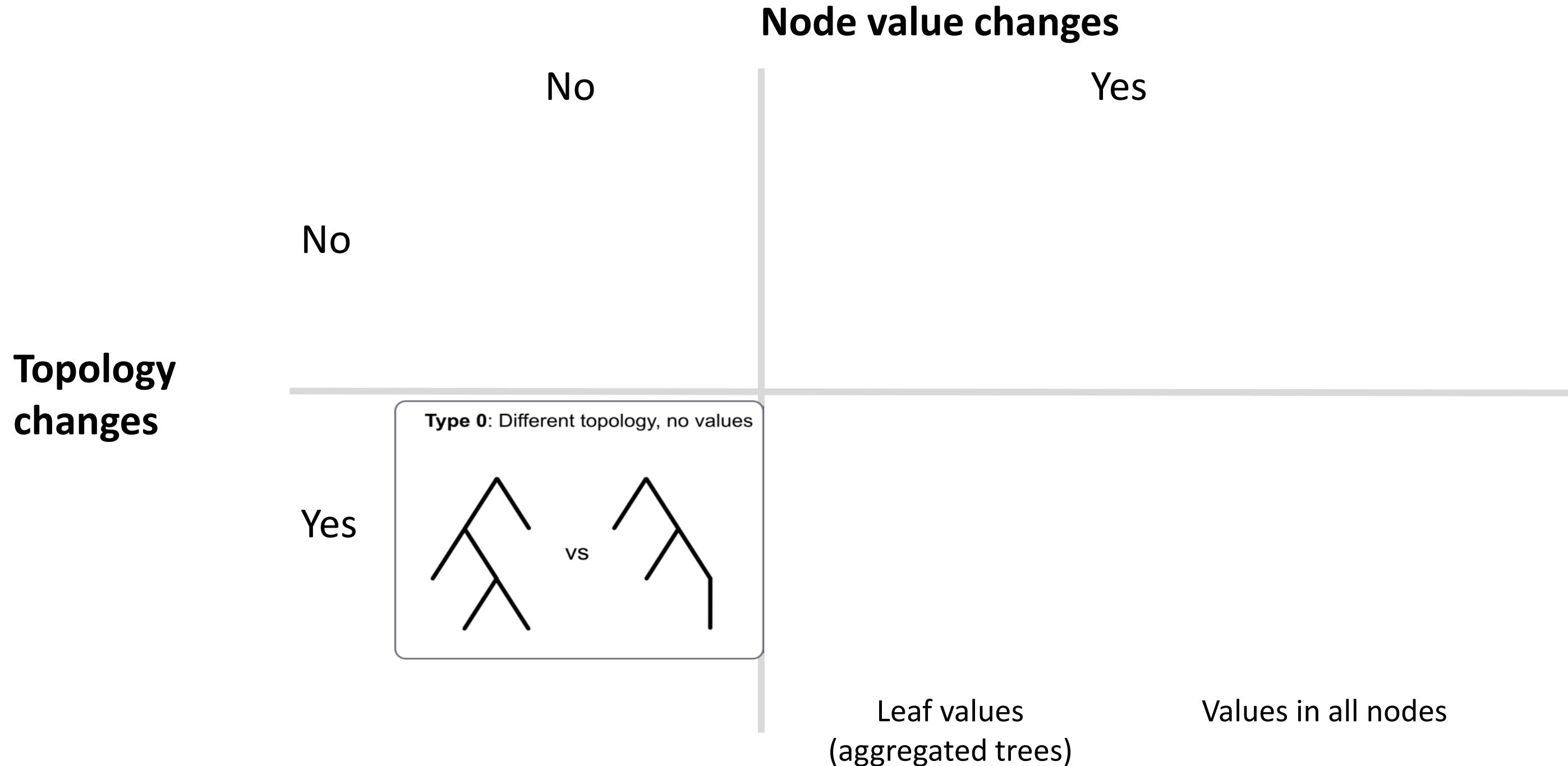
Gender  
↔  
State  
↓  
City



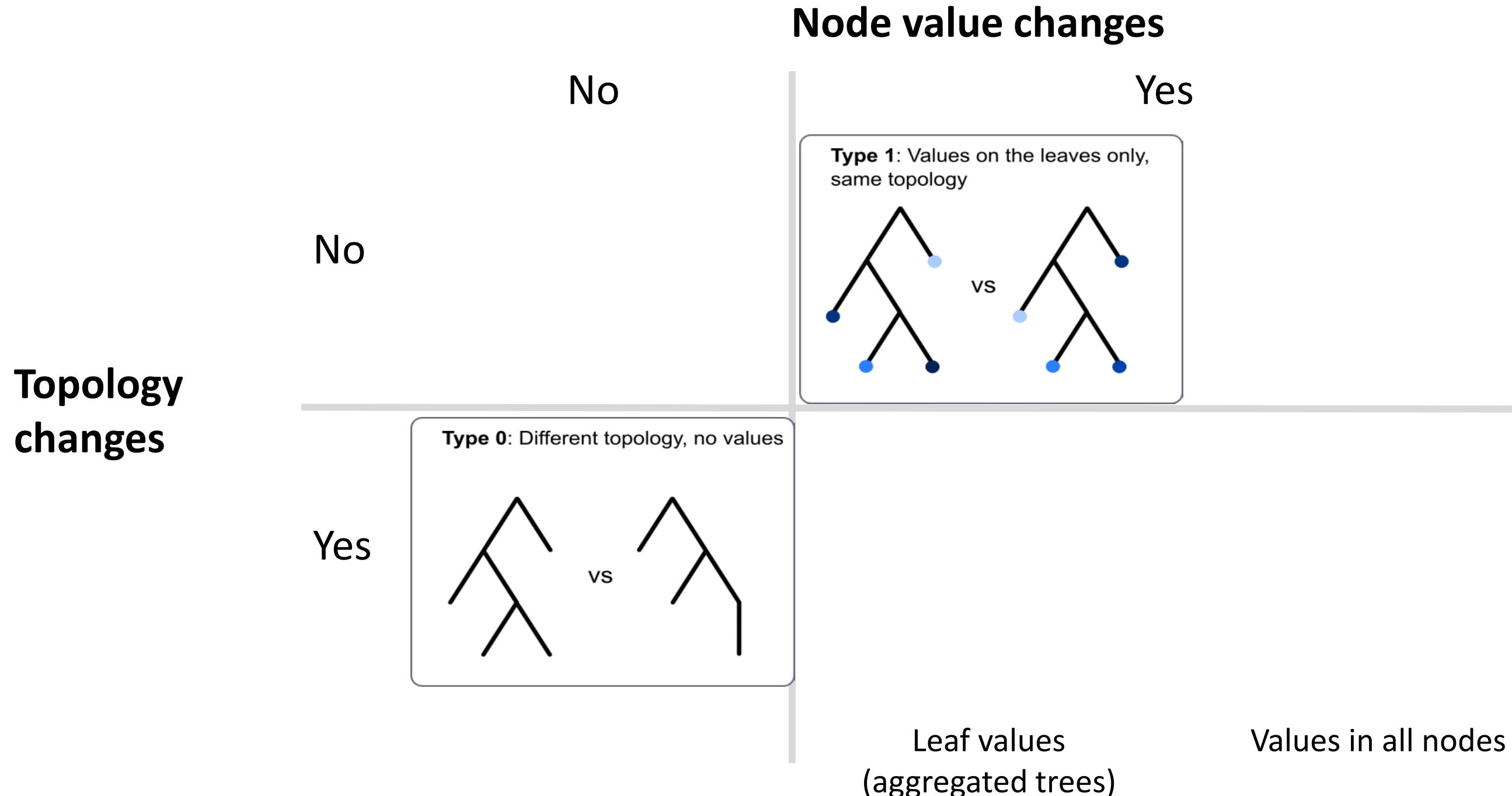
# Types of Tree Comparison



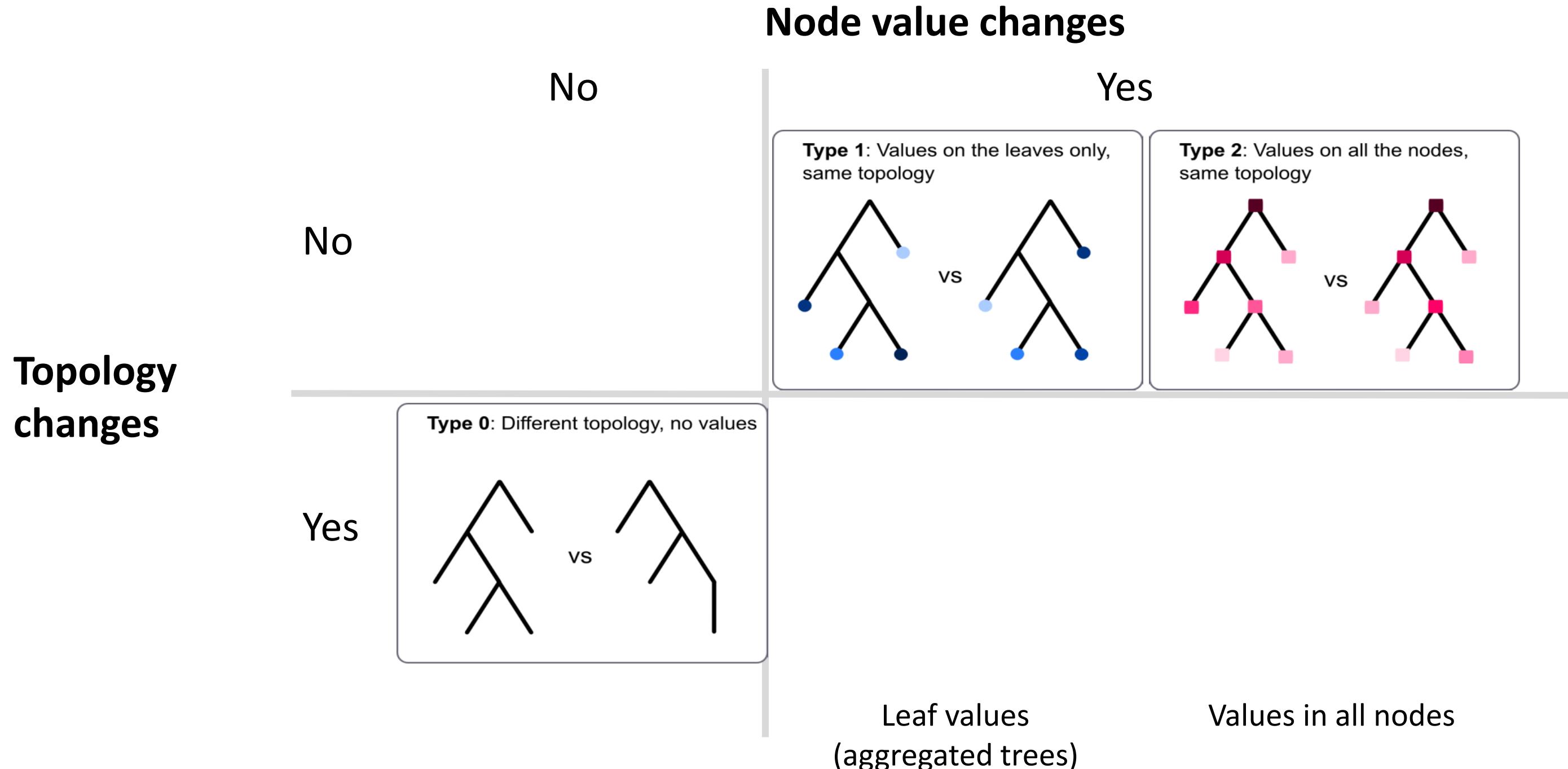
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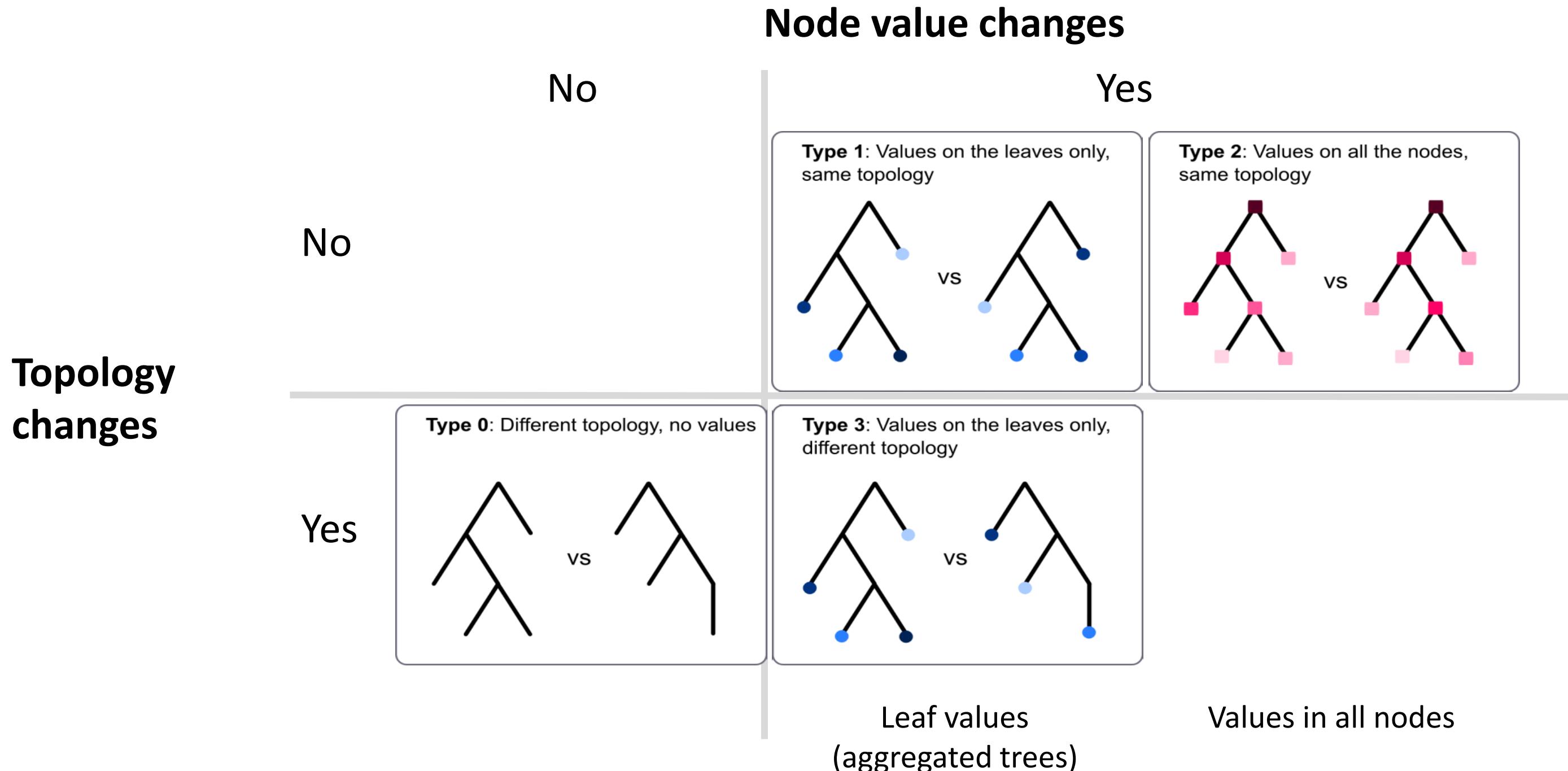
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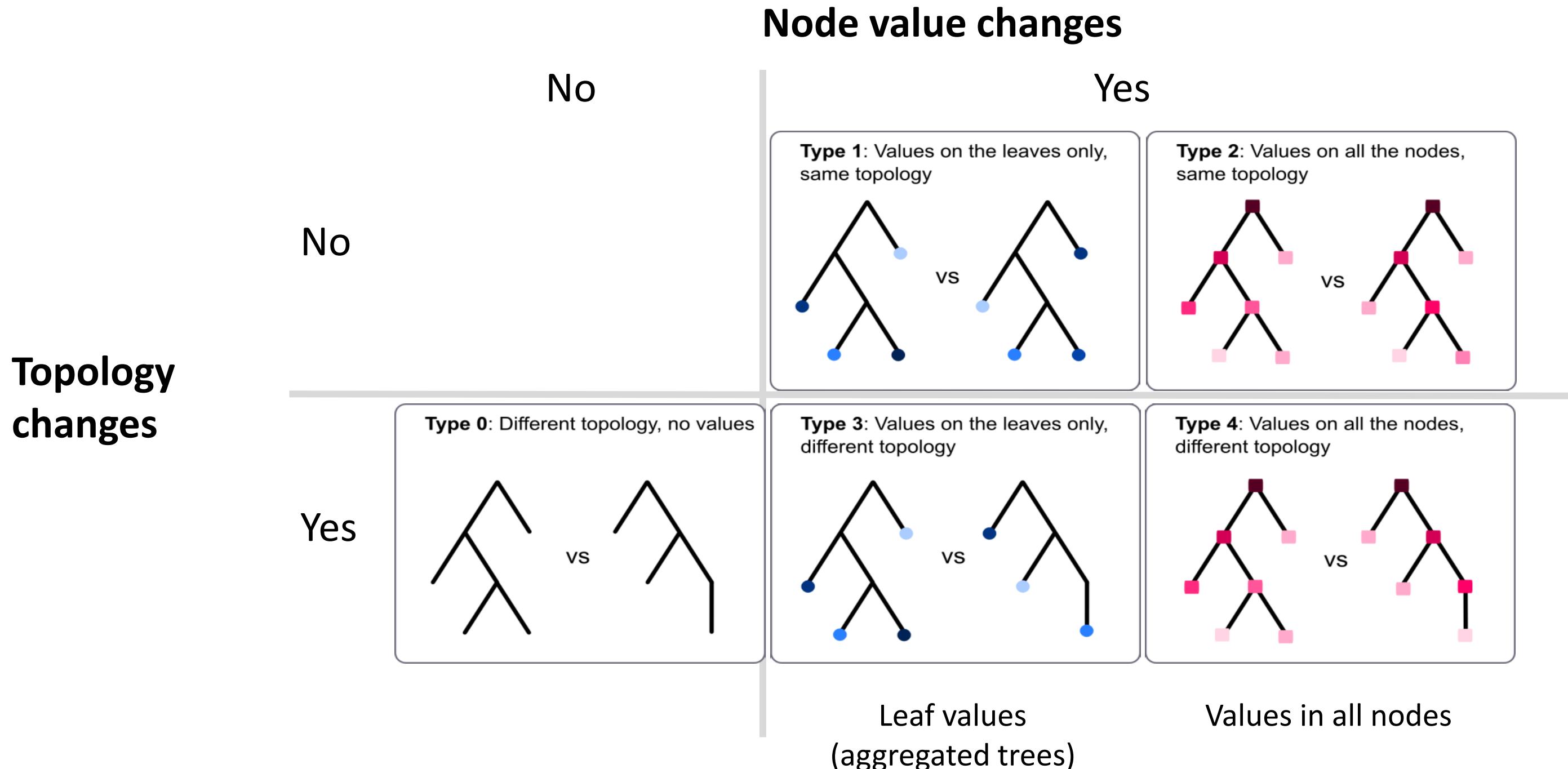
# Types of Tree Comparison



