

Shale Gas Extraction in the United States: Perspectives from Academic Publications and Geo-Located Twitter Conversations

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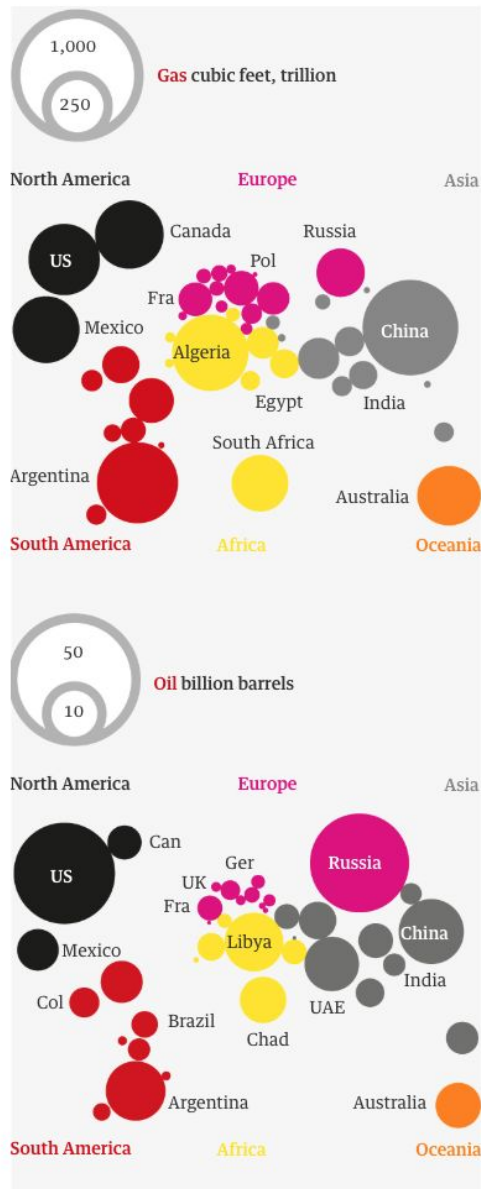
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ASSA 2019

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How much gas and oil is there in the world's shale reserves?



Guardian graphic. Source: US Energy Information Administration, Wet shale gas and tight oil resources as in September 2015

"The United States is in the midst of the **'unconventional revolution in oil and gas'** that, it becomes increasingly apparent, goes beyond energy itself. Today, **the industry supports 1.7m jobs** - a considerable accomplishment given the relative newness of the technology. **That number could rise to 3 million by 2020.** In 2012, this revolution **added \$62 billion to federal and state government revenues**, a number that we project could rise to about \$113 billion by 2020. It is helping to stimulate a manufacturing renaissance in the United States, improving the competitive position of the United States in the global economy, and beginning to affect global geopolitics."

Dr. Daniel Yergin, vice chair of global consulting firm IHS, Subcommittee on Energy and Power of the House Energy and Commerce Committee, Testimony submitted for Hearings on "America's Energy Security and Innovation" (February 5, 2013).

<https://docs.house.gov/meetings/IF/IF03/20130205/100220/HHRG-113-IF03-Wstate-YerginD-20130205.pdf>

Unprecedented development of fracking

In recent years, hydraulic fracturing and unconventional oil & gas developments **have increased exponentially across the United States:**

- Since 2005, technologies to more efficiently produce natural gas from shale and tight formations have driven prices down, spurring growth in consumption and net exports (EIA 2017)
- 4 million oil & gas related **wells** have been drilled in the United States
- 2 million of these have been **hydraulically fracture-treated**
- up to **95 percent of new wells** drilled today are hydraulically fractured
- 43% of the oil production and 67% of the natural gas production

(Source : US Dept. of Energy)



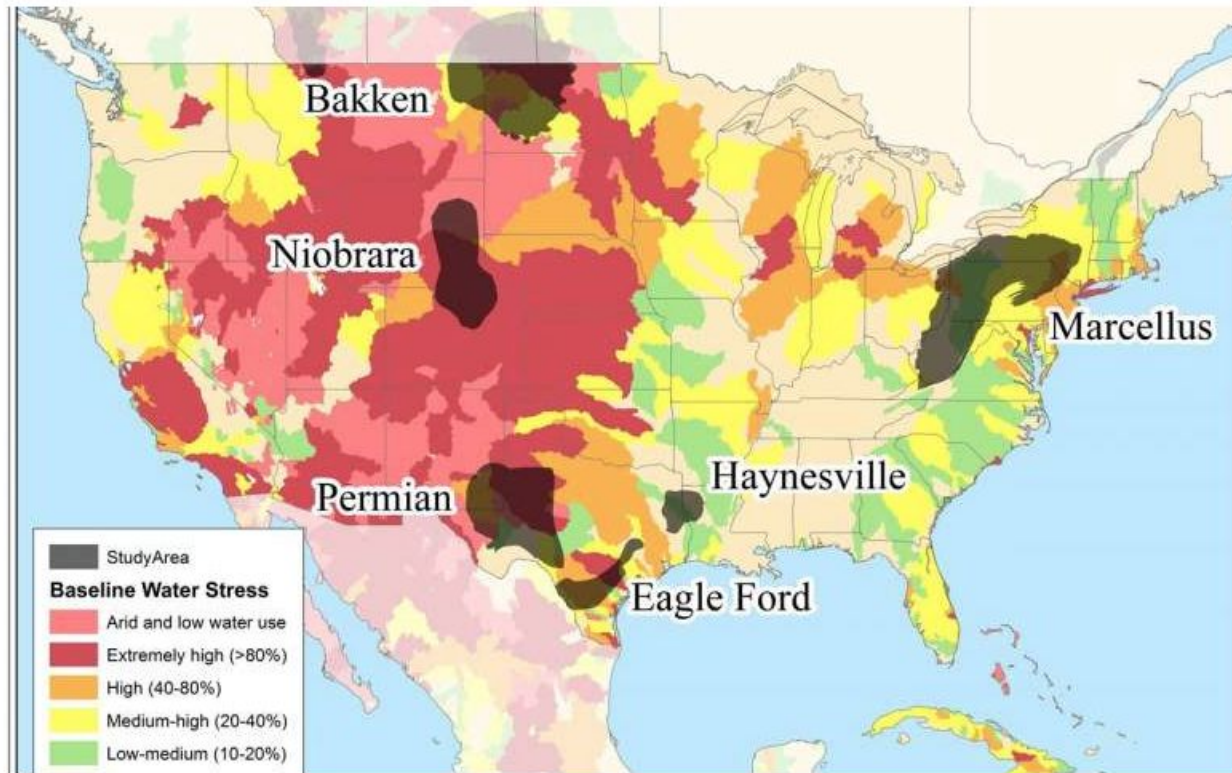
Estimate of Fracking Wells

State	Fracking Wells since 2005	Fracking Wells Drilled in 2012
Arkansas	4,910	719
Colorado	18,168	1,896
Kansas	407	236
Louisiana	2,327	139
Mississippi	9	Unavailable
Montana	264	174
New Mexico	1,353	482
North Dakota	5,166	1,713
Ohio	334	234
Oklahoma	2,694	Unavailable
Pennsylvania	6,651	1,349
Tennessee	30	Unavailable
Texas	33,753	13,540
Utah	1,336	765
Virginia	95	1
West Virginia*	3,275	610
Wyoming	1,126	468
TOTAL	81,898	22,326

(Environment America, 2013)

Water use for fracking has risen by up to 770 percent since 2011

August 15, 2018, Duke University



The volume of water used for fracking energy resources (gray areas) has risen sharply in recent years, raising concerns about its sustainability in regions where water resources are stressed. Credit: Duke University

These activities **have raised concerns** in some communities about potential environmental and health issues/impacts, especially on people living in communities proximate to hydrofracking sites.

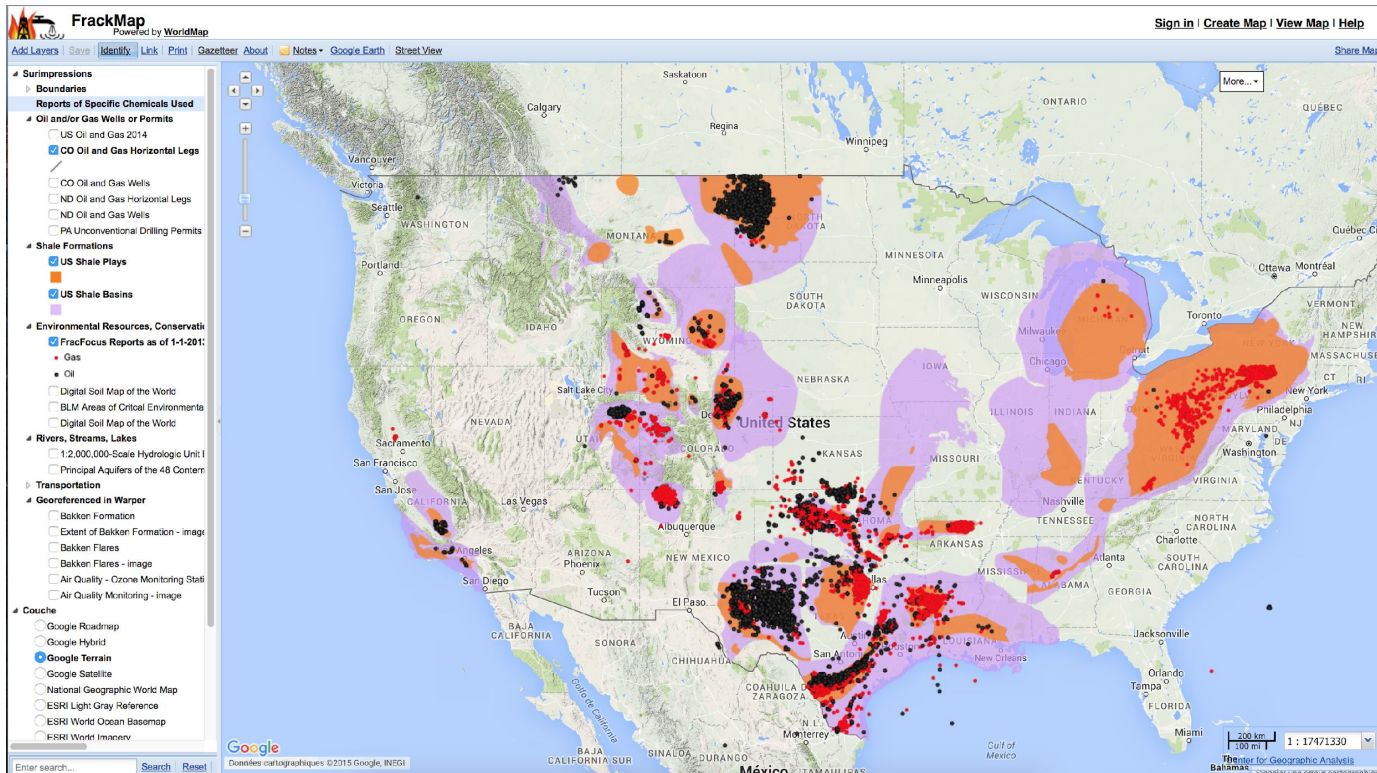
In this article, we explore the contrast between :

(1) the scientific publications about fracking and the potential questions about environmental and health impacts

(2) the perception of the local population

- The methodology used in this article is based on unstructured data from Twitter as well as scientific publications.
- Mapping techniques are also extensively used to map all the shale gas wells and the geo-located conversations on Twitter.

