

Student Training and Workforce Development at the USGS Water Resources Research Institutes

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Abstract: Measures of student training and workforce development are key academic, social, and economic metrics. A principal component of the United States Geological Survey Water Resources Research Act Program is the training of water scientists and engineers through participation in research and other mentoring. This training occurs through Water Resources Research Institutes known as the National Institutes for Water Resources. Though the institutes have a demonstrated record in student training, there has been limited synthesis of data on students trained at state and national levels to clarify these contributions to workforce development. We investigated student support at the 54 institutes from 2000 through 2015 using archived data, including a survey of institute practices. Institutes play a key role in water resources training within a greater science, technology, engineering, and mathematics (STEM) framework. Institutes pooled supported on average 678 ($sd = 83$) students per year (range 518 to 788), providing 10,853 student support years during this period. Individual institutes supported on average 201 ($sd = 102$) students per year (range 76 to 646). While 98% of institutes used data on students supported to fulfill required reporting, fewer used these data for institute promotion (45%), website or social media engagement (41%), and development/donor activities (16%). Consistency in data collection and management among institutes, coupled with refined use of student support data, such as documenting disciplines and dates of degrees earned, post-support job placement, and diversity and equity metrics, would further demonstrate the value of this investment in student training and workforce development.

Keywords: *STEM, United States Geological Survey, workforce development, student training, water resources*

Measures of student training and workforce development are key social, economic, and academic metrics valued by multiple sectors of society including industry, universities and colleges, and state and federal governments, among others. Skilled workers are in demand nationally and internationally (Bauer and Kunze 2004; Abella 2006; Carnevale et al. 2011; Boeri et al. 2012). In the United States of America (U.S.), concern regarding the future U.S. workforce and student training in science and technology has been expressed by the U.S. Congress (National Academy of Sciences 2007, 2010; U.S. Congress Joint Economic Committee 2012) as well as the President's Council of Advisors on Science and

Technology (2012). Further, the U.S. science, technology, engineering, and mathematics (STEM) workforce has connectivity worldwide as noted by Carnevale et al. (2011) "...STEM is already one of America's more global workforces and likely to become more so as innovation continues to expand globally."

The status of the STEM workforce, on which much scholarship and management of water resources is arguably based, has proven complex. Heterogeneity in the STEM labor market has been demonstrated by geographic location, U.S. citizenship, and employment sector (Xue and Larson 2014); and student diversion and attrition in the STEM disciplines affect workforce supply

and demand (Carnevale et al. 2011; Xue and Larson 2014). While academia may be facing a STEM skill surplus (Carnevale et al. 2011; Anft 2013; Xue and Larson 2014; Ghaffarzadegan et al. 2015), the private sector, and in particular government and government-related sectors, are experiencing skill shortages in some STEM areas (Carnevale et al. 2011; Xue and Larson 2014). For example, some federal agencies in the U.S. that require STEM cognitive competencies (Carnevale et al. 2011), including the United States Geological Survey (USGS), are facing future workforce shortages (USGS 2015). This is illustrated further by the USGS Bureau Workforce Plan: 2015-2020 (2015) which reports that 35% of permanent USGS employees were expected to be eligible for retirement in 2017. Concomitant with a skill shortage at the USGS is increasing pressure on our freshwater resources which is expected to be exacerbated by an increasing global population, climate change, geopolitical instability, and other factors (Eckstein 2010; Petersen-Perlman et al. 2012; Dawadi and Ahmad 2013; Gleick 2014), highlighting the importance of understanding current student training and workforce development in water resources research and management.

Recognizing the role and mandates of the USGS in water resources research, technology transfer, and student training (Water Resources Research Act 1984) we explored workforce development by examining student training through the USGS Water Resources Research Act (WRRRA) Program. One of four internal programs addressing the USGS Water Mission Area, the WRRRA Program conducts workforce training via the support of undergraduate and graduate level students, post-graduate associates, and interns as authorized by section 104 of the WRRRA (1984). The WRRRA Program is a Federal-State partnership which: plans, facilitates, and conducts research to aid in the resolution of State and regional water problems; promotes technology transfer and the dissemination and application of research results; provides for competitive grants to be awarded under the WRRRA, and; provides for the training of scientists and engineers through their participation in research and outreach (WRRRA 1984).

Individual member institutes authorized by the WRRRA (1984) are organized as the National

Institutes for Water Resources (NIWR). The NIWR cooperates with the USGS WRRRA Program to support, coordinate, and facilitate research through Annual Base Grants, National Competitive Grants, Coordination Grants, and in operating the NIWR-USGS Student Internship Program. In supporting students through the above grants and internship, institutes provide for the training of the next generation of scientists and engineers in support of WRRRA (1984) mandates. The life and physical sciences and engineering are among STEM occupational areas that are well represented in the WRRRA Program-NIWR research portfolio and student training activities. There are 54 university-based Water Resources Research Institutes or centers, one in each of the 50 U.S. states in addition to the District of Columbia, and the U.S. Territories of Puerto Rico, the U.S. Virgin Islands, and Guam.

The institutes chronicle a notable investment in workforce development overall, training more than 25,000 students in their first 50 years at more than 150 universities as well as mentoring USGS Interns (NIWR 2015). However, the synthesis, analysis, and presentation of these data at the state and national level to better understand and document institute contributions to education and workforce development have been modest to date. Further, the extent to which institutes individually collect, utilize, archive, or otherwise maintain data on students supported for use at the national, state, or local level has not been evaluated. Additionally, opportunities exist for exploring the use of data on students supported by institutes; including standardizing, collecting, and managing data to better define and inform the federal investment in these programs. As an example, the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), Educational Partnership Program (EPP) with Minority-Serving Institutions documents degrees earned by EPP graduated students and recruitment of EPP students into the NOAA workforce (Robinson et al. 2007). Here, we investigate student education and training activities of the WRRRA Program in the development of water resource professionals within the context of the STEM workforce. Findings will inform understanding of institute student support and the role this support plays in training the next generation of water scientists and managers.