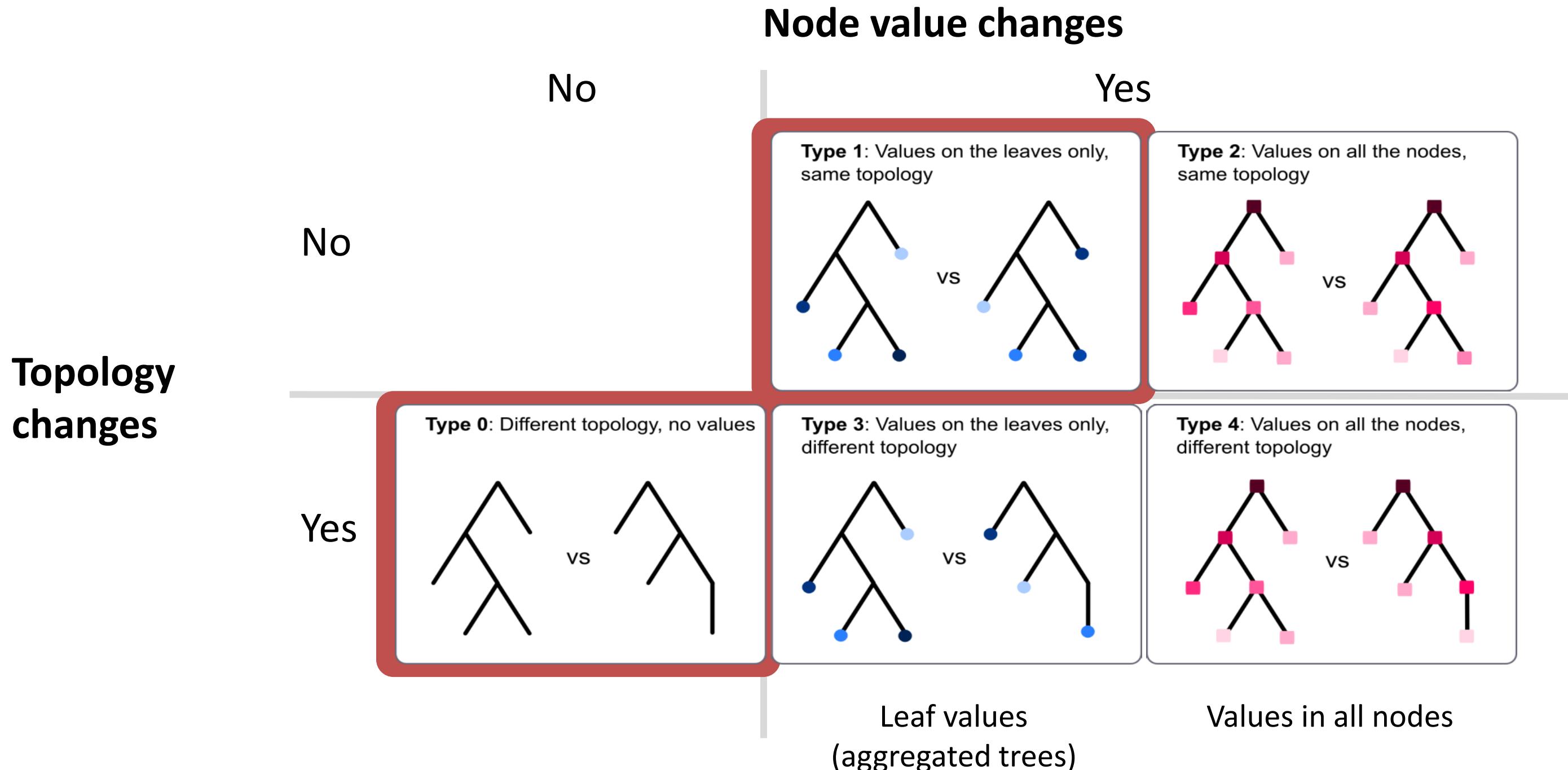
# Types of Tree Comparison



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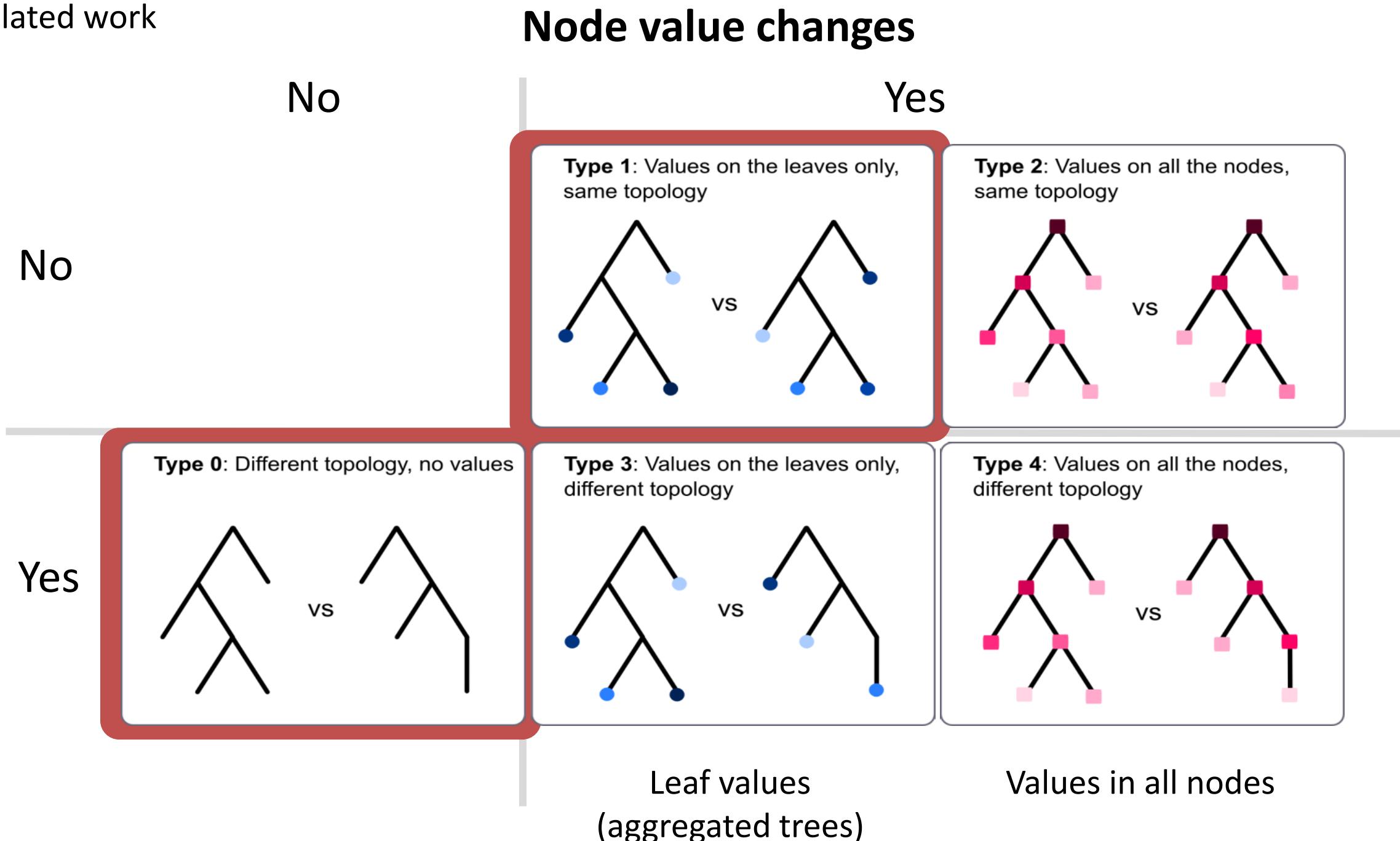
# Types of Tree Comparison



# Types of Tree Comparison

■ Addressed by related work

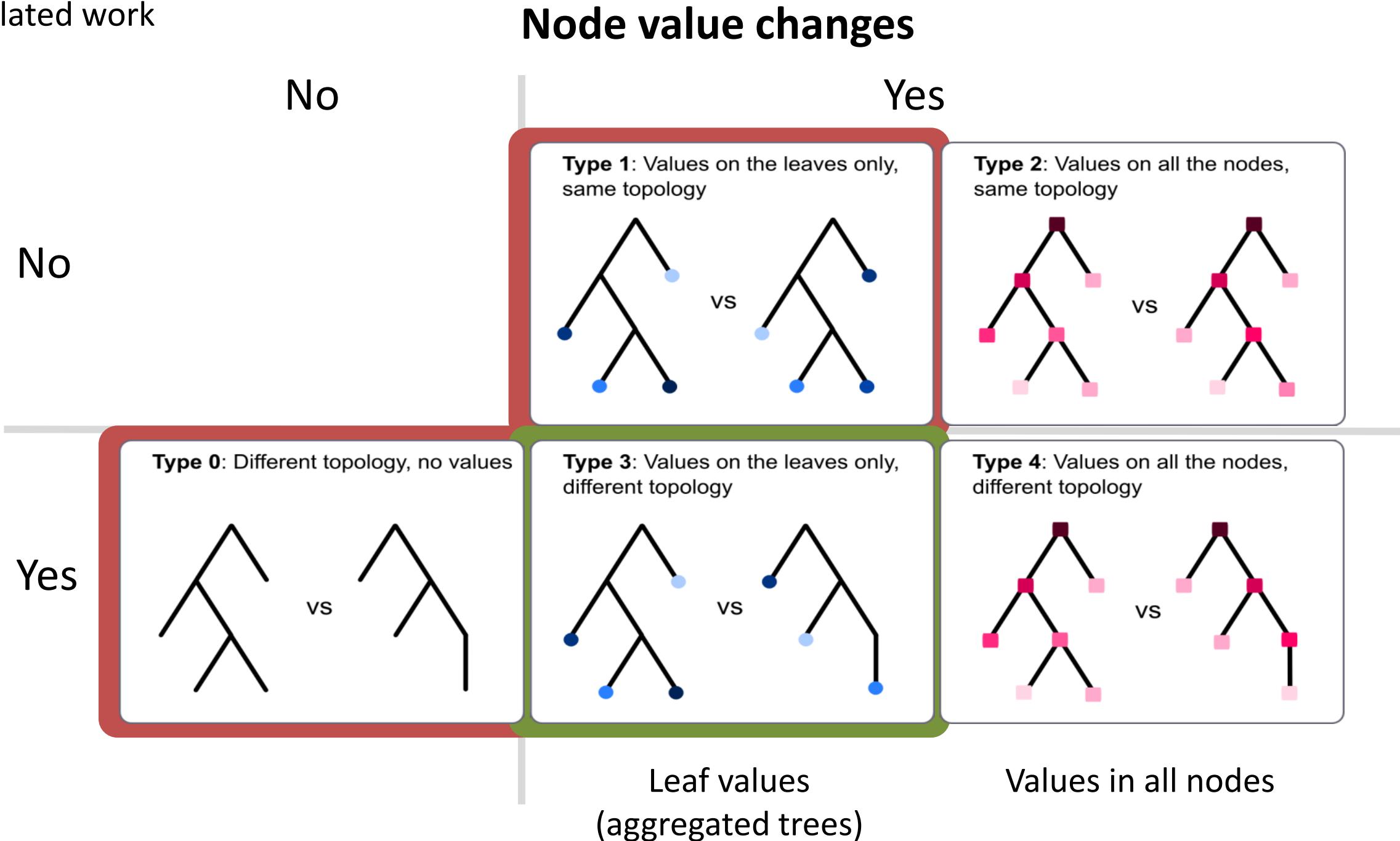
**Topology changes**



# Types of Tree Comparison

■ Addressed by related work

**Topology changes**



# Types of Tree Comparison

Addressed by related work

Partially addressed by related work

Topology changes

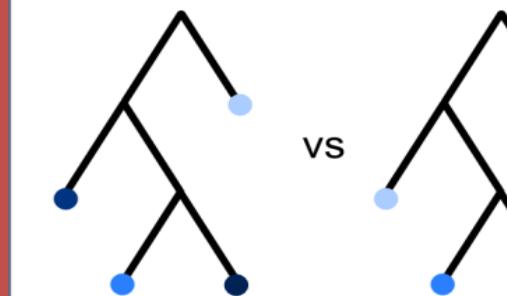
No

Node value changes

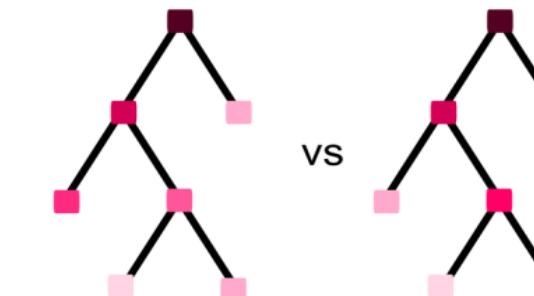
Yes

No

Type 1: Values on the leaves only, same topology

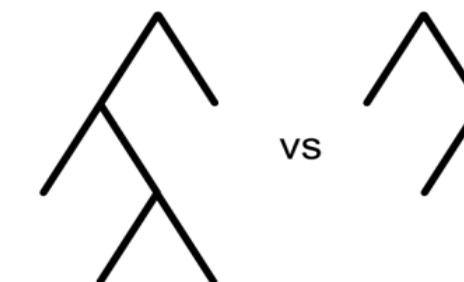


Type 2: Values on all the nodes, same topology

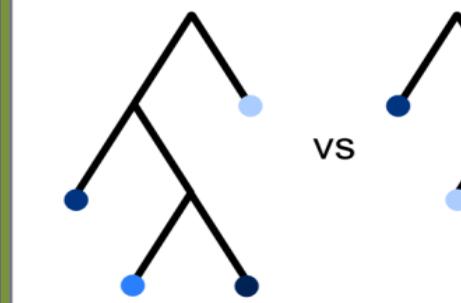


Yes

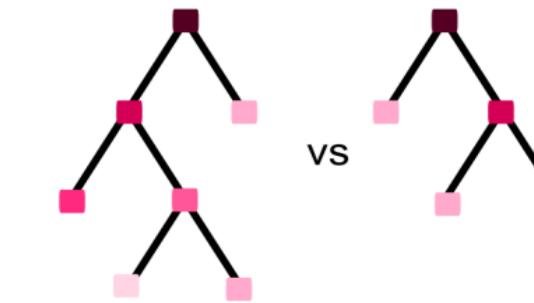
Type 0: Different topology, no values



Type 3: Values on the leaves only, different topology



Type 4: Values on all the nodes, different topology



Leaf values  
(aggregated trees)

Values in all nodes

# Types of Tree Comparison

Addressed by related work

Partially addressed by related work

Topology changes

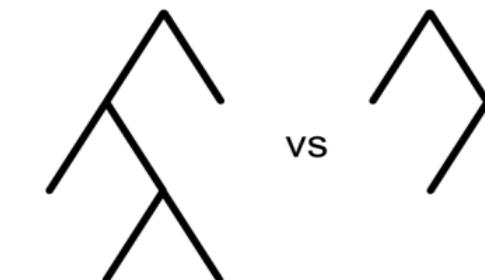
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Node value changes