FrackMap brings together a range of fracking related datasets



- Data: oil and gas permits, shale formations, horizontal legs, reports of specific chemical used
- Publicly available data

FrackMap offers a geographical illustration of the raw data

Harvard WorldMap a public domain collaborative mapping platform

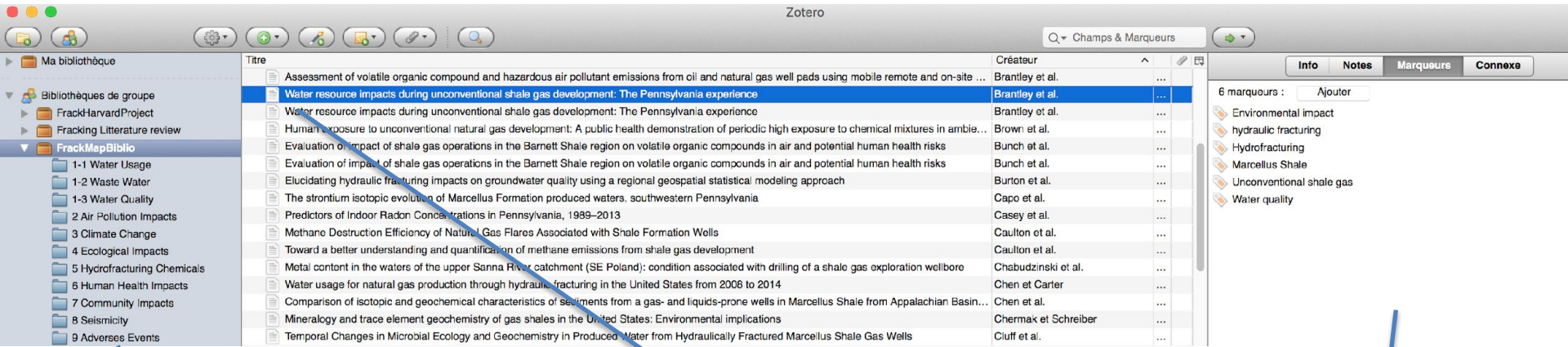
<http://worldmap.harvard.edu/maps/FrackMap>

(1) FrackMap-Biblio

To map, by state, the **current scientific knowledge and peer-reviewed literature** about potential environmental and health issues and impacts associated with U.S. shale gas plays.

FrackMap-Biblio : Methodology

- Review of current and past peer-reviewed literature
- Systematically searched and screened for studies about environmental and health impacts in the US
- **Studies published from January 2005 to December 2015.**
- **Databases** : PubMed, MEDLINE, ScienceDirect, Scopus, Web of science, Proquest, Google Scholar, etc.
- **Key research terms** were developed to ensure that all potentially relevant studies with content related to hydraulic fracturing and environmental and health impacts were identified.
- **Data location included for US** : State, County, City, Shale Play, River, Lake,
- References lists in the relevant studies were scanned to the scope of our review.
- References were classified by topics.



Type de document: Article de revue
Titre: Water resource impacts during unconventional shale gas development: The Pennsylvania experience
Auteur: Brantley, Susan L.
Auteur: Yoxtheimer, Dave
Auteur: Arjmand, Sina
Auteur: Grieve, Paul
Auteur: Vidic, Radisav
Auteur: Pollak, Jon
Auteur: Llewellyn, Garth T.
Auteur: Abad, Jorge
Auteur: Simon, Cesar
(...) Résumé: Improvements in horizontal drilling and hydrofracturing ha...
Publication: International Journal of Coal Geology
Volume:
Numéro:
Pages:
Date: 2014
Collection:
Titre de la coll.:
Texte de la coll.:
Abrév. de revue: International Journal of Coal Geology
Langue:
DOI: 10.1016/j.coal.2013.12.017
ISSN: 0166-5162
Titre abrégé: Water resource impacts during unconventional shale gas development
URL: http://www.sciencedirect.com/science/article/pii/S0166516...
Consulté le:
Archive:
Loc. dans l'archive:
Catalogue de bibli.: ScienceDirect

7 marqueurs : Ajouter

- Environmental impact
- hydraulic fracturing
- Hydrofracturing
- Marcellus Shale
- Pennsylvania
- Unconventional shale gas
- Water quality

**500 references
peer-reviewed + location**

- Library
- 1-1 Water Usage
- 1-2 Waste Water
- 1-3 Water Quality
- 10 International
- 11 Regulation
- 2 Air Pollution Impacts
- 3 Climate Change
- 4 Ecological Impacts
- 5 Hydrofracturing Chemicals
- 6 Human Health Impacts**
- 7 Community Impacts
- 8 Seismicity
- 9 Adverses Events
- TO REMOVE
- Trash

Tags

[More](#) [Refresh](#)

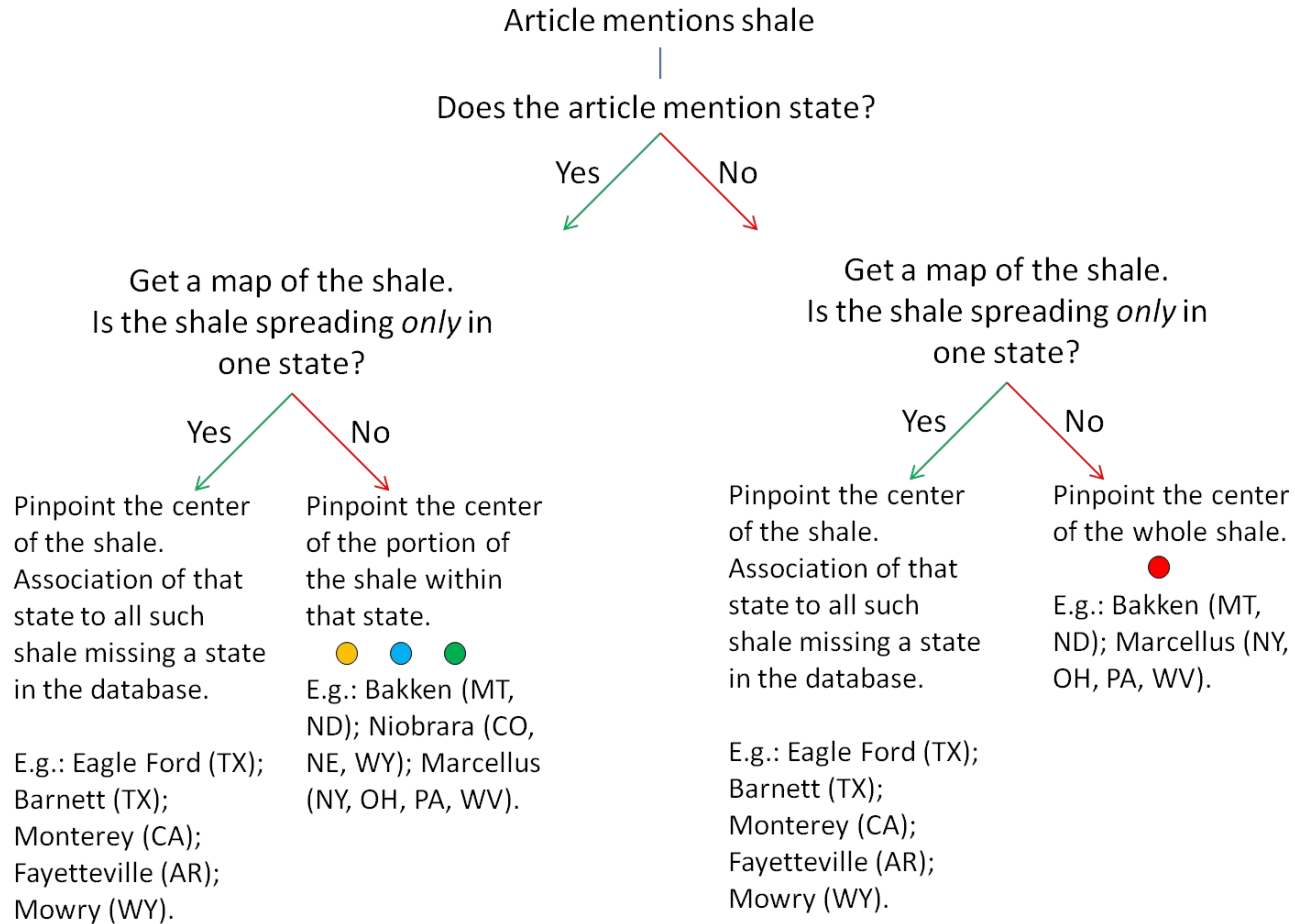
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Evaluation of impact of shale gas operations in the Barnett Shale region on volatile organic compounds in air and potential human health risks

