Automated Matchmaking Tool to Facilitate Federal–Community Adaptation Implementation

Carolyn Stwertka, PhD

Alexander Titus, Mary Albert, and Kathleen White

2018-'19 AAAS Science Technology and Policy Fellow

Chemical and Material Risk Management Program

DASD (Env)

SERDP • ESTCP SYMPOSIUM 2018 | Enhancing DoD's Mission Effectiveness

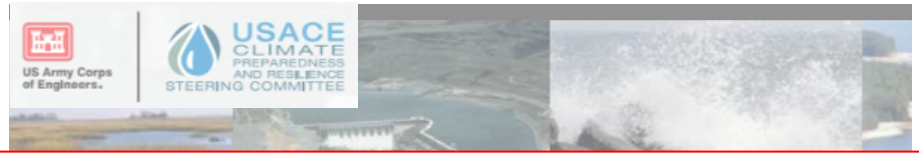
Every year, 100s of causalities, damages, and disruptions inflicted by extreme events

Rochester, NY in winter, 1991

Tyndall AFB, 2018

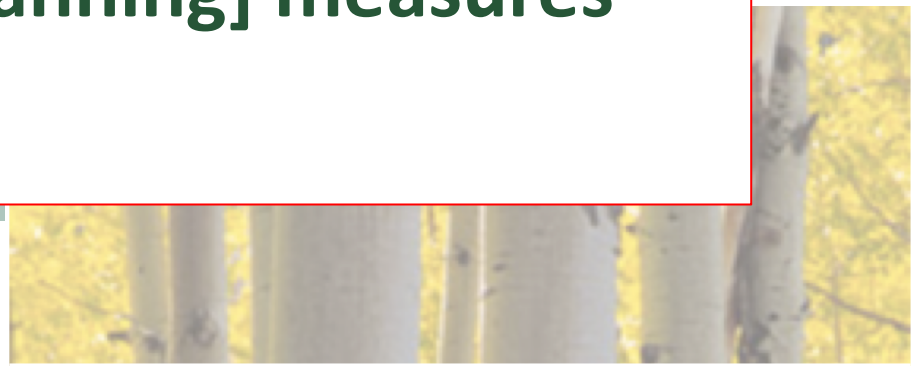
Climate Change Adaptation Planning

Executive Order -- Preparing the United States for the Impacts of Climate Change



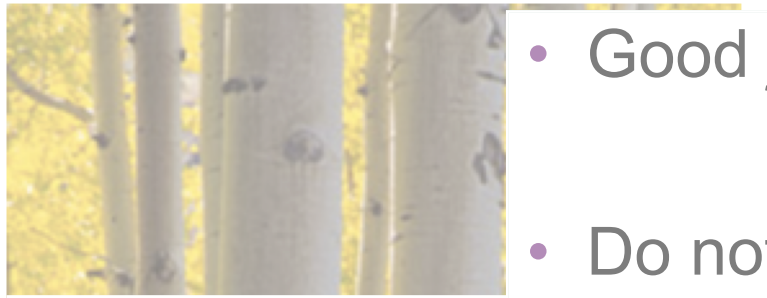
very few [climate adaptation planning] measures have been implemented.

(National Academy of Sciences, 2016)



Keene, New Hampshire
Climate Adaptation Action Plan

Adaptation planning is a decision-intensive and complex process

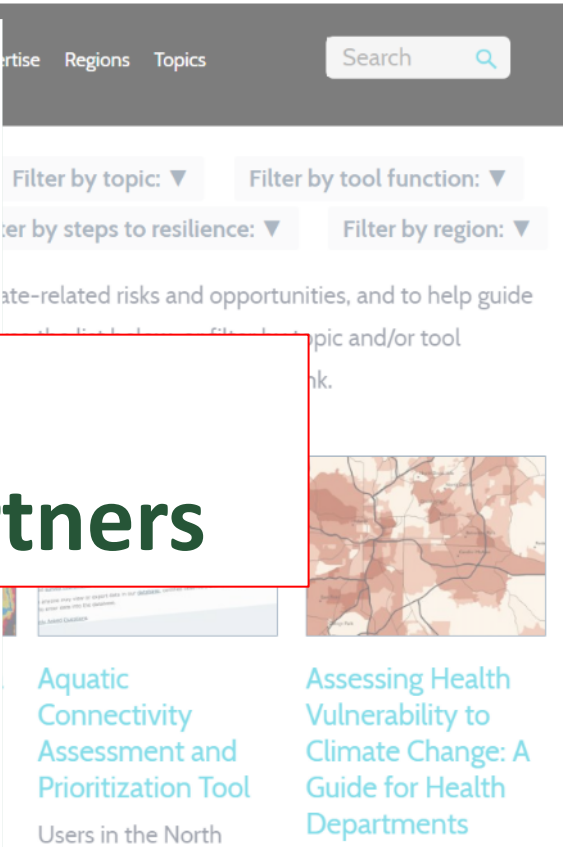


- Good job connecting science + planning
- Do not **prioritize impacts and strategies**

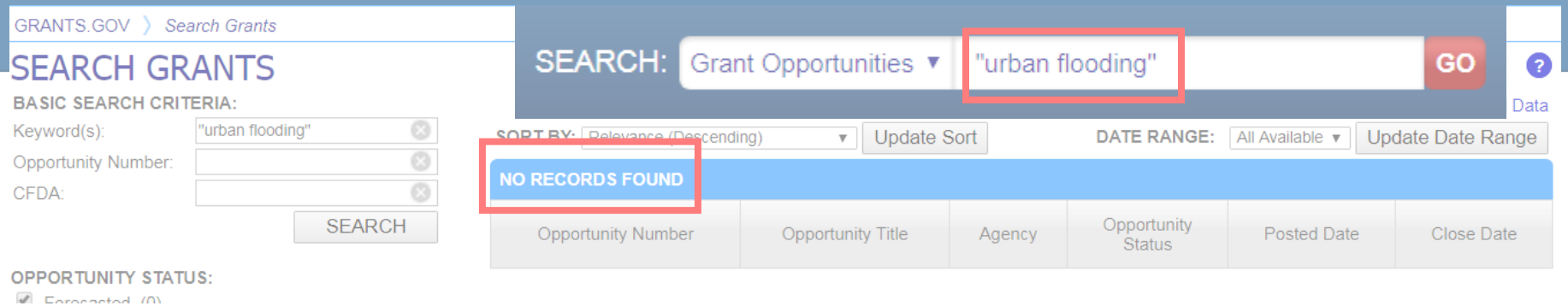
planners + science …

***need* planners + implementing partners**

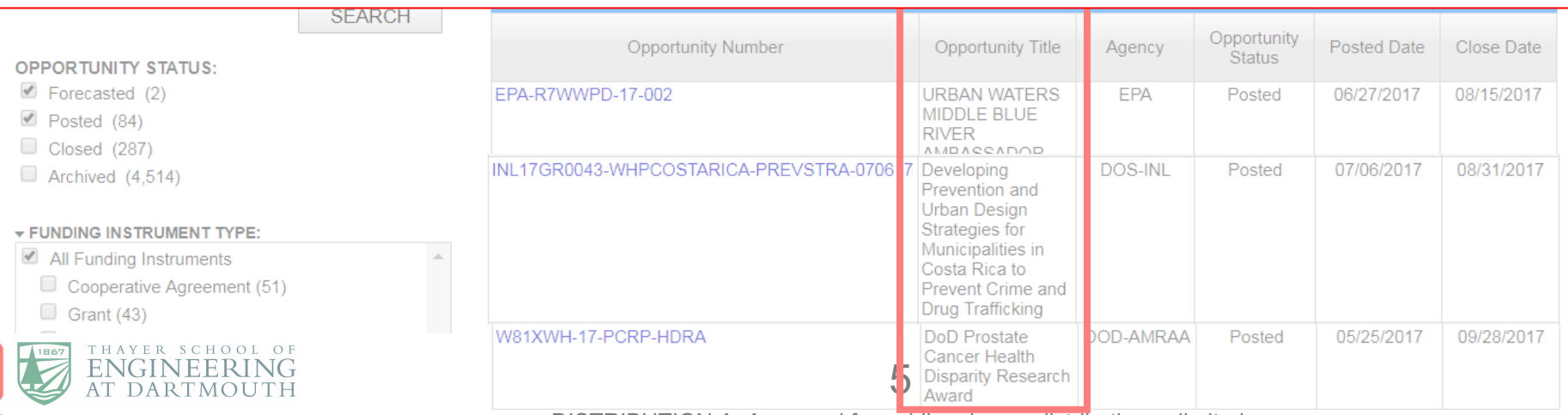
- Do not **identify co-benefits of actions** or **implementation responsibilities**
  - Cost and time
- Adaptation plans identify the **need for federal partners**, yet **few identify** which ones