Yes

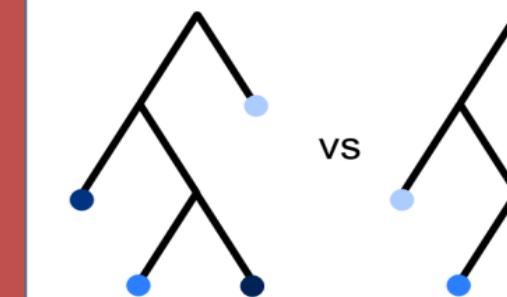
No

Type 0: Different topology, no values

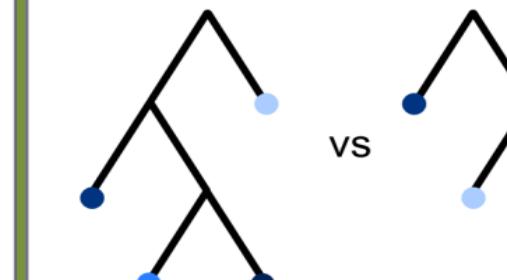


Yes

Type 1: Values on the leaves only, same topology

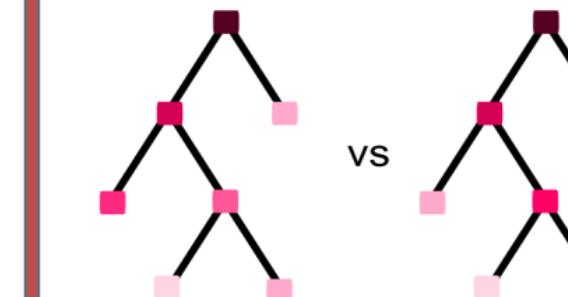


Type 3: Values on the leaves only, different topology

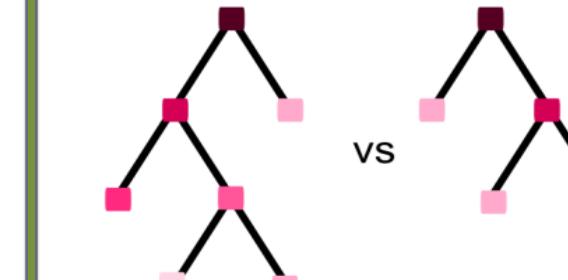


Leaf values  
(aggregated trees)

Type 2: Values on all the nodes, same topology



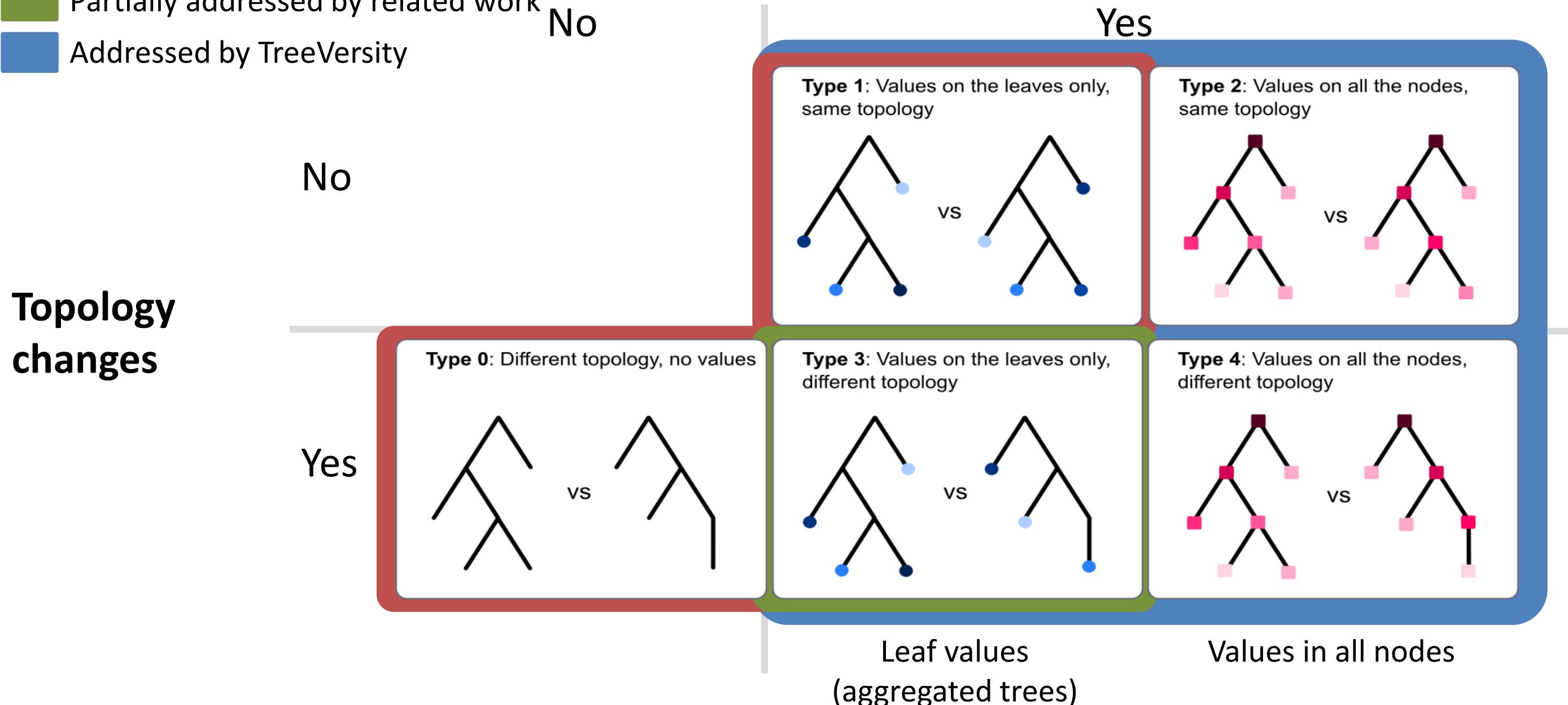
Type 4: Values on all the nodes, different topology



Values in all nodes

# Types of Tree Comparison

- Addressed by related work
- Partially addressed by related work
- Addressed by TreeVersity



Back to the problem

Product	Category	Refrigerate?	Boxed	QTY	Price
Apples	Fruit	No	No	220	\$2
Oranges	Fruit	No	No	110	\$3
Milk	Liquids	Yes	Yes	95	\$1
Bread	Staple	No	No	73	\$2
Cherries	Fruit	No	No	22	\$7.1
Orange Juice	Liquids	Yes	Yes	100	\$4
Cheese	Liquids	Yes	Yes	190	\$7

What Changed?

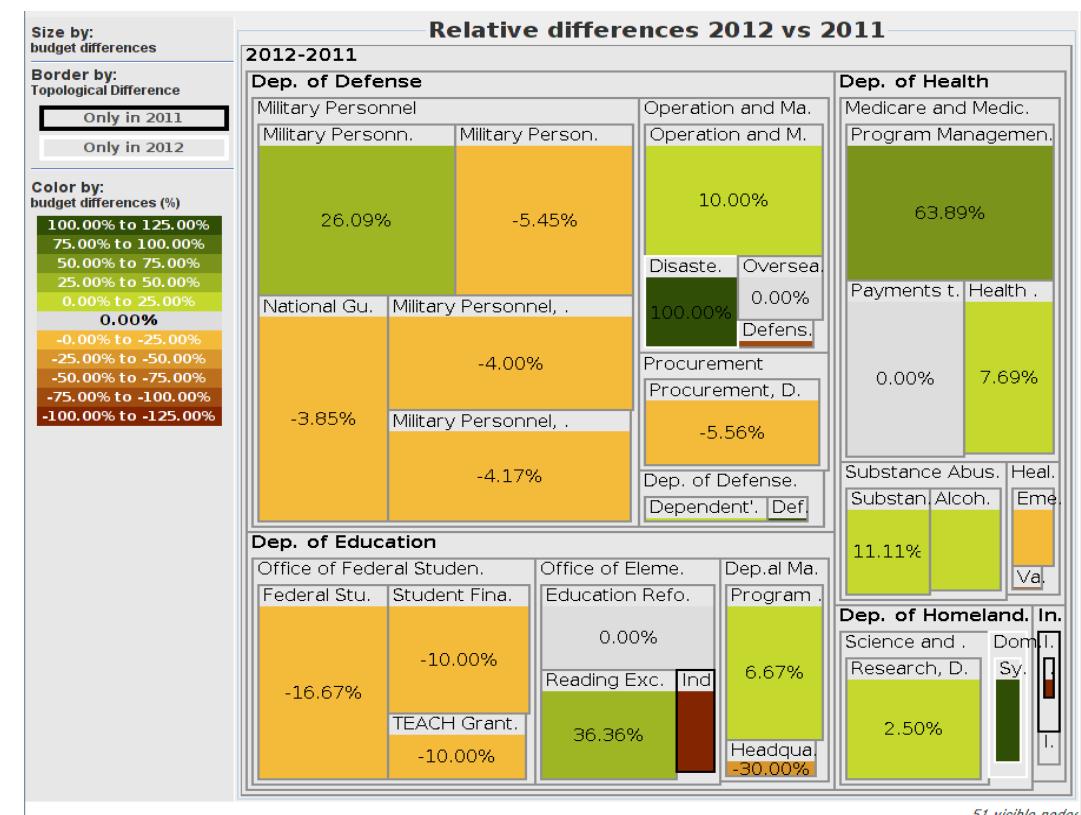
# Current solutions

# Current solutions

Node	Le...	budget diff	%budget diff
Domestic Nuclear Detection Office	2	\$500.00 M	100.00%
Defense Vessel Transfer Receipt Acc...	3	\$100.00 M	100.00%
Disaster relief	3	\$800.00 M	100.00%
Systems Acquisition	3	\$500.00 M	100.00%
Program Management	3	\$1.15 B	63.89%
Reading Excellence	3	\$400.00 M	36.36%
Dep. of Defense--Military	2	\$200.00 M	33.33%
Dep. of Homeland Security	1	\$550.00 M	27.50%
Military Personnel, Army	3	\$600.00 M	26.09%
Medicare and Medicaid	2	\$1.25 B	25.00%
Dependent's Education Gift Fund	3	\$100.00 M	20.00%
Alcohol, Drug Abuse, and Mental He...	3	\$100.00 M	14.29%
Substance Abuse Admin	2	\$200.00 M	12.50%
Substance Abuse and Mental Health...	3	\$100.00 M	11.11%
Operation and Maintenance, Defens...	3	\$200.00 M	10.00%
Health Care Fraud and Abuse Contro...	3	\$100.00 M	7.69%
Program Admin	3	\$100.00 M	6.67%
Science and Technology	2	\$50.00 M	2.50%
Research, Development, Acquisition...	3	\$50.00 M	2.50%
Military Personnel	2	\$150.00 M	1.20%
Dep. of Defense	1	\$150.00 M	0.80%
Dep. of Health	1	\$0.00	0.00%
Office of Elementary Ed	2	\$0.00	0.00%
International Security Assistance	2	\$0.00	0.00%
Overseas Humanitarian, Disaster, an...	3	\$0.00	0.00%
Education Reform	3	\$0.00	0.00%
Payments to Health Care Trust Funds	3	\$0.00	0.00%
Peacekeeping Operations	3	\$0.00	0.00%
/	0	\$-450.00 M	-1.10%
Dep.al Management	2	\$-50.00 M	-2.50%
Operation and Maintenance	2	\$-100.00 M	-2.63%
National Guard Personnel, Army	3	\$-100.00 M	-3.85%
Military Personnel, Navy	3	\$-100.00 M	-4.00%
Military Personnel, Air Force	3	\$-100.00 M	-4.17%
Military Personnel, Marine Corps	3	\$-150.00 M	-5.45%
Procurement	2	\$-100.00 M	-5.56%

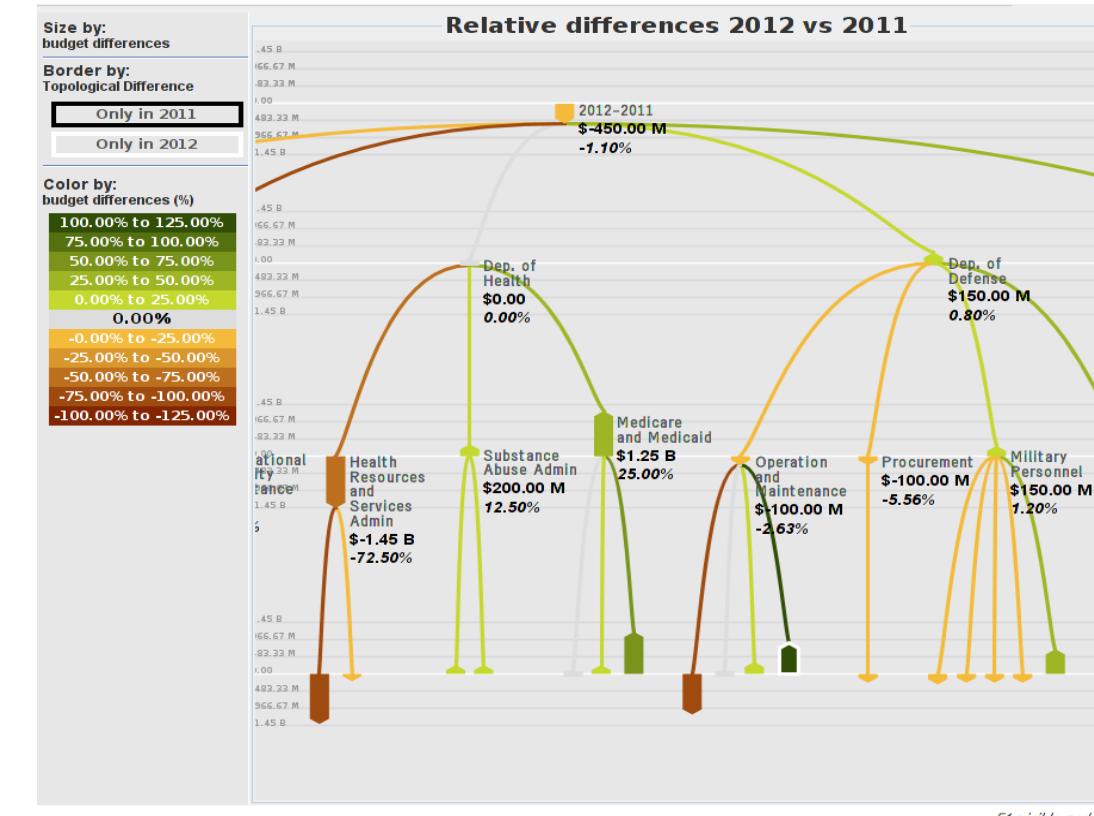
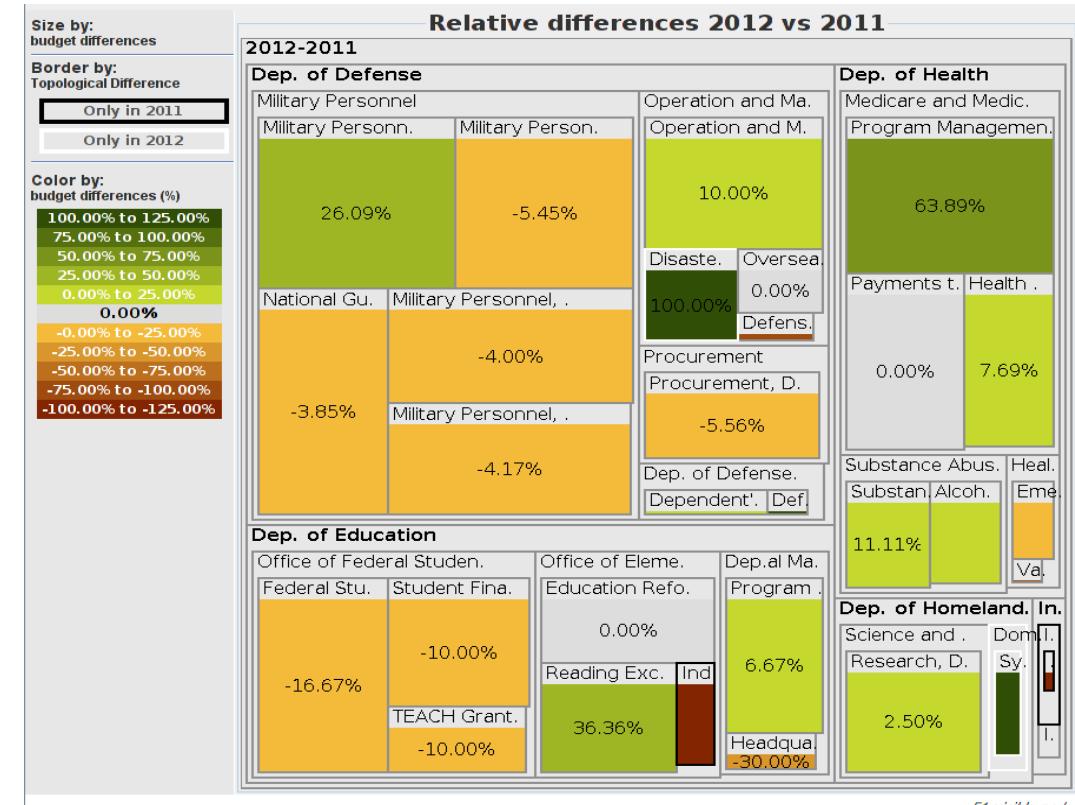
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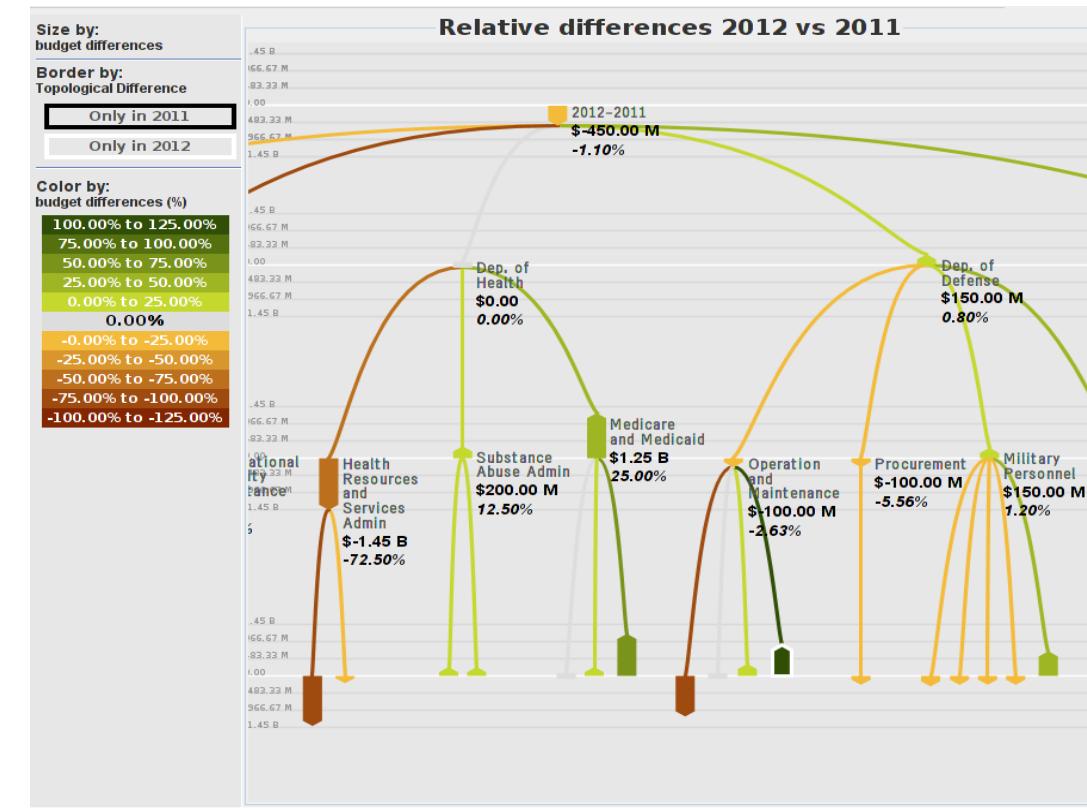
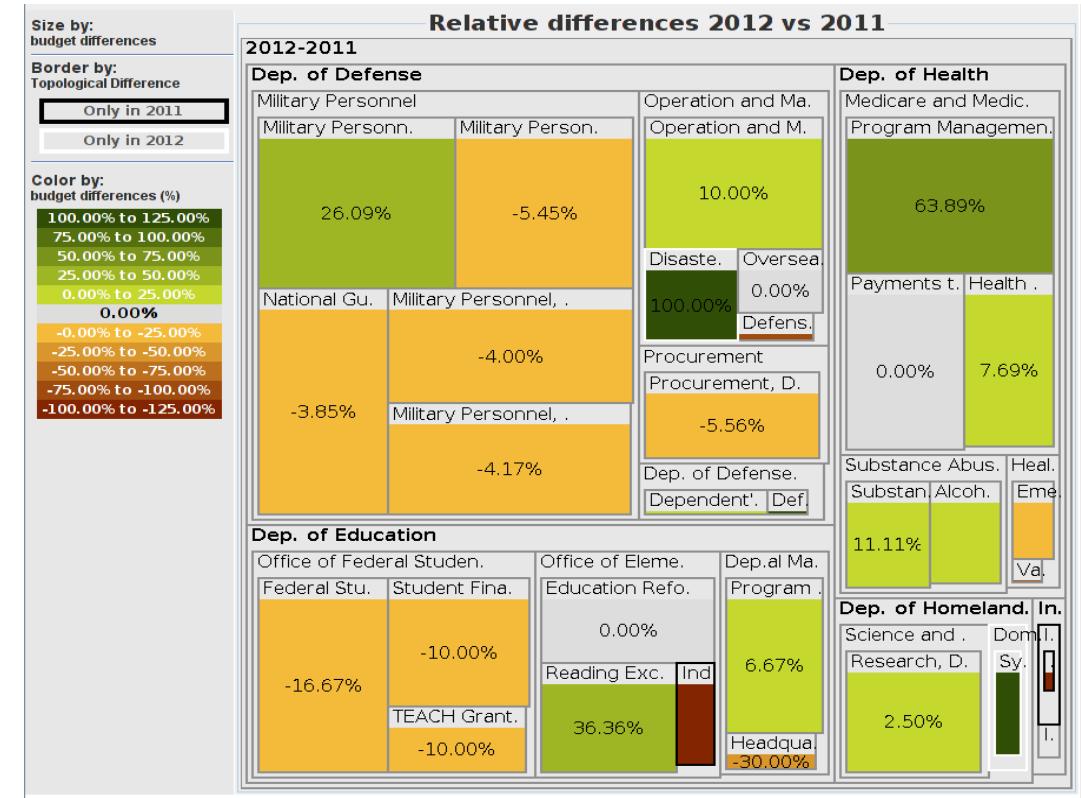
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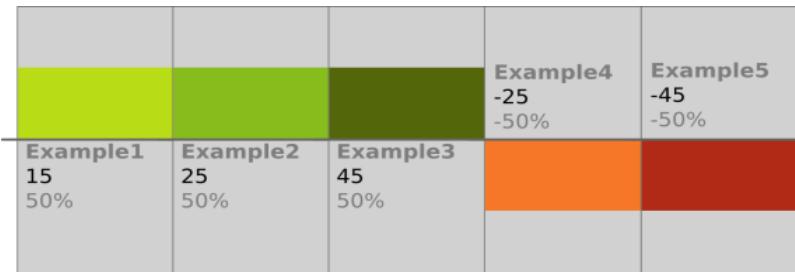