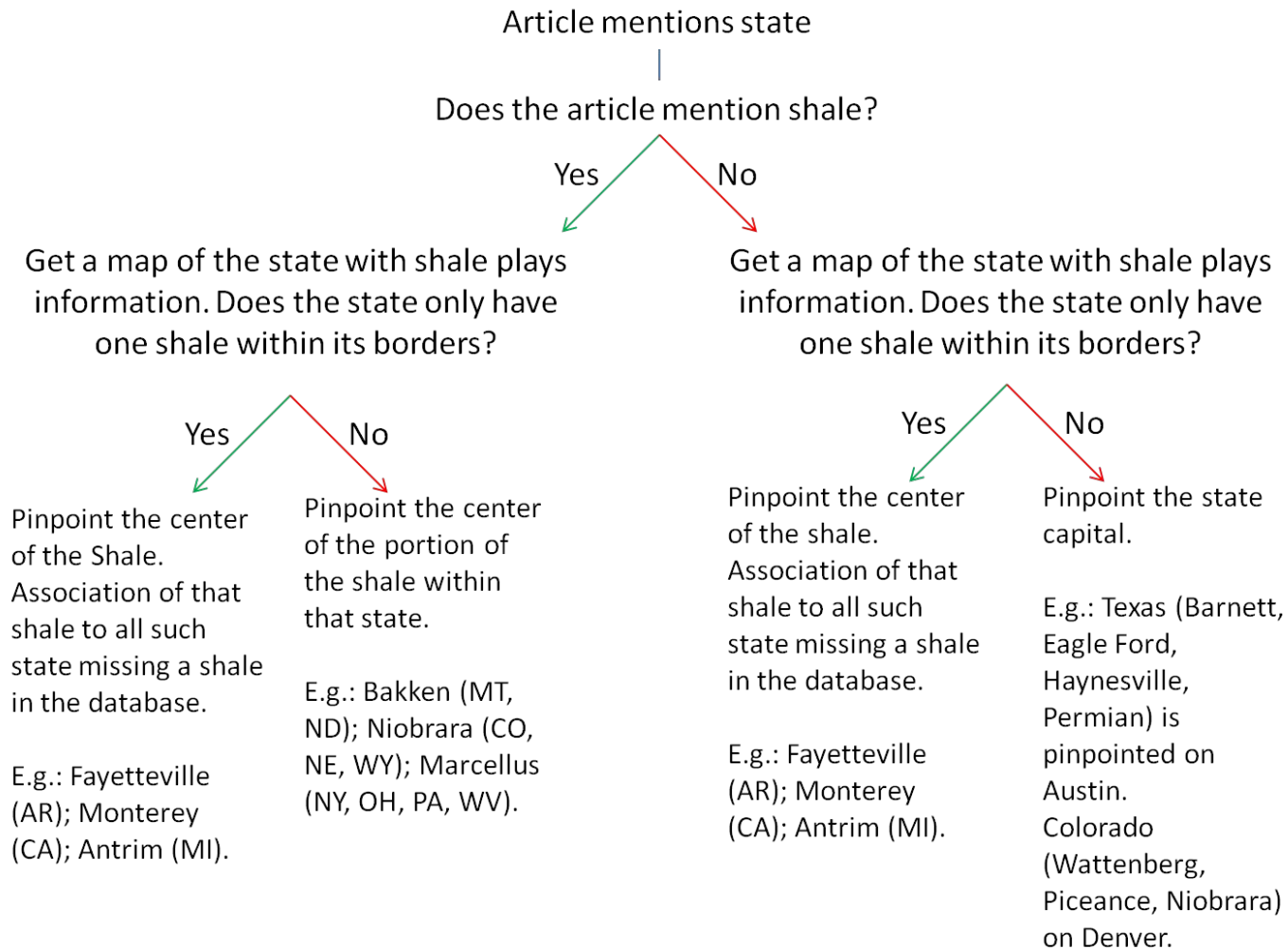
Added By	demarcen
Item Type	Journal Article
Title	Evaluation of impact of shale gas operations in the Barnett Shale region on volatile organic compounds in air and potential human health risks
Author	Bunch, A. G.
Author	Perry, C. S.
Author	Abraham, L.
Author	Wikoff, D. S.
Author	Tachovsky, J. A.
Author	Hixon, J. G.
Author	Urban, J. D.
Author	Harris, M. A.
Author	Haws, L. C.
Abstract	Shale gas exploration and production (E&P) has experienced substantial growth across the U.S. over the last decade. The Barnett Shale, in north-central Texas contains one of the largest, most active onshore gas fields in North America, stretching across 5000 square miles and having an estimated 15,870 producing wells as of 2011. Given that these operations may occur in relatively close proximity to populated/urban areas, concerns have been expressed about potential impacts on human health. In response to these concerns, the Texas Commission on Environmental Quality established an extensive air monitoring network in the region. This network provides a unique data set for evaluating the potential impact of shale gas E&P activities on human health. As such, the objective of this study was to evaluate community-wide exposures to volatile organic compounds (VOCs) in the Barnett Shale region. In this current study, more than 4.6 million data points (representing data from seven monitors at six locations, up to 105 VOCs/monitor, and periods of record dating back to 2000) were evaluated. Measured air concentrations were compared to federal and state health-based air comparison values (HBACVs) to assess potential acute and chronic health effects. None of the measured VOC concentrations exceeded applicable acute HBACVs. Only one chemical (1,2-dibromoethane) exceeded its applicable chronic HBACV, but it is not known to be associated with shale gas production activities. Annual average concentrations were also evaluated in deterministic and probabilistic risk assessments and all risks/hazards were below levels of concern. The analyses demonstrate that, for the extensive number of VOCs measured, shale gas production activities have not resulted in community-wide exposures to those VOCs at levels that would pose a health concern. With the high density of active wells in this region, these findings may be useful for understanding potential health risks in other shale play regions.
Publication	Science of The Total Environment
Volume	468-469
Pages	832-842
Date	January 15, 2014
Journal Abbr	Science of The Total Environment
DOI	10.1016/j.scitotenv.2013.08.080
ISSN	0048-9697
URL	http://www.sciencedirect.com/science/article/pii/S0048969713010073
Accessed	2016-01-13 07:18:20
Library Catalog	ScienceDirect
Tags	Air quality · Barnett Shale · Human health · Natural Gas · Risk Assessment · Shale

- Notes and Attachments**
- [ScienceDirect Snapshot \(html\)](#) ([Attachment Details](#))
 - [ScienceDirect Full Text PDF \(pdf, 903.7 KB\)](#) ([Attachment Details](#))

Methodology: gather geographical data within articles and pinpoint publications on a map



Methodology: gather geographical data within articles and pinpoint publications on a map



Spatial Relationships between Fracking Sites and Health Research

Surimpressions
Health & Human Ecology
FrackMap Biblio

- Human Health Impacts
 - 1.0
 - > 1.0 AND <= 2.0
 - > 2.0 AND <= 3.0
 - > 3.0 AND <= 6.0
 - > 6.0 AND <= 14.0
- Water Quality
- Waste Water

Ma bibliothèque

- Environmental Health
- frackmap
- Innovation
- Patient safety
- GI
- Regulation by Information
- Reputation
- Reputation Twitter
- Risk perception
- Risques
- Social Media
- TMD
- Doublets
- Non classés
- Corbelle

Bibliothèques de groupe

- FrackHarvardProject
- Fracking Literature review
- FrackMapBiblio
 - 1-1 Water Usage
 - 1-2 Waste Water
 - 1-3 Water Quality
 - 10 International
 - 11 Regulation
 - 2 Air Pollution Impacts
 - 3 Climate Change
 - 4 Ecological Impacts
 - 5 Hydrofracturing Chemicals
 - 6 Human Health Impacts
 - 7 Community Impacts
 - 8 Seismicity
 - 9 Adverses Events

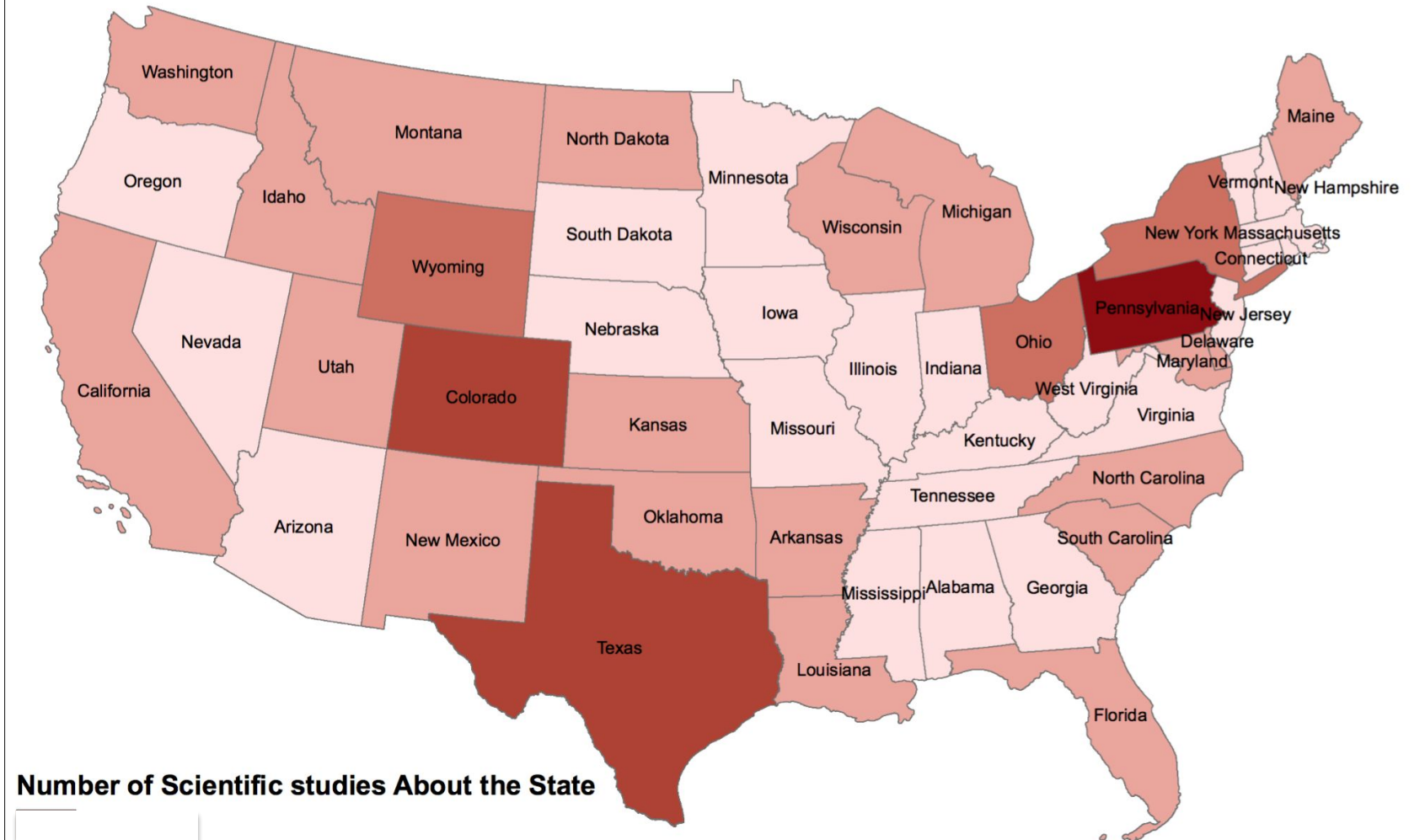
The

- Assessing worker exposure to inhaled volatile organic compounds from Marcellus Shale fo... Crature
- Hazard Ranking Methodology for Assessing Health Impacts of Unconventional Natural Gas... Bloodahl et al.
- Human exposure to unconventional natural gas development: A public health demonstratio... Boyle et al.
- Evaluation of impact of shale gas operations in the Barnett Shale region on volatile organi... Brown et al.
- Predictors of Indoor Radon Concentrations in Pennsylvania, 1989-2013 Bunch et al.
- Unconventional Natural Gas Development and Birth Outcomes in Pennsylvania, USA Casey et al.
- Natural Gas Operations from a Public Health Perspective Casey et al.
- Shale Gas Extraction in North Carolina: Research Recommendations and Public Health Im... Coborn et al.
- Occupational exposures to respirable crystalline silica during hydraulic fracturing Down et al.
- Evaluation of Some Potential Chemical Exposure Risks During Flowback Operations in Unc... Essewini et al.
- The Barnett Shale: From problem formulation to risk management Essewini et al.
- Birth Outcomes and Natural Gas Development: Methodological Limitations Ethridge et al.
- Assessment and longitudinal analysis of health impacts and stressors perceived to result fo... Fedak et al.
- The rush to drill for natural gas: a public health cautionary tale Fenar et al.
- Childhood cancer incidence in Pennsylvania counties in relation to living in counties with hy... Finkel et al.
- Iodide, Bromide, and Ammonium in Hydraulic Fracturing and Oil and Gas Wastewaters: En... Fryczek et al.
- Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates Harkness et al.
- Unconventional natural gas development and public health: toward a community-informed r... Jemielita et al.
- Environmental Health Advocacy: An Overview of Natural Gas Drilling in Northeast Pennsylv... Korfmecher et al.
- Air Contaminants Associated with Potential Respiratory Effects from Unconventional Resou... Lauver
- Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural C... McCawley
- Human health risk assessment of air emissions from development of unconventional natural... McKenzie et al.
- Spatial analysis of environment and population at risk of natural gas fracking in the state of... Meng
- Spatial analysis of environment and population at risk of natural gas fracking in the state of... Meng
- Lung Cancer Risk from Radon in Marcellus Shale Gas in Northeast U.S. Homes Meng, Qingmin
- High volume hydraulic fracturing operations: potential impacts on surface water and human... Mitchell et al.
- Spatial distribution of unconventional gas wells and human populations in the Marcellus Sh... Mitchell, Austin L.; Griffin, W. Michael; Casman, Elizabeth A.
- Updated methods for assessing the impacts of nearby gas drilling and production on neighb... Ogneva-Himmelsberger et H...
- Popular Epidemiology and "Fracking": Citizens' Concerns Regarding the Economic, Environ... Powers et al.
- Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Surve... Rabinowitz et al.
- Elevated Atmospheric Levels of Benzene and Benzene-Related Compounds from Unconve... Rich et Ormology
- Field Survey of Health Perception and Complaints of Pennsylvania Residents in the Marcell... Saberi et al.
- Reported health conditions in animals residing near natural gas wells in southwestern Penn... Slizovskiy, Ilya B. et al.

