

The Current and Mid-21st Century Geoscience Workforce

Christopher M. Keane

American Geosciences Institute

16 May 2018

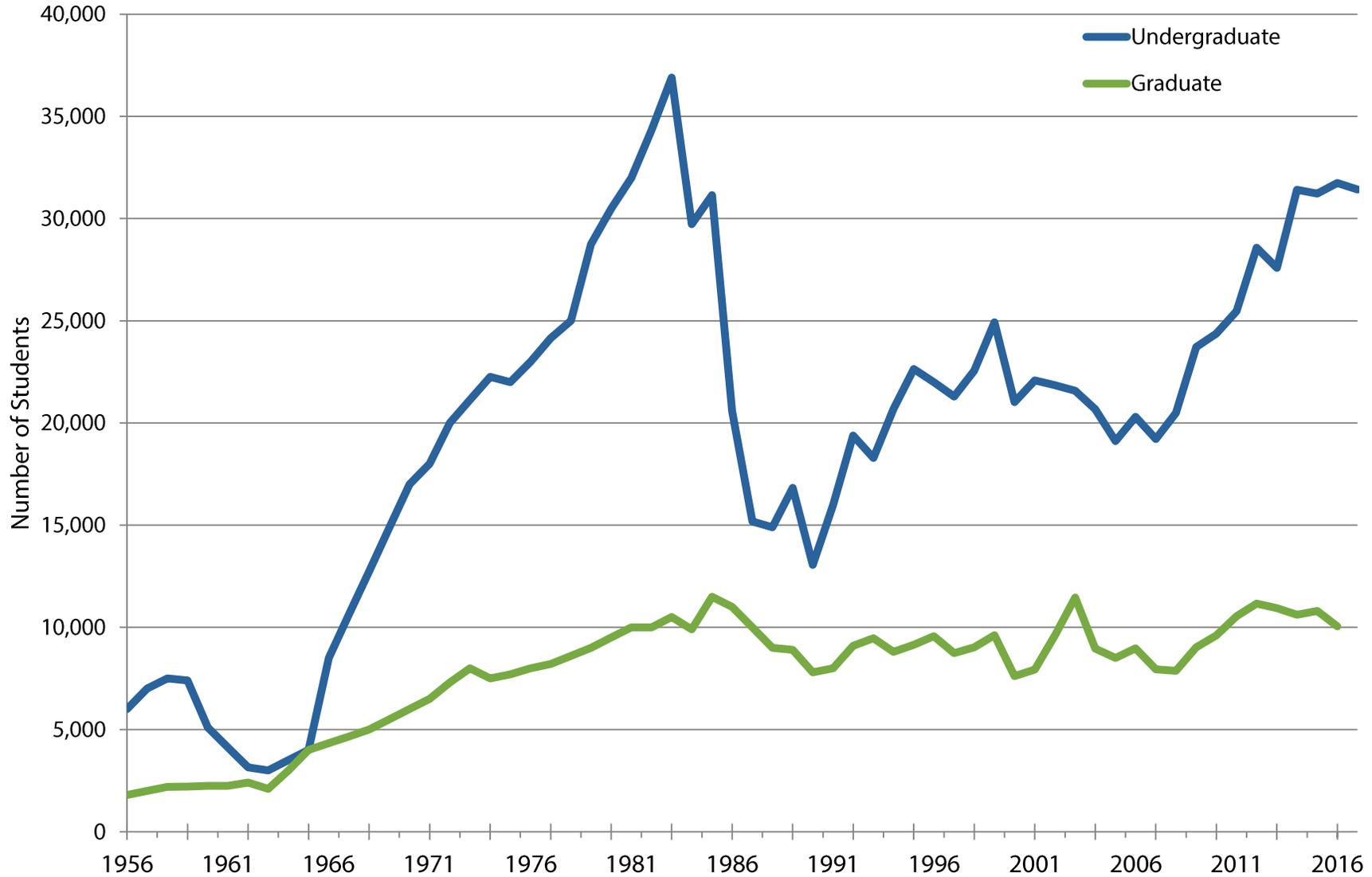
A Snapshot of Today

Data and Thoughts about the Geoscience Workforce Situation Today

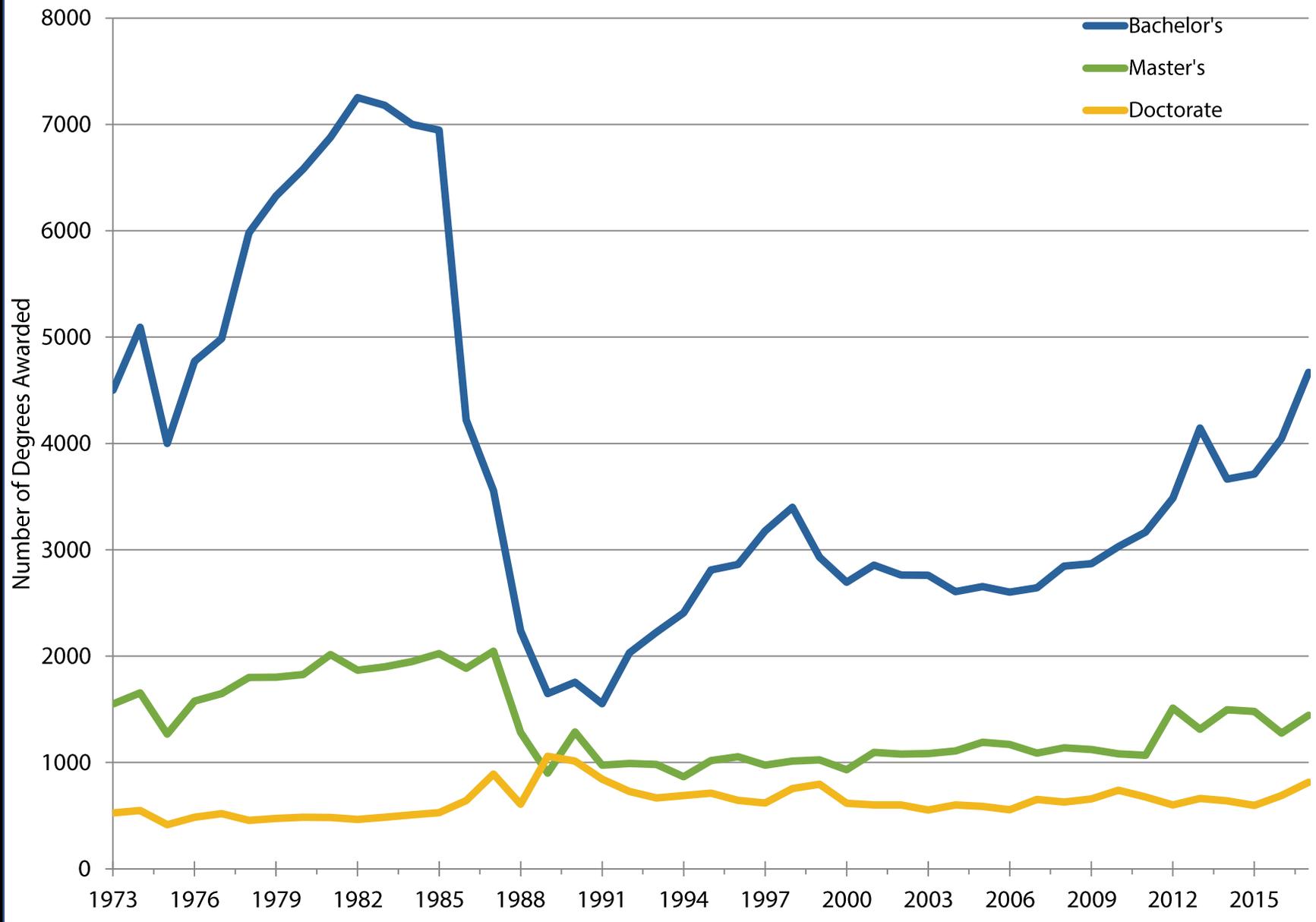
The Buzz... Enrollments

Undergraduate enrollments are noticeably declining

US Geoscience Enrollments 1955-2017



US Geoscience Degrees Granted 1973-2017



Issues to Consider... Enrollments

- We are seeing a lot of departments with noticeable declines in undergraduate enrollments
- We are seeing massive growth in some programs
- Appears to be rapid growth in online geoscience enrollments, some which are counted, but many which are not
- The data is not reflecting the sentiment

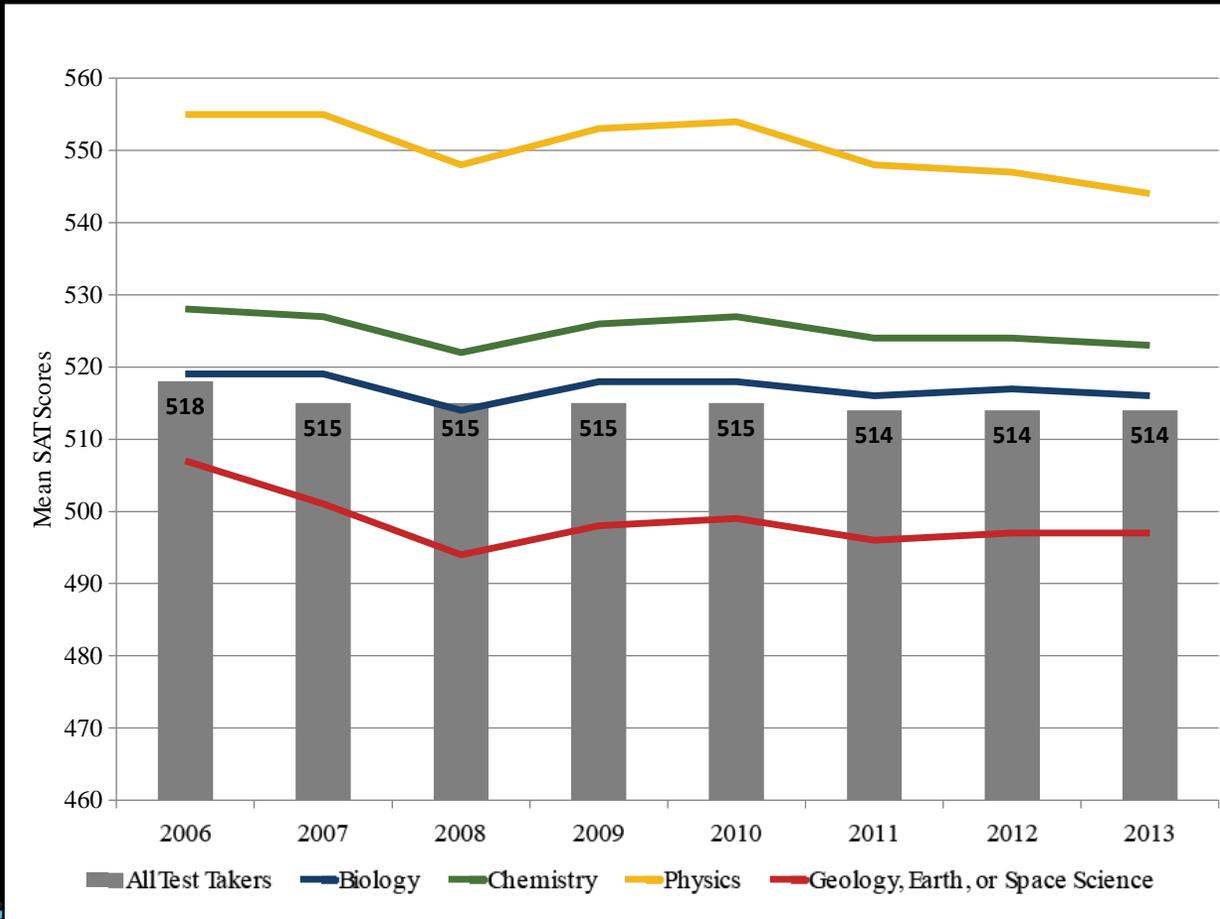
The Buzz... Student and Graduate Quality