The Bullet [Guerra Gómez, Buck-Colmean, Plaisant, Shneiderman 2012]

# The StemView: 5 characteristics of change

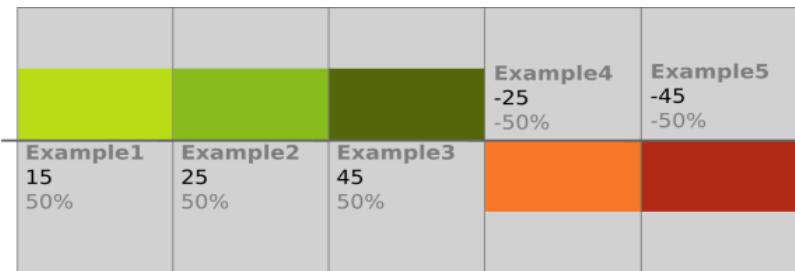
# The StemView: 5 characteristics of change

Actual Change (Color)

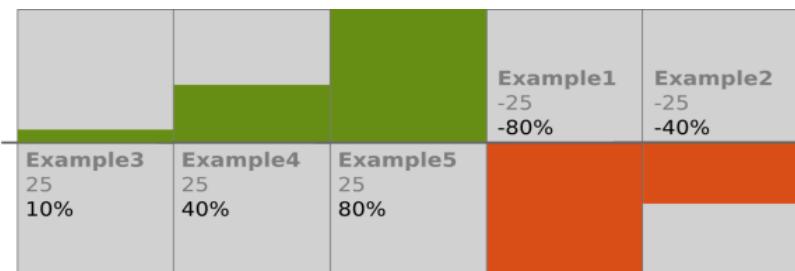


# The StemView: 5 characteristics of change

## Actual Change (Color)

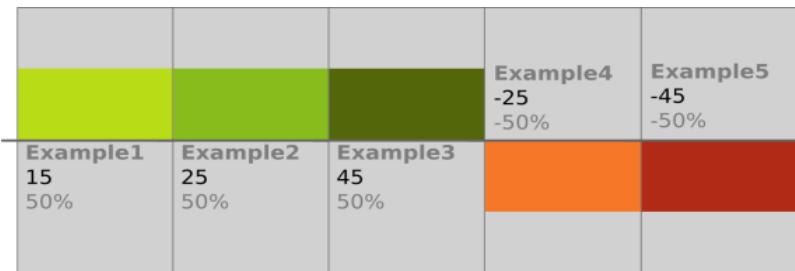


## Relative Change (Height)



# The StemView: 5 characteristics of change

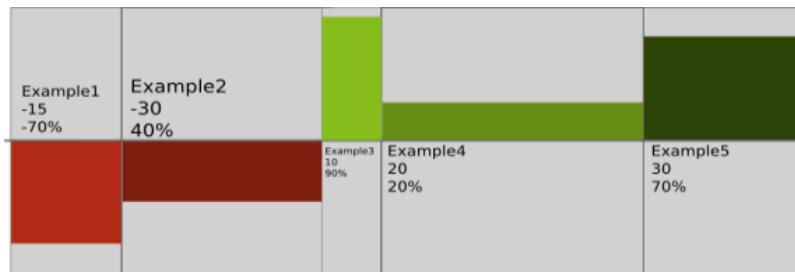
## Actual Change (Color)



## Relative Change (Height)

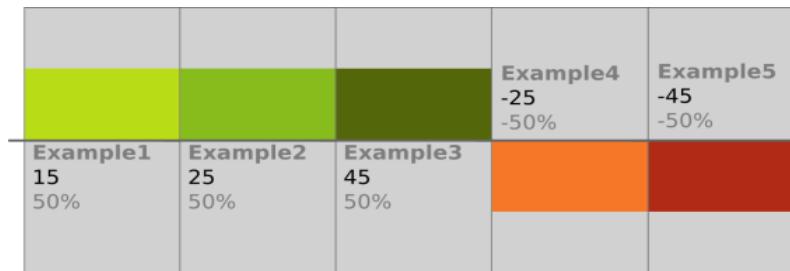


## Ending Value (Width)

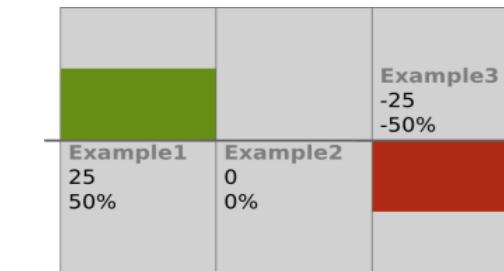


# The StemView: 5 characteristics of change

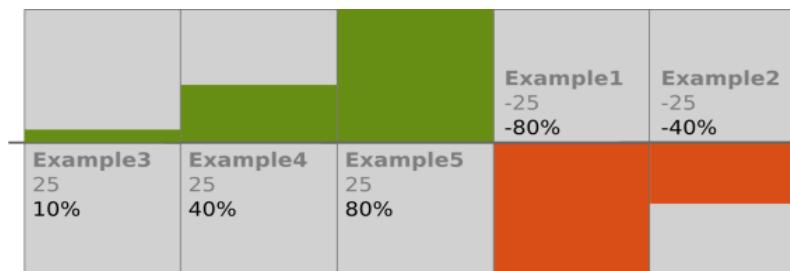
## Actual Change (Color)



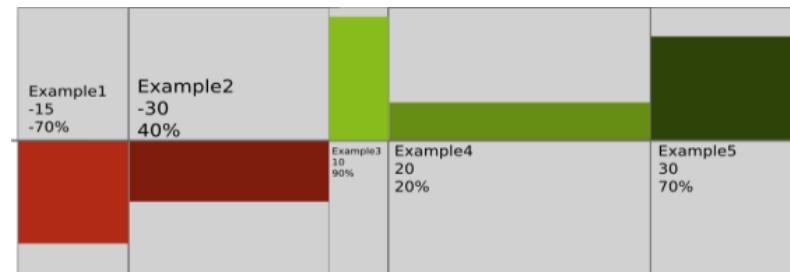
Direction



Relative Change (Height)

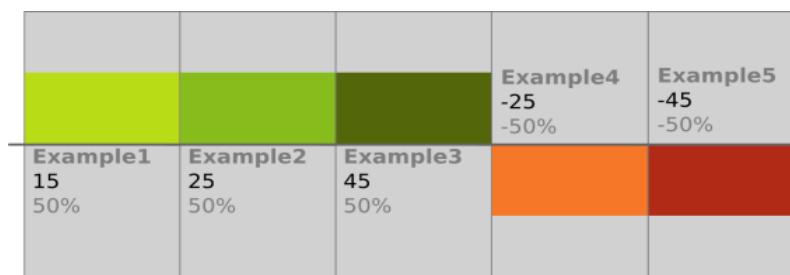


Ending Value (Width)

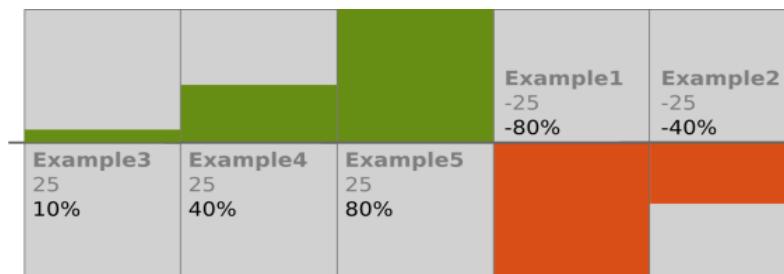


# The StemView: 5 characteristics of change

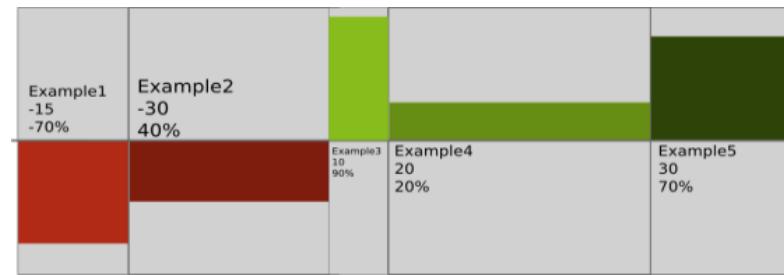
Actual Change (Color)



Relative Change (Height)



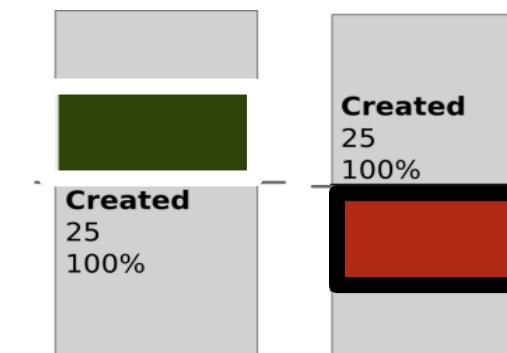
Ending Value (Width)