State: Pennsylvania Shale: Marcellus

Title	Author(s)	Year
Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates	Jemielita, Thomas; Gerton, George L.; Neidell, Matthew; Chillrud, Steven; Yan, Beizhan; Stute, Martin; Howarth, Marilyn; Saberi, Pouné; Faust, Nicholas; Penning, Trevor M.; Roy, Jason; Propert, Kathleen J.; Panettieri, Reynold A.	2015
Spatial analysis of environment and population at risk of natural gas fracking in the state of Pennsylvania, USA	Meng, Qingmin	2015
Lung Cancer Risk from Radon in Marcellus Shale Gas in Northeast U.S. Homes	Mitchell, Austin L.; Griffin, W. Michael; Casman, Elizabeth A.	2016
Field Survey of Health Perception and Complaints of Pennsylvania Residents in the Marcellus Shale Region	Saberi, Pouné; Propert, Kathleen Joy; Powers, Martha; Emmett, Edward; Green-McKenzie, Judith	2014
Exposure pathways related to shale gas development and procedures for reducing environmental and public risk	Ziemkiewicz, P. F.; Quaranta, J. D.; Darnell, A.; Wise, R.	2014

Scientific Studies Published About Environmental Health Impacts of Unconventional Gas Development



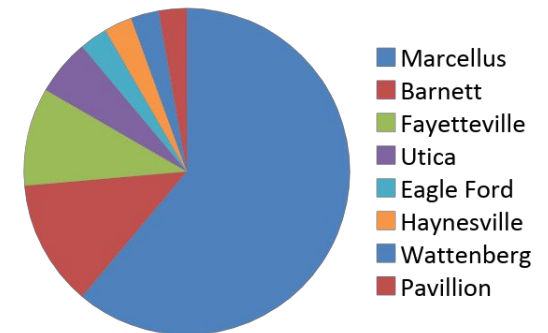
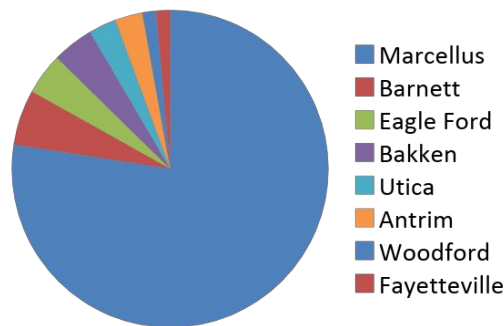
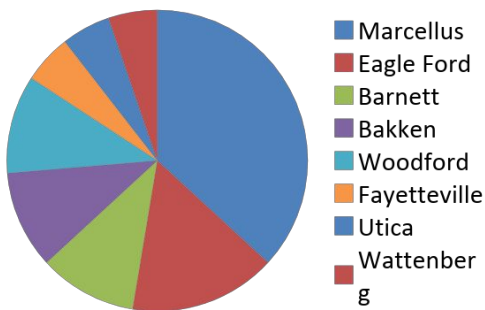
Source : Own Computation (Backus, A. and De Marcellis-Warin, N, 2016)

Water-related articles and [State; Shale] data

1-1 Water Usage	100%	23
Marcellus	30%	7
Eagle Ford	13%	3
Barnett	9%	2
Bakken	9%	2
Woodford	9%	2
Fayetteville	4%	1
Utica	4%	1
Wattenberg	4%	1

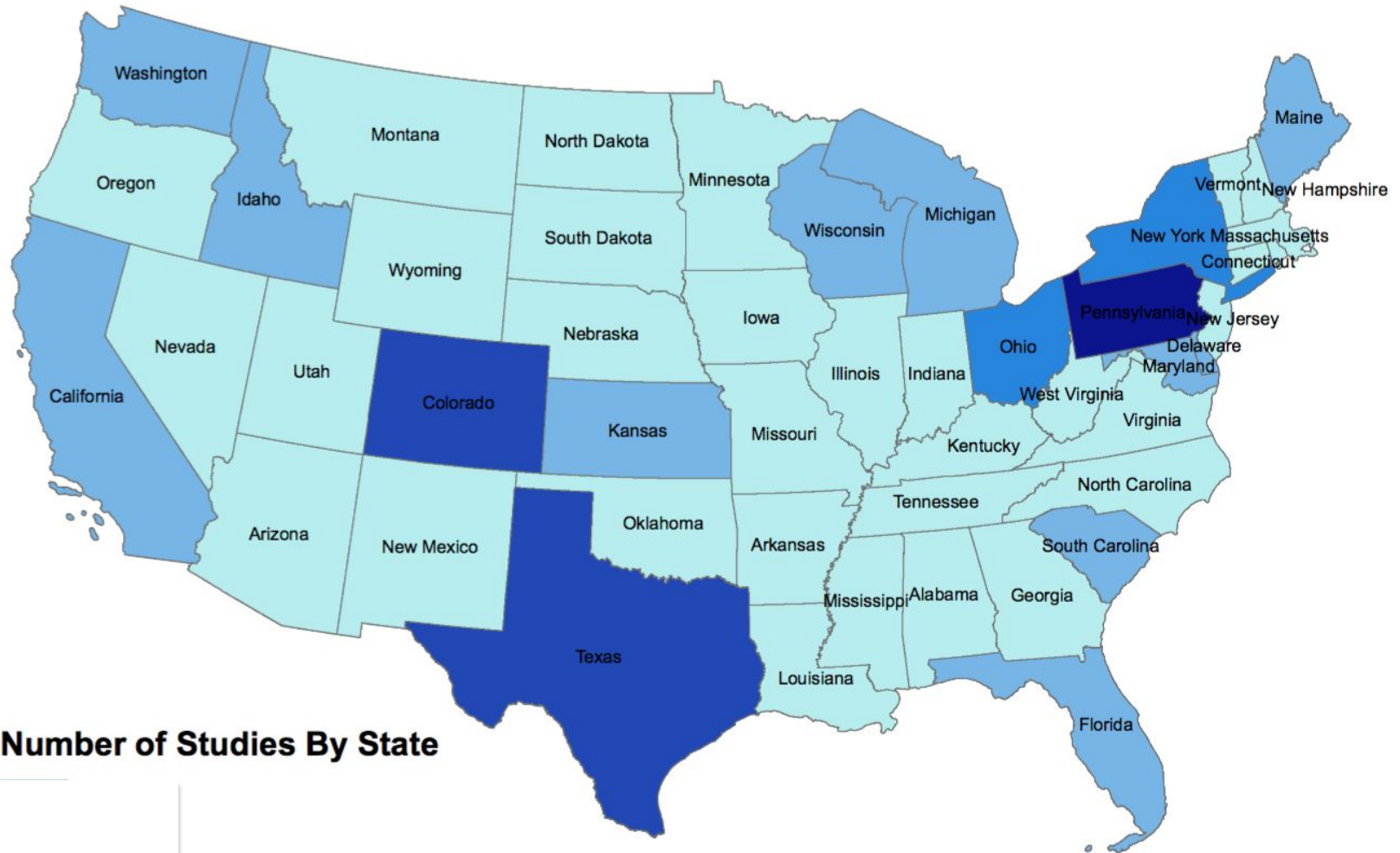
1-2 Waste Water	100%	76
Marcellus	72%	55
Barnett	5%	4
Eagle Ford	4%	3
Bakken	4%	3
Utica	3%	2
Antrim	3%	2
Woodford	1%	1
Fayetteville	1%	1

1-3 Water Quality	100%	80
Marcellus	55%	44
Barnett	11%	9
Fayetteville	9%	7
Utica	5%	4
Eagle Ford	3%	2
Haynesville	3%	2
Wattenberg	3%	2
Pavillion	3%	2



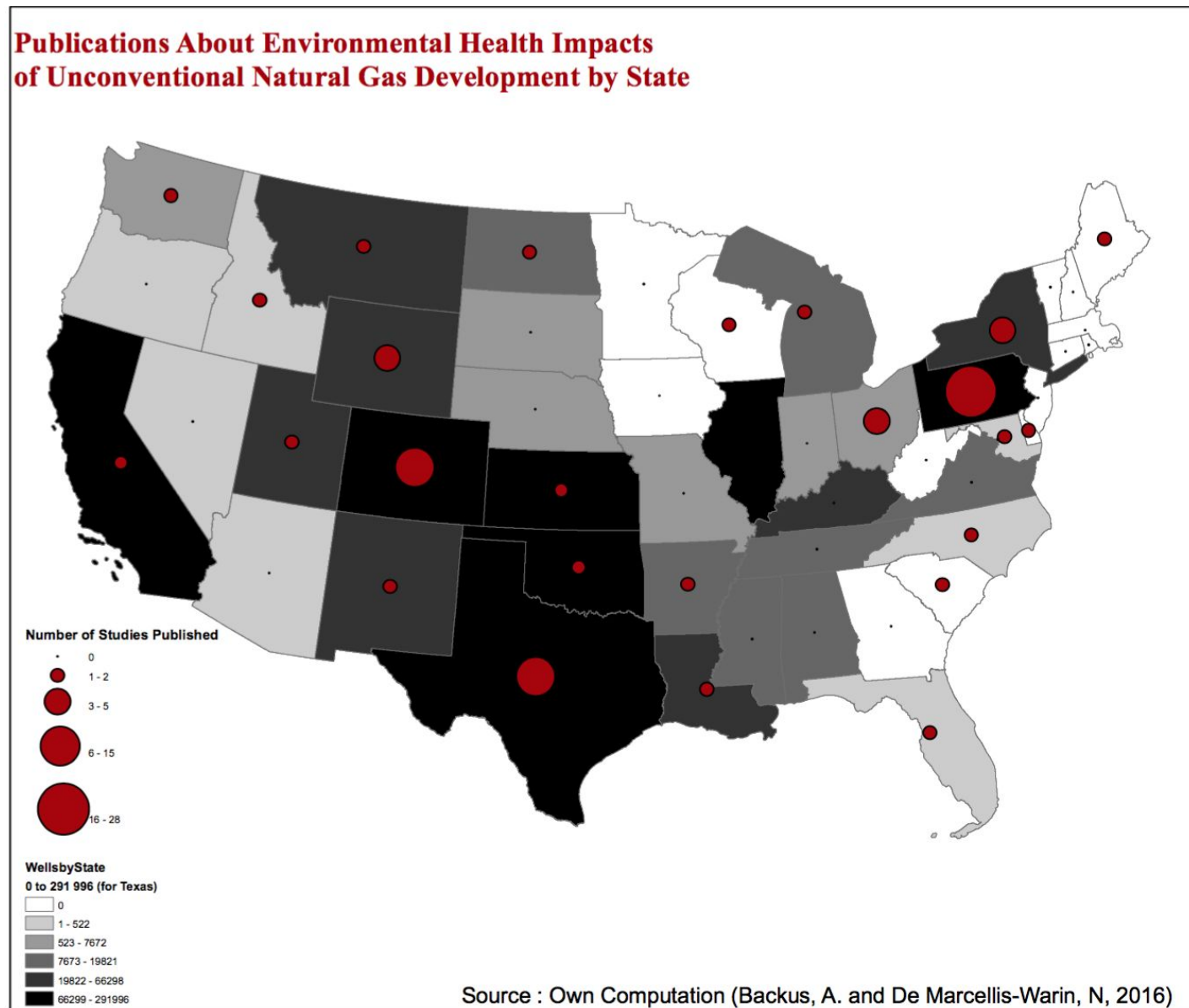
Here, only the mention « Haynesville » is accounted for. There's another single mention (1) for « Haynesville-Bossier », and another single mention (1) for « Texas-Haynesville ». Possible to merge the three Haynesville together (total number of mentions: 4).