The top 15% of students are the best we have ever had

The rest of the students are <<shakes head>>

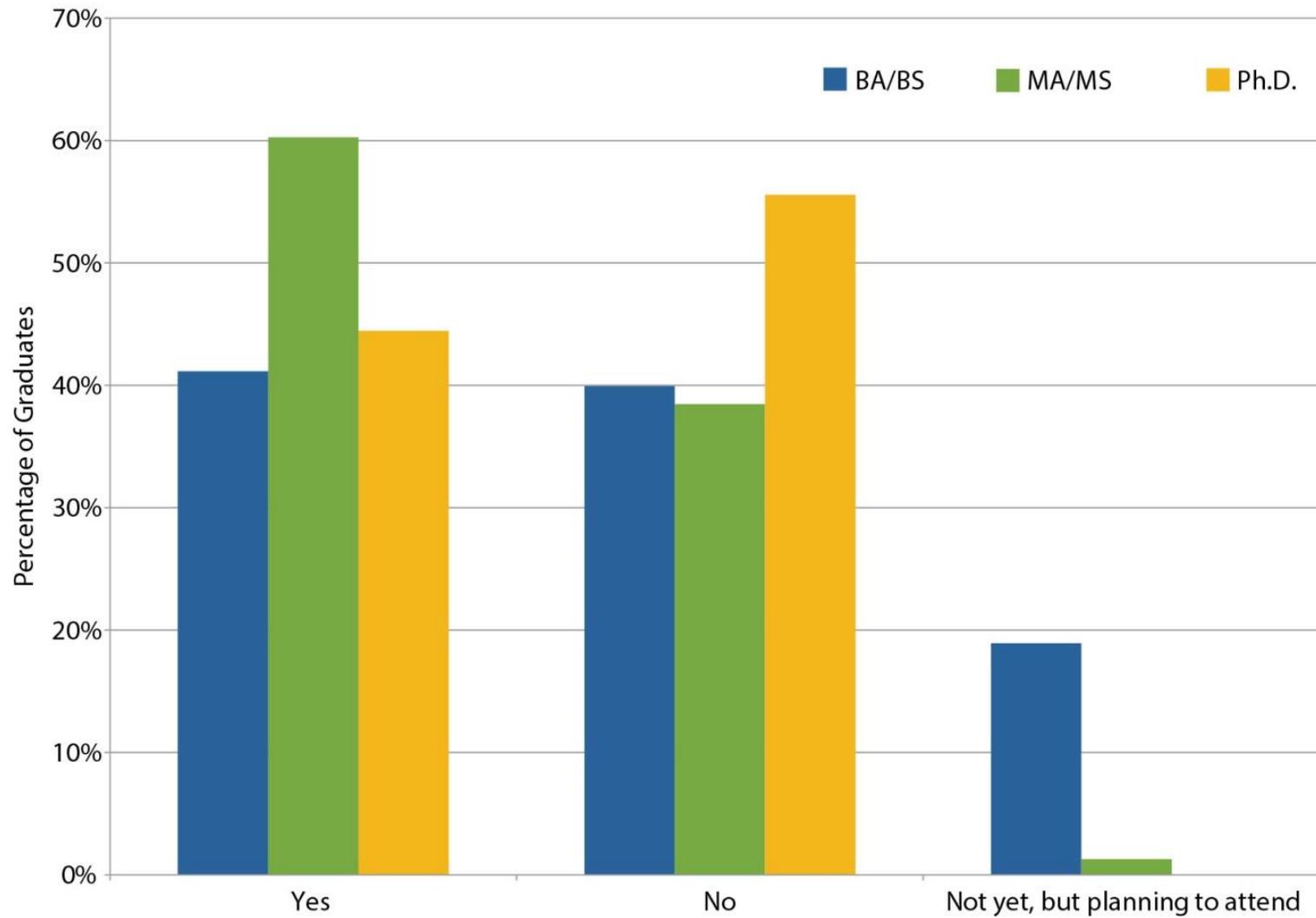
The Department Conundrum

Avg SAT Math Scores of STEM Majors

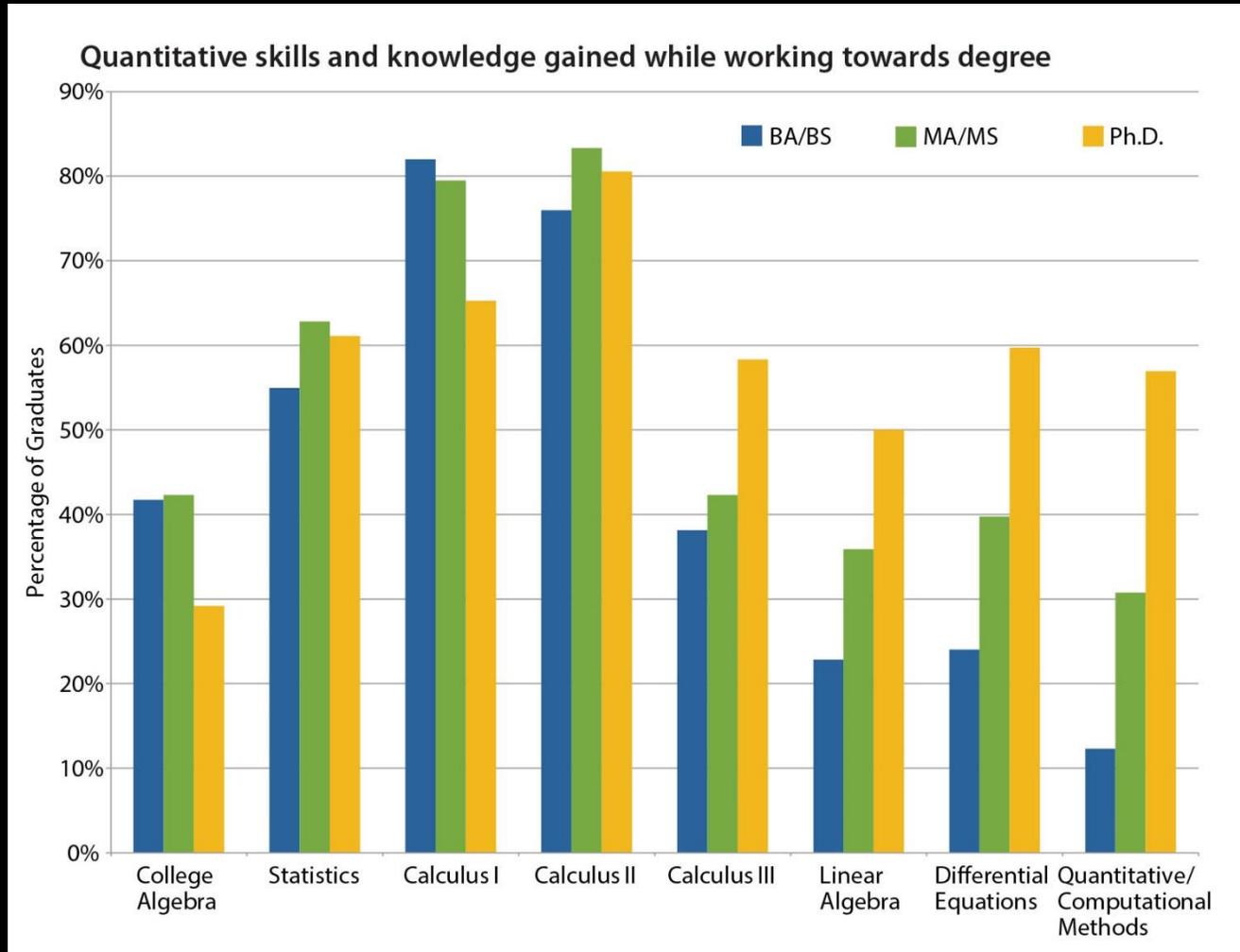


- A geoscience career is HARD. It requires lifelong RIGOROUS preparation
- Departments need students in the seats, and hard programs tend to be small