Methods

We investigated WRRRA Program student education and training activities for the most recent 16-year period for which federal reporting data were complete at the onset of our study, 2000 through 2015. Among our objectives were the compilation, synthesis, and analysis of archived data on students supported by the WRRRA Program at the state and national level; an understanding of the use of these data by member institutes, and; a gap analysis of data opportunities and needs associated with student training. All work presented was conducted in collaboration with the USGS, NIWR, and University of Hawai'i Water Resources Research Center (WRRC). Mean values are presented with one standard deviation (*sd*). Linear regression analysis was conducted to evaluate temporal trends with alpha set at 0.05.

Student Support at the Water Resources Research Institutes

We extracted archived data from a national institute reporting database (NIWR.net) on students supported by the 54 institutes as reported to the WRRRA Program. We compiled, synthesized, and analyzed data reported by each institute by year, student category, and funding instrument. Student categories included undergraduate students, master-level graduate students, doctoral-level graduate students, and post-doctoral associates. Available data did not specify Master of Arts or Master of Science degrees and master-level students are pooled here. Doctoral students are reported in NIWR.net as seeking Doctor of Philosophy (Ph.D.) degrees.

Funding instrument categories included Annual Base Grants, National Competitive Grant Program funding (NCGP), Coordination Grants, and the NIWR-USGS Internship program. Annual Base Grants require a minimum non-federal institute match of two dollars to every one federal dollar awarded. The NCGP requires a minimum non-federal match of one dollar to every one federal dollar awarded to institutes. Coordination Grants and the NIWR-USGS Internship program do not require non-federal funding match. As non-federal funding match may exceed minimum requirements, the ratio of federal to non-federal

dollars could vary by project. Student support reported in NIWR.net and analyzed here represents federal project dollars combined with any associated non-federal match. Available data did not allow discernment of student support by federal support vs. non-federal match.

Institutes reported the number of students they supported each year in NIWR.net. However, although individual students could potentially be supported for more than one year by an institute, identities or other identifiers of individual students supported were not reported. As such, it was not possible to ascertain the total number of individual (unique) students supported across years. Instead, multi-year student support was evaluated by calculating the sum of students supported in the years of interest, referred to here as student support years. To explore this student support from a national perspective, institute data were pooled to provide a comprehensive summary of support by student category and funding instrument each year.

Student Data and use of Student Metrics at the Water Resources Research Institutes

We report on the outcomes of a WRRRA Program Initiative to examine, document, and summarize the extent and use of data collected on students supported by individual institutes. The WRRRA Program asked institutes to complete a voluntary online survey of institute practices. Survey questions addressed types of data collected, how such data are obtained and managed, and current uses of these data. To explore survey nonresponse bias, a survey response rate was calculated by dividing the total number of completed surveys by the total number of member institutes and multiplied by 100. A survey was archived as complete if a survey participant clicked "done" and submitted the survey online. Item nonresponse rate by survey question was not calculated as the survey structure required participants to answer each question.

Gap Analysis for Data Opportunities and Needs Related to Student Support

Using results from the activities described above, we generated a gap analysis of data opportunities and needs related to student support at the USGS Water Resources Research Institutes.

This qualitative assessment derives from the synthesis of available data presented above and interpretation of these data by the authors. The gap analysis for select student support data elements includes a description of the current circumstances (current state), identifies an associated desired state (the opportunity), ascertains one or more deficiencies in achieving the desired state (the need or gap), and provides recommended actions to address the need identified.

Results

Student Support at the Water Resources Research Institutes

All institutes pooled ($N = 54$) supported on average 678 ($sd = 83$) students per year (range 518 to 788) providing 10,853 student support years from 2000 through 2015. The number of students supported increased (linear regression analysis, $p = 0.02$) during this 16-year period by approximately 10 students each year (Figure 1A).

Individual institute investment in student support varied as measured by student support years. Total student support years by institute during the 16-year period examined ranged from 76 to 646 (Figure 1B). On average, each institute provided 201 ($sd = 102$) years of student support in total from 2000 through 2015; the median number of student support years by institute over this period was 175.

Student Support by Degree Sought. From 2000 through 2015, the WRRRA Program-NIWR provided support for students working toward degrees at the undergraduate, master, Ph.D., and post-doctoral levels. The total 10,853 student support years were allocated as follows: 4,304 at the undergraduate level, 3,781 at the master level, 2,344 at the Ph.D. level, and 424 at the post-doctoral level. There were significant increases in the number of undergraduate and Ph.D. students, and post-doctoral associates supported from 2000 through 2015 (linear regression analysis, $p \leq 0.05$ for all) (Figure 2). Support of undergraduate students increased by five students per year during this period, followed by Ph.D. students with an increase of about four students per year, and post-doctoral associates at just over one student

per year. No change in the number of students supported over this period was detected for master-level students.

Student Support by Funding Instrument.

Funding instruments through which students were supported included Annual Base Grants, the NCGP, Coordination Grants, and the NIWR-USGS Student Internship Program (Figure 3). Annual Base Grants to member institutes were the primary funding mechanism from 2000 through 2015, accounting for 9,010 or 83% of all student support years. The next most common funding instrument for student support was Coordination Grants (1,640 student support years or 15% of all student support years), followed by the NIWR-USGS Internship Program (202 student support years or 2% of all student support years), and the NCGP (96 student support years or 1% of all student support years).

Student funding via Annual Base Grants increased significantly by approximately 14 students per year from 2000 through 2015 (linear regression equation, $p < 0.005$) with a trend toward increased variability in the number of students supported beginning in approximately 2007. The NIWR-USGS Internship Program decreased funding of students on average by just over one student per year from 2000 to 2015 and this was also significant (linear regression equation, $p < 0.005$). Funding of students via Coordination Grants also decreased on average by two students per year over the period examined, though this trend was not significant. In contrast to Annual Base Grants, there is a trend toward decreasing variability in number of students supported for Coordination Grants beginning in approximately 2007. The number of students supported via the NCGP remained constant at approximately six students per year from 2000 through 2015.