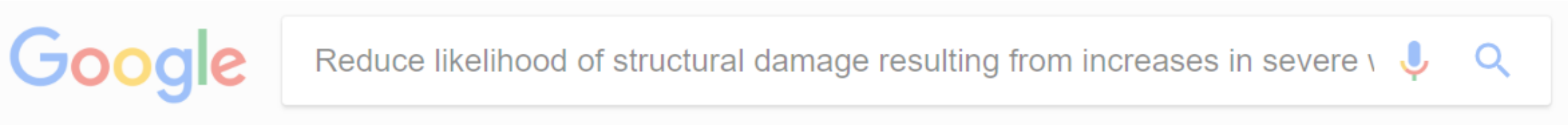
Existing tool for identifying federal grants



Opportunity: A more effective tool for matching climate vulnerabilities to federal agencies that can help fund these projects and reduce climate vulnerabilities!



Existing search engines

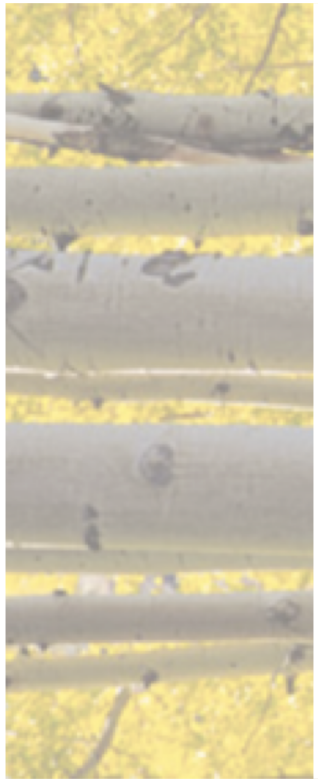


Can such a model be built using machine learning techniques?

US Army Corps
of Engineers®

Goal

Federal Agency Strategic Plans (SP)



Keene, New Hampshire Climate Adaptation Action Plan

	USACE	FEMA	DOT	EPA	HHS
Reduce the likelihood of structural damage …					
Create, adopt, implement city building codes …					
Create alternative route options for movement of …					
Safely and efficiently remove stormwater from the built …					
Engage energy providers to enhance local renewable …					

Automated completion using a machine learning model

Prioritized federal partner by climate action

Federal Strategic Plans (SPs)

- Prepared by every federal agency
- **Approved** every four years by OMB

ASAP

- Automated StrAtegic Prioritization (ASAP) matchmaking tool to Facilitate Federal–Community Adaptation Implementation
- *Can be used by feds, public, and private sectors*

ORISE US Army Corps of Engineers® THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

Which machine learning technique did we use?

We want to be able to mathematically trace how the machine learning occurred

Probability based

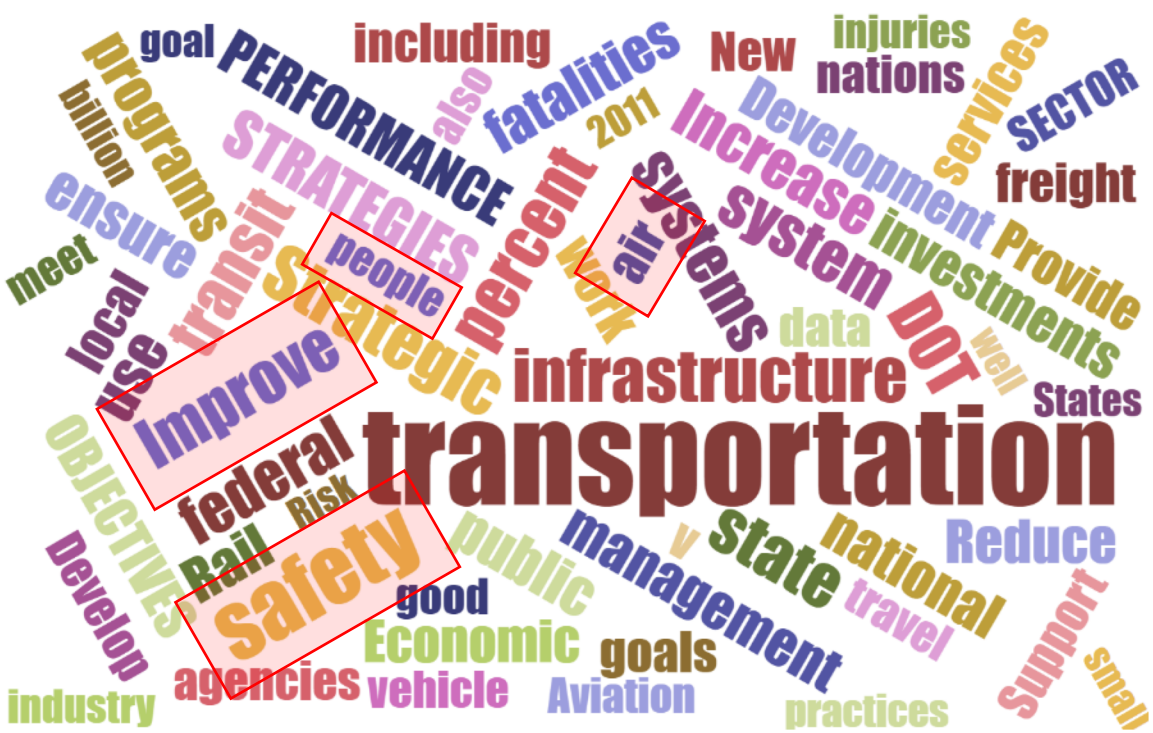
- Random forest
- Neural networks
- Deep learning

Vector-based

- Keyword search (TF-IDF) – Algorithm 1
- Semantic Indexing (LSI) – Algorithm 2

Algorithm 1: Word Clouds!