Graduating students who have participated in field camp



Workforce Skills Development



Things to Consider... Student & Grad Quality

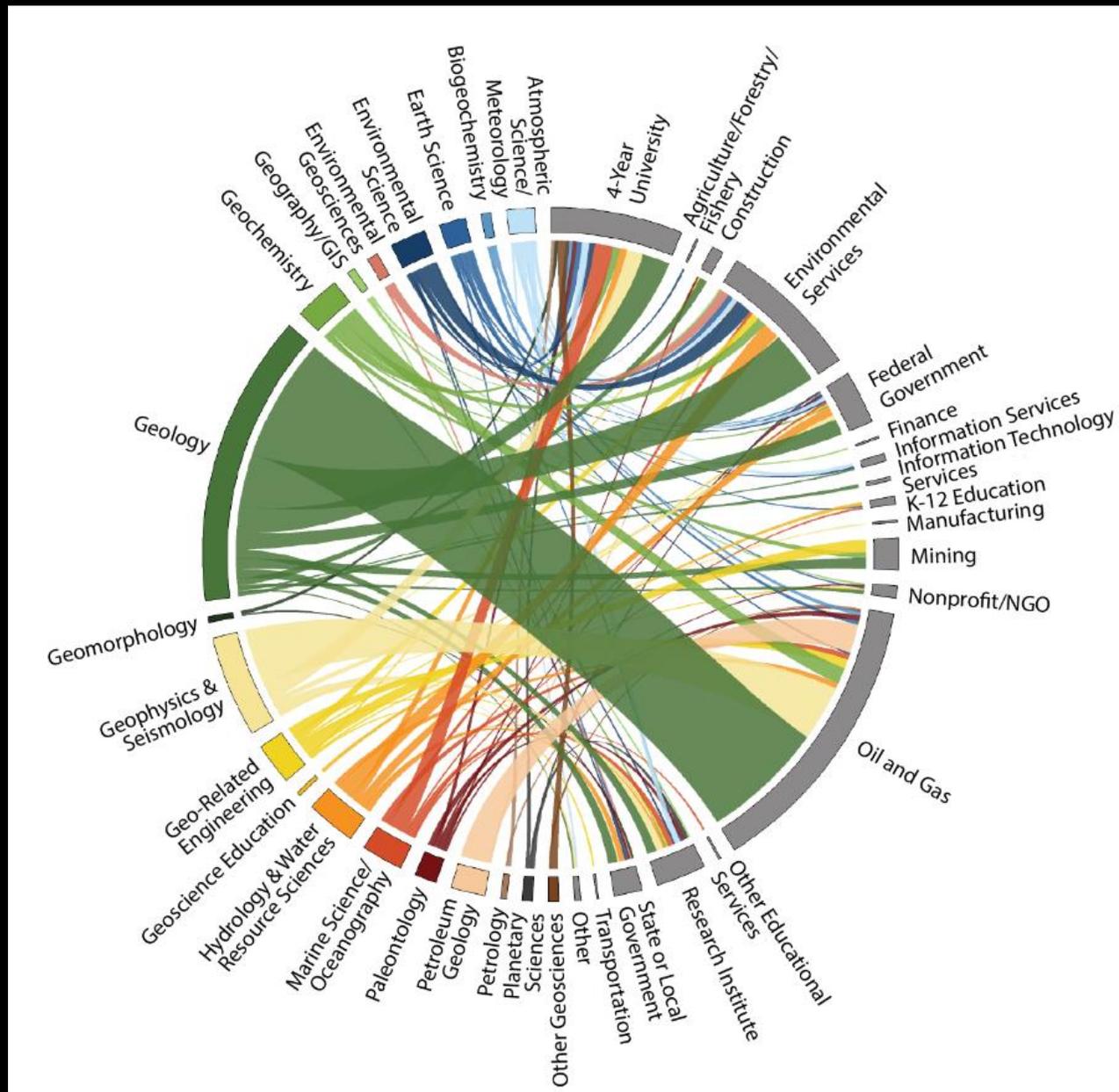
- Are we recruiting in the best talent at the start?
- Is today's curriculum meeting the needs of the market?
- Are our students career motivated?

The Buzz... Employment

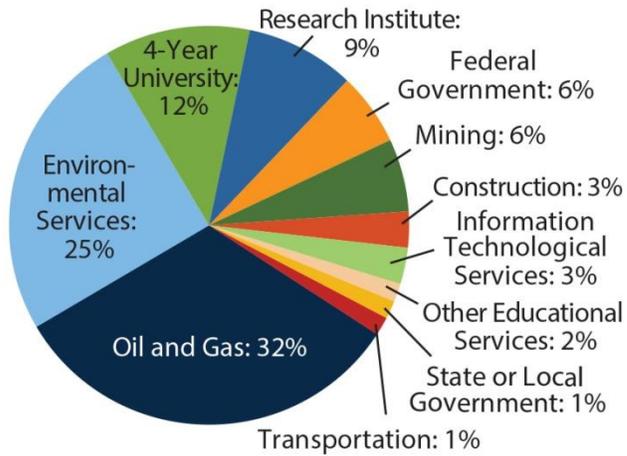
The job market has tightened up a lot!