Direction



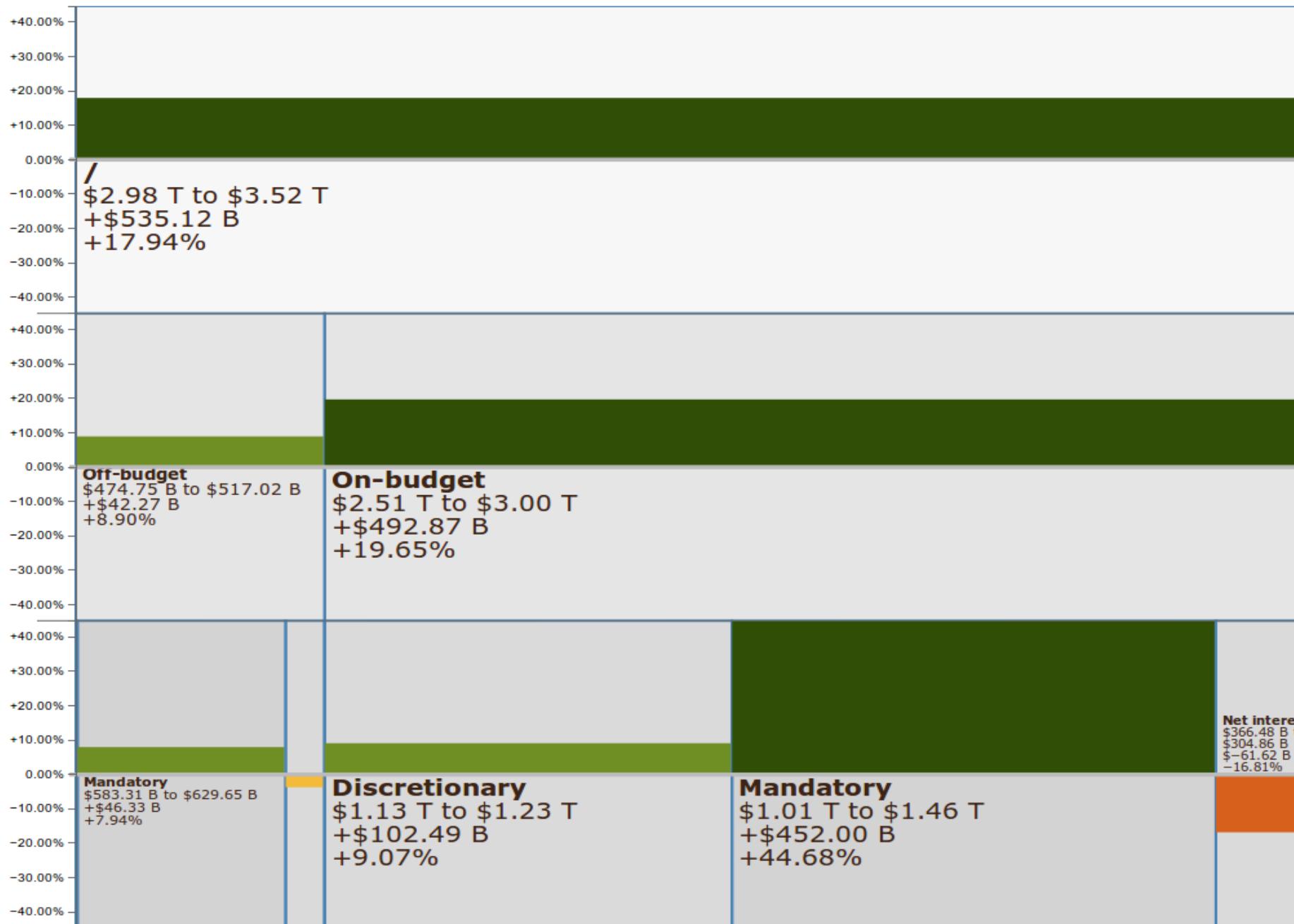
Created Node

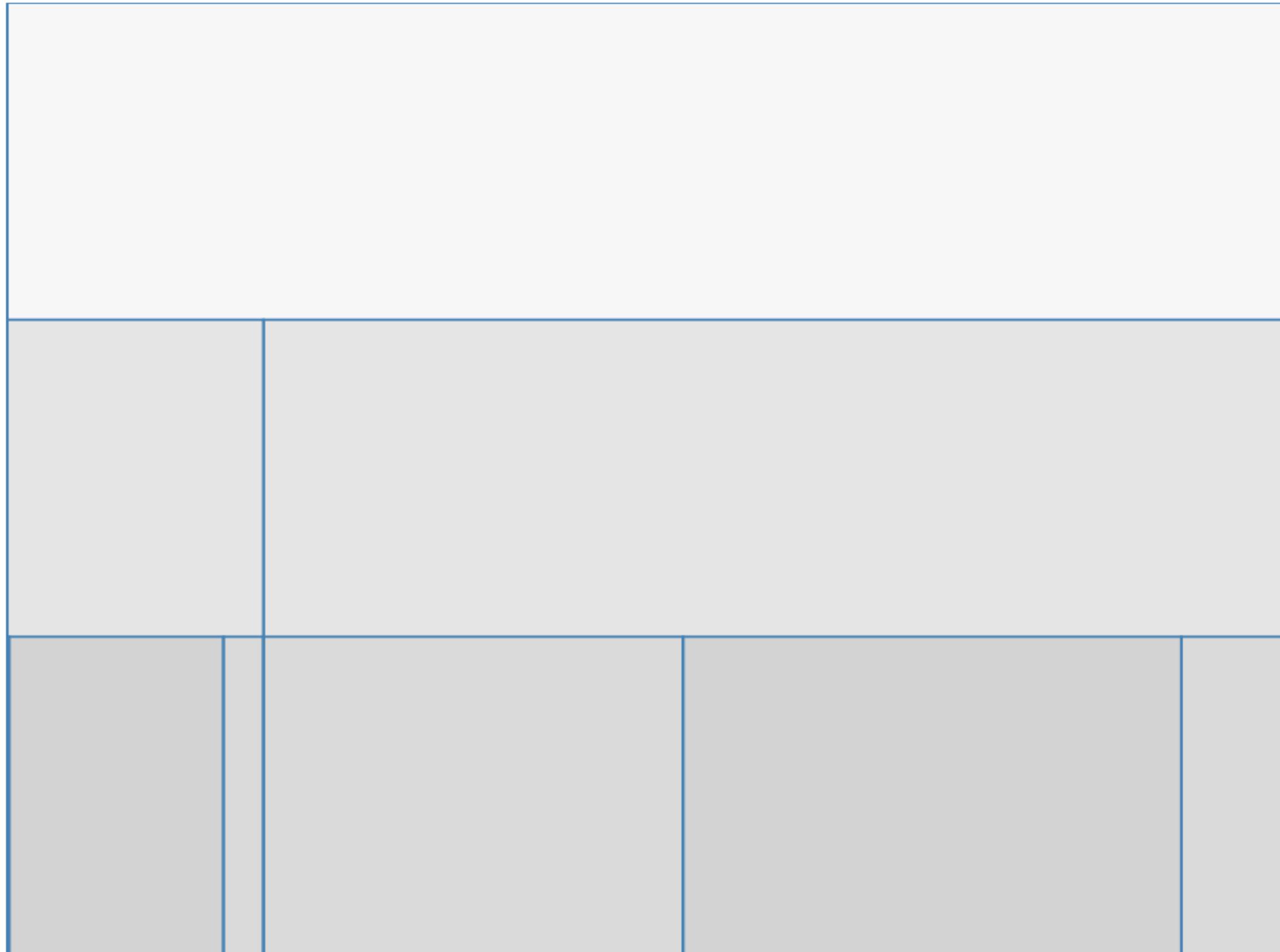


Removed node

Border

# The StemView





**/**  
\$2.98 T to \$3.52 T  
+\$535.12 B  
+17.94%

**Off-budget**  
\$474.75 B to \$517.02 B  
+\$42.27 B  
+8.90%

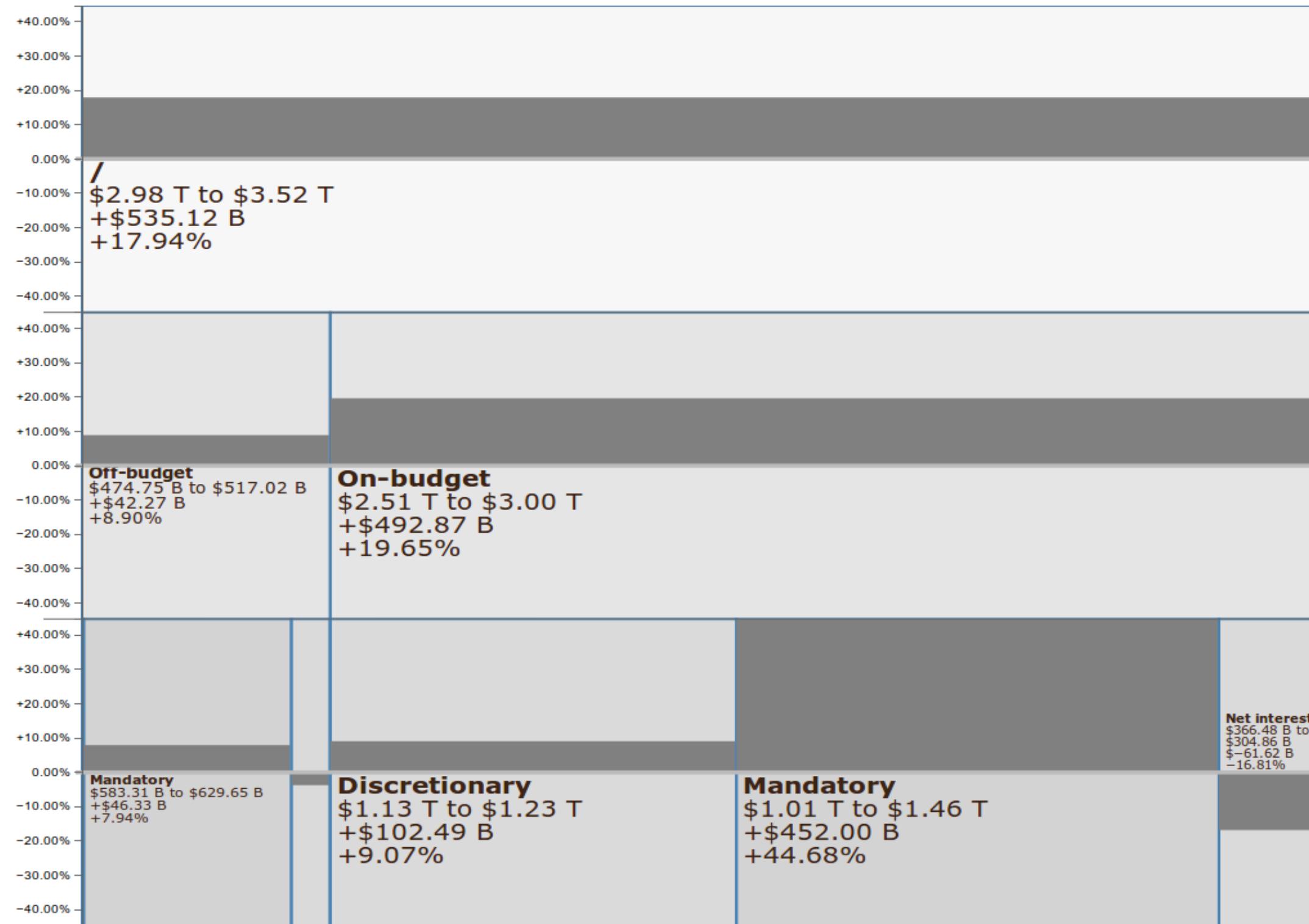
**On-budget**  
\$2.51 T to \$3.00 T  
+\$492.87 B  
+19.65%

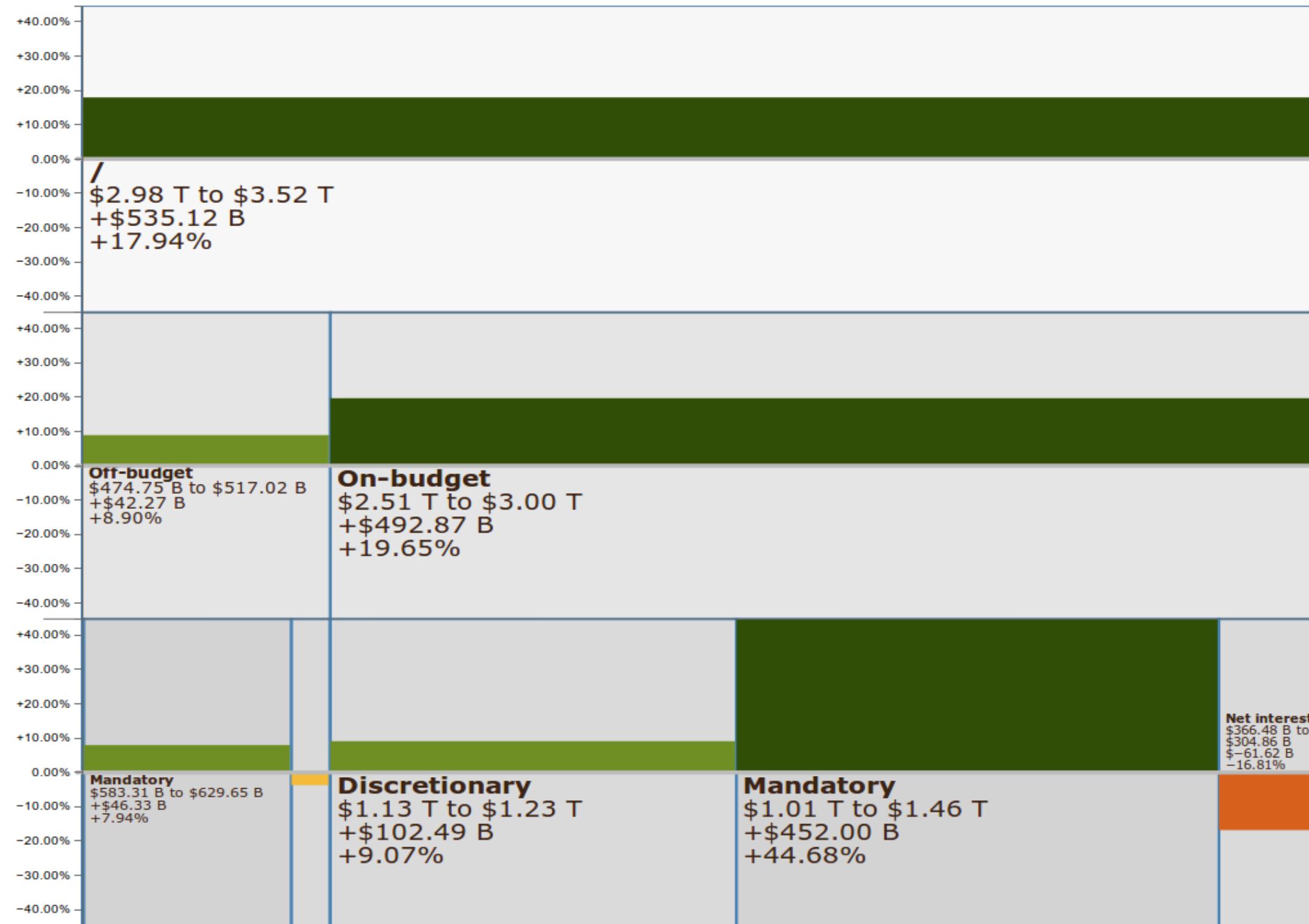
**Mandatory**  
\$583.31 B to \$629.65 B  
+\$46.33 B  
+7.94%

**Discretionary**  
\$1.13 T to \$1.23 T  
+\$102.49 B  
+9.07%

**Mandatory**  
\$1.01 T to \$1.46 T  
+\$452.00 B  
+44.68%

**Net interest**  
\$366.48 B to  
\$304.86 B  
-\$61.62 B  
-16.81%



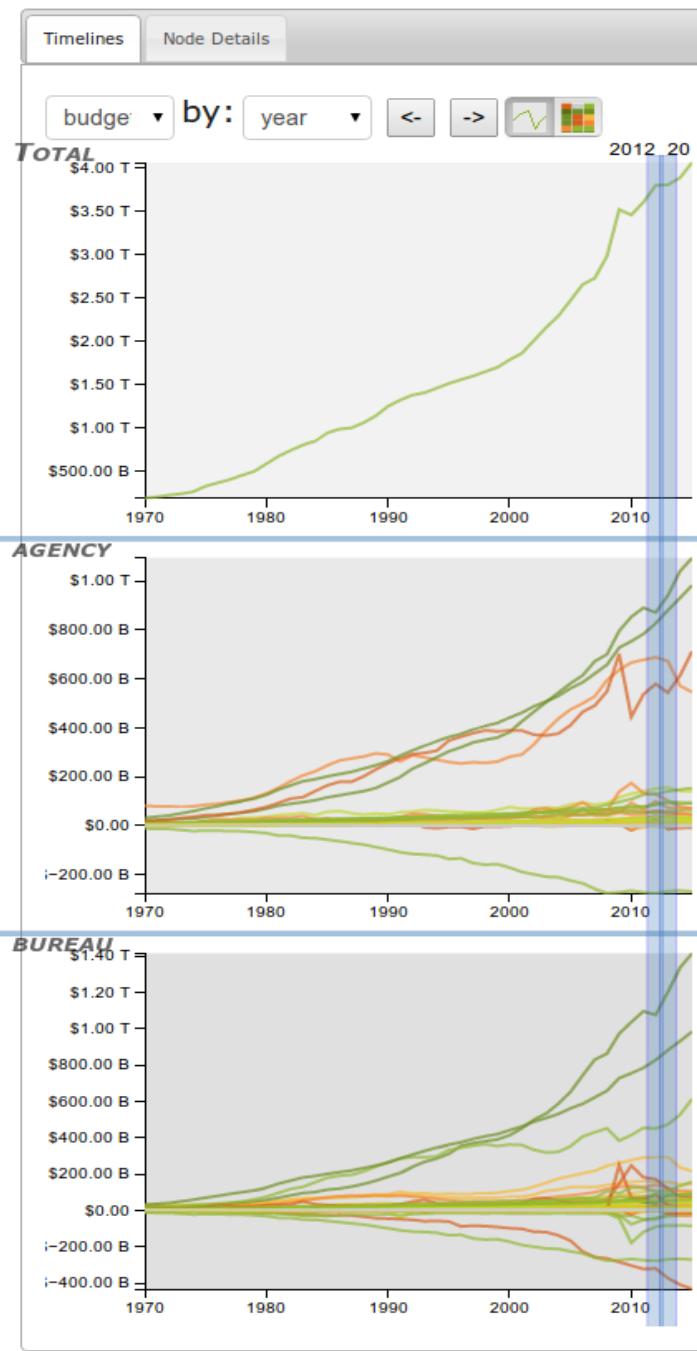






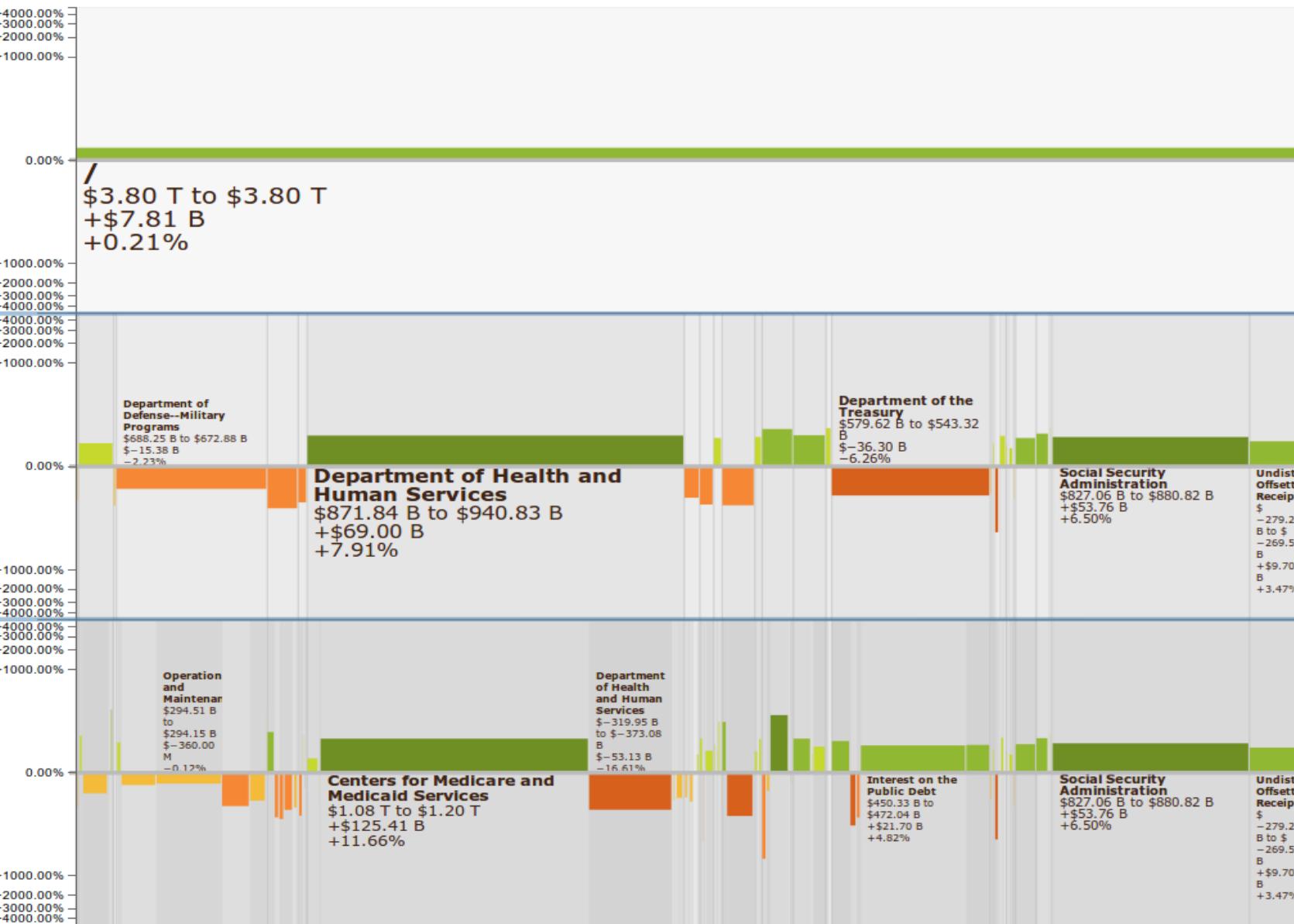


**Live Demo**



## US Federal Budget

Comparing 2012 to 2013



Showing 474 nodes. [Show all](#)  Show labels

**Controls**

**Legend**

Color by: budget Difference  4rt?