Department of Transportation
Strategic Plan 2014 - 2018



Environmental Protection Agency
Strategic Plan 2014 - 2018

Algorithm 1: Keyword vector space

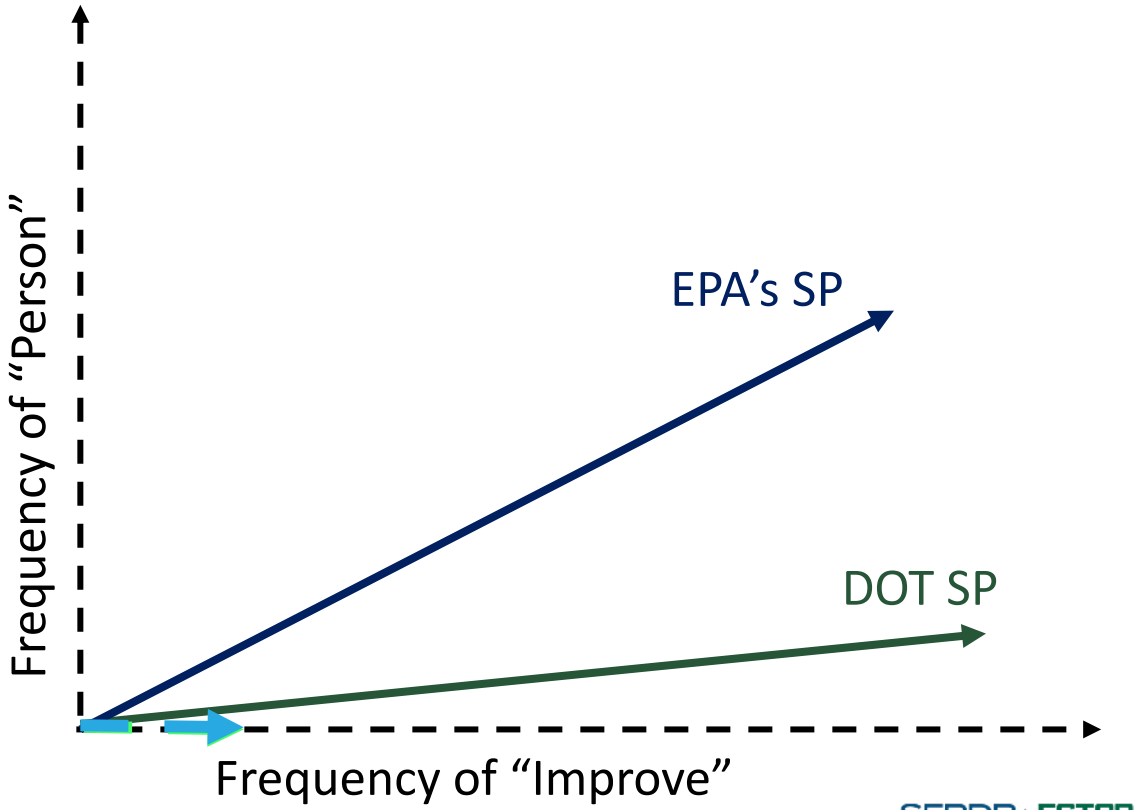
Keyword model (frequency)

	DOT SP	EPA SP
Improve	8	8
Person	1	5

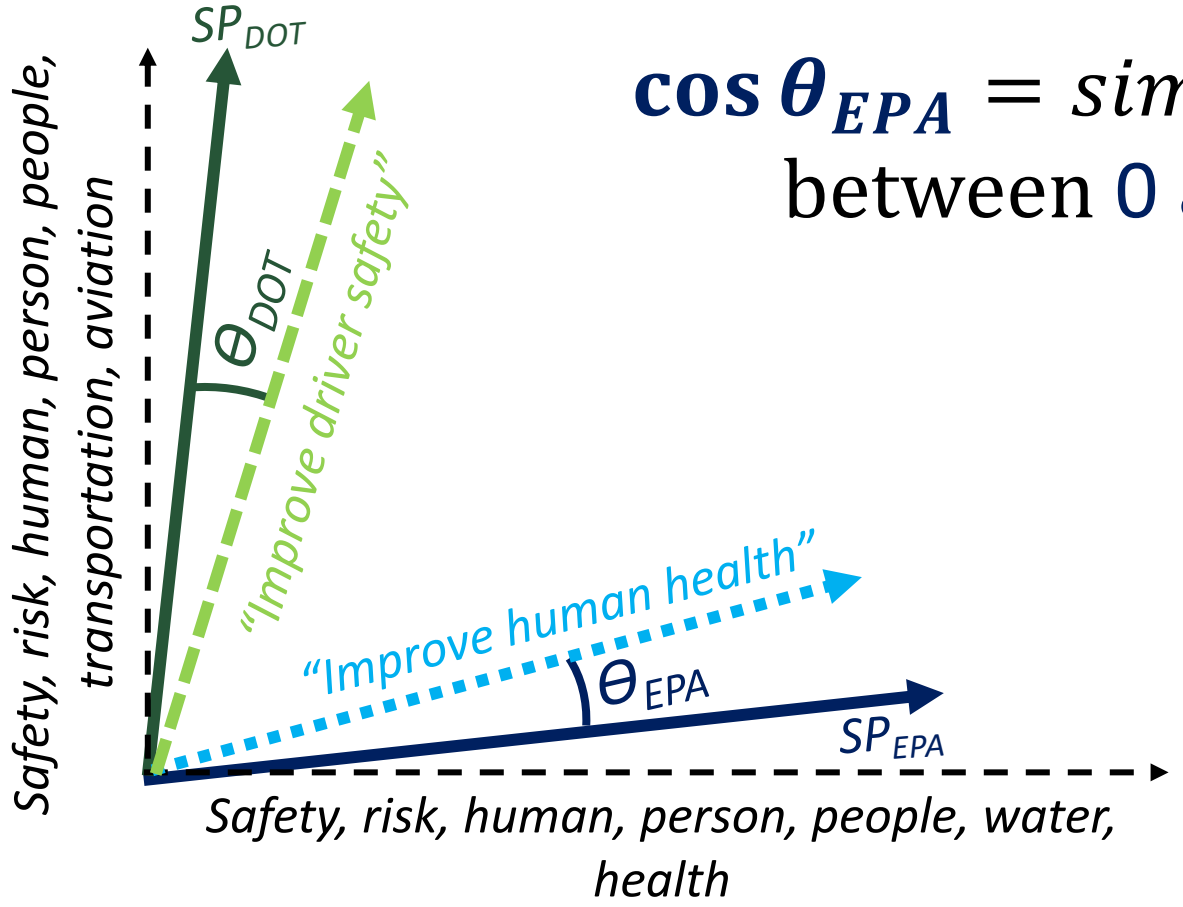
Query that model (frequency)

	"Improve driver safety"	"Improve human health"
Improve	1	1
Person	0	0

Vector Space Model (VSM)