Graduates aren't readily finding employment

New graduates are venting a lot of frustration

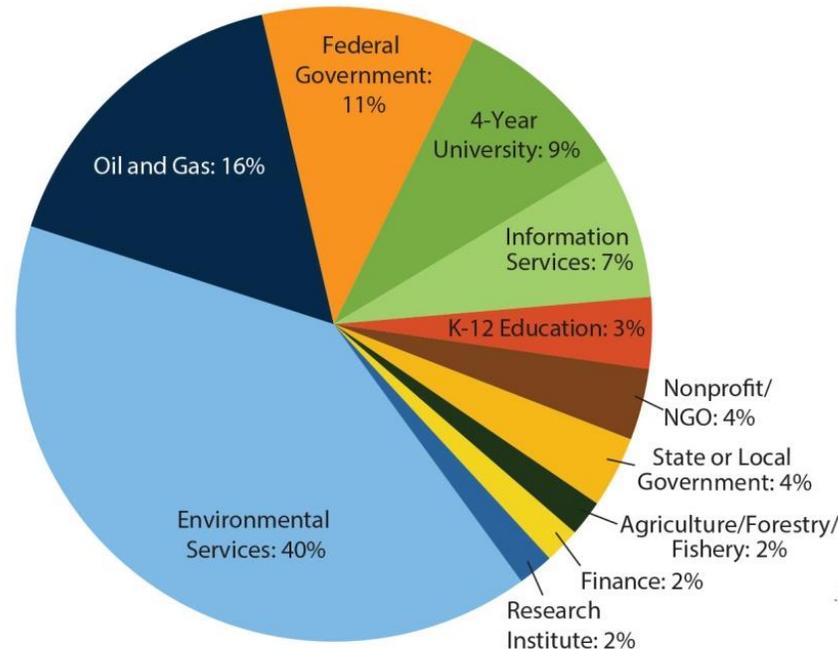


Industries Hiring BA/BS Graduates

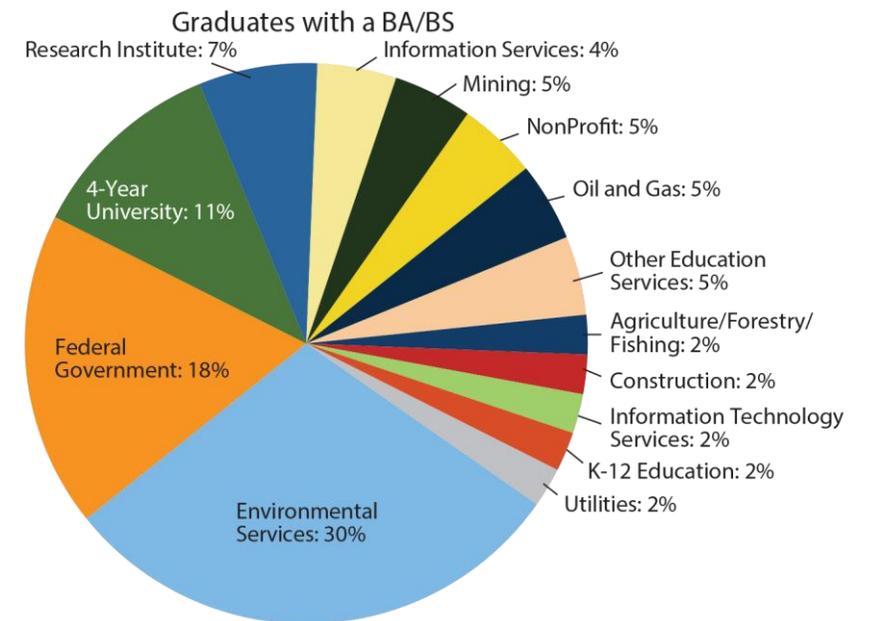


2014

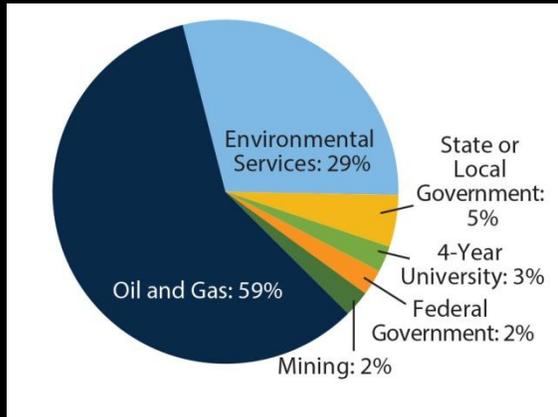
2015



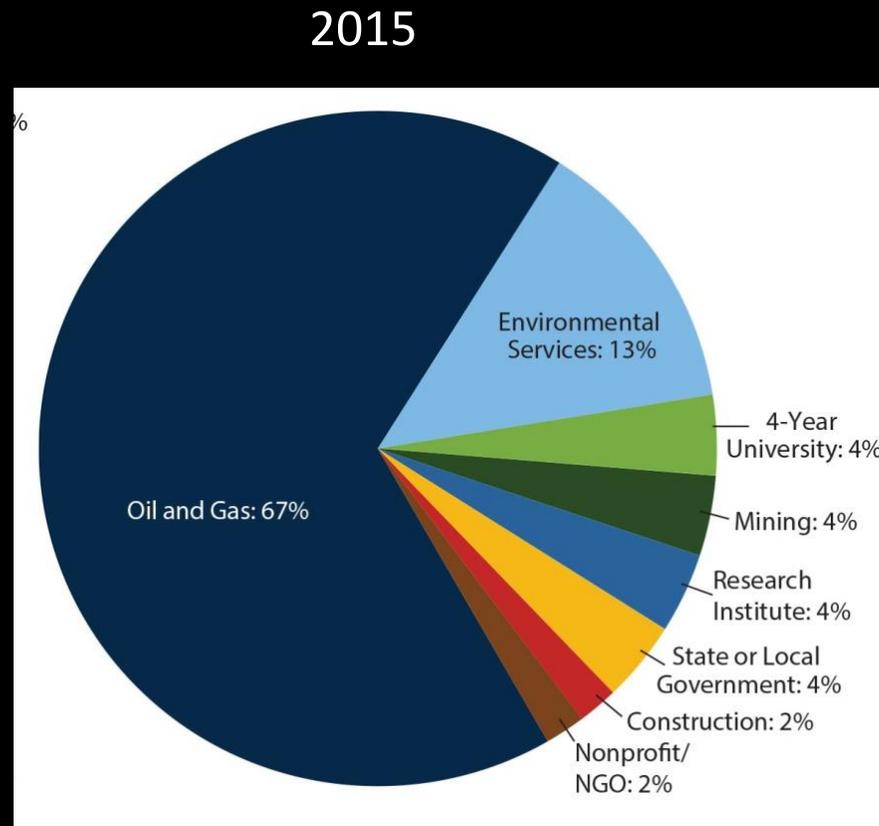
2017



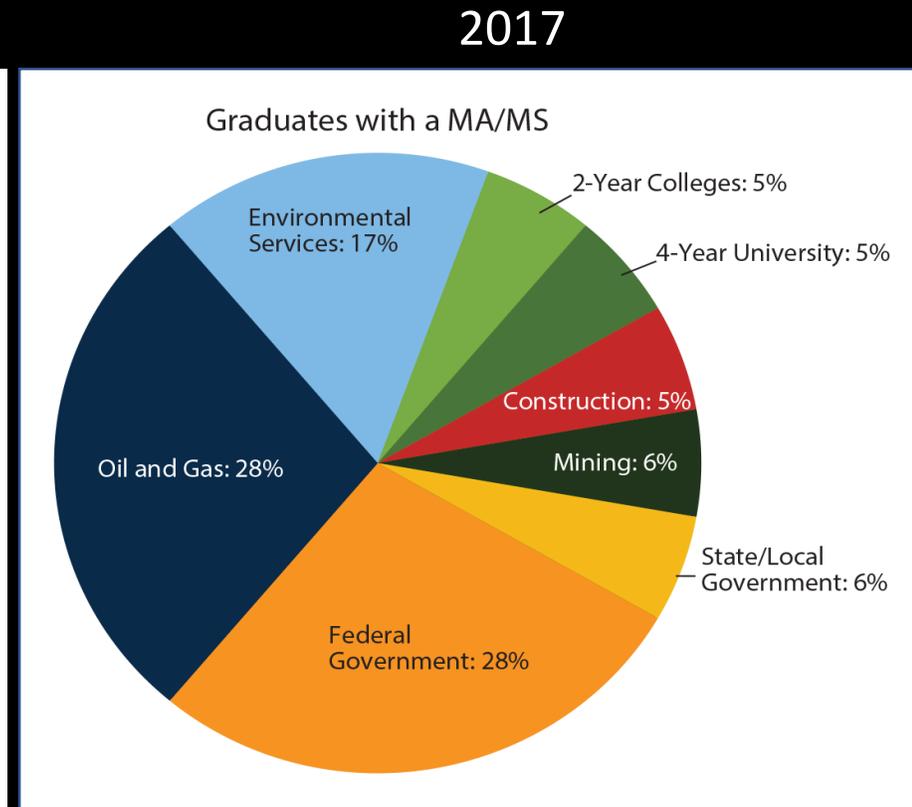
Industries Hiring MA/MS Graduates



2014

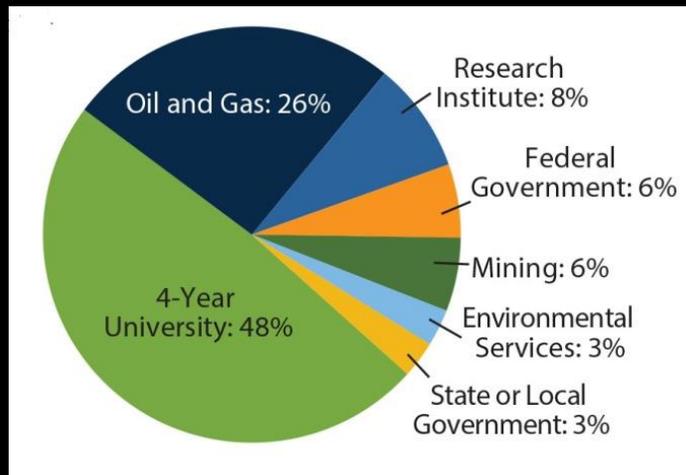


2015

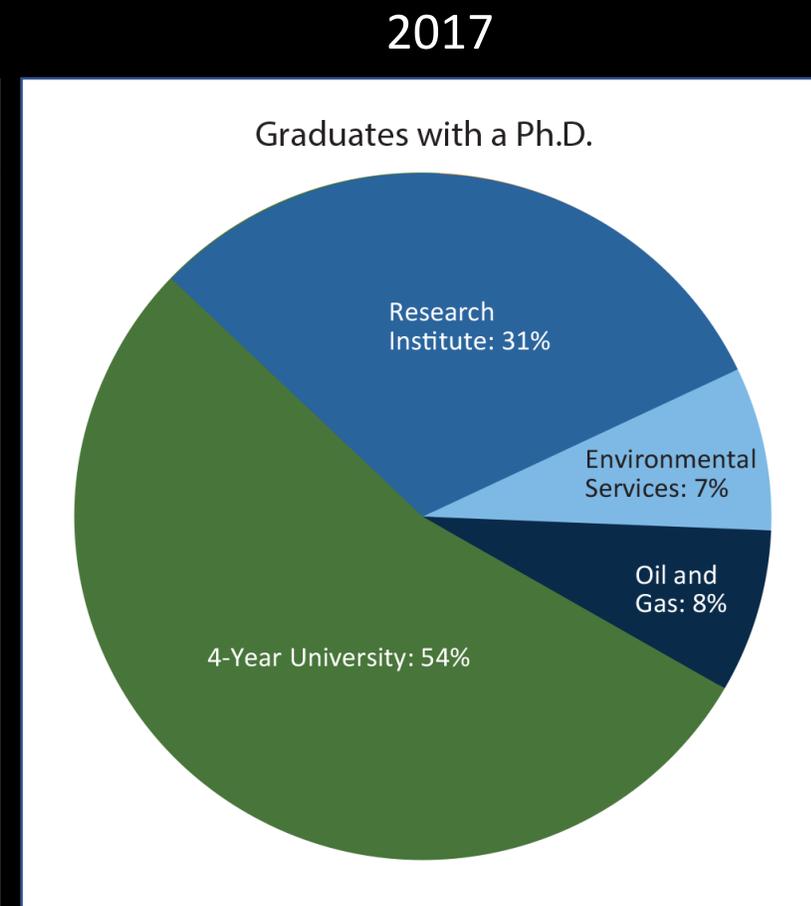
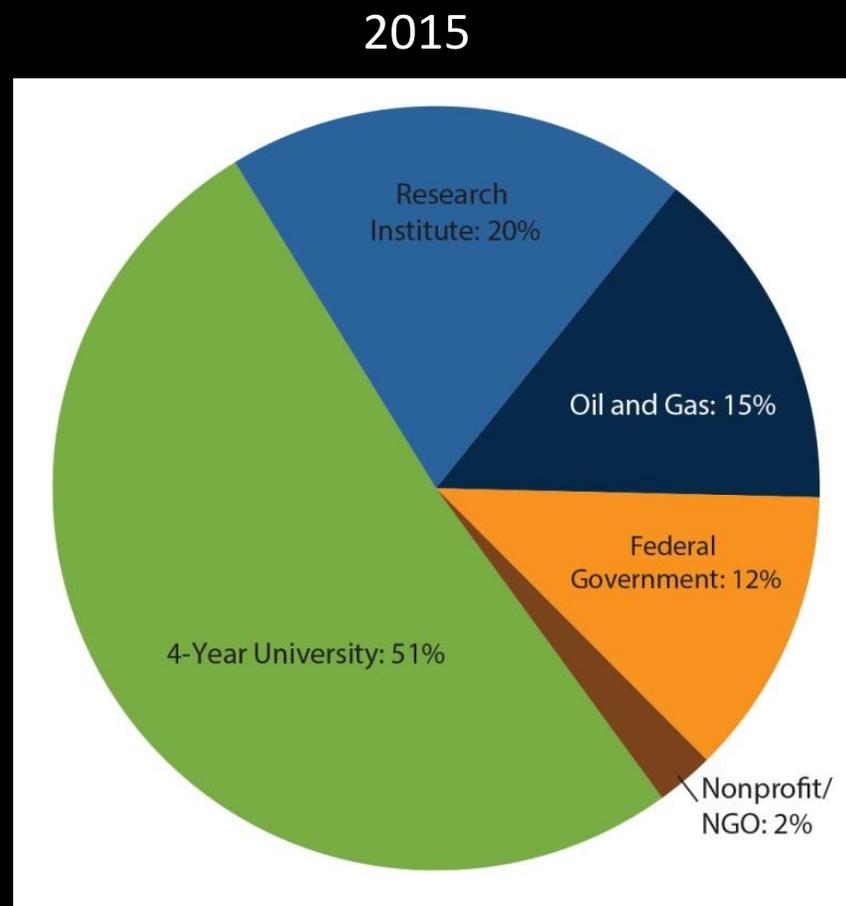