Publications About Water Quality of Unconventional Natural Gas Development



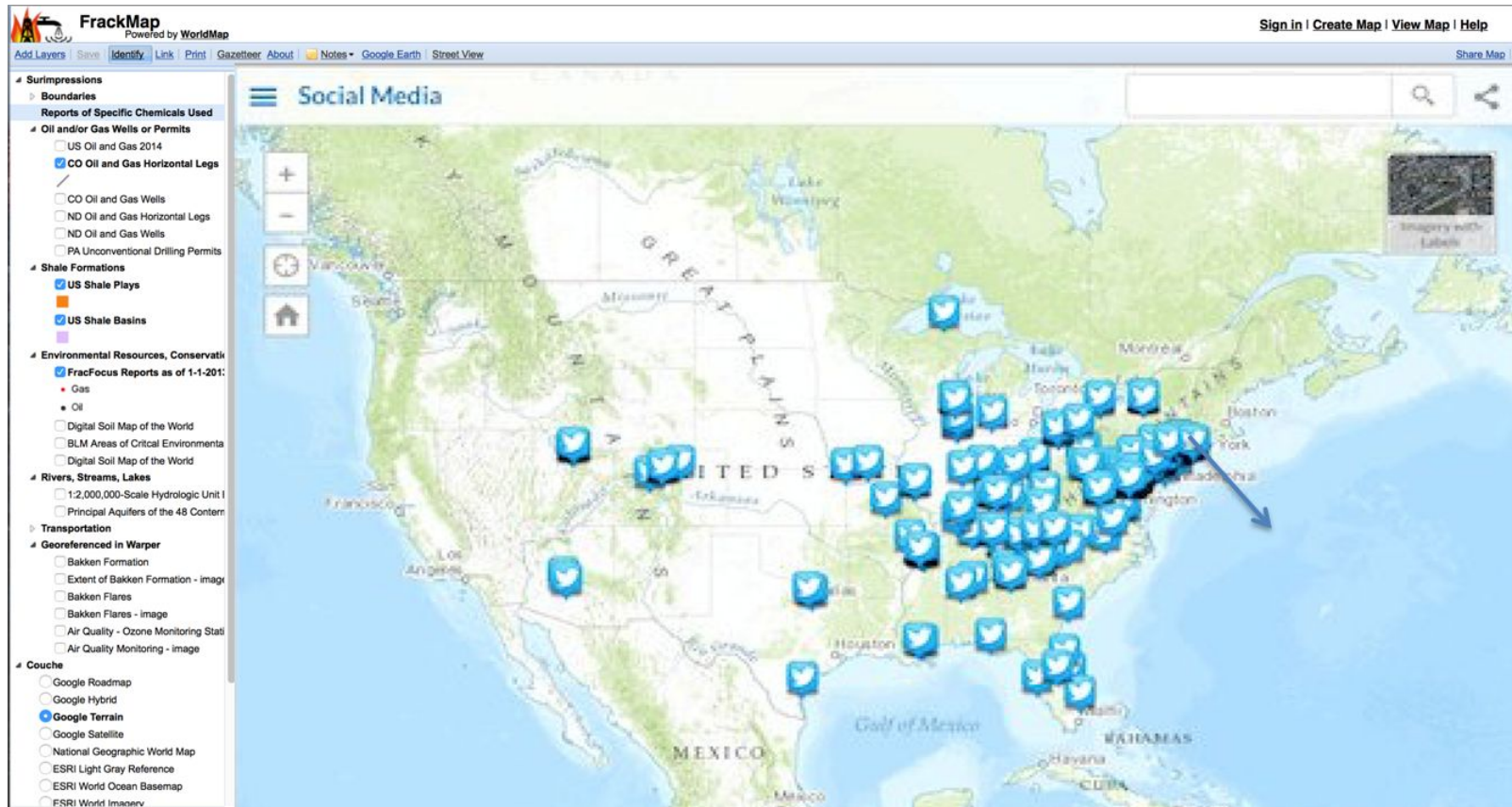
Number of Studies By State

Cross-analysis of FrackMap's data and FrackMap-Biblio's data



(2) FrackMap-Tweets

Track and illustrate public engagement with fracking-related issues by analyzing Twitter conversations (**65,000 geolocalized Tweets**)



FrackMap-Tweets : Methodology

Methodology for Harvesting Data:

1 Tweet = 140 characters maximum, including keywords-hashtags (+ image)

To map conversations on Twitter, using hashtags of the keywords used for FrackMap-Biblio

–#Fracking #FrackingWasteWater #FrackQuake #EarthQuake

–#ShaleOil #ShaleGas

–#Marcellusshale #Uticashale #BarnettShale #BakkenShale #EagleFordshale

Data from Harvard Center Geographic Analysis : « One Billion Tweets Project »