Algorithm 2 – semantic space model

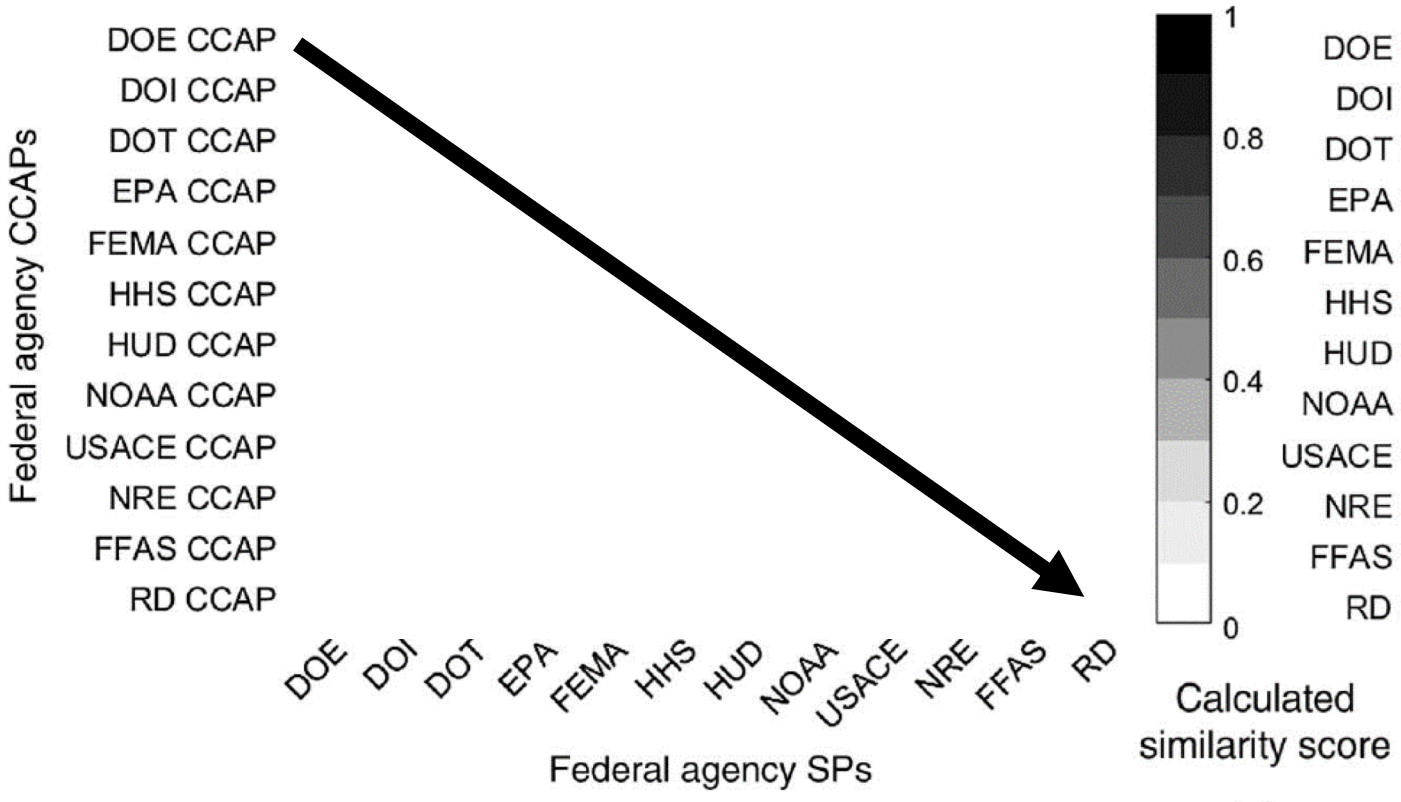


$$\cos\theta_{EPA} = similarity\ score$$

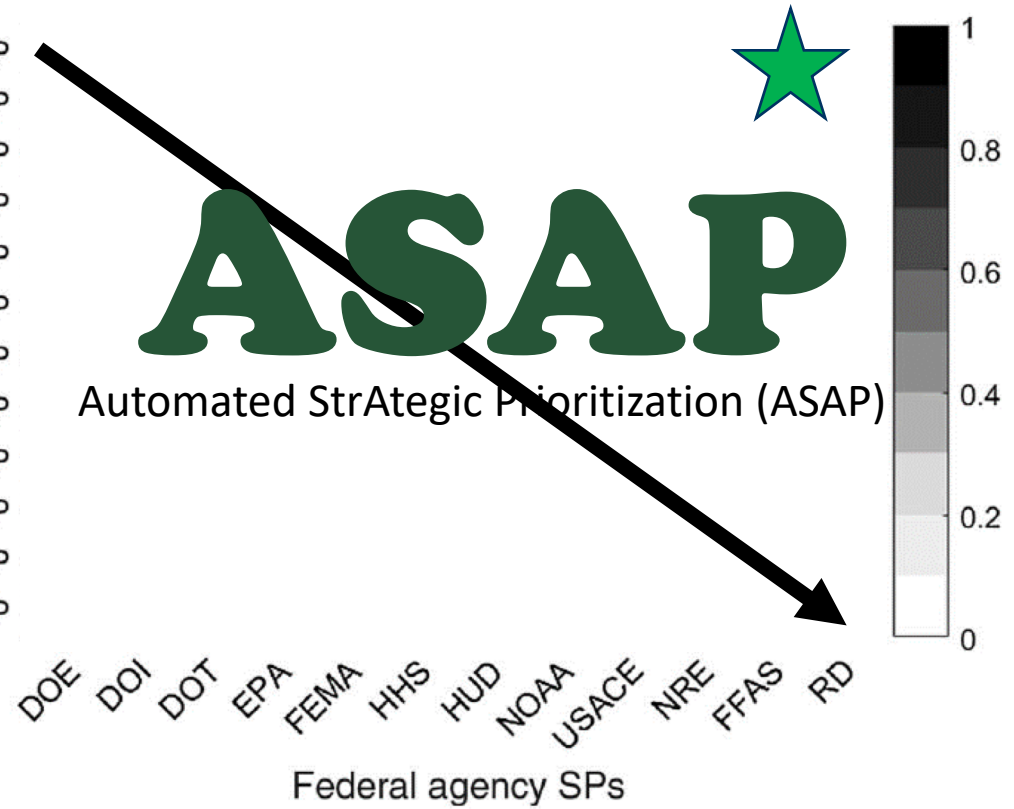
between 0 and 1

Verification matrices

Algorithm 1: keyword model



Algorithm 2: semantic model



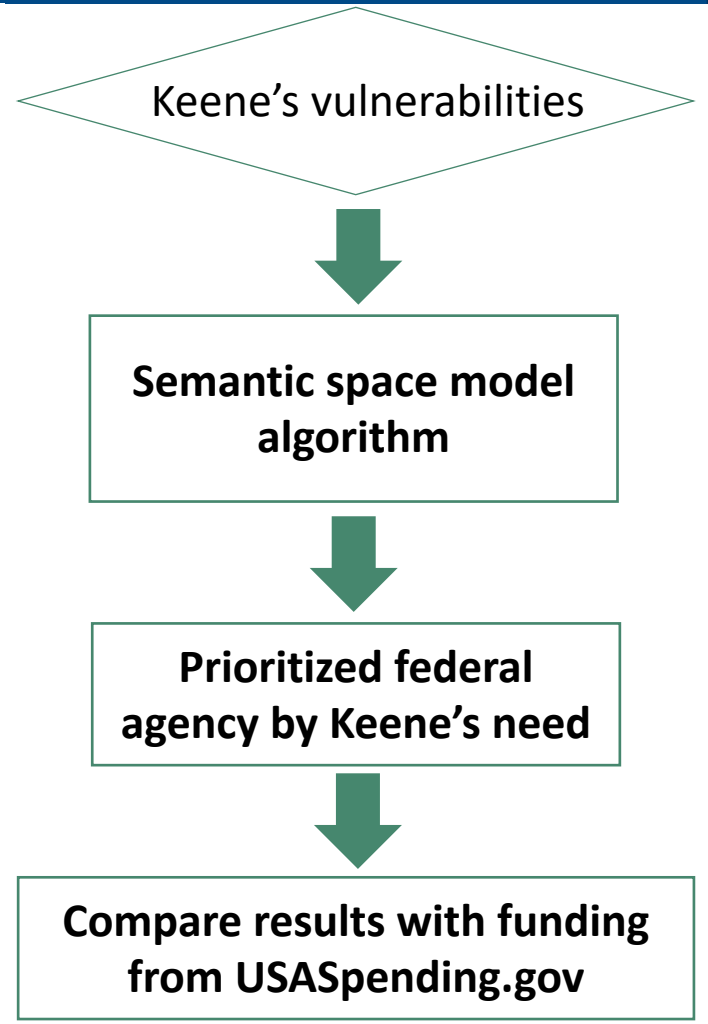
ASAP

Automated StrAtegic Prioritization (ASAP)