Student Data and use of Student Metrics at the Water Resources Research Institutes

Forty-four of 54 WRRRA Program-NIWR institutes participated in the survey on student data collection and use of student metrics for a survey response rate of 81%. Seventy percent of institutes responding to the survey indicated they keep and maintain the data they report to NIWR.net on students or fellows supported. Institutes manage

these data in a variety of ways (Figure 4). The most common way institutes manage these data is in the original file reports submitted by institute researchers, other faculty, or the institute itself (70% or 31 institutes). NIWR.net is the second most common tool used by institutes to manage student or fellow data (52% or 23 institutes), followed by software spreadsheets (36% or 16 institutes), fiscal

or human resources files (20% or nine institutes), and database systems other than NIWR.net (16% or seven institutes). Four institutes (9%) reported they manage these data in other ways.

Fifty-nine percent of institutes responding to the survey indicated they do not collect and maintain any data on students or fellows supported beyond that which is required for NIWR or USGS reporting

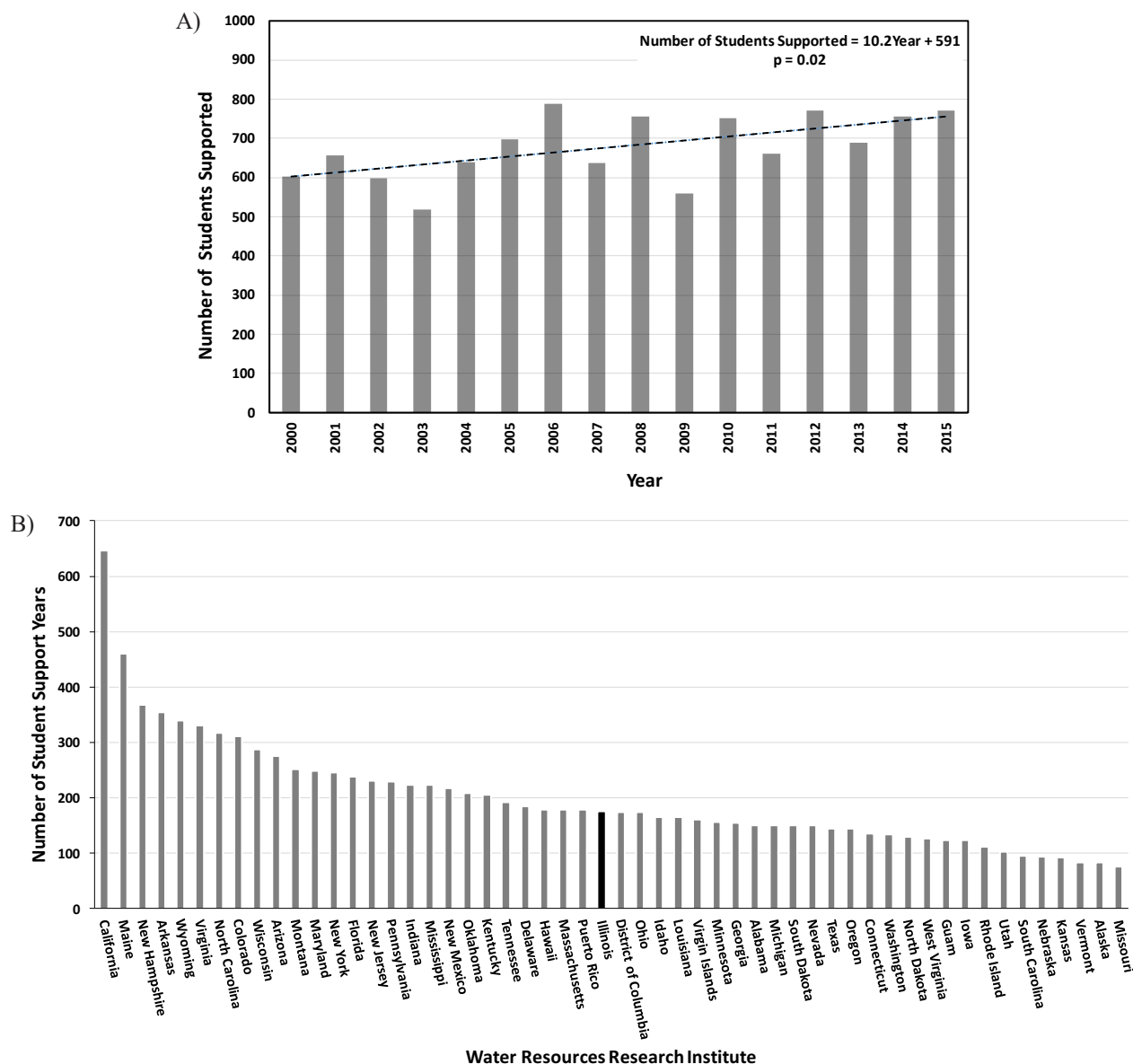


Figure 1. Student support at the United States Geological Survey, Water Resources Research Act Program from 2000 through 2015 by A) number of students supported by year for all water resources research institutes pooled. Linear regression (dashed line) analysis shows a significant increase in students supported during the period examined ($p = 0.02$); and B) number of student support years by water resources research institute for all years pooled. The median number of student support years is indicated by the black bar (Illinois). A student support year is defined as the support of one student for one year.

purposes with the remaining 41% of institutes reporting they do collect and maintain data beyond that required for reporting purposes.

Most institutes report they are collecting data on student or fellow name (80% or 35 institutes) and degree sought (82% or 36 institutes). However, confirming the functional linking of these two data fields and other student training data fields collected was not within the scope of the present work. Other information collected by institutes included date of degree earned and funding instrument/type (41% or 18 institutes for both). About one in four institutes (27% or 12 institutes) collect and maintain student contact information. Nine percent of institutes (four institutes) collect and maintain data on student post-support professional (job) placement.