–Harvard CGA Geolocated Archive

–September 2012 to December 2015

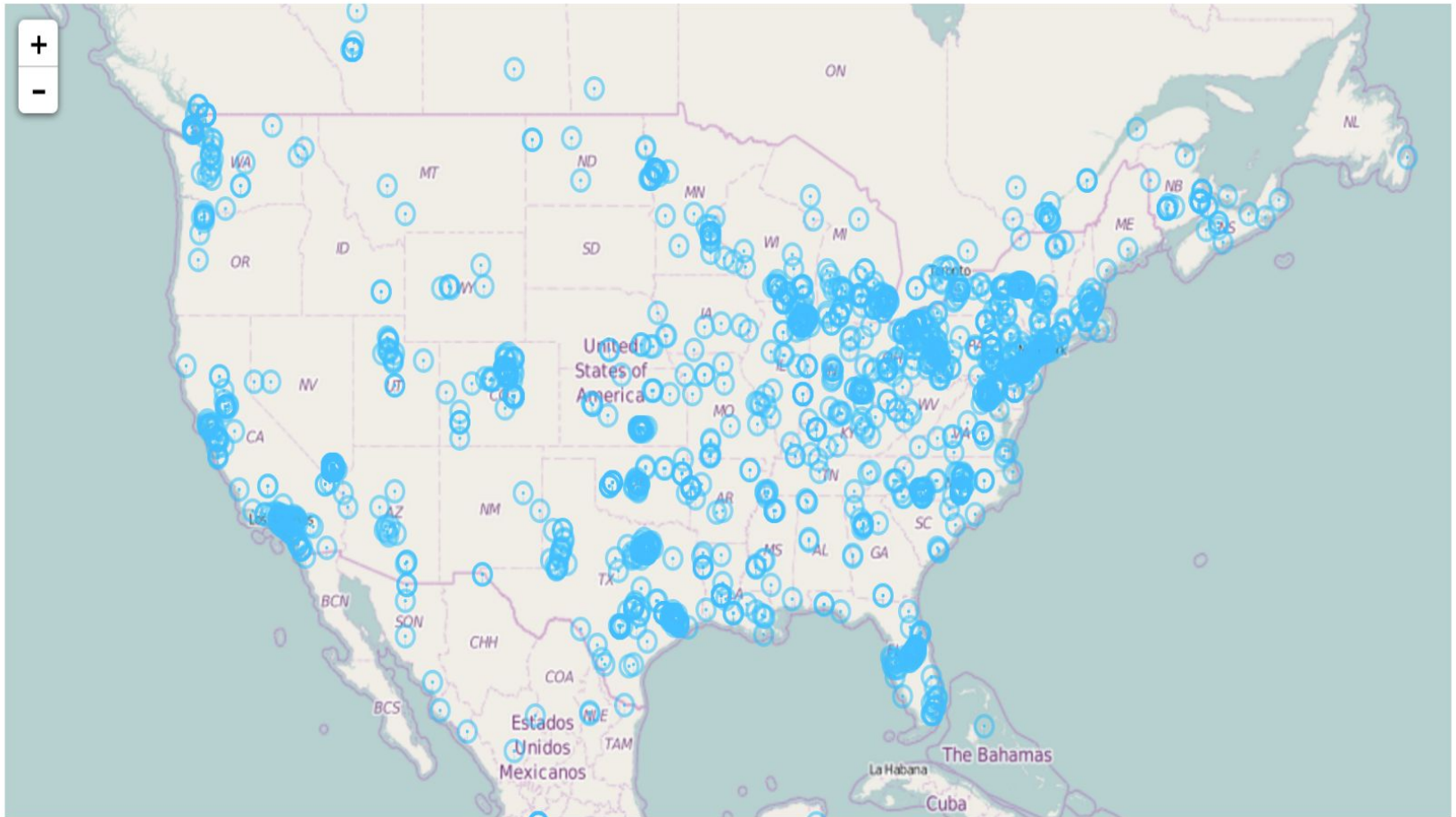
–Geotagged Tweets

–List of # and keywords

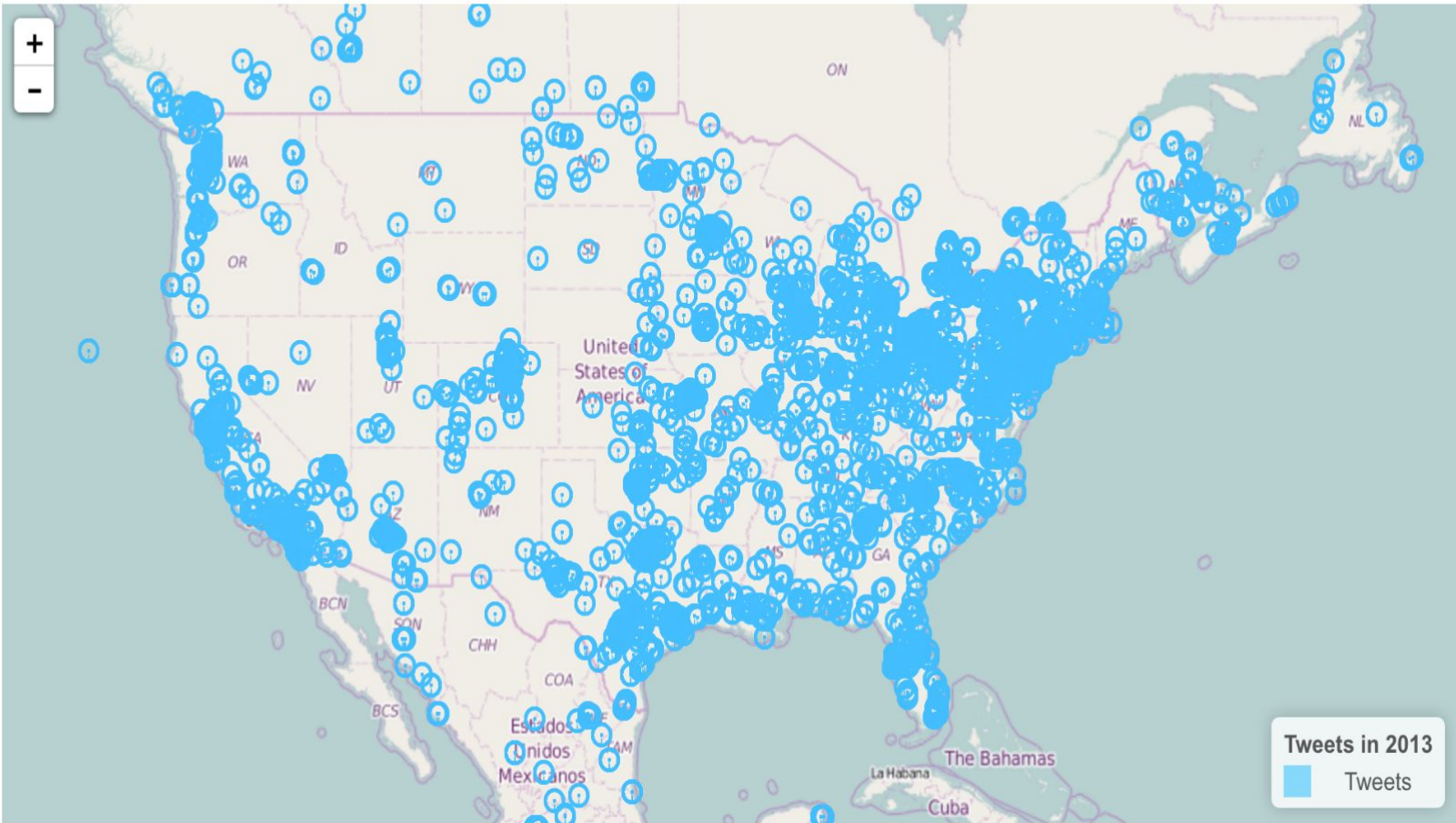
➤ **65 000 tweets**

Use of the **Nuance-R technological Platform** (PI: Warin, T. 2015)

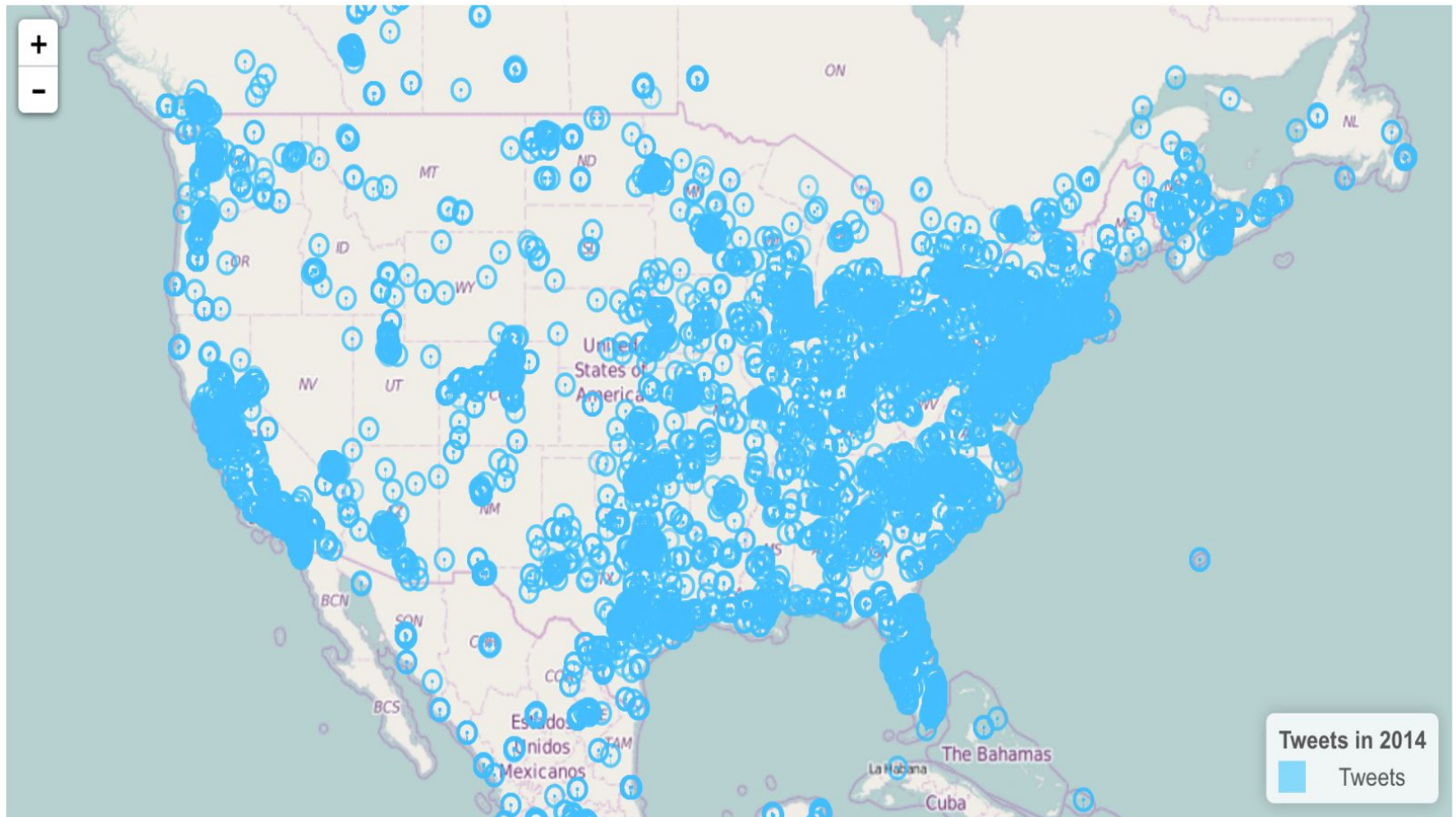
Mapping the tweets [2012]



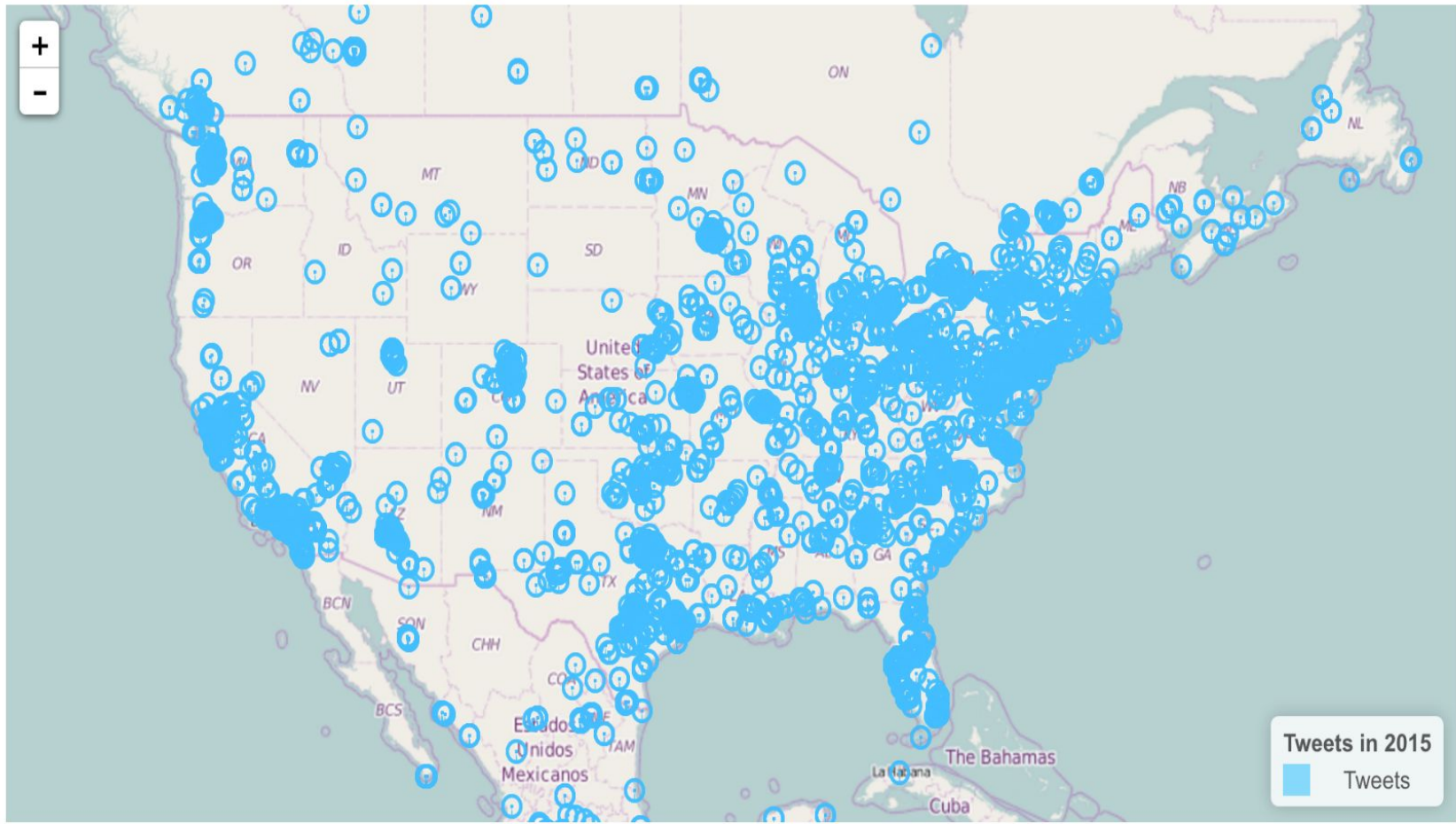
Mapping the tweets [2013]