Case Study: Keene, NH

Keene, New Hampshire
Climate Adaptation Action Plan

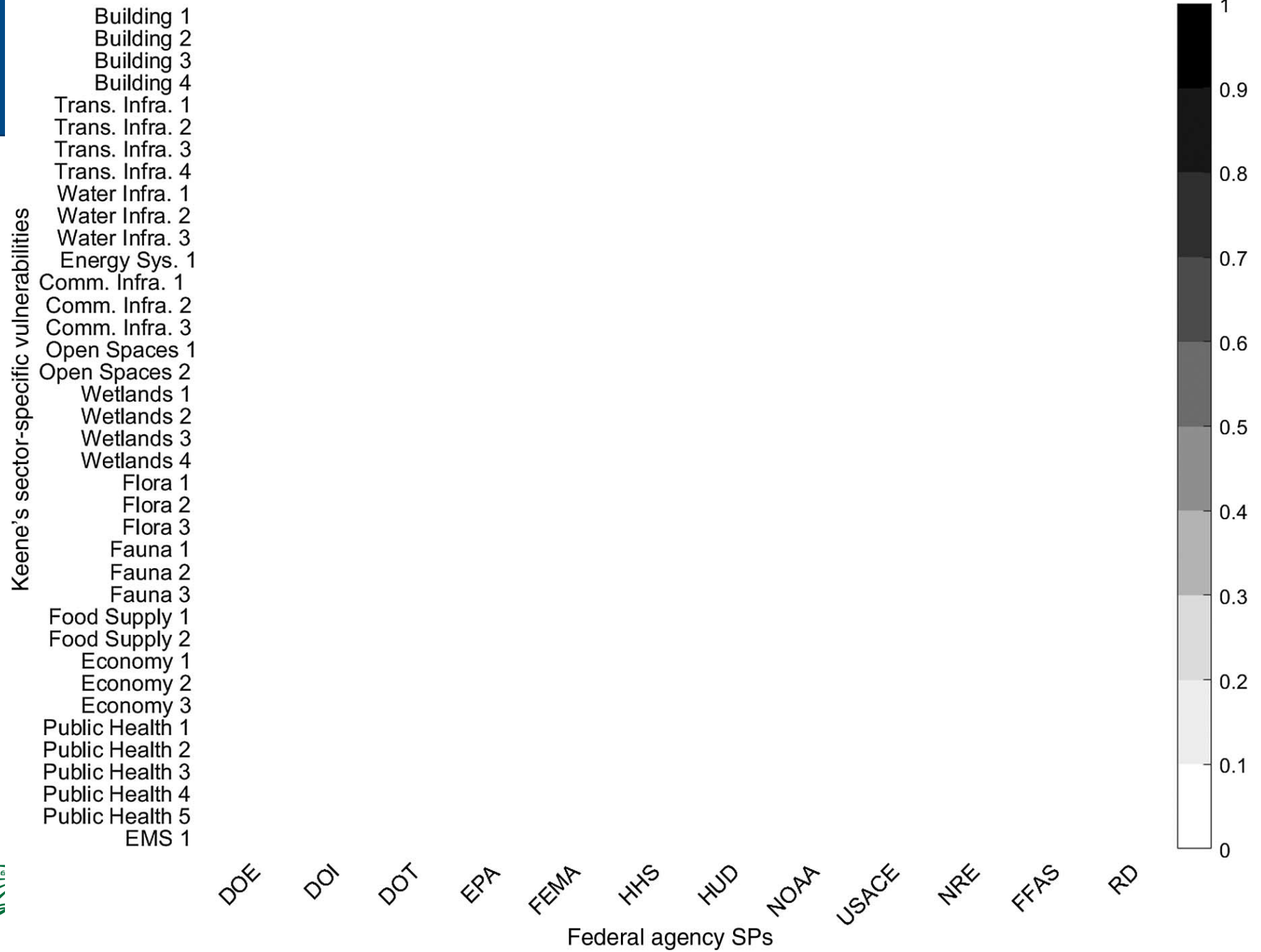
- Early climate activist
- includes a section on assessing the **community** and **sector specific climate vulnerabilities**
- Keene split its climate vulnerabilities **into 12 sectors**, each containing **1 - 5 paragraphs**
- **Does not** contain information about **previous** federal funding, or **future federal partners**.
- **Compare** output for the case of Keene to awards and subawards from the ***USASpending.gov***



ORISE US Army Corps of Engineers® THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

SERDP • ESTCP SYMPOSIUM #SerdpEstcp2018

Sector-specific climate vulnerabilities in Keene, NH

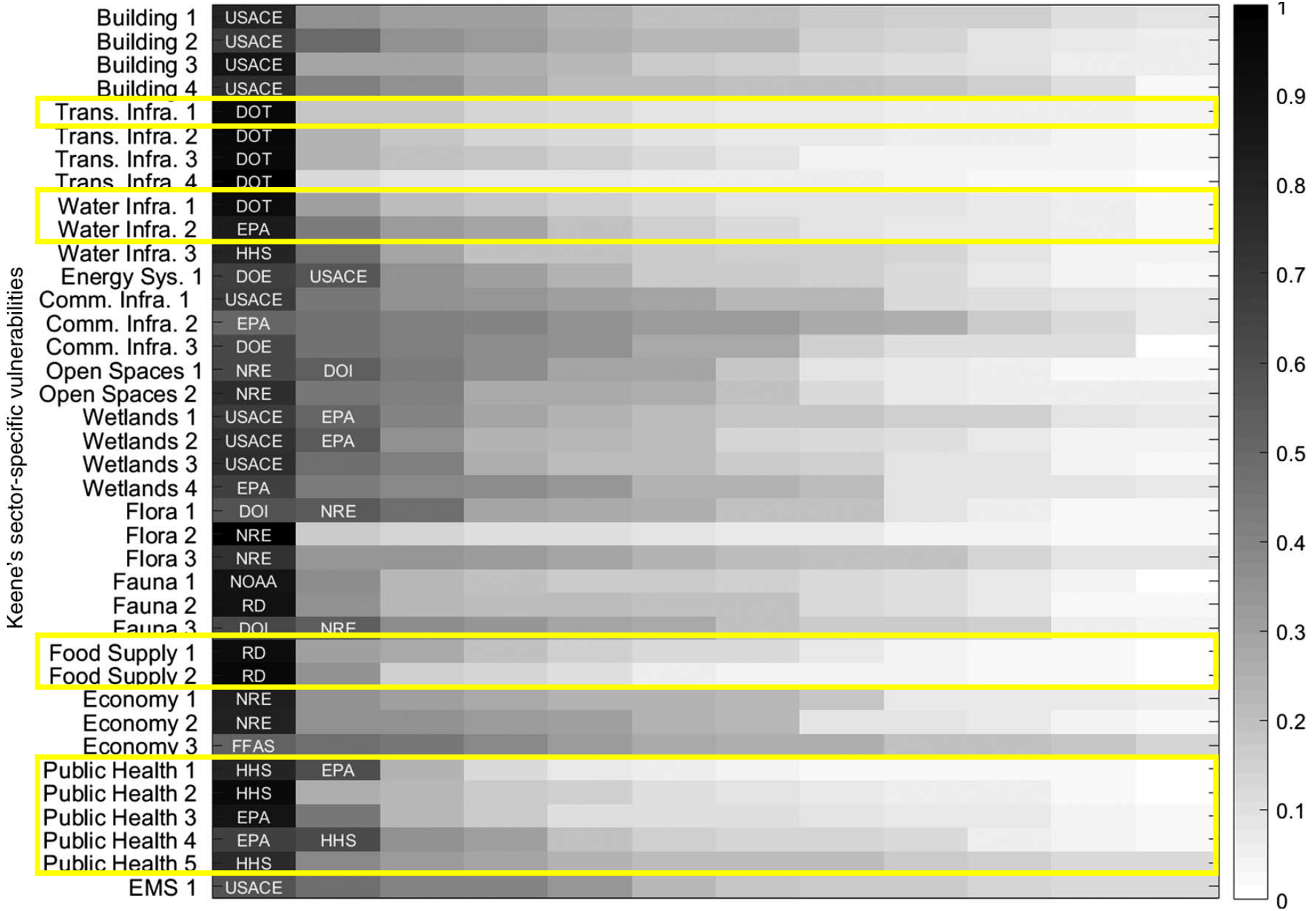


ORISE US Army Corps of Engineers®

SERDP • ESTCP SYMPOSIUM

#SerdpEstcp2018

Sector-specific climate vulnerabilities in Keene, NH with highest scoring federal partners



ORISE

SERDP • ESTCP SYMPOSIUM
#SerdpEstcp2018

Keene, NH Results: did highest priority issues have high scores?