The current use of student support metrics by institutes is principally for required reporting. Essentially all institutes responding to the survey

(98% or 43 institutes) report using these data for required NIWR, USGS, or university reporting purposes. Less than one-half of institutes responding use these data for institute promotion (45% or 20 institutes) or website and social media engagement (41% or 18 institutes) (Figure 5). Seven institutes (16%) use data on students or fellows supported for development/donor activities. Two institutes (5%) use data on students or fellows supported for other purposes.

The importance of student support/training to both the mission of individual institutes as well as nationally is widely acknowledged by institutes with $\geq 80\%$ of all institutes responding student support/training is “very important” to both.

Gap Analysis for Data Opportunities and Needs Related to Student Support

A gap analysis for data opportunities and needs related to student support is provided in

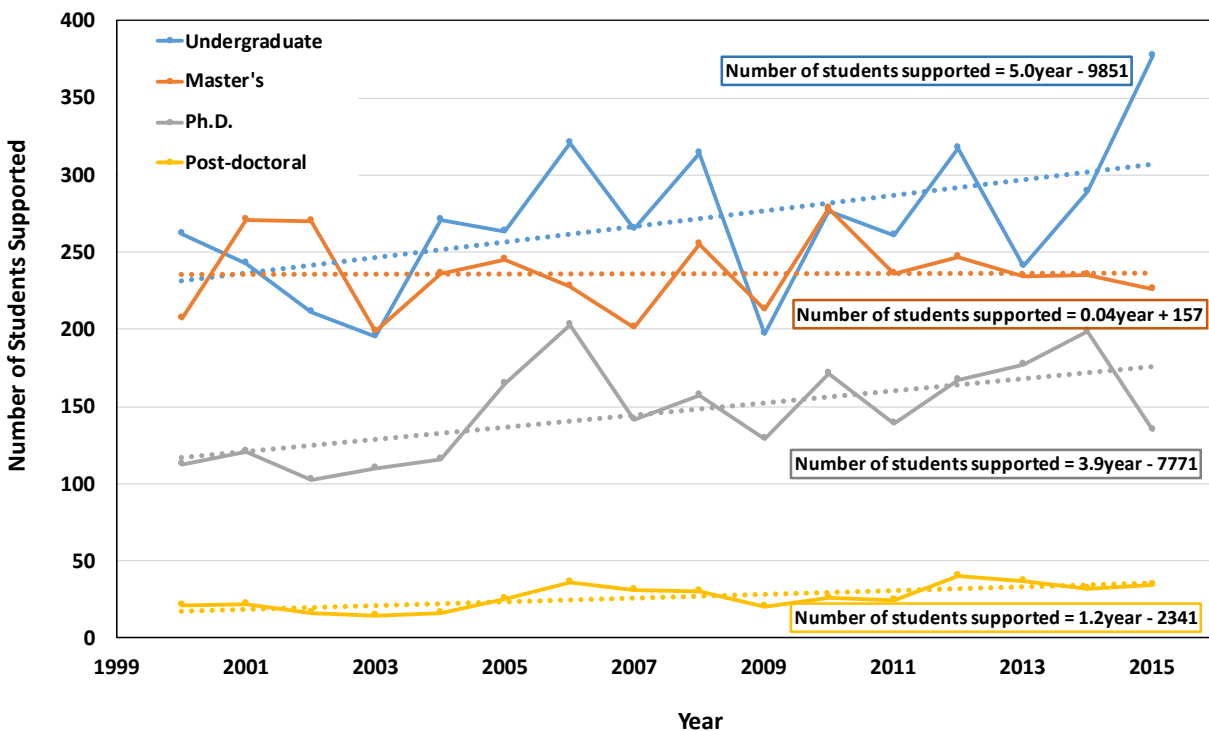


Figure 2. Number of students supported by the United States Geological Survey, Water Resources Research Act from 2000 through 2015 by year and university degree sought for all water resources research institutes pooled. Solid lines connect data points by year. Dotted lines are fitted using linear regression. Number of students supported significantly increased for undergraduate students (blue circles), Ph.D. students (gray circles), and post-doctoral associates (yellow circles) (linear regression analysis, $p \leq 0.05$ for all); no significant change was detected for master students (orange circles).

Table 1. Overall, four areas were identified that provide opportunities to increase the utility and value of student support data and associated metrics. These four areas address: achieving consistent and comparable data collection among institutes; achieving consistent and comparable data management among institutes; utilizing metrics associated with student training broadly and effectively internally and externally, and; enhancing data collected to document student training outcomes and inform strategic investment in student support.

Selected deficiencies (gaps) to capitalizing on the opportunities noted above are also provided in Table 1. While specific gaps are provided for each area, a gap identified for all areas is a user-friendly, enhanced, and interactive online database readily accessible to individual institutes, NIWR, and the WRRRA Program. Other gaps identified include: clear national guidelines on collection and reporting of student support data; opportunities for use of student training metrics that are well defined

and supported at the state or national level; and data on job recruitment, placement, and retention of supported students. Eight specific actions are also identified in Table 1 to address one or more described gaps.