**Height by:**

budget Percentage  4rt?

**Sort by:**

Name

**Width by:**

budget Ending Val

**Border Color:**

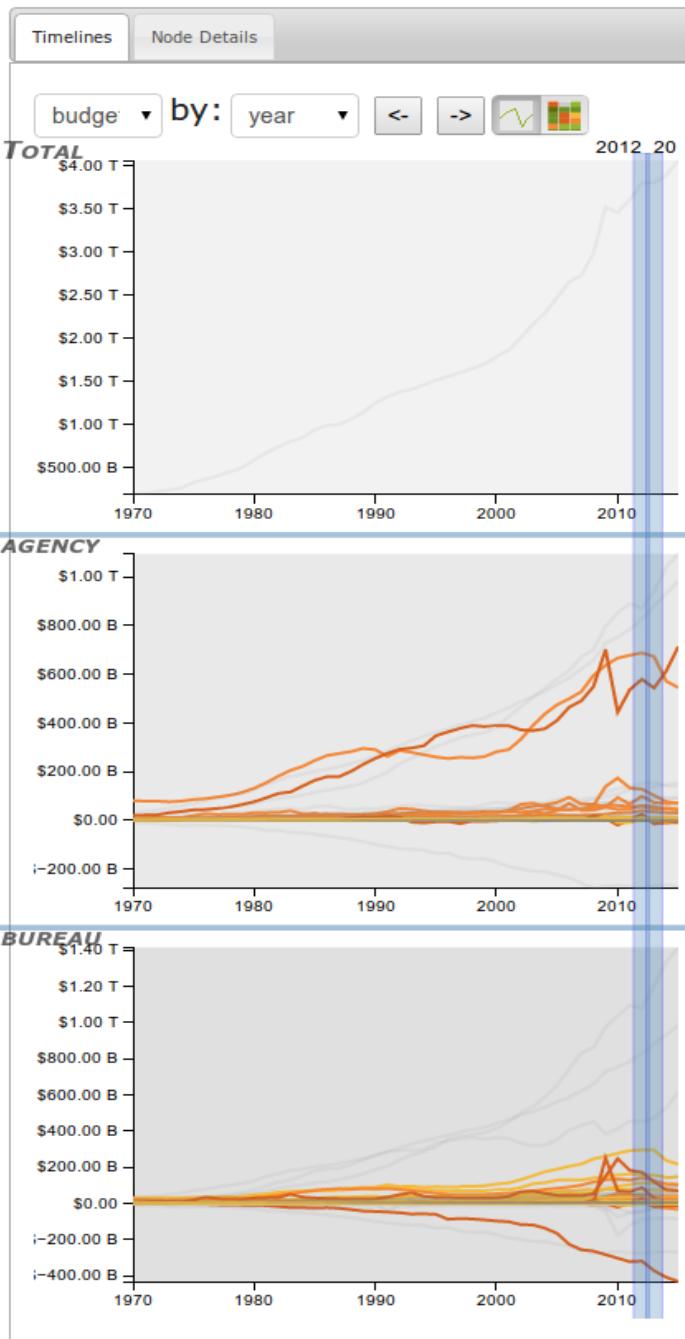
Removed  Created

▶ What changed?

▶ Hierarchy

▶ Filters:

# The Reporting Tool

**US Federal Budget**

Comparing 2012 to 2013

**\$3.80 T to \$3.80 T**  
 $+\$7.81 \text{ B}$   
 $+0.21\%$

**Department of Defense--Military Programs**  
 $\$688.25 \text{ B to } \$672.88 \text{ B}$   
 $-\$15.38 \text{ B}$   
 $-2.23\%$

**Department of Health and Human Services**  
 $\$871.84 \text{ B to } \$940.83 \text{ B}$   
 $+\$69.00 \text{ B}$   
 $+7.91\%$

**Department of the Treasury**  
 $\$579.62 \text{ B to } \$543.32 \text{ B}$   
 $-\$36.30 \text{ B}$   
 $-6.26\%$

**Social Security Administration**  
 $\$827.06 \text{ B to } \$880.82 \text{ B}$   
 $+\$53.76 \text{ B}$   
 $+6.50\%$

Undistrib  
Offsetting  
Receipts  
\$  
-279.29  
B to \$  
-269.59  
B  
+\$9.70  
B  
+3.47%

**Operation and Maintenance**  
 $\$294.51 \text{ B to } \$294.15 \text{ B}$   
 $-\$360.00 \text{ M}$   
 $-0.17\%$

**Centers for Medicare and Medicaid Services**  
 $\$1.08 \text{ T to } \$1.20 \text{ T}$   
 $+\$125.41 \text{ B}$   
 $+11.66\%$

**Department of Health and Human Services**  
 $\$319.95 \text{ B to } \$373.08 \text{ B}$   
 $-\$53.13 \text{ B}$   
 $-16.61\%$

**Interest on the Public Debt**  
 $\$450.33 \text{ B to } \$472.04 \text{ B}$   
 $+\$21.70 \text{ B}$   
 $+4.82\%$

**Social Security Administration**  
 $\$827.06 \text{ B to } \$880.82 \text{ B}$   
 $+\$53.76 \text{ B}$   
 $+6.50\%$

Undistrib  
Offsetting  
Receipts  
\$  
-279.29  
B to \$  
-269.59  
B  
+\$9.70  
B  
+3.47%

Showing 474 nodes. [Show all](#)  Show labels**Controls**

Legend

What changed?

**Topology**

457 nodes were on both

8 nodes were removed

9 nodes were created

**Absolute overall change**

145 nodes decreased more than  $-\$14.00 \text{ M}$

124 nodes increased more than  $+\$11.00 \text{ M}$

**Relative overall change**114 nodes decreased more than  $-10.73\%$ 90 nodes increased more than  $+9.84\%$ **Absolute change by Level**43 agency decreased more than  $-\$1.00 \text{ M}$ 

182 agency didn't change

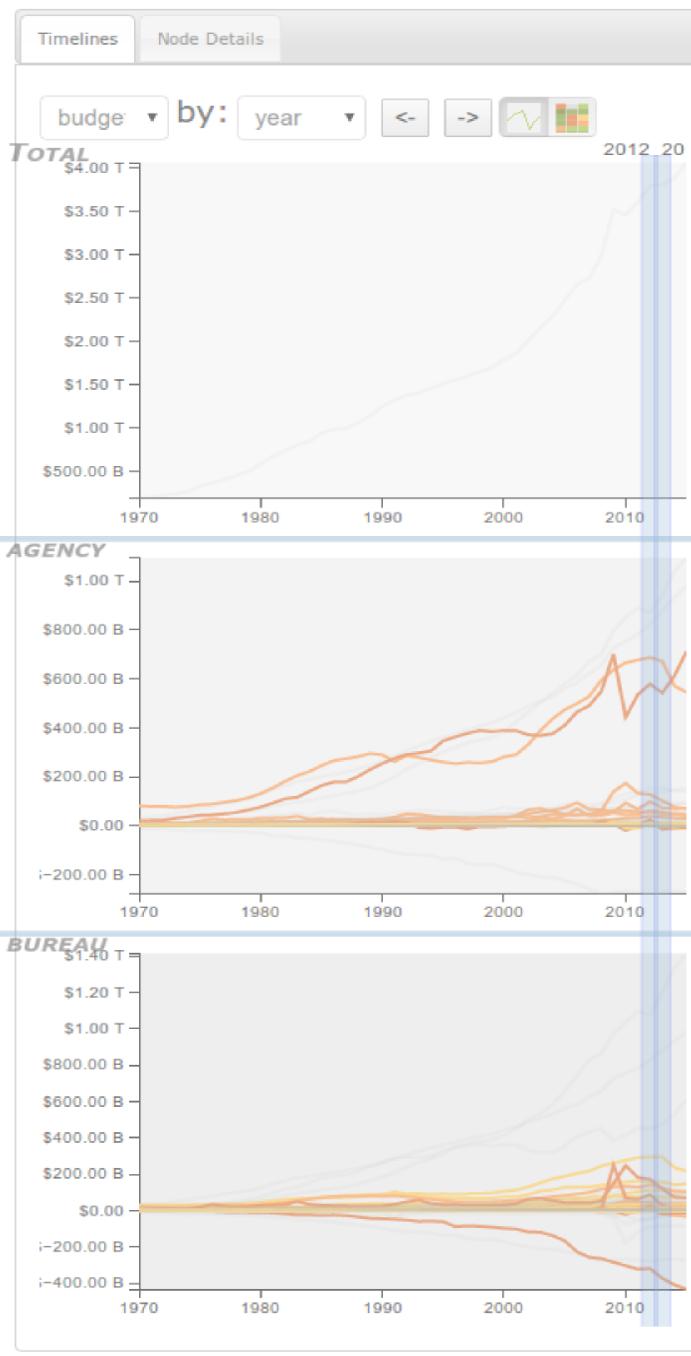
103 bureau decreased more than  $-\$29.00 \text{ M}$ 77 bureau increased more than  $+\$23.00 \text{ M}$ **Relative change by Level**42 agency decreased more than  $-0.93\%$ 

183 agency didn't change

65 bureau decreased more than  $-21.43\%$ 39 bureau increased more than  $+18.50\%$ 

Hierarchy

Filters:



## US Federal Budget Comparing 2012 vs 2020

### What changed?

#### Topology

457 nodes were on both

8 nodes were removed

9 nodes were created

#### Absolute overall change

145 nodes decreased more than -\$14.00 M

\$3.80 T to +\$7.81 B  
+0.21%

#### Absolute overall change

124 nodes increased more than +\$11.00 M

#### Relative overall change

114 nodes decreased more than -10.73%

90 nodes increased more than +9.84%

#### Absolute change by Level

43 agency decreased more than -\$1.00 M

182 agency didn't change

103 bureau decreased more than -\$29.00 M

77 bureau increased more than +\$23.00 M

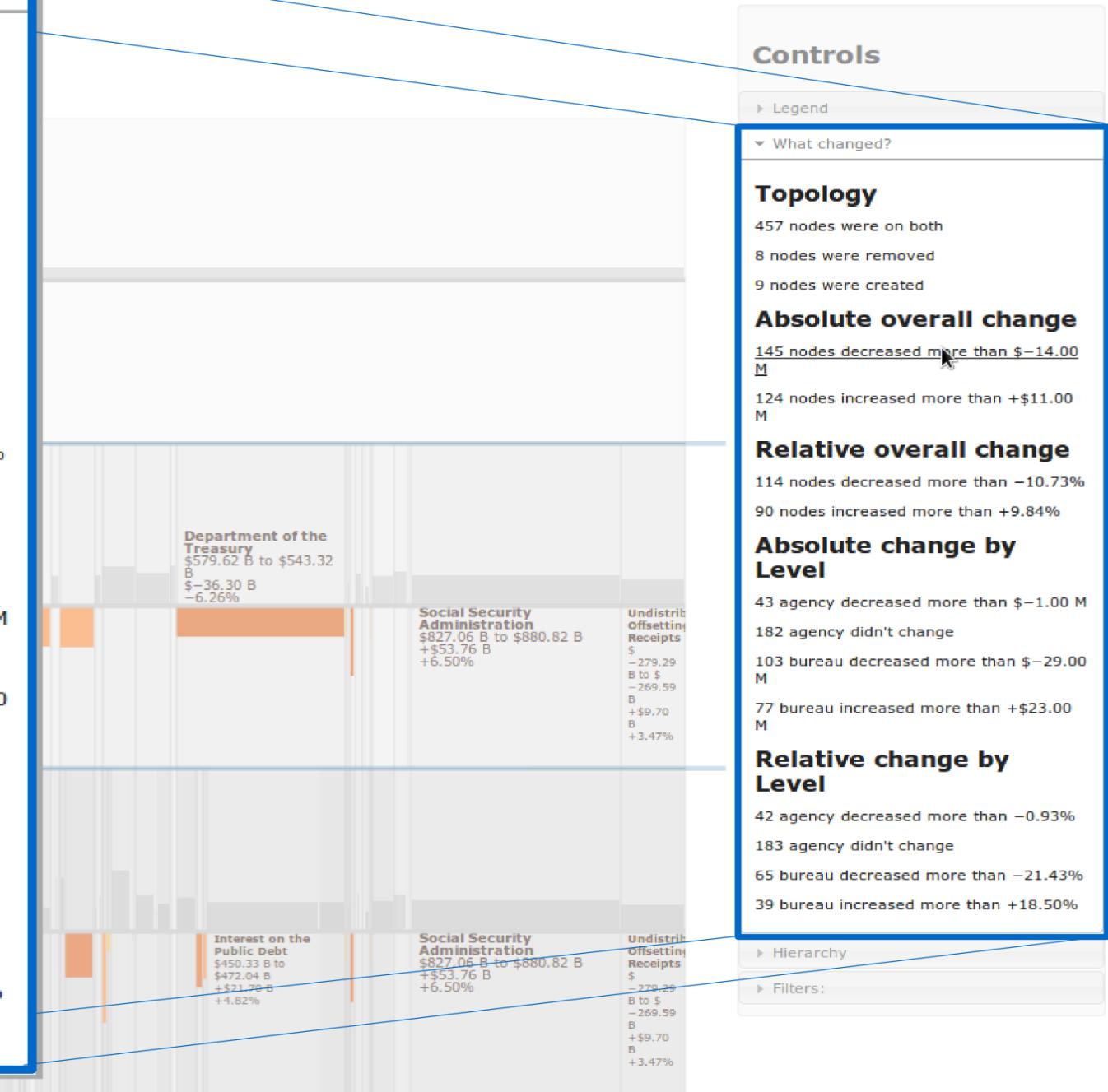
#### Relative change by Level

42 agency decreased more than -0.93%

183 agency didn't change

65 bureau decreased more than -21.43%

39 bureau increased more than +18.50%





## strengths & weaknesses

13 case studies with 9 partners



Drugs' adverse effects  
2,964 Records  
5 Time points  
Type 4 tree comp



Lung cancer death rates  
1,716 Records  
13 Time points  
Type 2 tree comp



Passengers flying in the US  
65,524 Records  
162 Time points  
Type 3 tree comp



Students demographics  
227,158 Records  
5 Time points  
Type 3 tree comp



Product's sales and inventories  
63,068 Records  
4 Time points  
Type 1 tree comp



US Federal Budget  
4,845 Records  
56 Time points  
Type 3 tree comp



Imports/exports in the continent  
119,741 Records  
19 Time points  
Type 3 tree comp