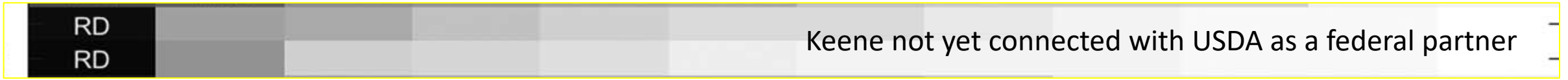
Transportation Infrastructure #1 *"Large amounts of snowfall and icestorms all have the ability to affect roadways and bridges"*

USASpending.gov: In 2015, Keene was awarded a DOT grant to buy snow removal equipment!

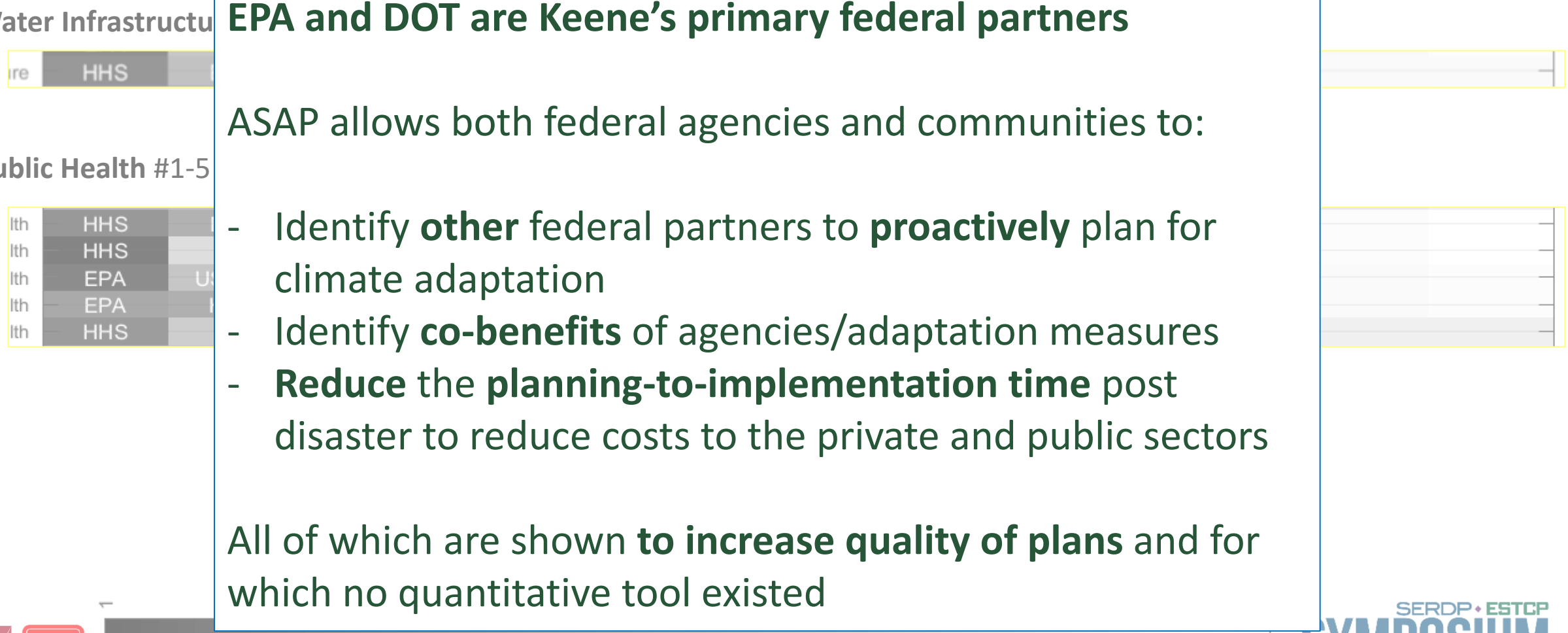
Water Infrastructure #2 *"The capacity of existing culverts, the design of current stormwater infrastructure increases in impervious surfaces all contributed to the system's vulnerability"*

USASpending.gov: In 2011, Keene received an EPA grant to improve their storm and wastewater infrastructure through EPA's capitalization grant!

Food Supply #1 and #2



Keene, NH Results: partnerships and cobenefits



EPA and DOT are Keene's primary federal partners

ASAP allows both federal agencies and communities to:

- Identify **other** federal partners to **proactively** plan for climate adaptation
- Identify **co-benefits** of agencies/adaptation measures
- **Reduce** the **planning-to-implementation time** post disaster to reduce costs to the private and public sectors

All of which are shown **to increase quality of plans** and for which no quantitative tool existed

Conclusions

In response to increases in climate damages and increased planning efforts, we found:

- Need to improve connection between planners + implementers
- Opportunity for automated machine learning matchmaking tool

To address that need, we built a semantic vector-based tool called ASAP:

- We tested it, and found it identified highest priority problems with relevant funding – and correctly identified top federal partners

In added value:

- Coordinate adaptation & disaster response needs with federal agencies
- Reduce public and private costs following disasters
- Quantitatively identify federal-federal partnerships for a first step towards a more cohesive government-wide climate strategy

Path forward

- USACE launching ASAP for public use!

- Continued improvements
  - Case studies with ASAP tool when launched
  - Testing and improving different machine learning algorithms
  - Incorporating new machine training data as it becomes available

How to learn more

Automated Strategic Prioritization Matchmaking Tool to Facilitate Federal–Community Adaptation Implementation

Carolyn H. Stwertka[1]; Alexander J. Titus[2]; Mary R. Albert, Ph.D.[3]; and Kathleen D. White, Ph.D., P.E.[4]