Discussion

Student Support at the Water Resources Research Institutes

The USGS Water Resources Research Institutes play a key role in providing training in water resources within a greater STEM occupational framework, as evidenced by the support of approximately 700 students each year via federal WRRRA Program funding. Though investigation of specific disciplines studied by supported students was beyond the scope of this study, institute research and associated student training is focused heavily on STEM disciplines. The increase in overall student support from 2000 through 2015, by about 10 students each year, is

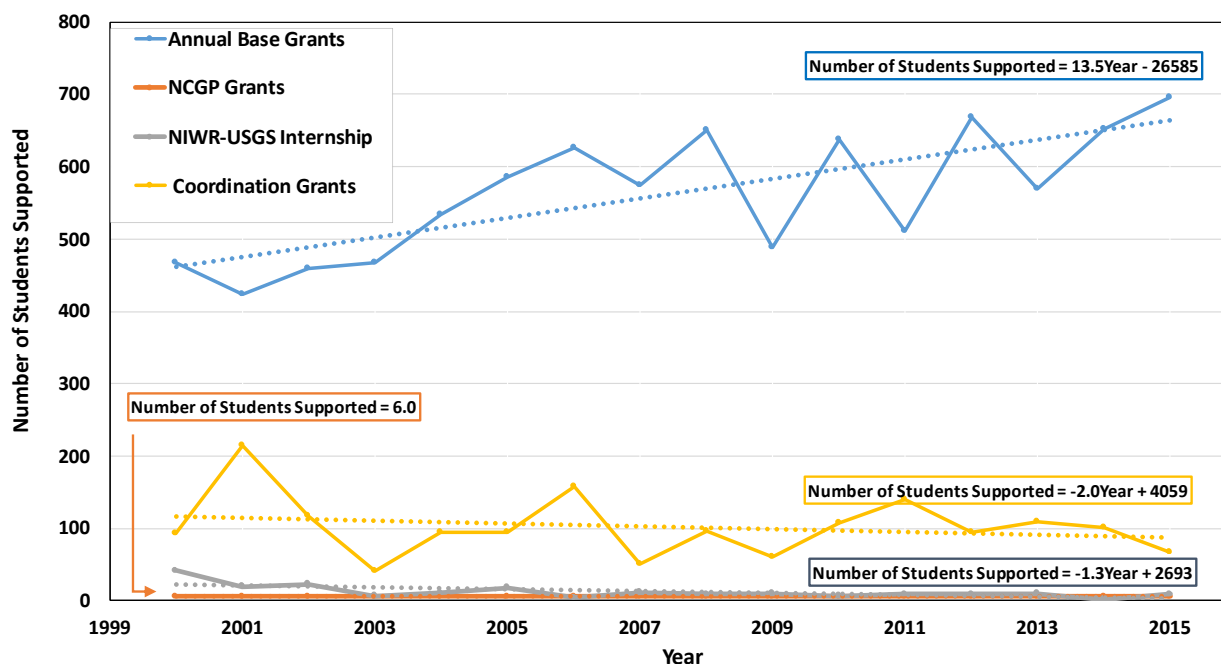


Figure 3. Number of students supported by the United States Geological Survey, Water Resources Research Act Program from 2000 through 2015 by federal funding instrument for all water resources research institutes pooled. Solid lines connect data points by year. Dotted lines are fitted using linear regression. Number of students supported significantly increased for Annual Base Grants (blue circles) and significantly decreased for the NIWR-USGS Student Internship Program (gray circles) (linear regression analysis, $p < 0.005$ for both); no significant change was detected for the National Competitive Grant Program (NCGP; orange circles) or Coordination Grants (yellow circles).

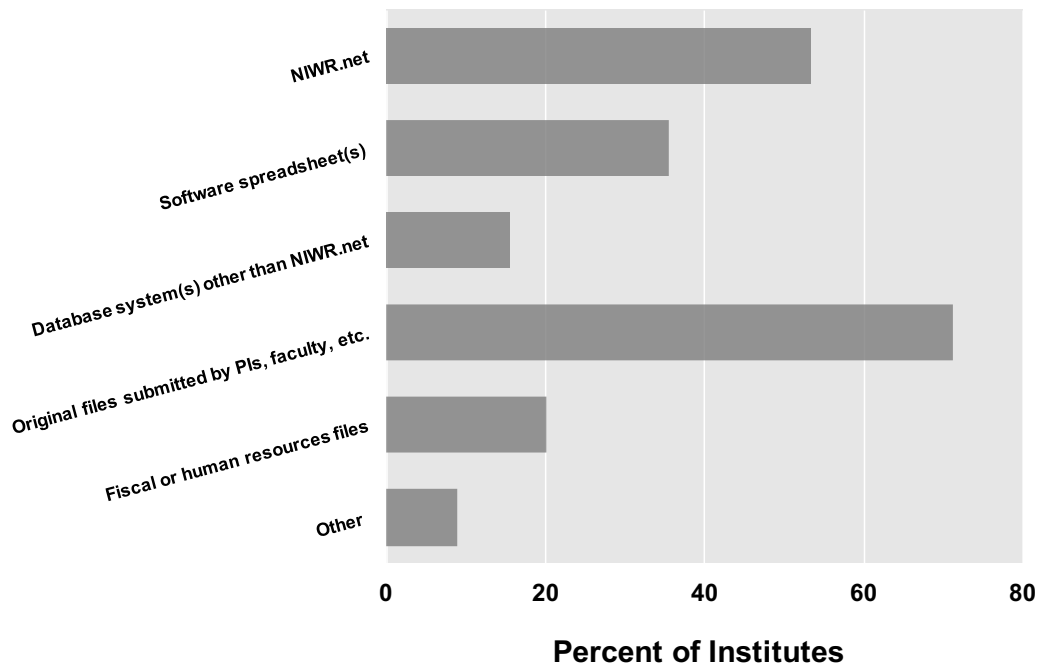


Figure 4. Water Resources Research Institute responses to the survey question, “How does your state water institute manage data on students or fellows supported?” The total number of institutes responding to this question was 44. Individual institutes could choose multiple responses; percentages may not add to 100%. PIs refer to Principal Investigators of funded research. NIWR.net is the federal reporting database to which institutes are required to submit yearly reporting.

