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Gender Representation in Faculty and Leadership at Land Grant and Research Institutions

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ABSTRACT

Representation of women in agricultural science was 5% in 1979, increasing to 12% by 2005. The near equal numbers of women and men receiving Ph.D. degrees in agricultural science in 2012 (44 to 56%, respectively) would suggest an upward trend of women scientists above 12% should be occurring over time. To monitor possible trends in the representation of women in agricultural science, we quantified the numbers of women at land grant institutions at the faculty and higher administration level and in leadership positions within scientific societies, industry boards, and government research positions. The survey results showed that female faculty in the agricultural sciences increased from 12% in 2005 to 23% in 2014; however, female representation in leadership positions in academia were low, with department chairs (18%), society leadership (18–36% ranging across societies), and deans of colleges of agriculture (9 out of 50) lagging behind men. Similarly, the number of women on the executive boards of agricultural industries (11%) and at the USDA-ARS (26%) are still lower than the proportion of women with Ph.D.'s in agricultural sciences. These results suggest progress toward gender representation that reflects the number of qualified women at the faculty level, but it seems that representation is limited after the graduate training level, at the faculty level and beyond. We must be diligent in crop and soil sciences in mentoring female students and young faculty to ensure progress of female scientists to all levels of leadership in academia and the private and public sector.

Core Ideas

- Female faculty in agricultural sciences has increased from 12 to 23% in the last 10 yr.
- Higher leadership positions within academia, industry, and government research positions are primarily held by men.
- The proportion of women with Ph.D. degrees in agricultural sciences is still higher than those with careers and leadership positions.

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It could be argued that the ongoing concern about recruiting and retaining women in science, technology, engineering, and mathematics (STEM) has roots back to the first formative years of the Land Grant Institutions (LGIs) in the United States, after their establishment in 1862 and 1890. One of the primary missions of the LGIs was to increase the proportion of women at their institutions (Bowman, 1962), in an effort to improve the numbers of women receiving higher education since their first permissible admittance to U.S. colleges in 1837 (begun at Oberlin College in 1837; Graham, 1978). While most educational training programs for women focused primarily on "home economics", LGIs found that most female students preferred more STEM oriented subjects that had been intended for males–resulting in the employment of women in a broad range of jobs that were not in any way related to home economics, including participating in and teaching STEM subjects (Bowman, 1962). Despite this promising beginning over 150 yr ago, the number of women in STEM professions has continued to lag well behind men.

There has been much consternation, targeted recruitment, creation of focused support programs, and academic study into increasing the numbers of women in STEM (McGuire et al., 2012). Some progress has been made, particularly at institutions other than LGIs. The training of women in some STEM disciplines has shown improvement; for example, women earned bachelor's degrees in STEM in equal numbers to men by 1996 (Luckenbill-Edds, 2002), and doctoral degrees in biology also reached equality between men and women (McGuire et al., 2012). In fact, the stages where the numbers of women decrease during the academic training process, were considered gone at the bachelor's and master's levels by the 1990s, such that the number of women and men at these academic stages reached equal numbers (Luckenbill-Edds, 2002). Despite the equal numbers of women and men obtaining degrees at these levels, there is still evidence of fewer women in the sciences at many levels, from doctoral training programs to eventual career placement. In fact, for engineering and natural sciences, at each successive stage in the academic and career pathways (bachelor's, master's, doctorate, faculty, administration) the retention of women drops in comparison to the previous stage (Goldberger and Crowe, 2010; Kaminski and Geisler, 2012). Women are particularly underrepresented in leadership positions, receive lower salaries, and produce fewer publications than their male colleagues during their

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Abbreviations: LGI, Land Grant Institution; STEM, science, technology, engineering, and mathematics.

career (McGuire et al., 2012). However, the reasons are less clear–is it by choice, or due to hostile environments, or the lack of ability (Luckenbill-Edds, 2002)? Whatever the reason, the result of fewer women in STEM has likely led to reduced opportunities in terms of diversity of thought, creativity, and talent (Luckenbill-Edds, 2002).