J. Water Resour. Plann. Manage., 2018, 144(12): 04018081

Carolyn.h.Stwertka.ctr@mail.mil

2018-'19 AAAS Science Technology and Policy Fellow

Chemical and Material Risk Management Program

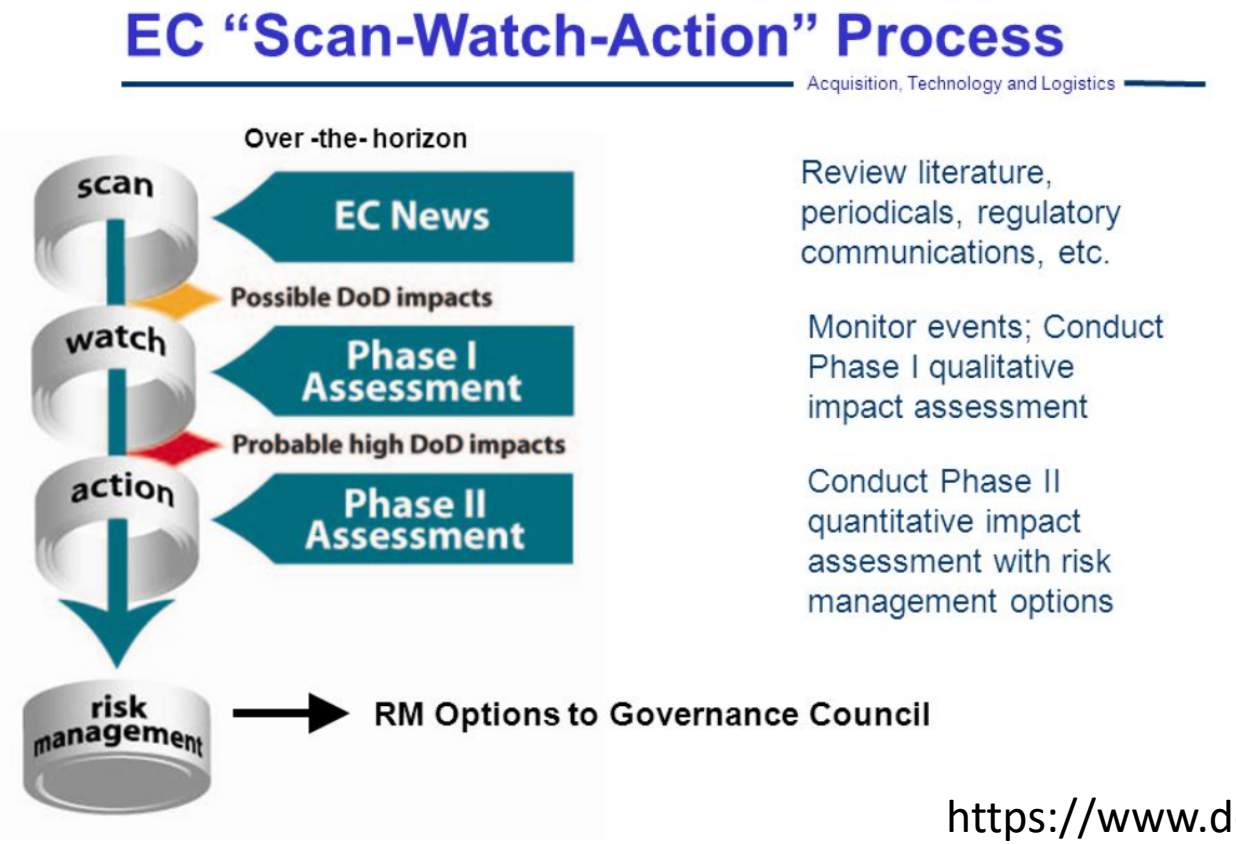
DASD (Env)

Questions

- 1) How might your research be applied to decision making at the department of defense?
- 2) What other methods might you use to train a model on semantics?
  - Supervised vs. unsupervised
- 3) Now that you are within the government, how would you approach the problem differently?
  - Ask lots of questions!! Learn the fed story and why implementation is difficult.

How might your research be applied to decision making at the department of defense?

- Automated scanning and screening of emerging contaminants



https://www.denix.osd.mil/

What other methods might you use to train a model on semantics?

- Supervised vs. Unsupervised (method I used) learning

Extra slides

- How might this be used?
- Future efforts?
- Why didn't you use DoD?
- How did you choose agencies?
- What type of data would you use to validate?

Expading beyond Keene

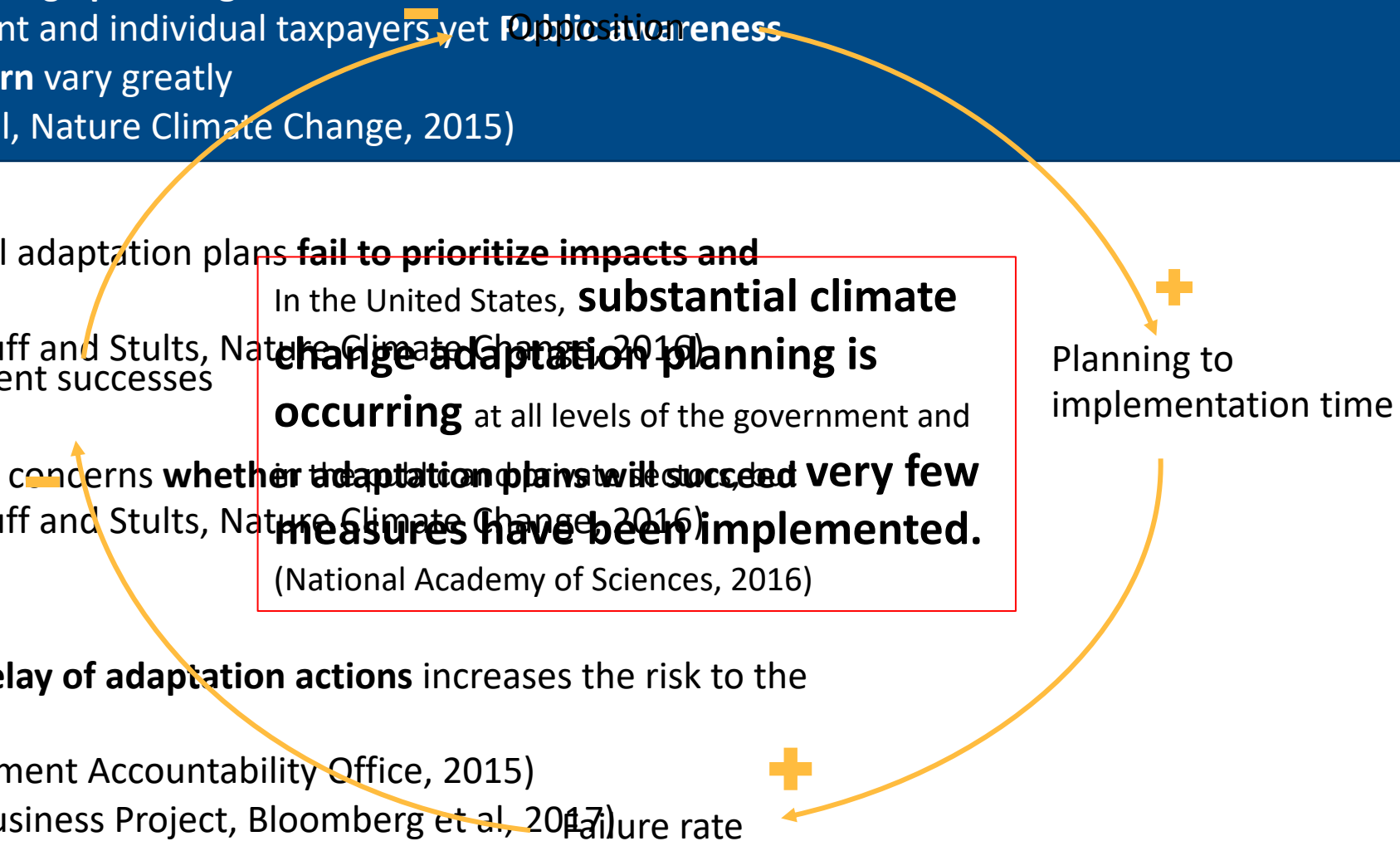
- ASAP matched Keene's communication infrastructure and emergency services vulnerabilities with USACE, EPA, and DOE, and USACE, respectively (Fig. 5; Table S2). Expert analysis indicates that FEMA might be the best primary match for these issues—hence the lower ASAP scores of the matched agencies. As discussed previously, FEMA's training dataset is not of the same quality as the other agencies included. Future development of the ASAP tool will strengthen FEMA's training data and could also expand the boundary of inquiry to all federal agencies.