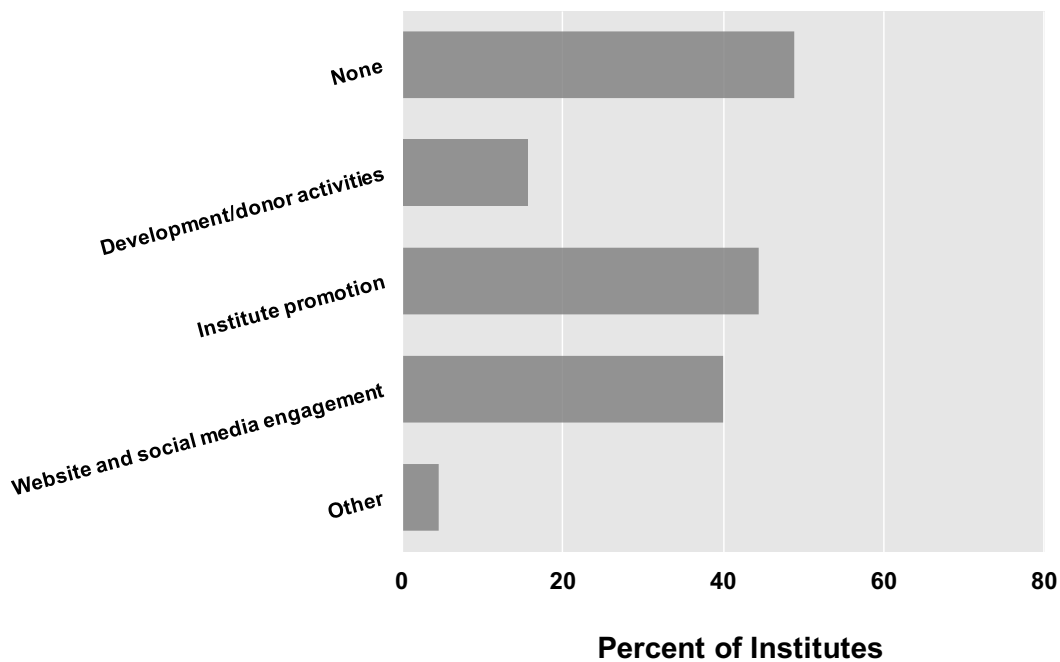


Figure 5. Water Resources Research Institute responses to the survey question, “[Other than required reporting], in what ways does your state water institute currently use data on students or fellows supported?” The total number of institutes responding to this question was 44. Individual institutes could choose multiple responses; percentages may not add to 100%.

Table 1. Gap analysis for data opportunities and needs related to student training at the United States Geological Survey (USGS) Water Resources Research Institutes.

Current State	Desired State (Opportunity)	Deficiency (Gap or Need)	Action
1. Data collection on student training is inconsistent among state water resources research institutes.	Data collection on student training is consistent and comparable among state water resources research institutes.	Clear national guidelines on data collection and reporting of student support and training.	Clarify national guidelines on student data collection and reporting.
			Improve standardization of student data collection.
			Update and enhance information collected on student training.
		User-friendly, enhanced, and interactive online database.	Evaluate, identify, and implement tools to enhance student support tracking and outcomes.
2. Management of data on students supported is inconsistent among state water resources research institutes.	Management of data on students supported is consistent and comparable among state water resources research institutes.	User-friendly, enhanced, and interactive online database.	Evaluate, identify, and implement tools to enhance student support tracking and outcomes.
3. Metrics associated with student training are underutilized.	Metrics associated with student training are broadly utilized.	User-friendly, enhanced, and interactive online database.	Evaluate, identify, and implement tools to enhance student support tracking and outcomes.
		Opportunities for use of student training metrics are well defined and supported at the state and national level.	Develop strategies for use of student support metrics at the state and national level and share with state water resources research institutes.
			Conduct outreach and “inreach” on student support and associated metrics with USGS, state water resources research institutes, stakeholders, constituents, and others.
4. Outcomes of student training are not documented.	Outcomes of student training are documented and investment in student support is strategic.	User-friendly, enhanced, and interactive online database.	Evaluate, identify, and implement tools to enhance student support tracking and outcomes.
		Data on workforce placement of supported students.	Identification and ranking of alumni search strategies for populating student training database(s).
		Data on recruitment, placement, and retention of supported students within the USGS.	Develop and conduct survey to evaluate role of institutes in workforce training and recruitment at the USGS.

a judicious investment in our nation's workforce. The absolute increase in investment in student training is laudable given the static federal funding of the institutes during the time-period examined (WRRRA 1964, 1984) and speaks to the recognition of student training and workforce development as a vital service provided by the WRRRA Program via institutes.

Students supported by institutes represent individuals who are likely to have contributed to the greater STEM workforce and the level of this training provides some insight on the nature of these contributions. As the largest single category of students trained from 2000 through 2015, undergraduate students are notable insofar as workforce undergraduate-level STEM competencies are increasing in value nationally and internationally (Carnevale et al. 2011). Training of undergraduate students, irrespective of an earned degree, can address workforce trends. In manufacturing, a need for sub-baccalaureate STEM skills was reflected in an estimated 600,000 unfilled technical positions in 2011 in the U.S. alone (Deloitte and The Manufacturing Institute 2011). Over 25% of STEM workers are educated at the post high-school diploma, sub-baccalaureate level and the wages of these workers exceed those of their non-STEM counterparts (Carnevale et al. 2011). The life and physical sciences and engineering, including engineering technicians, are among STEM occupational areas that are well represented in institutes' research portfolios and, by extension, student training (though some portion of WRRRA Program supported students may represent non-STEM disciplines). Undergraduate study also results in a subset of supported students subsequently earning baccalaureate or higher degrees, credentials possessed by the majority of those occupying STEM jobs (Carnevale et al. 2011). Further, undergraduate student participation in research is correlated with student engagement (Miller et al. 2011) and success (Fechheimer et al. 2011) and undergraduates who participate in multi-year research experiences report enhanced workforce preparation (Thiry et al. 2011; Thiry et al. 2012). Undergraduate student training is clearly a fundamental aspect of workforce development, and the increase in undergraduate support by institutes from 2000 through 2015 is notable.