These same issues are likely even more pervasive at LGIs, in part due to the historically male dominated nature of agriculture itself in the United States (Alesina et al., 2013). Several studies have clearly documented persistence of fewer women than men at LGIs in recent times (Buttel and Goldberger, 2002; Goldberger and Crowe, 2010). The history of gender imbalance within LGIs can be at least partially linked to the fact that, among the major academic disciplines, agricultural science has one of the smallest proportions of women scientists, as has historically been the case since the early development of agricultural science itself (Buttel and Goldberger, 2002). Goldberger and Crowe (2010) state that the source of inequality may be linked to the nature of the elements required to be successful as an agricultural scientist and that women may not have had as much opportunity for experience or training in these elements as men. These elements that are primarily unique from other disciplines include: the need to collaborate with entities outside of the academic sphere; being successful at engaging, communicating, and effectively delivering research impacts with public groups; and oftentimes having a direct, hands-on level of experience with agricultural production methodology (Goldberger and Crowe, 2010). Also included in that list could be the ability to translate basic research into deliverable, applicable solutions relevant to production systems, a unique requirement for success in agricultural science. The argument is that something in the characteristics of these elements themselves may somehow add to the gender imbalance, with fewer women than men, within the discipline of agricultural science (Goldberger and Crowe, 2010). The source of bias associated with these elements may not be inherently obvious, but could be a starting point for further investigation.

Despite the vulnerability to gender imbalance in the agricultural sciences, less emphasis has been paid on studying and examining the state of women in the academic training and career pathways (Buttel and Goldberger, 2002; Goldberger and Crowe, 2010), particularly for the flagship institutions of agricultural science training, the LGIs. In 1972, the ratio of male to female faculty over all state universities was 5 to 1, with more than half of these institutions lacking women in any top-level administrative position, and over one-third not considering women for such positions during a 5-yr period prior to the study (Arter, 1972). For agricultural scientists as a whole, the situation was more severe than the state universities as a whole–with women agricultural scientists making up only 5% of the total number of scientists in 1979 and 8% in 1996 (Buttel and Goldberger, 2002). In 2005, Goldberger and Crowe (2010) documented the percentage of women in "Crop Production Sciences" to be approximately 12%. These small percentages are not reflected in the number of doctoral degrees awarded to women in agricultural sciences and natural resources (including the disciplines of agronomy and soil science) which totaled 44% in 2012 (NSF, 2012). While not on par with the equality of doctoral degrees in biology, this statistic offers some evidence that numbers of females may be reaching near equality with men at the doctoral level in agricultural sciences. However, these percentages are not reflected in the representation of women at upper levels within academic leadership in agricultural science, including faculty positions, department chairs, and deans.

Nevertheless, due to the continued paucity of women that enter agricultural science as a career, it is imperative that research should continue to concentrate on documenting the presence of women at all levels of LGIs. Research should focus on the effectiveness of measures that have been taken to increase representation of women to reflect the levels of qualified women with Ph.D.'s (44% in 2012). Because the number of women has been found to be particularly low in the plant and soil sciences (Buttel and Goldberger, 2002), efforts should be focused on these particular disciplines in the LGI system. Further, if efforts within the LGI system have made increases in the proportion of women placed in faculty positions, there is likely to be evidence of improved representation in agricultural leadership positions including presence on editorial boards, industry leadership, and federal research positions. This is the case because LGIs are typically the source institutions for most women that enter into these positions. For example, for editorial boards, there is evidence that while there is a general increase of female leadership over time, women still rarely make up more than 20% of these boards (Cho et al., 2014). Crowe and Goldberger (2009) found through surveys of nearly 1000 LGI faculty members that women faculty were less likely (based on Hierarchical Linear Modeling) than their male counterparts to both receive industry support or participate in private consulting for industry. They concluded that this disparity could be due to a scarcity of women entering disciplines within agricultural science that historically and currently have stronger relationships with industry overall, including agronomy and crop science (Crowe and Goldberger, 2009). These results clearly show a continuing lack of women earning Ph.D.'s going on to become LGI faculty members, resulting in low numbers of women entering administrative leadership positions within LGIs, serving on editorial boards, or holding leadership positions in industry. Because LGIs are also an important source for government agricultural research scientist positions, representation of women in these career scientist positions may also be low. It is imperative to continue to frequently monitor gender representation at all levels of the LGIs and for agricultural science leadership positions likely to have close connections with this conduit. In this way, existing constraints, if any, that limit women moving past their Ph.D.'s to career and leadership positions can be addressed.