2017

Industries Hiring PhD Graduates



2014



Things to Consider... Employment

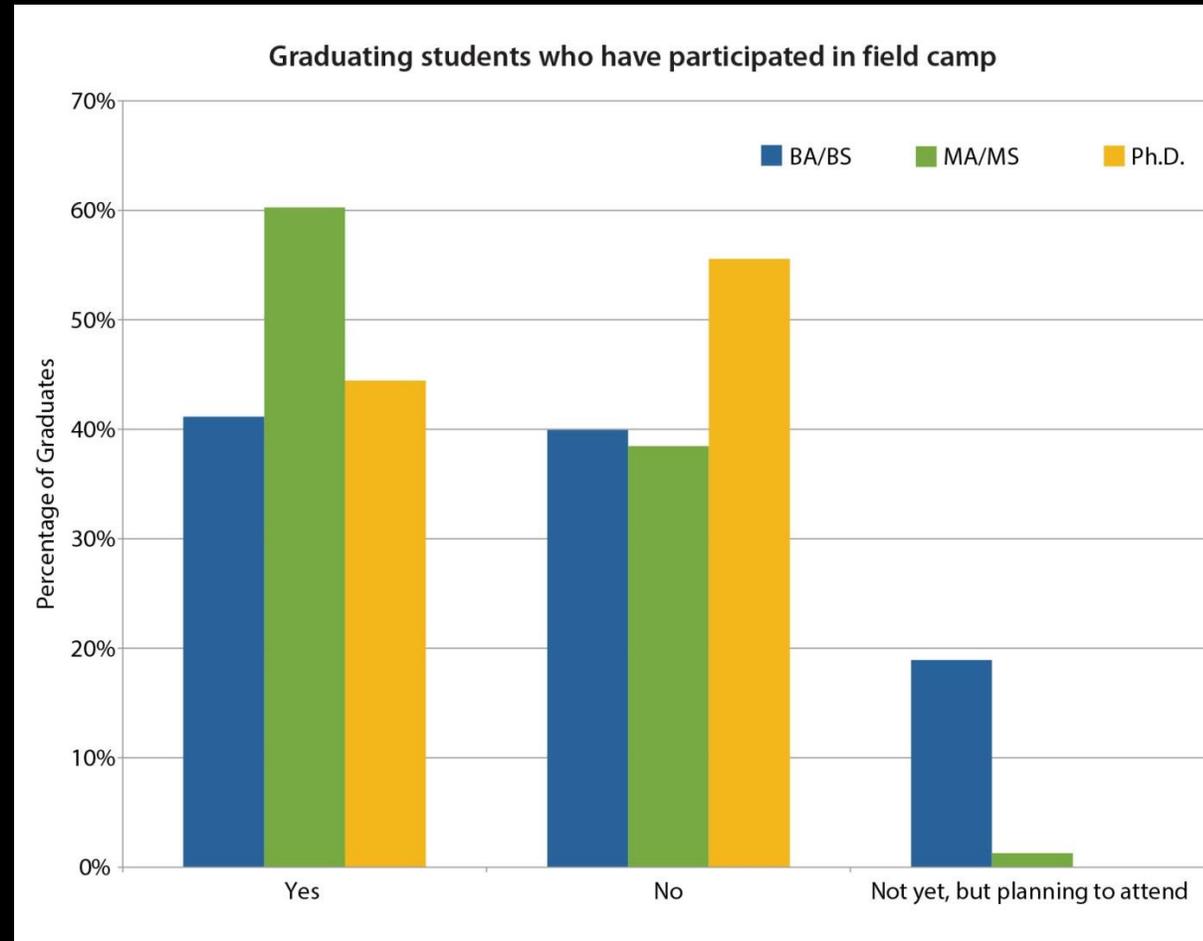
- The job market has gotten soft
 - Reduced hiring in oil and gas
 - Uncertainty in the environmental sector
 - Growth in mining tempered by technological advances
- We still have an issue with student recognition of the spatial dependency of geoscience employment
- People are not hired for more than one reason:
 - No jobs available
 - The skills offered do not match what is needed

The Buzz.... Diversity

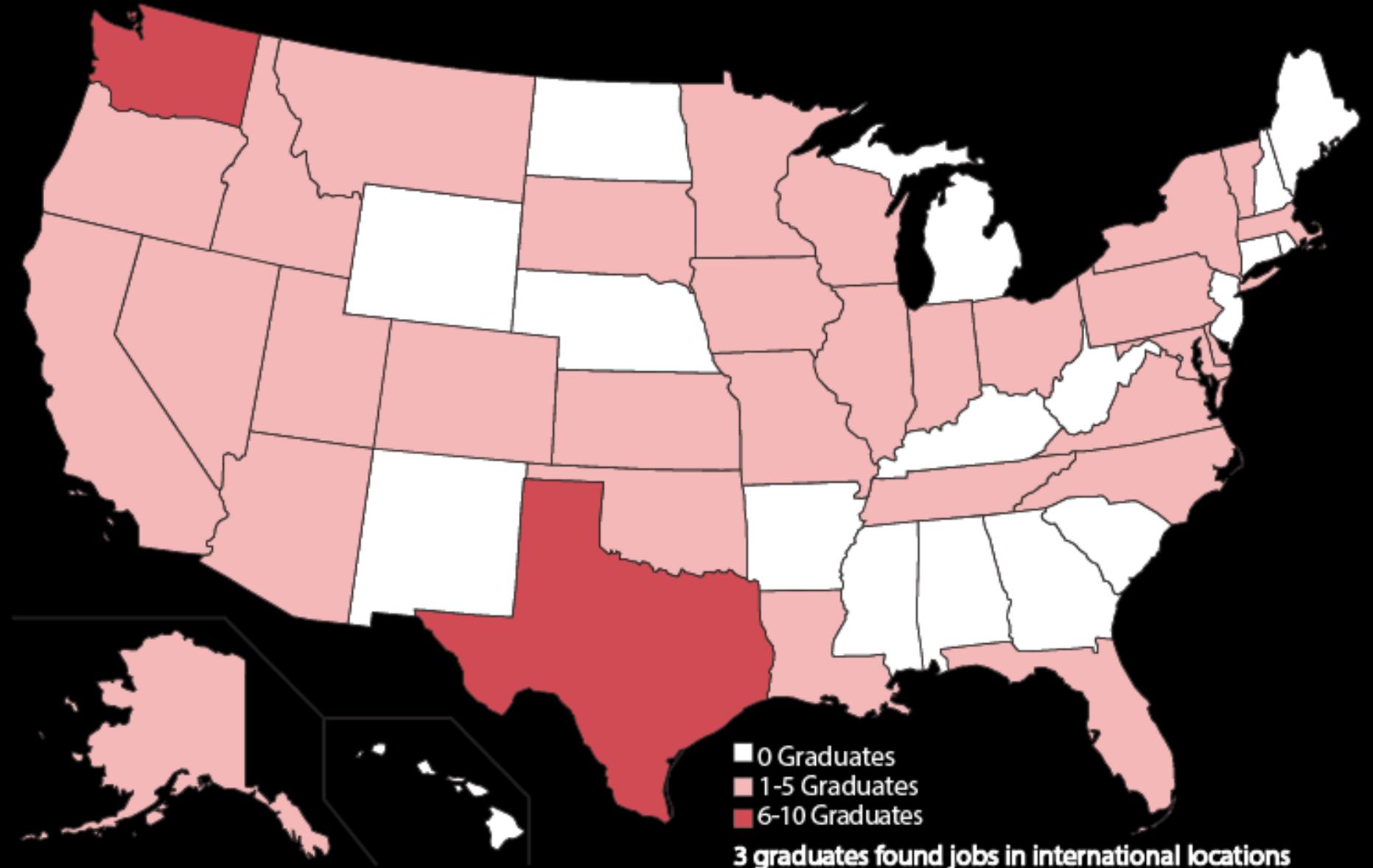
Diversity continues to be an intractable problem for geoscience

Other fields express their gratitude as we make them look good!

Challenge of Co-curricular Costs



Challenges of Mobility



Things to Consider... Diversity

- Diversity is becoming nearly impossible to track since 2010
 - Multi-racial classification
 - Respondent changing ethnicity responses based on economic outlook
- What drives our motivation?
 - Are we just trying to check boxes or transform our discipline?
- We currently pull 91% of our students from less than 12% of the population
 - True diversity will come with engaging the whole population – mostly through first-generation college students
 - Challenges of field camp and spatial dependency of jobs

Peering into the Future

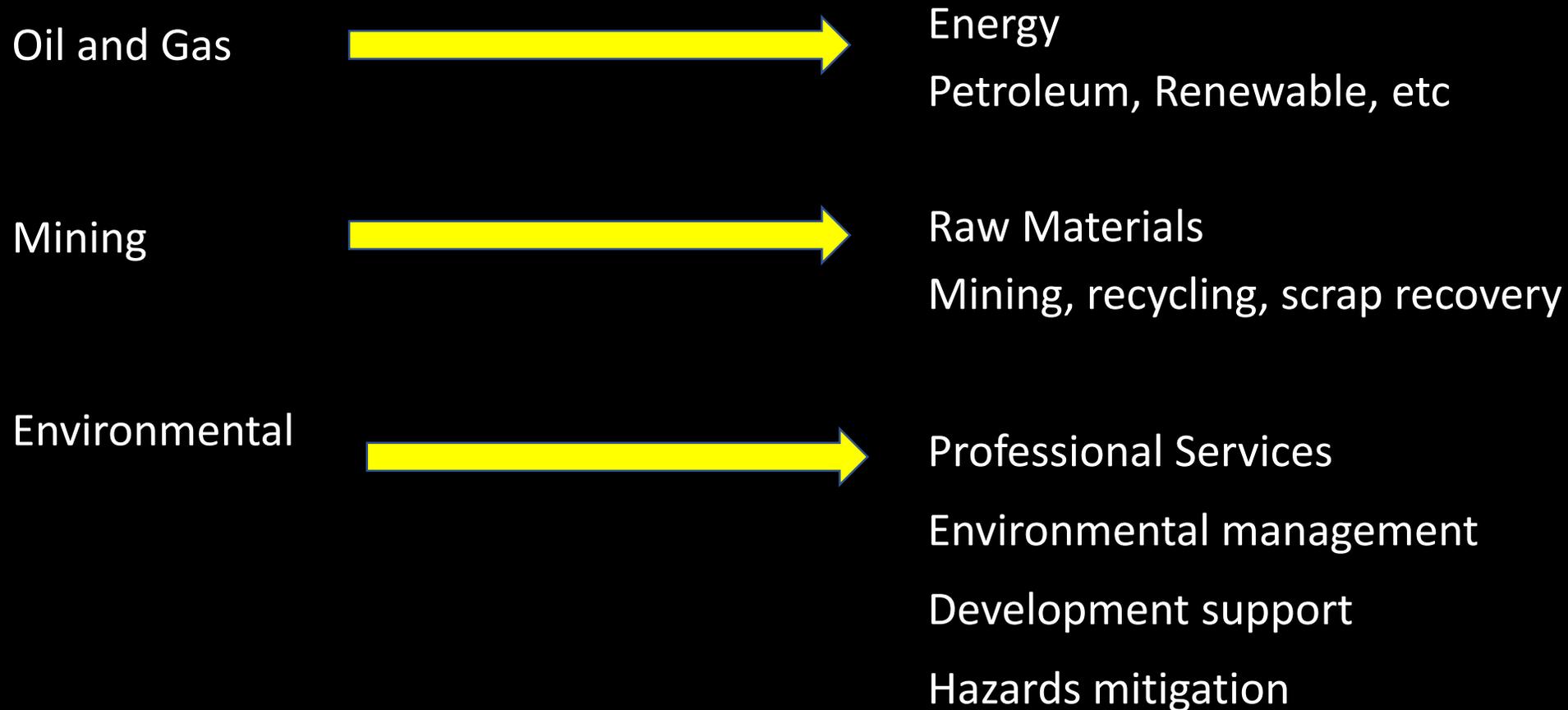
Emerging Disruptions that will define the future workforce

The Mid-21st Century Workforce?