In 2015, just 12% of the U.S. population held an advanced degree, those beyond the baccalaureate (Ryan and Bauman 2016), though this level of training is increasingly important in disciplines related to water resources. In 2018, 64% of all STEM occupations are estimated to require a level of education at the bachelor's degree or higher and this is particularly relevant in the life and physical sciences, areas related to water resources, where nearly one-half of these occupations will require advanced degrees (Carnevale et al. 2011). Congruently, 60% of institute student support has been directed toward those pursuing advanced degrees or receiving post-doctoral training. Master-level student training by institutes is second only to that of undergraduate student training and master student support represents the greatest component of graduate student support at institutes. This likely speaks to the roles of master-level training as preparation for direct post-degree employment as well as for doctoral-level study in some disciplines. The available data did not allow for the determination of the terminal degree earned by students supported by institutes, information which would assist in defining the outcomes of student support. It is unclear why, in contrast to all other student categories, there has been no increase in master-level student training by institutes over the 16-year period examined.

Support provided by institutes at Ph.D. and post-doctoral levels represents students seeking the highest levels of educational achievement. Pooled, the increase in student support for doctoral and post-doctoral students accounts for about one-half of the overall increase over the time period examined (with the remainder of the increase supporting additional undergraduate students). Academia has been identified as having a STEM Ph.D. surplus, particularly with regard to disciplines common to water resources (Teitelbaum 2003; Anft 2013) while other sectors, including government, may be facing a shortage (Carnevale et al. 2011; Xue and Larson 2014). Investigation of the degrees held by employees of key U.S. agencies, such as the USGS, would enrich the understanding of the potential value of institute student support to these agencies. One transcendent circumstance of the U.S. workforce at all levels and sectors is the retirement wave of workers born

from 1946 to 1964, the “baby boomer” generation. Baby boomer retirements are predicted to have a disproportionately greater affect in STEM (Carnevale et al. 2011), and by extension water resources research and management disciplines, which institute trained students may address.

The variability of student support years among institutes over the time period examined is of interest. Each institute receives an annual core federal award of equal value, the variability in student support among institutes thus reflects other circumstances. For example, the structure and content of competitive research proposals awarded funding through each institute, i.e., researchers’ requests for student support within proposals or the success of proposals that include student training, may both vary by institute. The variability observed may also result from WRRR Program researchers directing student training costs to leveraged intra- or extramural funding, even if students are participating on WRRR Program projects, and the inconsistent reporting of these students among institutes. Further, variable garnering of extramural funding by institutes and the application of these funds toward exceeding the minimum required WRRR Program non-federal match results in some institutes having a larger funding base from which to support student training. The variability in the number of students supported by institute may also reflect differences in the cost required to support students at various institute universities as well as variable costs associated with supporting undergraduate vs. graduate students.

The investment in student support by institutes reported here is conservative, documenting only students supported or trained via the WRRR Program and reported via NIWR.net. As previously noted, a mandate of some federal WRRR Program funding requires institutes to match non-federal project funds to federal dollars awarded, with some institutes exceeding the minimum required match. This leveraging amplifies the federal investment and increases the reach of institute student training, though it is not clear that consistent reporting of student training associated with non-federal match funds is occurring. Additionally, many institutes support students on projects not reported to the NIWR.net database, for example, select

intra- and extramural funds obtained by institute researchers and directed to student training. Thus, the magnitude, influence, and reach of institute student support is greater than that documented by current reporting protocols. Achieving data collection and reporting on student training that is consistent and comparable among institutes, and appropriately recognizes leveraged support, would ameliorate some of the above uncertainties.

The primary WRRR Program funding mechanism by which students are trained at institutes is via competitive Annual Base Grants awarded to scholars researching issues related to water resources at our nation’s universities. Regardless of degree sought by supported students, students are mentored and trained under the supervision of these scholars while participating in funded research, a documented contributor to student success (Fechheimer et al. 2011), persistence in STEM disciplines (Lopatto 2004, 2007) and workforce preparation (Thiry et al. 2011; Thiry et al. 2012).

The decline of students supported in the NIWR-USGS internship program is unfortunate as this program “provides undergraduate and graduate students with career enhancing field, laboratory, and research experience through participation in USGS activities as interns” (USGS 2018). Like undergraduate research, internships have been shown to be a high impact learning experience, result in high student engagement, and are uniquely perceived by students as relevant to long-term career goals (Miller et al. 2011). Thiry et al. (2011) showed that participation in out-of-class experiential activities such as internships and research by STEM undergraduates nurtured professional and personal gains. Mentoring, inclusive of internships and undergraduate research, has also been identified as having the largest perceived impact on academic performance for minority students in STEM disciplines (Kendricks et al. 2013). Concordant with the above, employers increasingly value internships as a pipeline for workforce recruitment (Robinson et al. 2007; Nace 2017). The collaborative NIWR-USGS Internship may be an underutilized asset that has the potential to serve as an enhanced conduit for diverse employee recruitment at the USGS and beyond.

Student Data and use of Student Metrics at the Water Resources Research Institutes

The local archiving of data on student support by a majority of institutes, albeit by a variety of protocols, presents an opportunity to utilize archived data for documenting post-support outcomes, such as degrees earned (in addition to sought) and workforce placement. Data management protocols most certainly impact the effectiveness and responsiveness with which institutes can access, query, and summarize student support metrics. The use of the NIWR.net database for data management by just over one-half of institutes responding suggests it presently does not exhaustively meet the database needs of institutes or that institutes do not have the access or information technology capacity to optimize use of NIWR.net. The reported use of original file reports or fiscal or human resources files by nearly all institutes (90%), coupled with modest use of other database systems (16% of institutes) and software spreadsheets (36% of institutes), clearly indicates opportunities exist to enhance and facilitate management of student support data at the institute and national WRRR Program levels.