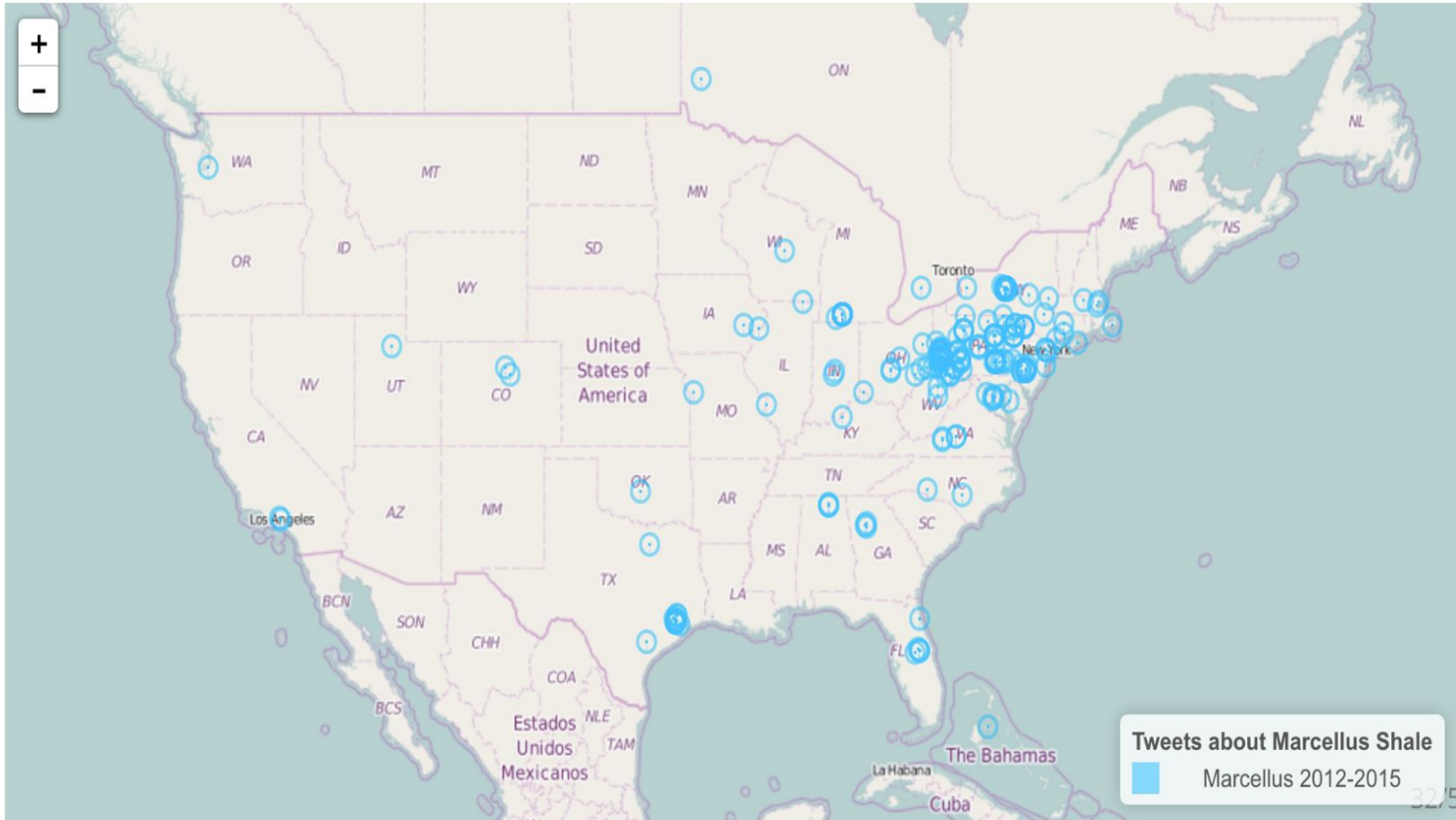
Mapping the tweets [2014]



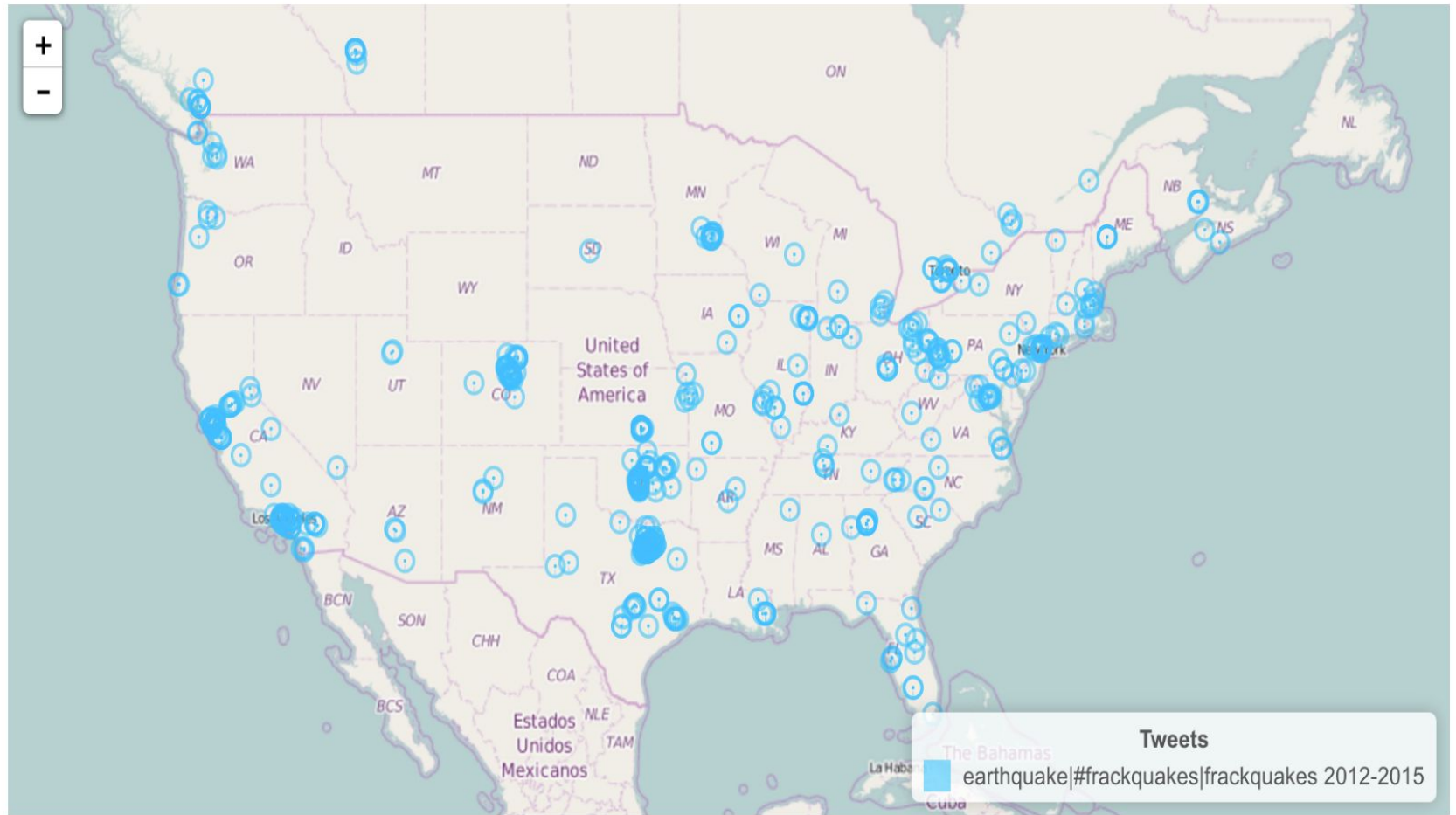
Mapping the tweets [2015]



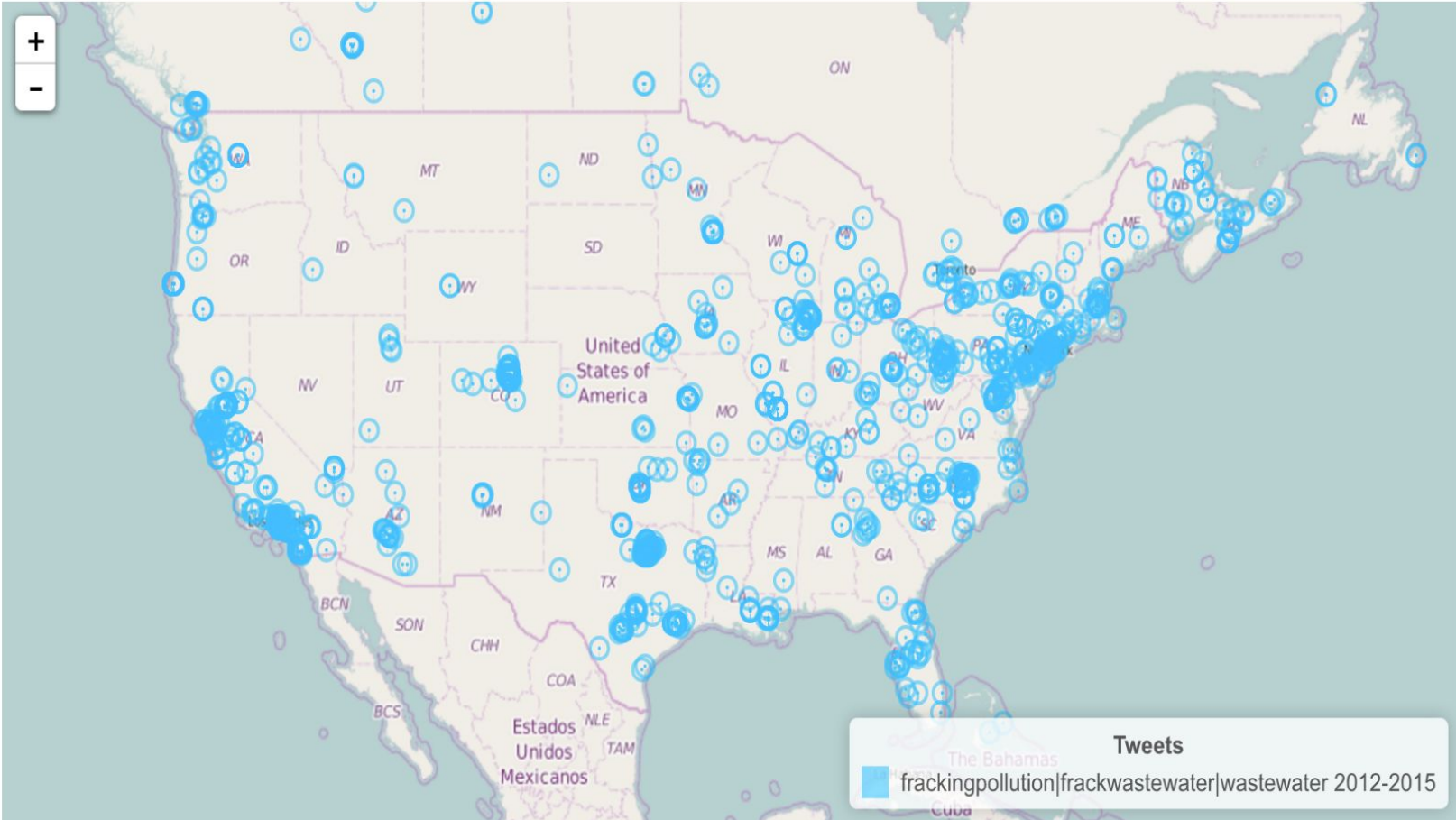
Mapping the tweets by shale play : Marcellus