The current major will be an experienced practicing professional into the 2060's



We Need a 21st Century Vernacular



Change is Afoot

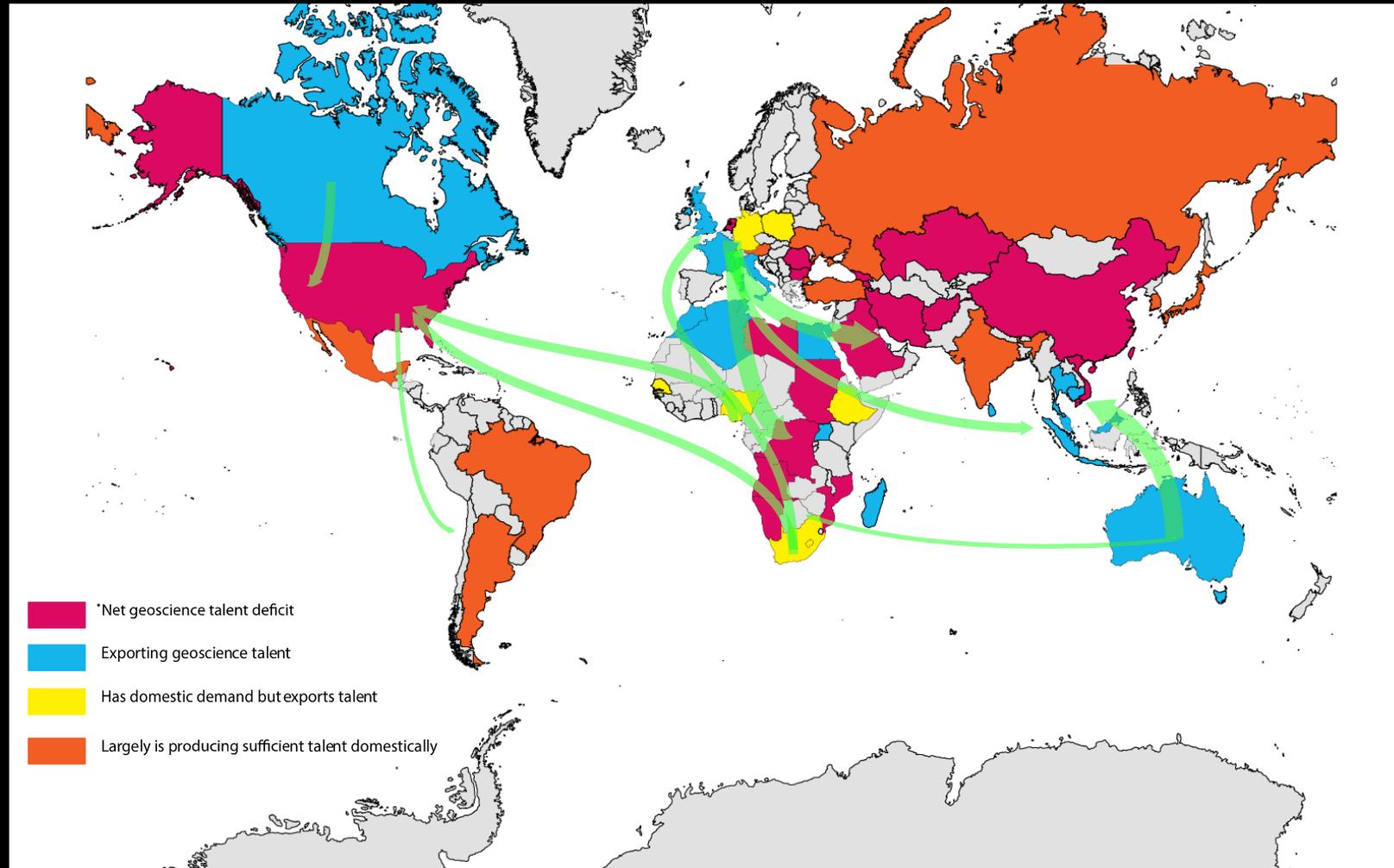
We are in a transformative period for geoscience as a profession

- Globalization and mobility of labor
- Automation impacts “white collar” professions
- Changes in activities that are part of typical geoscience work

Critical Global Challenge

- China, India, and Indonesia have more than 65 millions students in undergraduate programs
- Unmistakable improvement in graduate quality
- The US has 20 million college students (13 million in 4-year programs)
- If we only tap from 12% of our population, how do we compete?

Geoscience Talent Flows



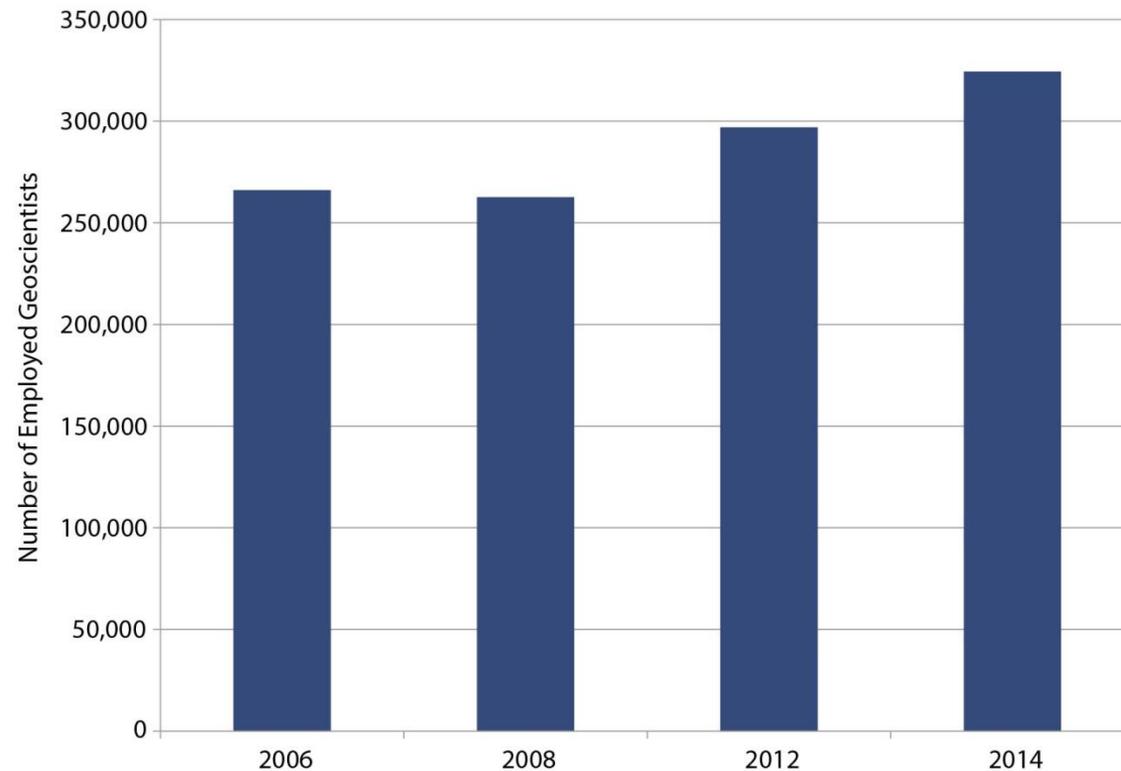
The Do-We or Don't-We STEM Shortage Debate

- For STEM there are plenty of Degree Holders
- For Geoscience, there are not enough degree holders
- For STEM and Geo, there have not been enough:

QUALIFIED INDIVIDUALS

Current Geoscience Workforce

Figure 4.11: Total Number of Employed Geoscientists in the United States



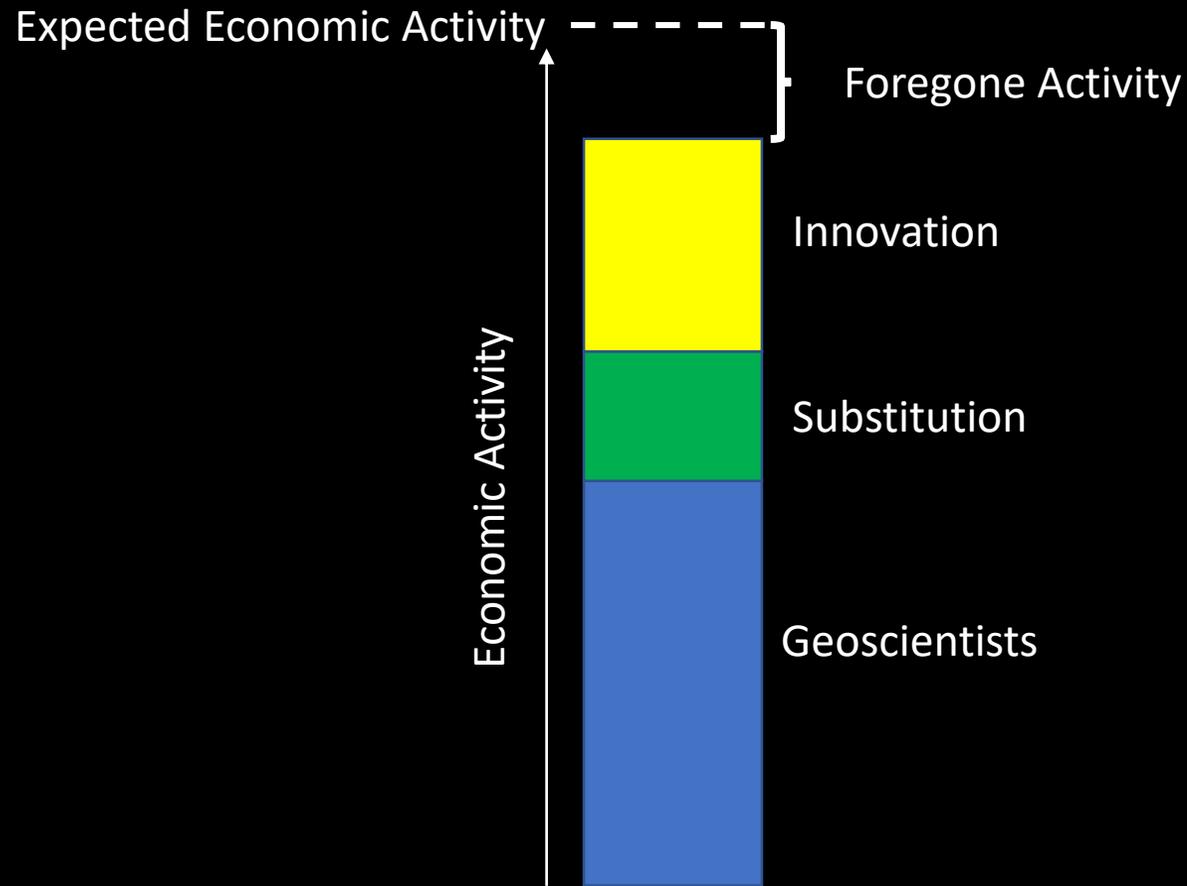
AGI Geoscience Workforce Program; Data derived from the U.S. Bureau of Labor Statistics, Employment Projections