In an effort to continue monitoring the gender status of women within the upper levels of LGIs as well as in leadership positions outside of LGIs in crop and soil science, we asked the following questions:

1. What proportion of women are in careers in agricultural sciences following attainment of the Ph.D.?
2. What proportion of women are attaining leadership roles in professional agricultural societies and industry?

We hypothesized that:

1. Gender parity has improved since the 1970s at all levels of the LGIs.
2. The proportion of women in leadership roles in various sectors of the agricultural sciences has improved.

MATERIALS AND METHODS

To obtain a broad view in a single point of time of the current status of women within the agricultural sciences career pathways, with a focus on LGIs, data were collected from publicly available sources, primarily relying on information that each institution or company publicly listed on their websites. By doing so, we hoped to minimize any bias that might occur from requesting self-reported data from each institution while also obtaining the information quickly and comprehensively. Data were collected from August to December 2014. This method does differ from the previous most recent LGI data collected in 2005 (Goldberger and Crowe, 2010), but does provide an unbiased single time check of the proportion of women at the faculty and higher administrative position levels.

University Data

One land grant institution was selected from each state in the United States, which represented the primary agricultural research institution in that state (Table 1). Within each LGI, the agricultural college surveyed was identified as the college containing the departments of agricultural sciences and included (but were not limited to): Agronomy, Crop Science, Plant Science, Soil Science, and Natural Resources/ Environmental Science. Leadership roles targeted within each college and agricultural department included the following categories: Dean, Associate/Assistant Dean, Department Chair (or Department Head depending on the convention used in each department), and Faculty. The websites of each university were used to identify these roles and the gender of each person within those roles. Photos of each faculty member were also researched to ensure there was no bias or assumption regarding the gender associated with first names.

Agricultural Science Society Data

The membership of the tri-societies including the American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA) was obtained through a request to the society on 8 June 2015 by A. Cho. This request was fulfilled through communication with N. Ehresman (membership and certification representative for these societies). For purpose of analysis, the "unknown" gender category, which were those who did not identify their gender, was eliminated from the analysis. Leadership roles for each of the tri-societies were determined by identifying the ratio of female to male members on their respective boards; this information was obtained through the individual society's webpages.

Journal Data

A list of the top Agronomy and Soil Science journals were determined using the Journal Citation Report (JCR) and impact factor rating. The top 14 ranked journals for Agronomy and the top 9 ranked journals for Soil Science were reviewed for this paper (Table 2). Editorial leadership roles and gender were identified for each journal, including Editor-in-Chief, Associate Editors, Chief Editor, and Executive Editor. These roles were identified by using websites of the journals.

Table 1. List of land grant universities (LGIs) evaluated for faculty, department chairs, and deans in 2014.

State	University
Alabama	Auburn University
Alaska	University of Alaska- Fairbanks
Arizona	University of Arizona
Arkansas	University of Arkansas
California	University of California- Davis
Colorado	Colorado State University
Connecticut	University of Connecticut
Delaware	University of Delaware
Florida	University of Florida
Georgia	University of Georgia
Hawaii	University of Hawaii- Manoa
Idaho	University of Idaho
Illinois	University of Illinois at Urbana-Champaign
Indiana	Purdue University
Iowa	Iowa State University
Kansas	Kansas State University
Kentucky	University of Kentucky
Louisiana	Louisiana State University
Maine	University of Maine
Maryland	University of Maryland- College Park
Massachusetts	University of Massachusetts-Amherst
Michigan	Michigan State University
Minnesota	University of Minnesota
Mississippi	Mississippi State University
Missouri	University of Missouri
Montana	Montana State University
Nebraska	University of Nebraska-Lincoln
Nevada	University of Nevada- Reno
New Hampshire	University of New Hampshire
New Mexico	New Mexico State University
New York	Cornell University
North Carolina	North Carolina State University
North Dakota	North Dakota State University
Ohio	Ohio State University
Oklahoma	Oklahoma State University
Oregon	Oregon State University
Pennsylvania	Pennsylvania State University
Rhode Island	The University of Rhode Island
Rutgers	Rutgers, The State University of New Jersey
South Carolina	Clemson University
South Dakota	South Dakota State University
Tennessee	University of Tennessee
Texas	Texas A&M
Utah	Utah State University
Vermont	University of Vermont
Virginia	Virginia Tech
Washington	Washington State University
West Virginia	West Virginia University
Wisconsin	University of Wisconsin-Madison
Wyoming	University of Wyoming