Mapping the tweets by topic : Earthquake

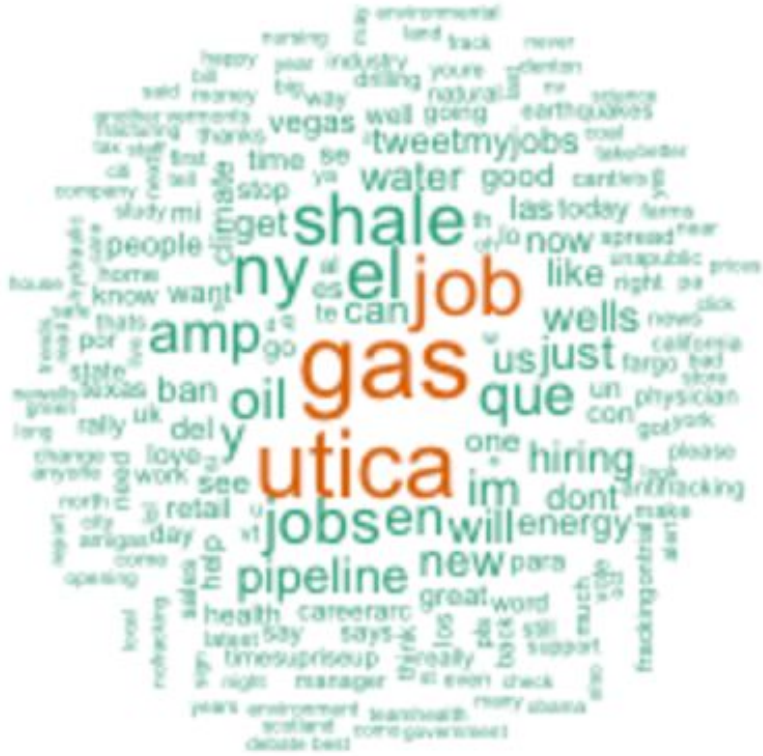


Mapping the tweets by topic : Water Impacts



Opinion Formation: "Relevant" words by count

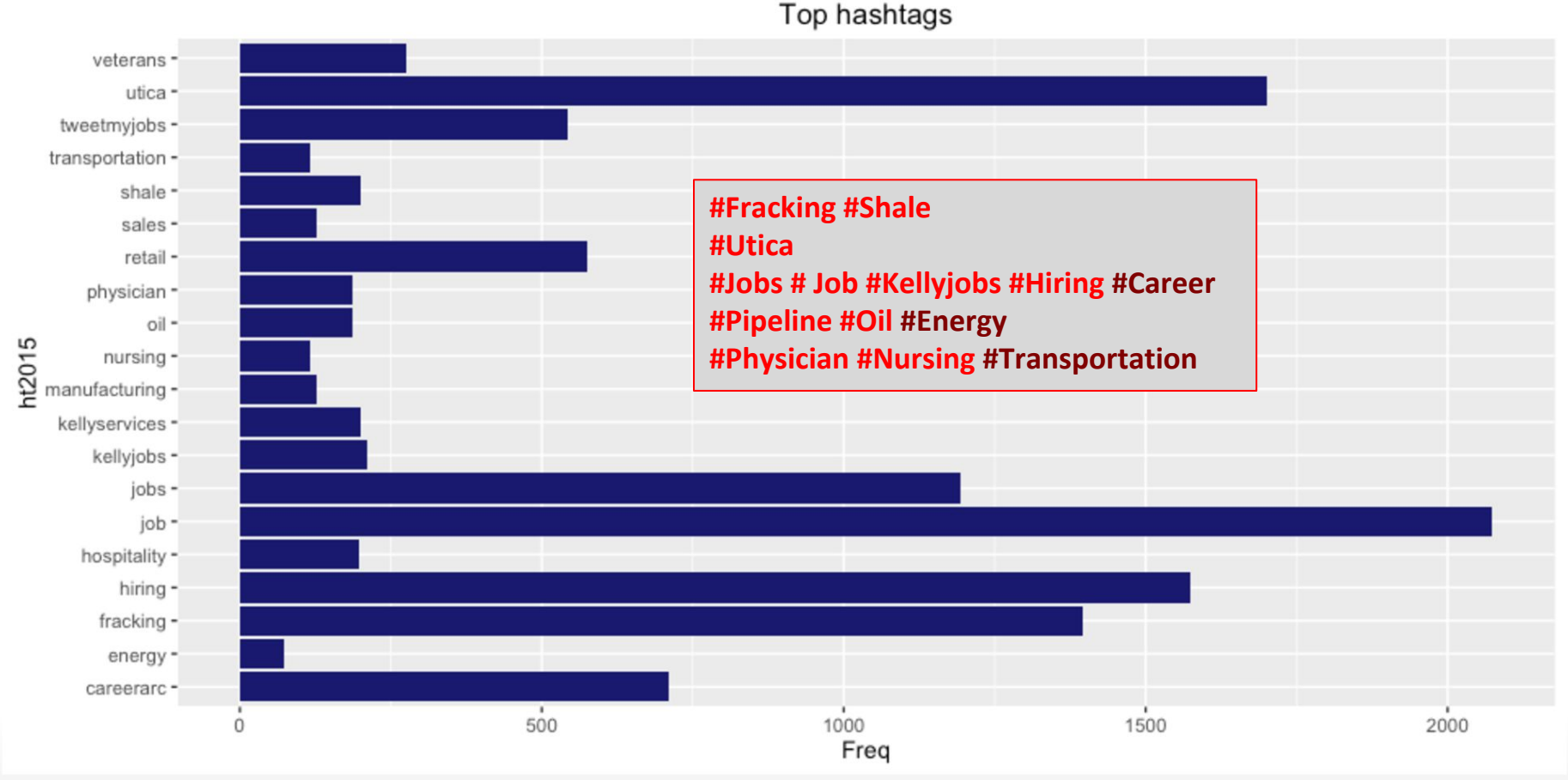
2012 to 2015



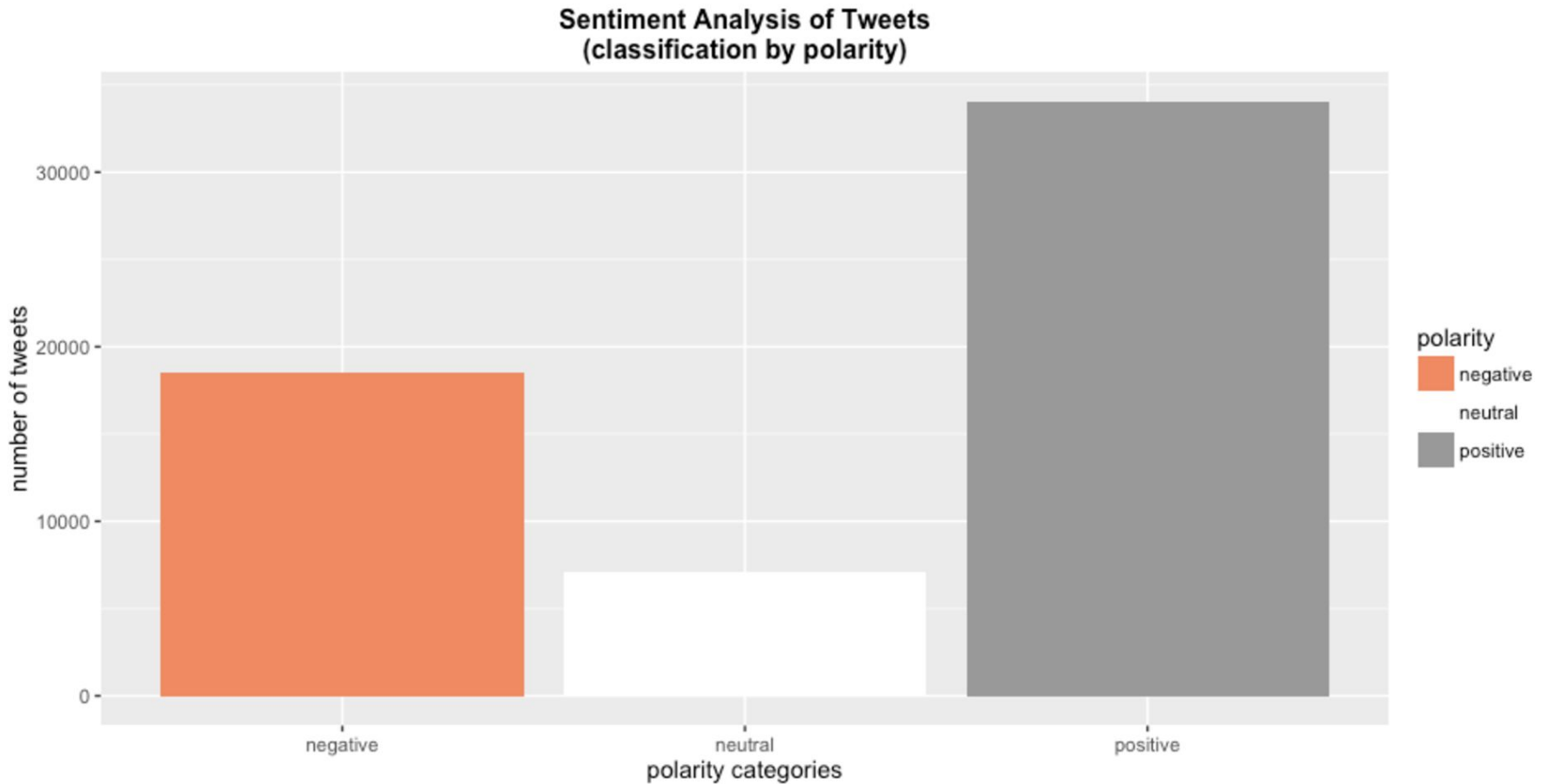
2015



Opinion Formation: Most used hashtags, 2015



Sentiment Analysis: Classification by Polarity



Conclusion

- **FrackMap is an innovative tool to communicate through maps and interactive data visualization**
 - **FrackMap-Biblio** : identify and map concerns and explore the spatial relationships between hydrofracking activities and environmental & health research
 - **FrackMap-Tweets** : track public engagement with fracking-related issues by analyzing Twitter conversations.

FrackMap could help regulators and industry to implement best risk management practices and invent safer practices.

- Twitter is an interesting platform :
 - to study opinion formation and the nature and pace of the spread of an information through Twitter conversations
 - The conversation is more about **#jobs, #jobs, #jobs**