Notable Recent Changes in 2016/17

- Early exit of ‘froth’ majors, but sharp shift to online programs
- Oil and Gas had no hiring of BS grads, and major decline in graduate hires
- Federal projections still show ~90,000 FTE shortage by 2024

How do we rectify these contradictions?

How Labor Demand is Estimated



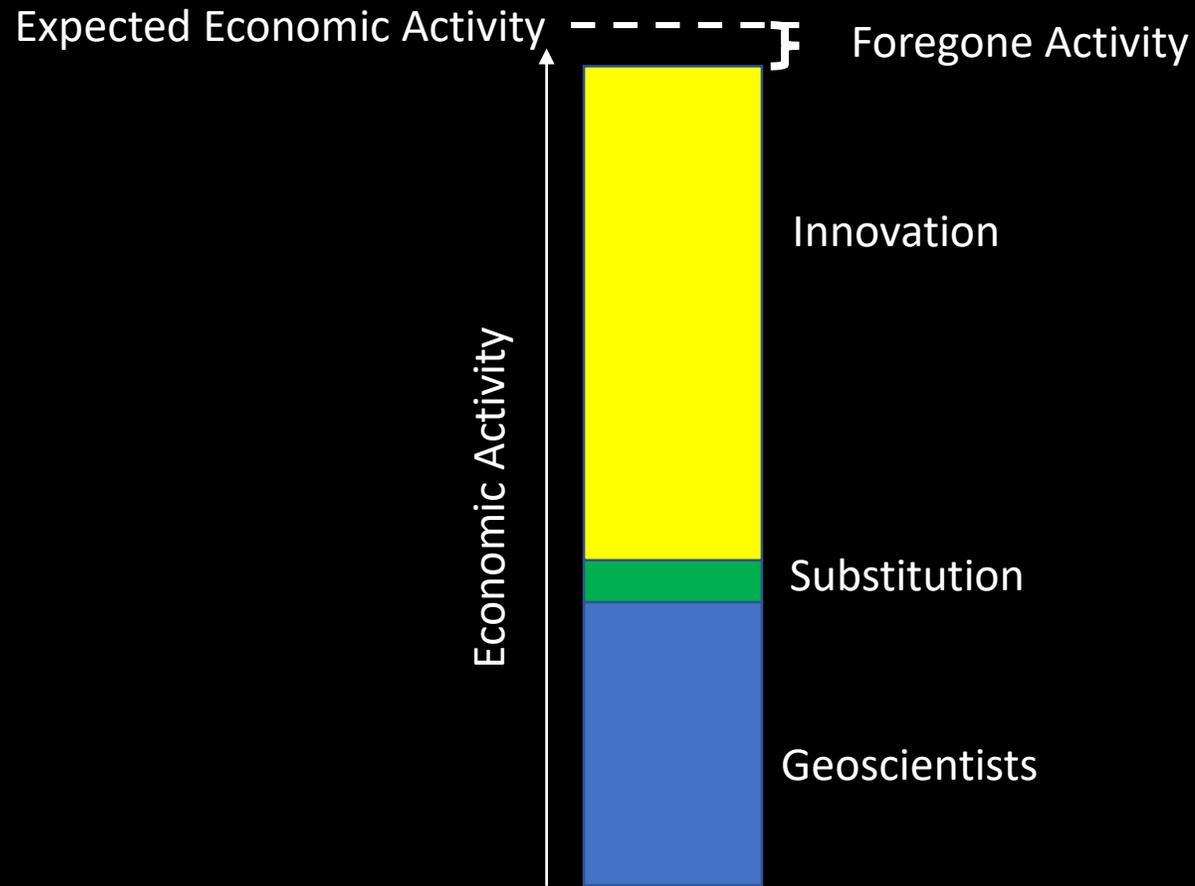
D = Total Labor Demand (FTE)

X = Economic Activity Per Person

n = Total Workers

$$D = nX$$

Rise of Machine Learning in Geoscience



D = Total Labor Demand (FTE)

X = Economic Activity Per Person

n = Total Workers

X' = New Economic Activity Per Person

If $X' = 5X$, then n drops substantially, while D remains the same.

So What is Driving Innovation?

Cheap computing and new machine learning approaches

Mining Industry and Machine Learning

- Mining companies determined 80-82% of their geoscientists time was in searching, cleaning, and prepping data
- GoldCorp spent \$1 Billion with IBM to develop Watson for Natural Resources
- Over 100,000 geoscientist and engineering jobs have been lost in the Gold Industry worldwide because of automation.
- Drone expertise is also an emerging skill in mining and environmental employment



Watson
for Natural Resources

IBM

Drive innovation and monetize your technology investments

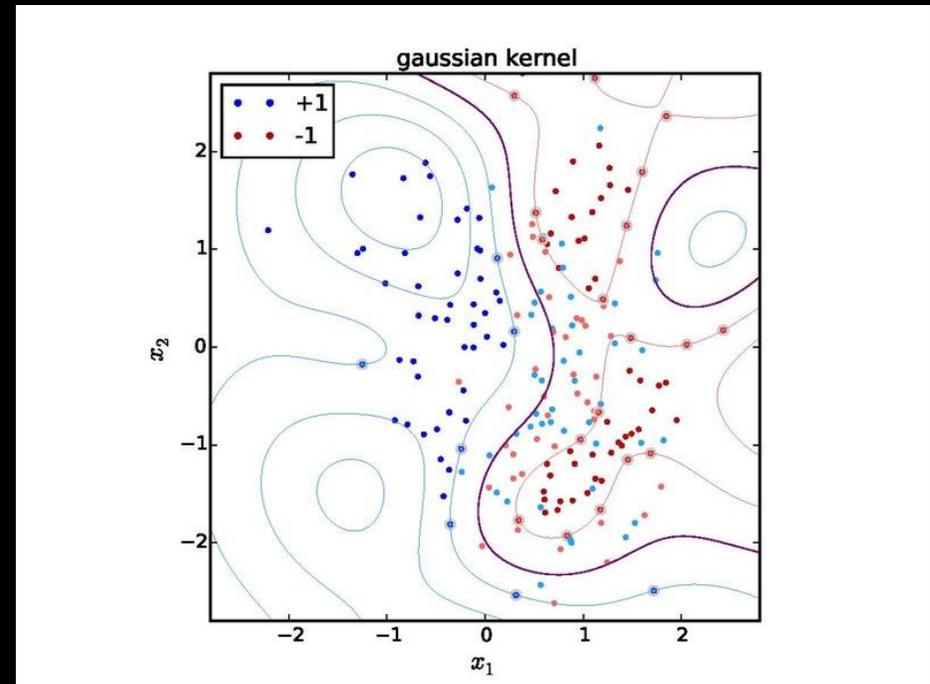
Peter Coleman,
CEO & Managing Director, Woodside Energy: Our business case for Watson

Want to get involved?
Contact Tim Workman,
IBM Watson NR Program Director
tim.workman@ca.ibm.com

How you can join the IBM Watson Innovation Program

How Does Machine Learning Impact Geoscience?

- If the fundamental of a task is pattern matching/identification, then it is readily automatable.
- Kernel Vector Machines are some of the simplest ML processes, but extremely effective in geoscience

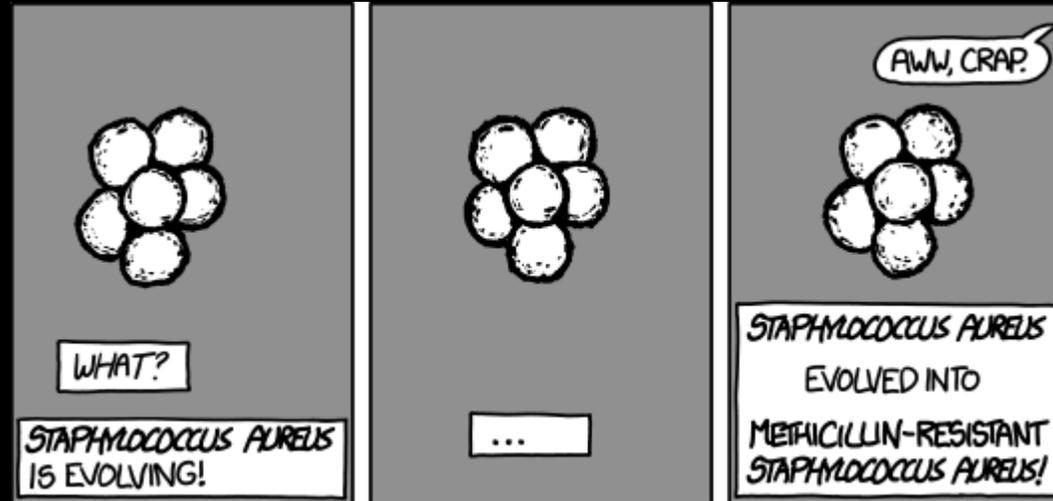


Is Machine Learning Effective in Geoscience?