- Climate change **poses significant risk** to the federal government and individual taxpayers yet **Public awareness and concern** vary greatly
  (Lee et al, Nature Climate Change, 2015)

- Many local adaptation plans **fail to prioritize impacts and strategies**
  (Woodruff and Stults, Nature Climate Change, 2016)

- This raises concerns **whether adaptation plans will succeed**
  (Woodruff and Stults, Nature Climate Change, 2016)

- **Further delay of adaptation actions** increases the risk to the nation
  (Government Accountability Office, 2015)
  (Risky Business Project, Bloomberg et al, 2017)



In the United States, **substantial climate change adaptation planning is occurring** at all levels of the government and in the private sector, but **very few measures have been implemented.**
(National Academy of Sciences, 2016)

Training Data

Federal Strategic Plans

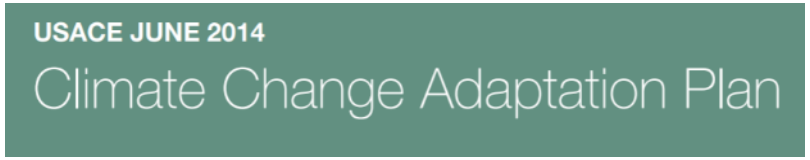
- Prepared for every agency
- Approved every four years

Verification Data

Federal Climate Change Action Plans (CCAPs)

- Prepared by every agency
- Proxy for risks and vulnerabilities within community climate action plans

---



Algorithm 1: Keyword vector space

Federal Strategic Plans

DOC | DOE | DOI | EPA | FEMA | HHS | HUD | USACE | USDA

	DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
Term 1									
Term 2									
Term 3									
Term 4									
Term 5									
Term 6									
Term 7									
Term 8									
Term 9									

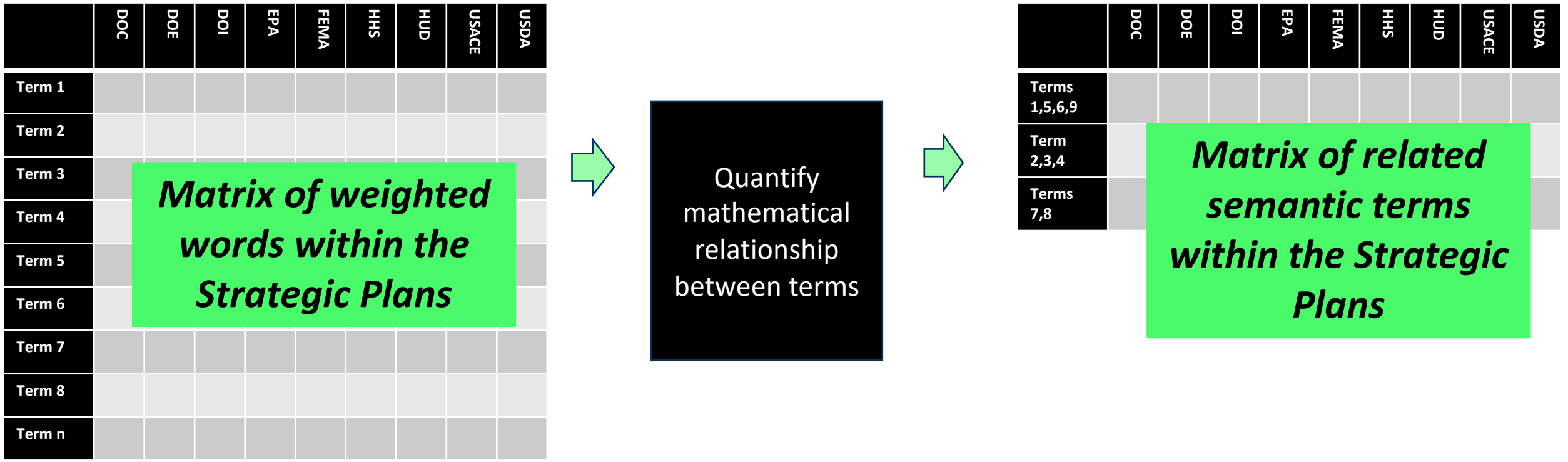
Rank by term frequency (TF)

Scale up rare terms (IDF)

	DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
Term 1									
Term 2									
Term 3									
Term 4									
Term 5									
Term 6									
Term 7									
Term 8									
Term 9									

Matrix of weighted words by Strategic Plan

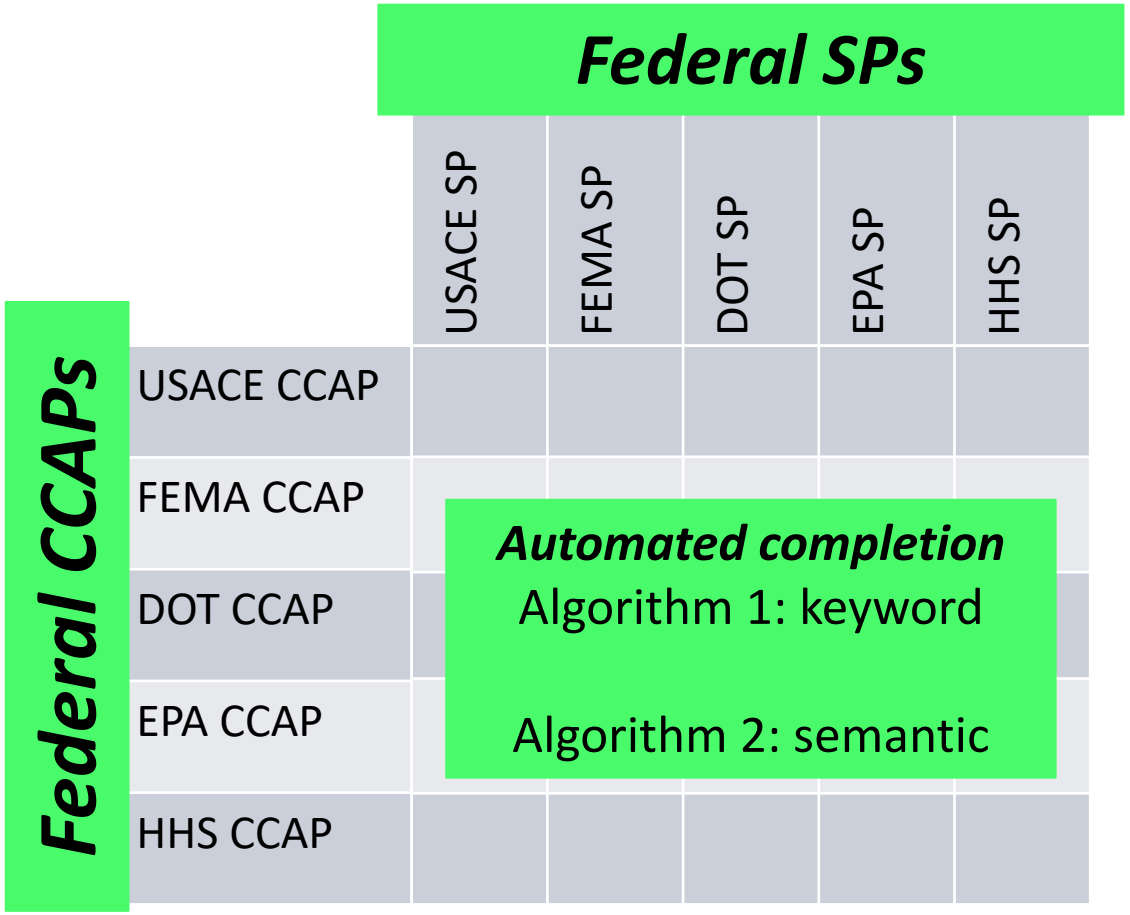
Algorithm 2: Semantic vector space



Verification of model concept

Federal climate change adaptation plans (CCAPS)

- Prepared by every agency
- **Proxy** for risks and vulnerabilities within community climate action plans



Federal Strategic Plans (SPs)

- Prepared by every agency
- **Approved** every four years by OMB