Traffic bottlenecks data  
96,205 Records  
24 Time points  
Type 3 tree comp

# FDA Case Study

# The task

**How do drug adverse effects  
change over time?**

# **EBGM: Empiric Bayes Geometric Mean**

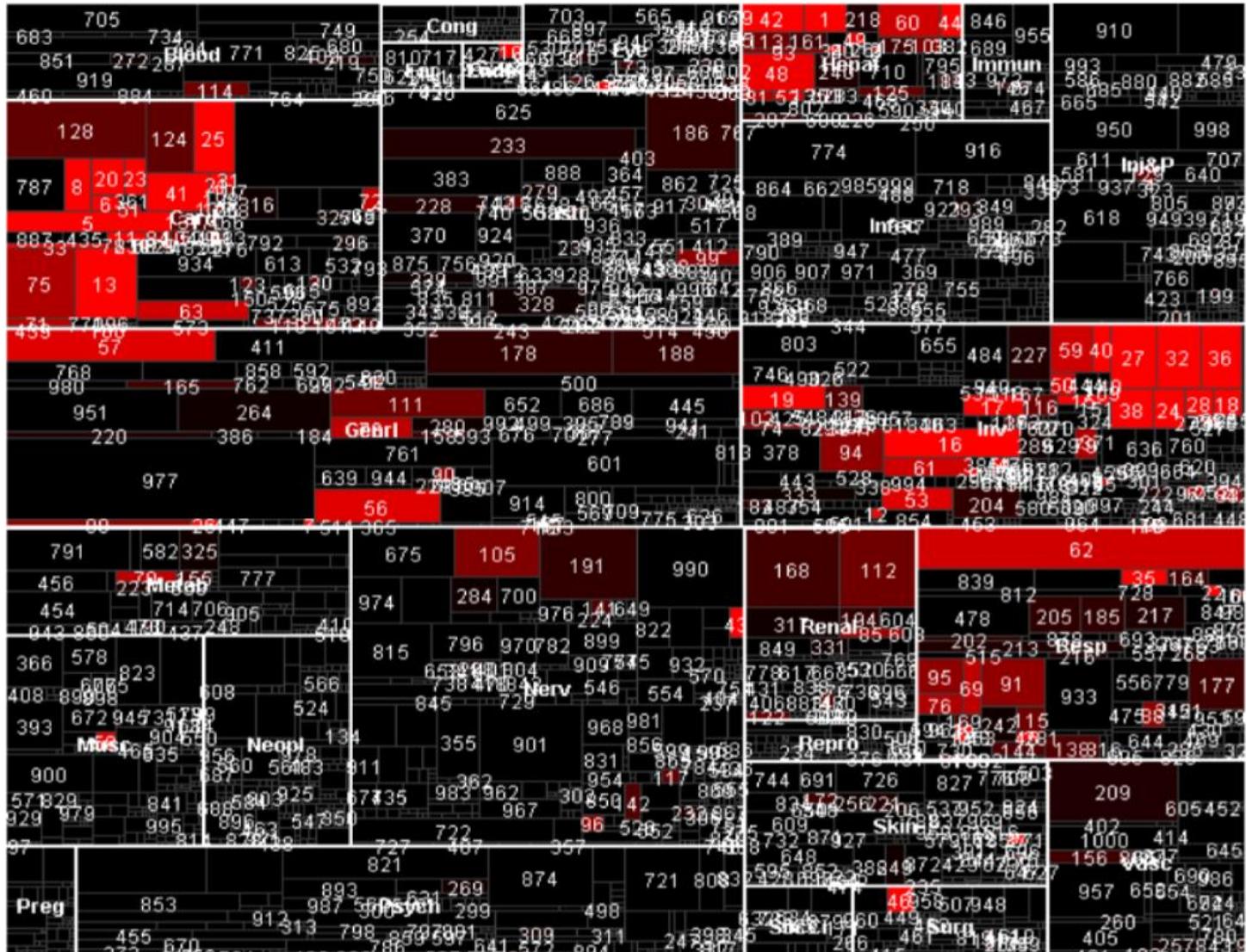
## **EBGM: Empiric Bayes Geometric Mean**

In human:

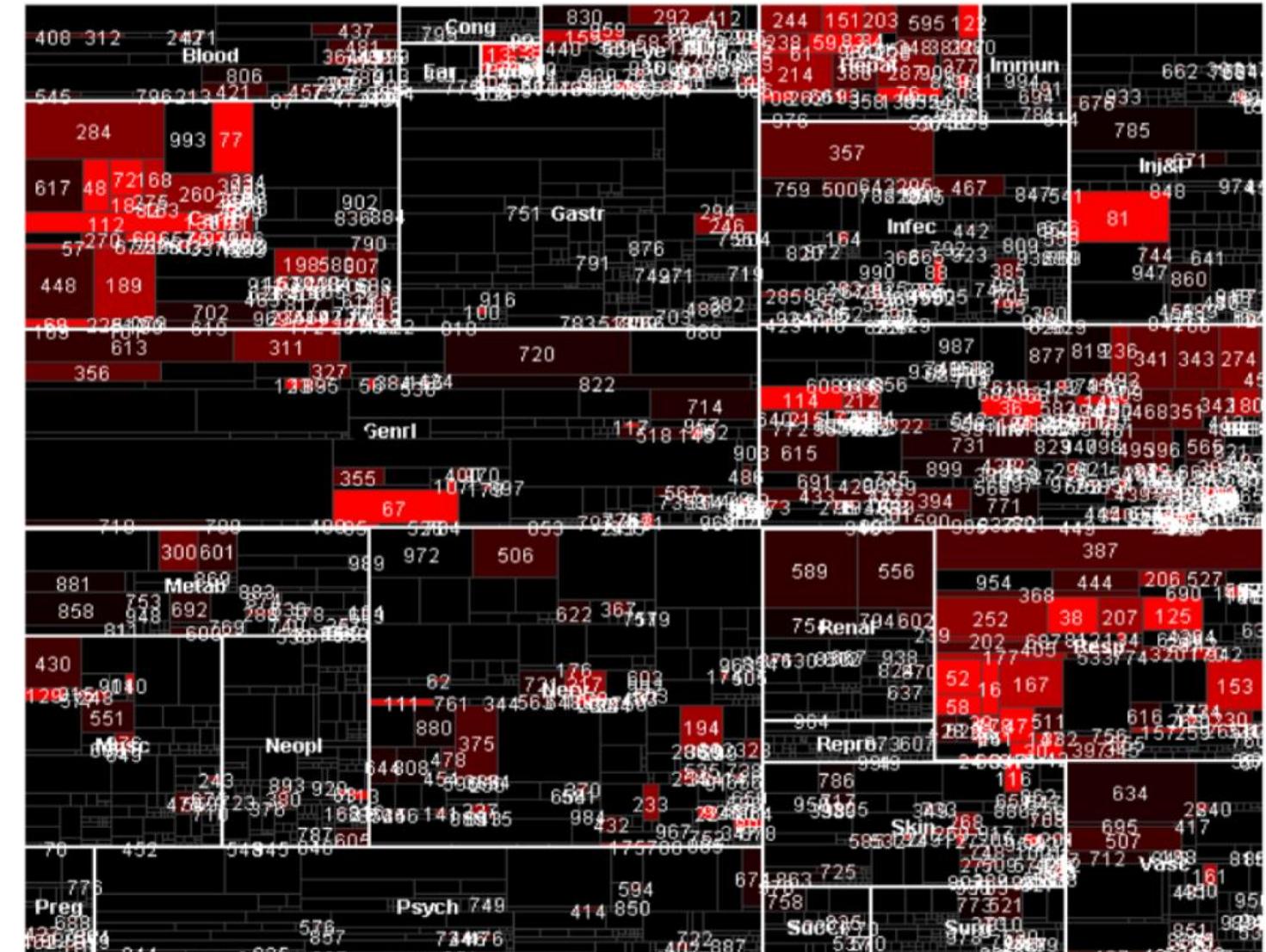
An index of how many more than expected reports of an adverse effect have been received

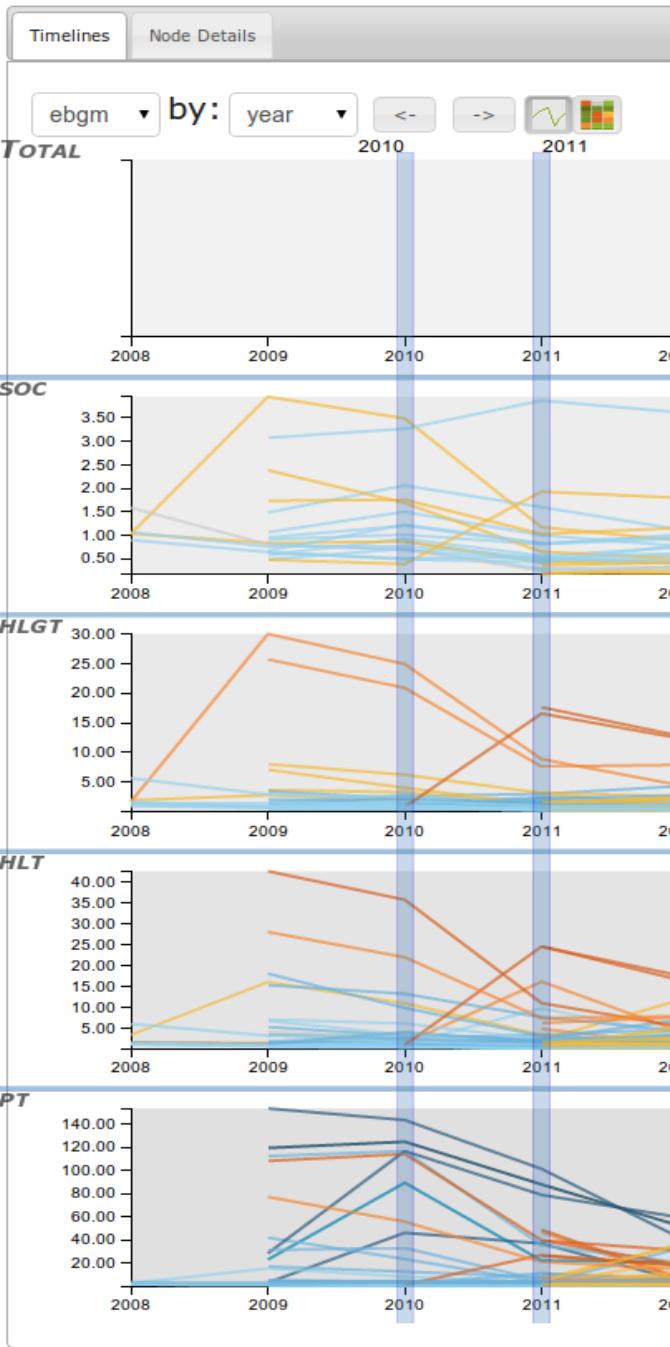
# Sector Maps

Year 1



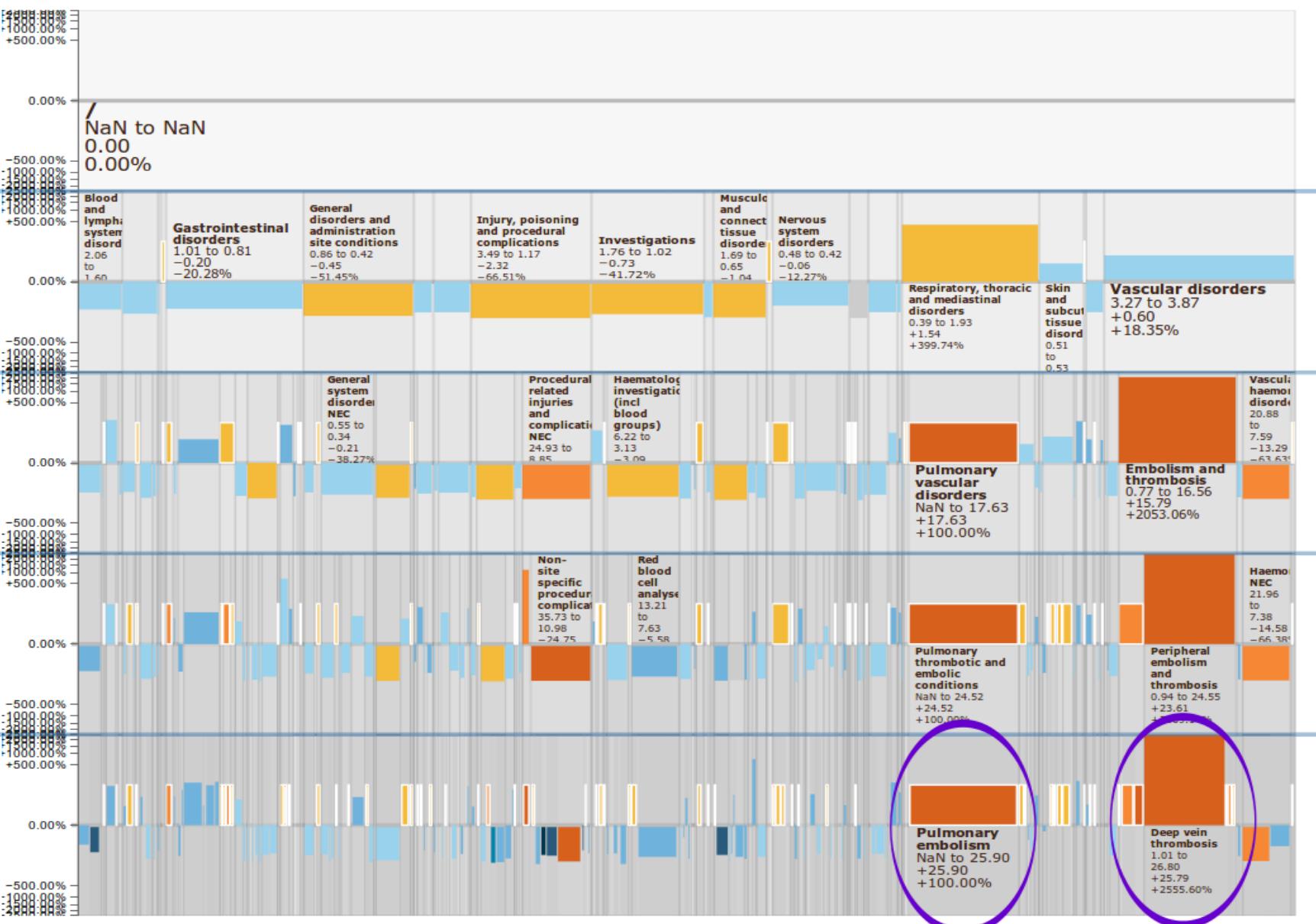
**Year 2**





## FDA Adverse Drug Effects

Comparing 2010 to 2011



## Controls

**Legend**

**Color by:** Non-Overlapping  4rt?

+124.40 to +273.16	+273.16
+45.64 to +122.21	+122.21
+11.93 to +44.61	+44.61
+1.56 to +11.56	+11.56
+0.02 to +1.48	+1.48
-0.02 to -1.48	-1.48
-1.56 to -11.56	-11.56
-11.93 to -44.61	-44.61
-45.64 to -122.21	-122.21
-124.40 to -273.16	-273.16

**Height by:** ebgm Percentage  4rt?

-2	-1	0	1	2
1.00 to 1.00				
+62.64 to +62.64				
+851.87% to +851.87%				

**Sort by:** Name

**Width by:** n Max Value

**Border Color:** Removed Created

▶ What changed?  
▶ Hierarchy  
▶ Filters:

*“The work I can achieve with TreeVersity is equivalent to years of analysis with our previous methods”*

*“TreeVersity easily showed us multi-years of the data in a graphical form at once without having to download the data into excel and create graphics. We can do that analysis now, but TreeVersity was much quicker.”*

*“I've spent many hours in color coded Excel files expressing changes at query and category levels. The visualization and what changed views made this process much more efficient and easier to share.”*

*“Numerous examples of obvious, but heretofore unrevealed patterns were discovered.”*

*“We use Hyperion and excel for analysis. However, TreeVersity made it much easier to see multi-year trends.”*

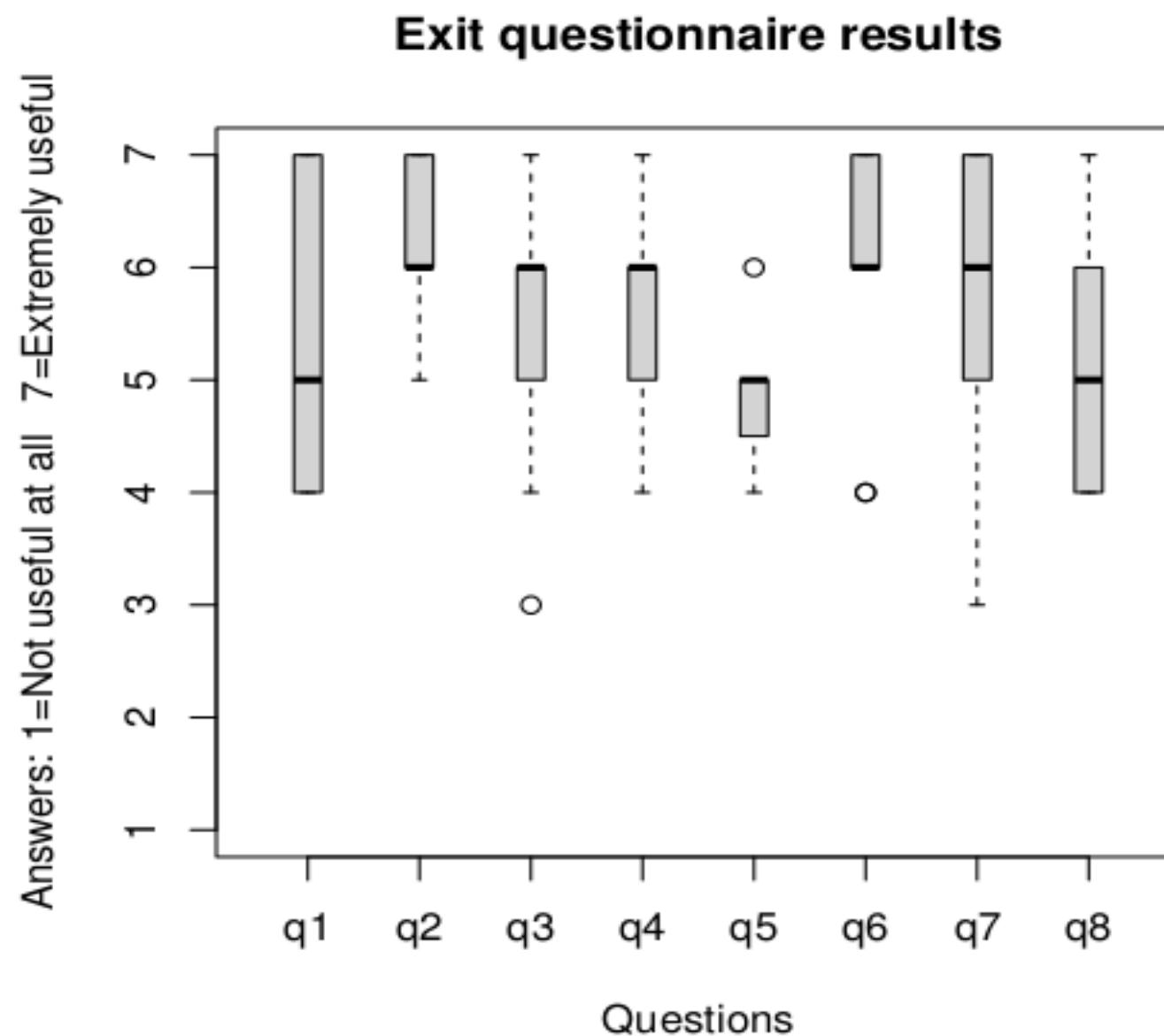
*We need to run it in-site, and cannot install all the requirements*