- GoldCorp Assessment:
- Contrived problems had a 35x decrease in solution time using Watson than a senior geoscientist team
- First real-world problem:
 - Senior geoscientist team: 1080 person-hours to solve the problem
 - Nearly all of the time was in data management and processing.
 - Watson for Natural Resources: 14 minutes

Is Machine Learning a Threat?

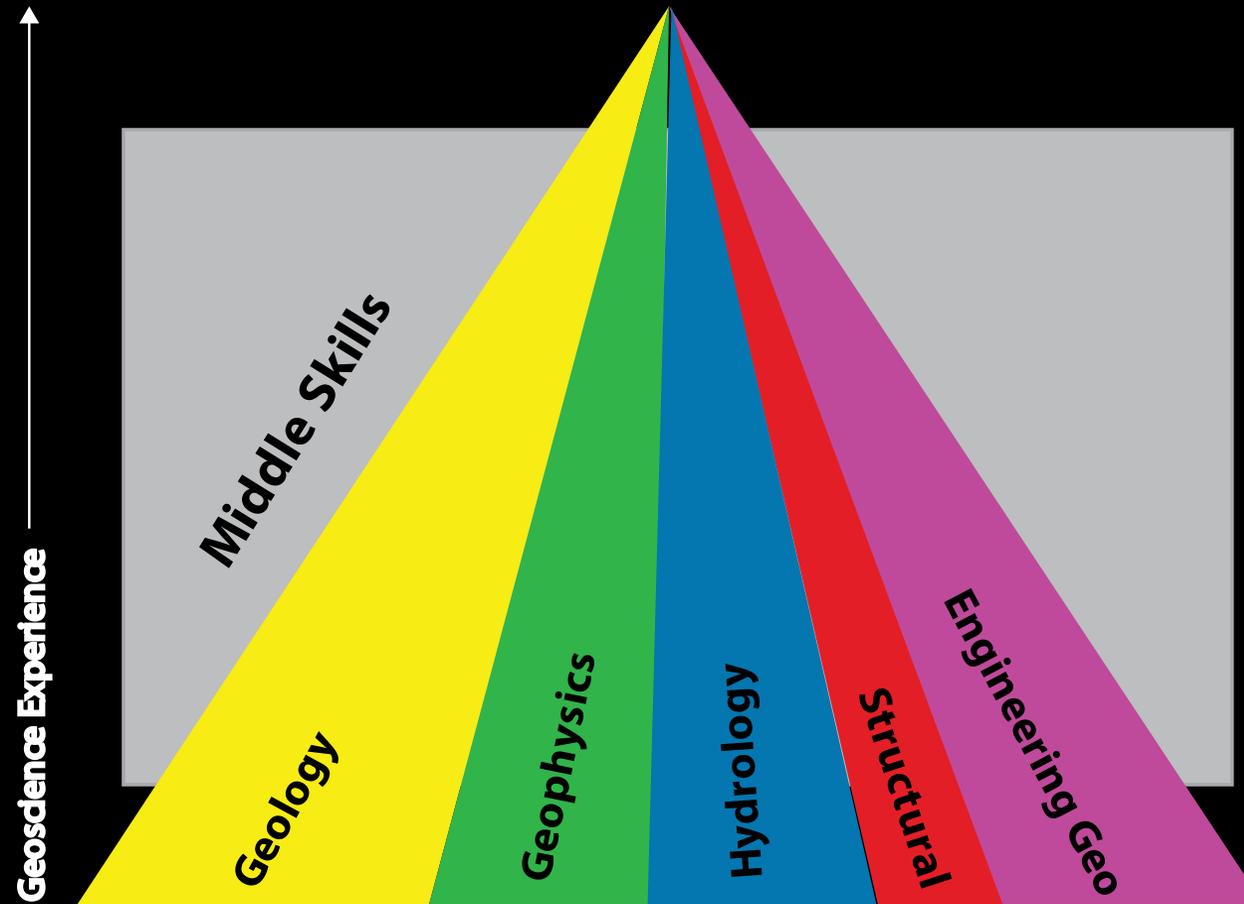
- Only if we do not evolve!



- Traditional occupations are disappearing (loggers, interpreters, etc)
- Move towards the “augmented geoscientist” – who focuses on domain problem solving with robust tools at their disposal.

So What are the Impacts?

Traditional View of Labor Classes



A Change in the Labor Definitions

- As middle skills jobs disappear (e.g. well logging, core logging, seismic interpretation, spatial analyst, etc)... two new geoscience occupational zones may emerge
- “Geological Cognatives”
 - Fully utilize their geoscience problem solving to tackle the hard problems
- “Makers/Sensors”
 - The epicurean geoscientist who knows the geoscience and can apply a spectrum of science and engineering
 - Developers of the new data feeds

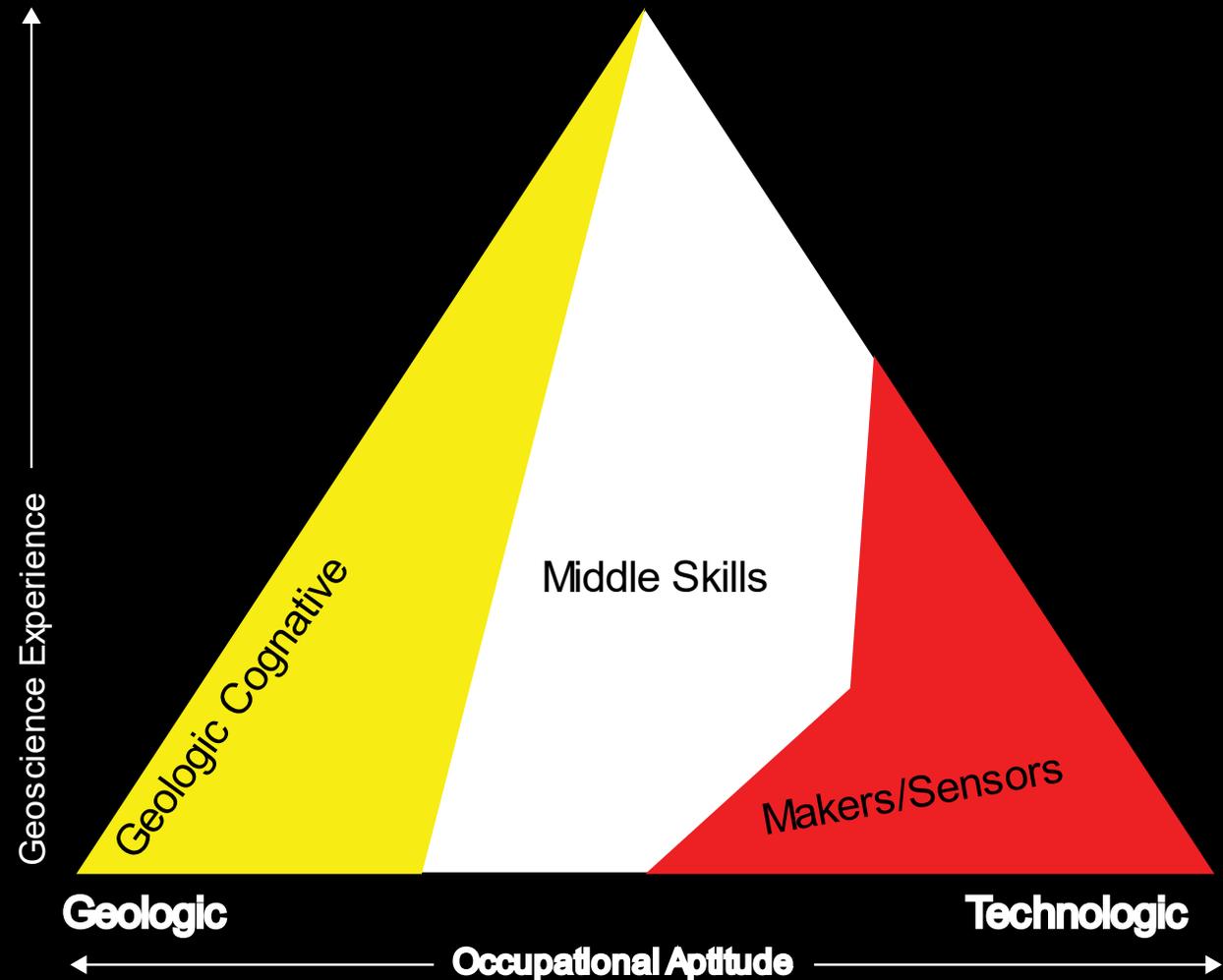
A New Labor Pyramid for Geo

Geologic Cognatives:

Fully utilize their geoscience problem solving to tackle the hard problems

Makers/Sensors:

The multiskilled geoscientist who knows the geoscience and can apply a spectrum of science and engineering to develop new data feeds



“With every retirement we destroy a geoscience job. With every new hire we are creating a geoscience job we can’t even begin to describe. The new hires will define these jobs of the future.”

- Daniel Malchuk, BHP at PDAC 2018

Identified Competencies by Employers

- Geoscience Thinking
 - Earth science habits of mind
 - Problem solving in the context of open and dynamic systems
 - Work by analogy, inference, and the limits of certainty
 - Intellectual flexibility to apply skills to new scenarios

Identified Competencies by Employers

- Technical Skills
 - Problem solving with real data
 - Quantitative Skills
 - DiffEq/Linear Algebra
 - Stats
 - Programming
 - Experience with authentic research and data collection
 - Critically evaluate literature
 - Data analysis skills and tools
 - Technological diversity – no black boxes
 - Preparation for life-long learning

Identified Competencies by Employers

- Field Skills
 - Field Camp/Experiences
 - Spatial cognition and geoscience synthesis
 - Uniquely difficult to substitute
 - GIS
 - Essential for building large data sets

Big Emerging Issues

- **Victories**

- Strong enrollment
- Strong demand for field experiences
- Salaries remain high, but more sustainable
- Female participation remains at ~44-48%
- Environmental sector absorbed energy and mining retrenchment

- **Challenges**

- Low quantitative capabilities of graduates
- Replacement of middle-skill geo by machine learning
- Declining quality of new majors
- Regulatory uncertainty is a drag on hiring

Meet the Future on its terms

- Differential Equations – fluids
- Linear Algebra – multivariate systems
- Machine learning – have you trained a Kernel Vector Machine yet?
- Understanding and mastering geologic thinking (field experience)
- Maker culture – IOT/Drones now, what is next?

For more information

<https://www.americangeosciences.org/workforce>

workforce@americangeosciences.org