Enhanced data management of student information in consistency and scope would also improve interpretation of these data at all programmatic levels. The ongoing collection of an assortment of student training elements (data types/fields) by a majority of member institutes is a platform for embarking on these efforts. Though 80% of institutes report local collecting of data on student names, the functional linking of unique student identifiers, such as name, with other data fields such as degree(s) sought is unknown and was beyond the scope of this study. While institute investment in student support years was calculated, the lack of accessibility to data on student identifiers prevented the calculation of the absolute number of individual (unique) students supported over multiple years at both institute and national scales. However, the types of data collected presently by some institutes, such as student name and degree sought, indicate the potential for using archived data to generate meaningful student training outcome metrics, such as degrees earned and post-support job placement of supported students.

To our knowledge, no information on the diversity of students supported by institutes or the

participation of minority and underserved groups in institute student training is currently known or collected. Presently, workforce diversity remains below targeted levels at the USGS (USGS 2015). A trifecta of mentoring, undergraduate research, and academic support has been shown to increase diversity and retention in undergraduate STEM disciplines (Wilson et al. 2012); all areas in which institutes have a university role. Program's implementing such actions have demonstrated success in preparing minority scientists and engineers for academic achievement (Summers and Hrabowski 2006) including enhancing minority representation in the NOAA workforce (Robinson et al. 2007). Enhanced minority and underserved student engagement at the institutes, and development and implementation of metrics to better define this engagement, are identified as avenues toward achieving race, ethnic, gender, and disability diversity within the greater USGS workforce.

Enhanced collection of student support data and management of these data and derived metrics will benefit from clear and supportive guidelines from WRRR Program leadership in collaboration with individual institutes on the type and scope of data sought. For example, just 41% of institutes participating in the survey report collecting or maintaining data on funding sources of student support at the institute level, though this is a codified element of federal reporting on student training funded by the WRRR Program. Thus, these data, while reported to the WRRR Program via NIWR.net by institutes, may not be readily archived for use at the institute level. Further, the robustness of data on student training could likely be enhanced through ongoing clarification of WRRR Program reporting requirements, particularly with regard to leveraged funding. Additionally, as noted previously, data management protocols (e.g., user-friendly databases) impact the effectiveness with which institutes can access, query, and summarize student support metrics, but also critically affect the capacity of individual institutes to collect these data in a consistent and comparable manner.

With over 80% of institutes reporting that student training is very important both at the institute and national level, the value of student training is broadly recognized. As such, considerable

opportunity exists to enhance and expand use of alumni metrics to evaluate effectiveness of WRRRA Program student support as well as amplify state, regional, and national support for institutes both within and outside of the USGS.

Gap Analysis for Data Opportunities and Needs Related to Student Support

Our gap analysis of student support data opportunities and needs is a sample framework from which understanding of student training efforts and outcomes might be enhanced with an emphasis on student data collection and management, and use of alumni data. Ultimately, knowledge of student support outcomes, such as post-support degrees earned and workforce placement, can document the value of the federal and state investment in institute supported students as well as direct this investment strategically to meet federal mandates and societal workforce needs.

Across all data opportunities described, a cross-cutting deficiency (gap) identified is the lack of a user-friendly, enhanced, and interactive online database for use by institutes, the WRRRA Program, and NIWR. Such a database would facilitate collection, management, and effective use of student support and training data while allowing for the eventual documentation of post-support outcomes. While NIWR.net is a functional database, its utility for routine use by personnel at institutes is not currently realized and extant NIWR.net data fields do not address all identified gaps.

Key outcomes of the gap analyses are proposed actions to prepare for and initiate data collection on job recruitment, placement, and retention of institute supported students, including by the USGS. Additionally, data on degrees earned and workforce placement can assist individual institutes and the WRRRA Program in refining student support investment to optimize value to students themselves, i.e., investment might be directed to increase the probability of student professional success in response to workforce needs. Exploration of the diversity, equity, and participation of minority and underserved groups receiving student support could assist in determining to what extent student support

is meeting diversity targets at local, state, and national levels.

The 11 specific actions identified in Table 1 to address one or more described gaps support four strategic opportunities available to WRRRA Program leadership to engage individual institutes. Individual institute engagement is critical insofar as individual institutes may have developed and implemented *ad hoc* alumni data solutions at the state level that may be scaled nationally. Other solutions that may have significant utility at the national level may require adaptation to be equally useful at the state and university level and vice versa. Additionally, where possible, extant solutions to similar needs should be leveraged. For example, the National Sea Grant College Program (Sea Grant) in the U.S. Department of Commerce's NOAA, has a similar management framework to the WRRRA Program; including being comprised of individual member programs at our nation's universities and colleges and parallel legislative mandates. Sea Grant efforts to document student training nationally continue to increase (National Sea Grant College Program 2018) and about one in five NOAA personnel are estimated to have been trained or supported by the National Sea Grant College Program (Authors, unpublished data). More broadly, information about students supported by NOAA programs are compiled with a focus on NOAA mission-related STEM disciplines (NOAA 2018) in part through a Student Tracker Database that identifies students trained with EPP funds (Robinson et al. 2007). Solutions developed and implemented by Sea Grant or other relevant entities that could be applied or adapted by the WRRRA Program to address gaps is recommended.

Conclusion

The USGS Water Resources Research Institutes play a significant role in training our nation's water resource research and management professionals and contribute to the development of the STEM workforce. The concentration of institute student support at the undergraduate and master-level of study is appropriate to predicted workforce needs. The participation in research by institute supported students at all levels of study,

particularly undergraduates, is likely to increase students' future success. However, the NIWR-USGS Internship program may be an underutilized asset and presents an opportunity to potentially bolster workforce recruitment, particularly at the USGS. Opportunities also exist to augment data collection and data management on institute student training and refine the use of these data, such as documenting disciplines and dates of degrees earned by students, and post-training job placement. Another notable opportunity is initiating collection of information on student diversity and participation of minority and underserved groups in institute student training. Student training is recognized by institutes as an important programmatic element and support to more broadly utilize metrics associated with student training is recommended. Increased use of such information would illustrate the contributions of this training to workforce development at the state and national level. Exploration of institute alumni workforce placement will also illuminate the role student support plays in training the next generation of water scientists and managers in all sectors, and further clarify the value of this investment to society.

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