*It shows too much information*

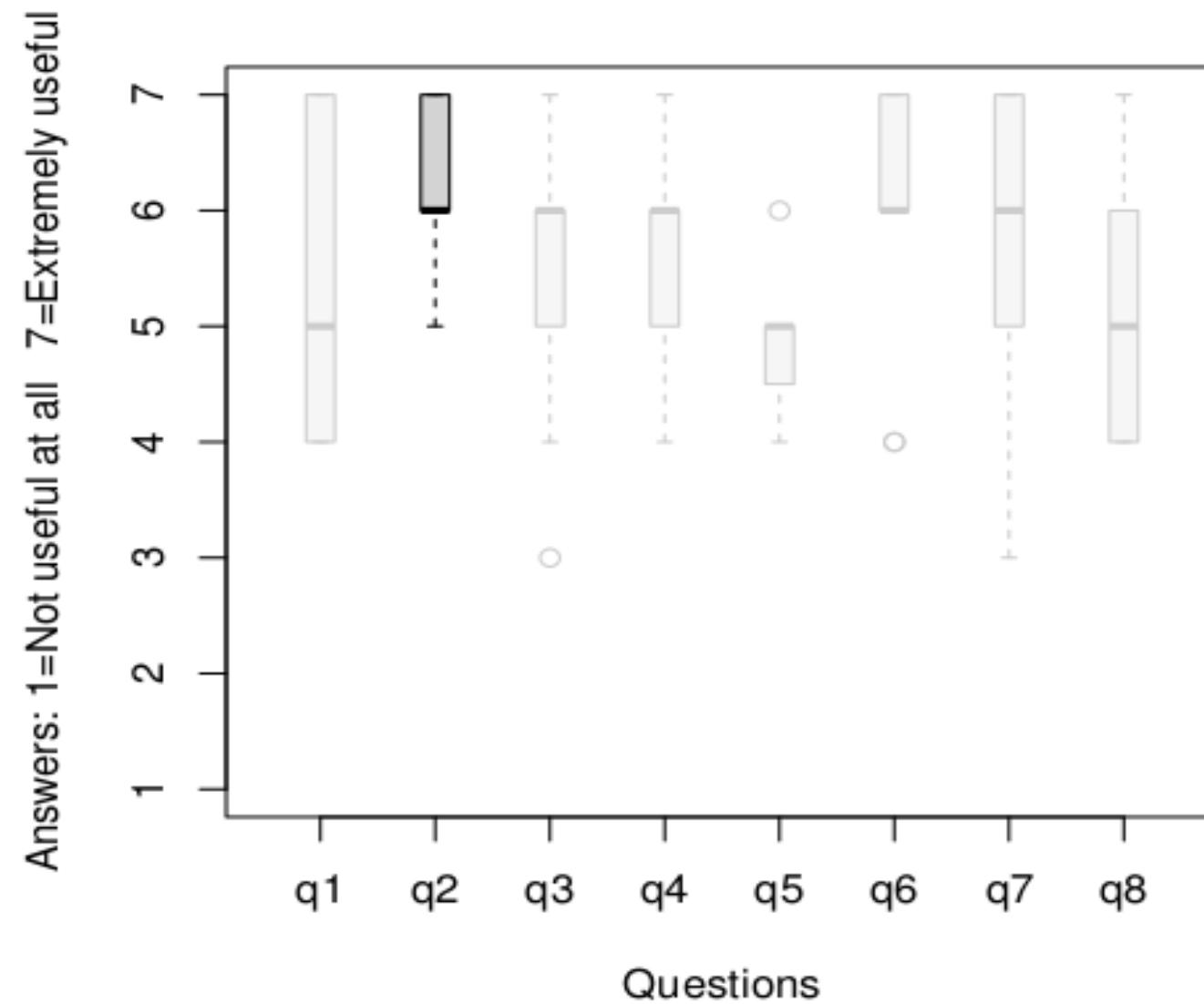
*We need to see more information*

*It requires some training to understand the StemView*

- q1: For this particular case study TreeVersity was:
- q2: In general the tool is likely to be:
- q3: Did the reporting tool help direct your exploration?
- q4: Did you find the StemView comprehensible?
- q5: Did you find the Bullet comprehensible?
- q6: Would you like to continue working with Treeversity?
- q7: Would you be willing to install and use Treeversity on your own?
- q8: How does this compare to your original expectations before starting with the tool.



## Exit questionnaire results

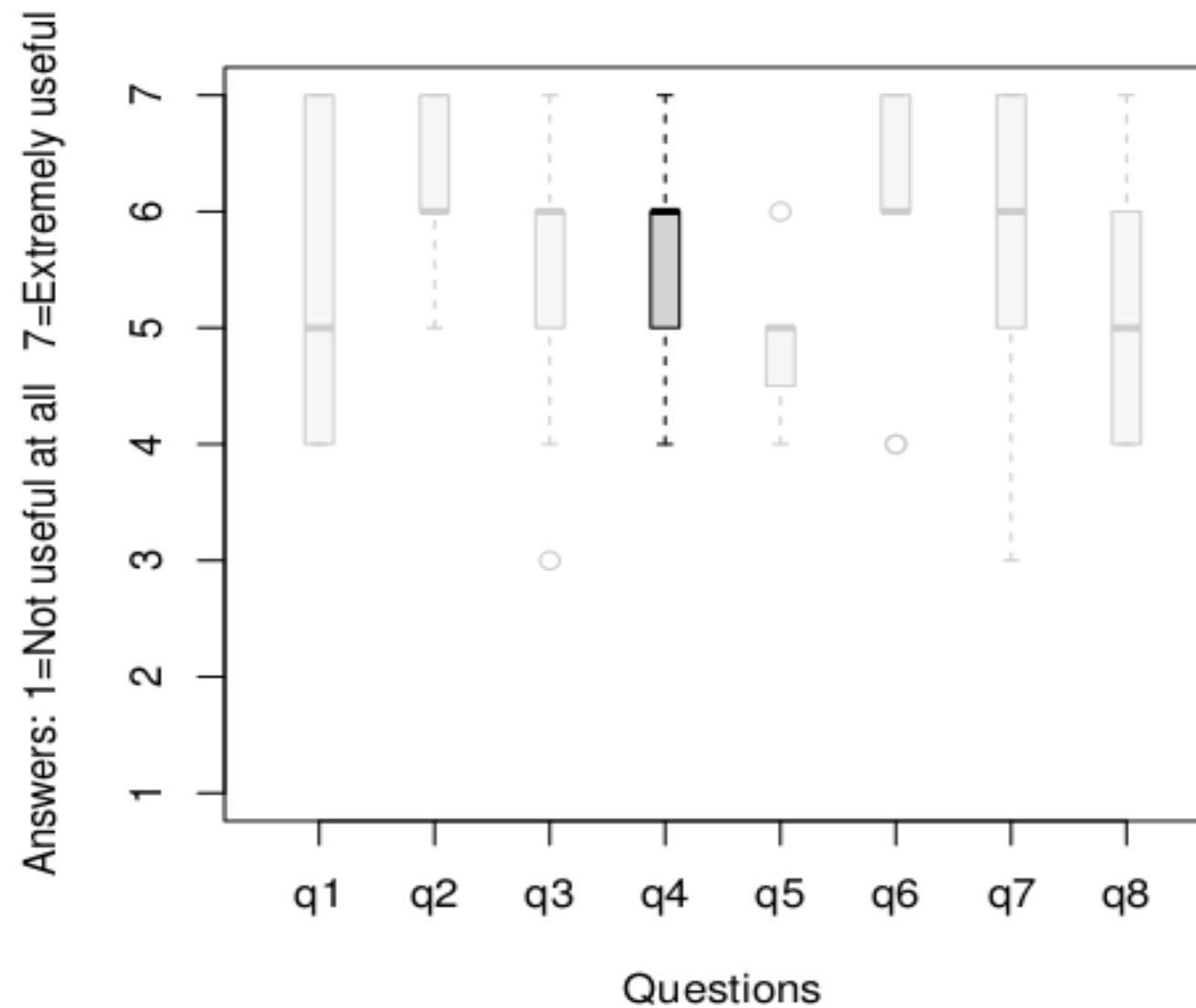


q2: In general TreeVersity2 is likely to be

1: Not useful at all

7: Extremely useful

## Exit questionnaire results

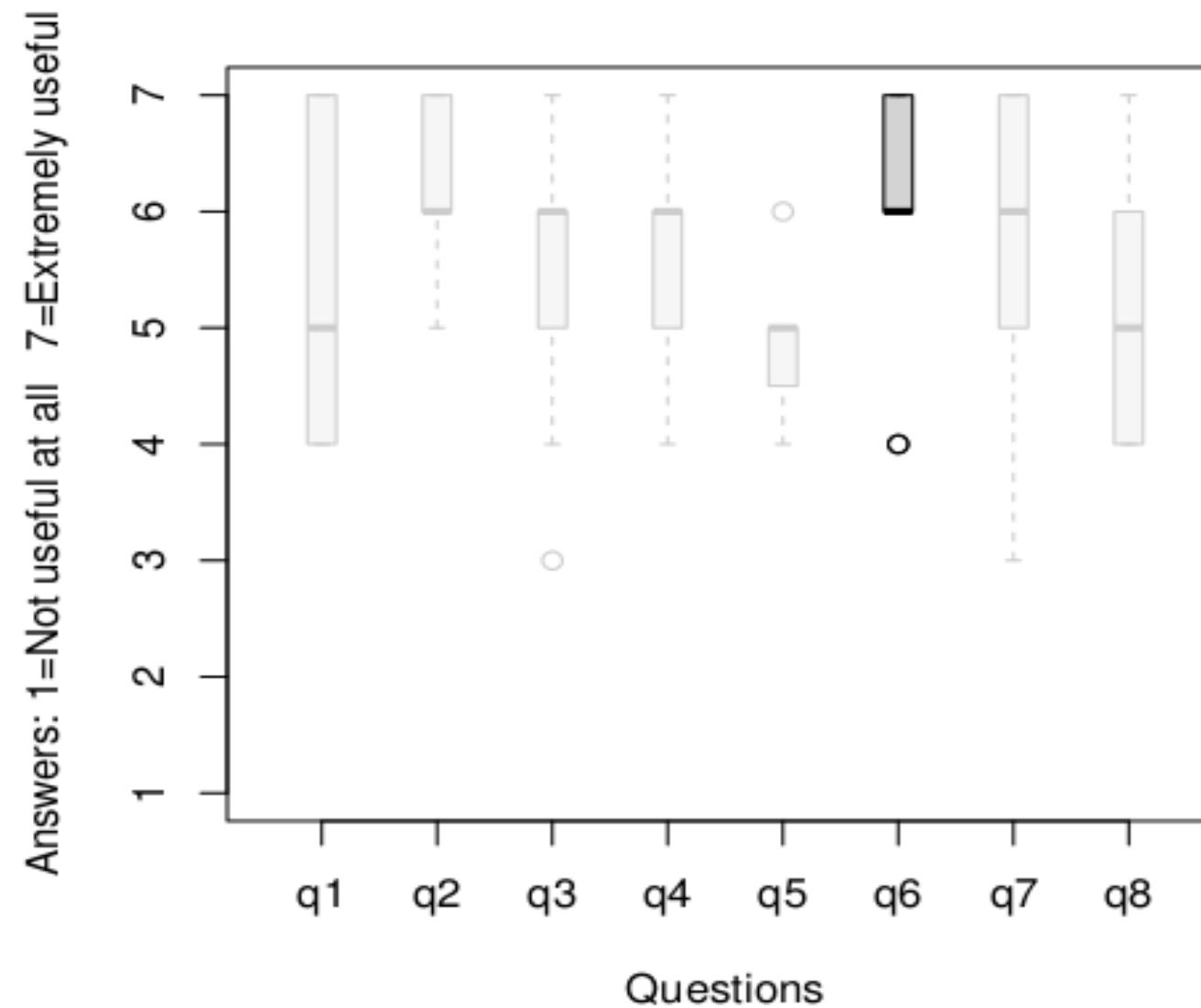


q4: Did you find the StemView comprehensible?

1: Not comprehensible at all

7: Extremely easy to comprehend

## Exit questionnaire results



q6: Would you like to continue working with Treeversity

1: Not at all

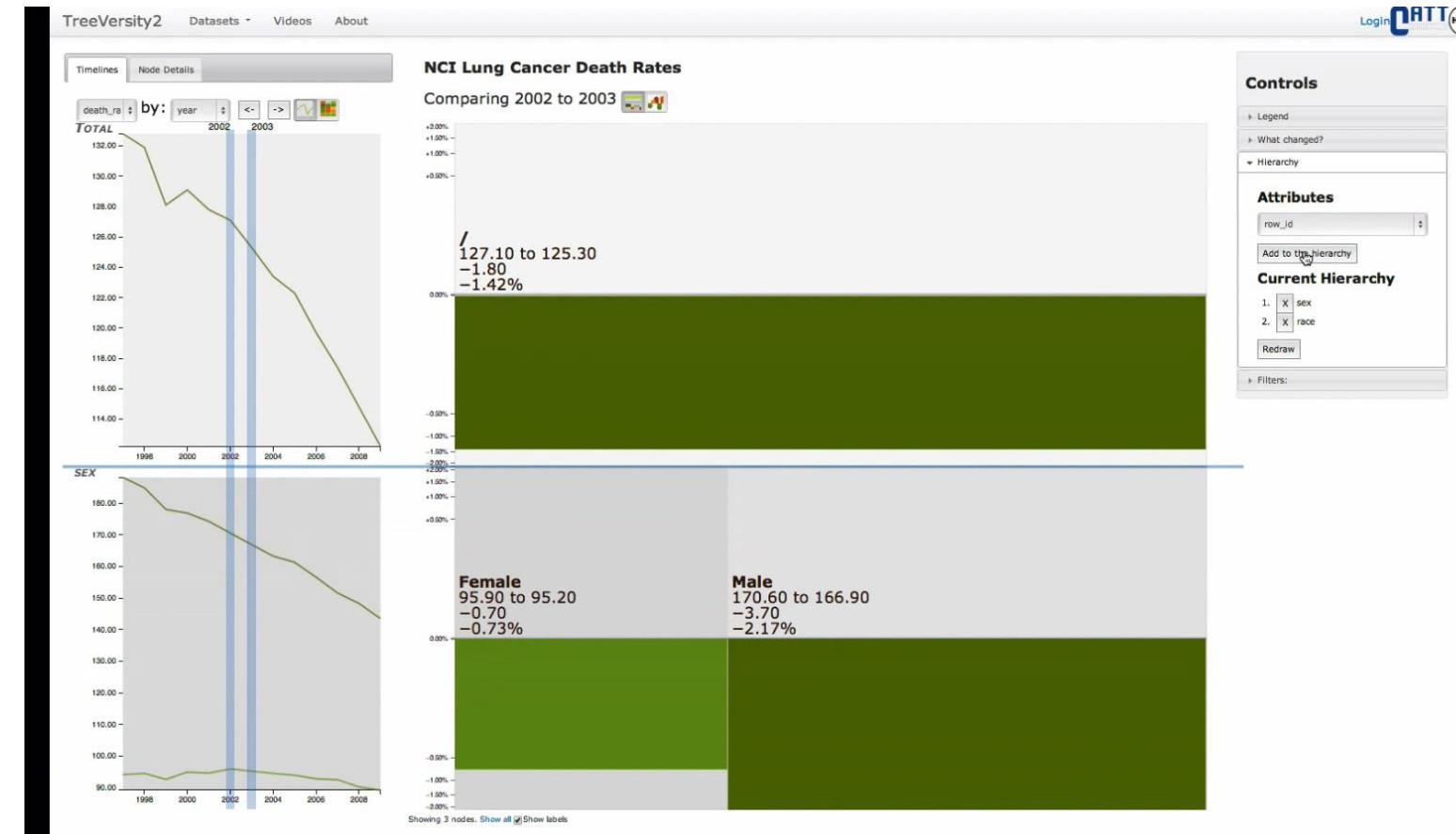
7: I will definitely use it

# Acknowledgements

- Center for Advanced Transportation Technologies (CATT Lab)
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- The Fulbright International Science and Technology Scholarship
- Audra Buck-Coleman
- Palo Alto Research Center, a Xerox Company
- Our Reviewers
- Our case studies partners

# Thank you!

- StemView shows 5 characteristics of change
- Dynamic/Fixed/Hybrid Hierarchies that aggregate or not
- Created and removed nodes
- Not only leaf nodes
- Reporting tool



<http://treeversity.cattlab.umd.edu>

John Alexis Guerra Gómez  
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<http://duto.co/aguerra>



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