Table 2. List of journal editorial boards evaluated for gender representation in crop and soil sciences in 2014.

Crop peer reviewed journals	Soils peer reviewed journals
Advances in Agronomy	*Soil Biology Biochemistry*
GCB Bioenergy	*Biology and fertility of soils*
Agricultural and Forest Meteorology	*Plant and Soil*
Theoretical and Applied Genetics	*Soil and Tillage Research*
Plant and Soil	*Geoderma*
Industrial Crops and Products	*Catena*
Plant Pathology	*Valdose Zone*
European Journal of Agronomy	*European Journal of Soil Science*
Irrigation Science	*Applied Soil Ecology*
Agronomy for Sustainable Development	*European Journal of Soil Biology*
Pest Management Science	
Postharvest Biology and Technology	
Journal of Agronomy and Crop Science	
Field Crops Research	

Table 3. List of companies evaluated for the proportion of women holding leadership positions on the senior, leadership, or executive director boards in 2014.

Company name
Agrium
Arkema
BASF
Bayer
CF Industries
China Agri-Industries
Dow Executive Committee
Dow Functional Leaders
DSM
Du Pont
FMC
K+S
Monsanto
Mosaic
Potash Corp.
Sabic
Sasol
Solvay
SQM
Sumitomo Chemical
Syngenta
Uralkali

Industry Leadership Roles

To determine the proportion of women in leadership positions in the primary production agricultural industries, data was accessed about public companies in the Forbes Global 2000 (for 2014; http://www.forbes.com/lists/2010/18/global-2000–10_The-Global-2000_Rank.html). To define and focus the list of companies, search terms were used including: (i) "all countries, all states of the U.S." to include all relevant companies both domestic and international; and (ii) "specialized chemical companies" and "diversified chemical companies" to isolate the agricultural companies involved primarily in agronomic production (as opposed to food processing or distribution) in particular. These filters were inclusive of the large-scale agricultural companies that represent the private agricultural industry sector (Table 3).

Table 4. Chi-square test for parity among proportions of various categories for leadership positions in the agricultural sciences evaluated in 2014.

Factor	Chi-square	*N*
Faculty	610.9*	1829
Department chair	35.3*	50
Dean	20.5*	50
ASA general membership	2246.8*	7460
CSSA general membership	1251.7*	5568
SSSA general membership	1412.9*	6584
Tri-society graduate student membership	24.1*	1374
Crop science journal editorial boards	47.5*	89
Soil science journal editorial boards	16.3*	59
Industry	157.5*	254
USDA-ARS	443.5*	1892

* $P < 0.001$, df = 1.

Company leadership roles were identified as those positions within the company identified as senior, leadership, or executive director boards of these companies. These boards were identified using company websites.

USDA-ARS

A 2014 report of the USDA-ARS status on Equal Employment Opportunity was used to identify the gender breakdown of research scientists within the agency (USDA-ARS, 2014). Positions within the GS13-15 were used as a representation of research scientists within the USDA-ARS.

Data Analysis

Chi-square statistic was calculated for all categories (except tri-society leadership due to cell values less than 5) using Excel. Proportions were tested for parity at the $P = 0.05$ level (Table 4).

RESULTS

Since the passage of the Women in Science and Technology Equal Opportunity Act 35 yr ago, which states that women should have equal opportunities in education, training, and employment in the scientific fields (Handelsman et al., 2005), it appears that the United States has nearly accomplished equal representation of men and women in agricultural science at the graduate training level (NSF, 2012). This was the case

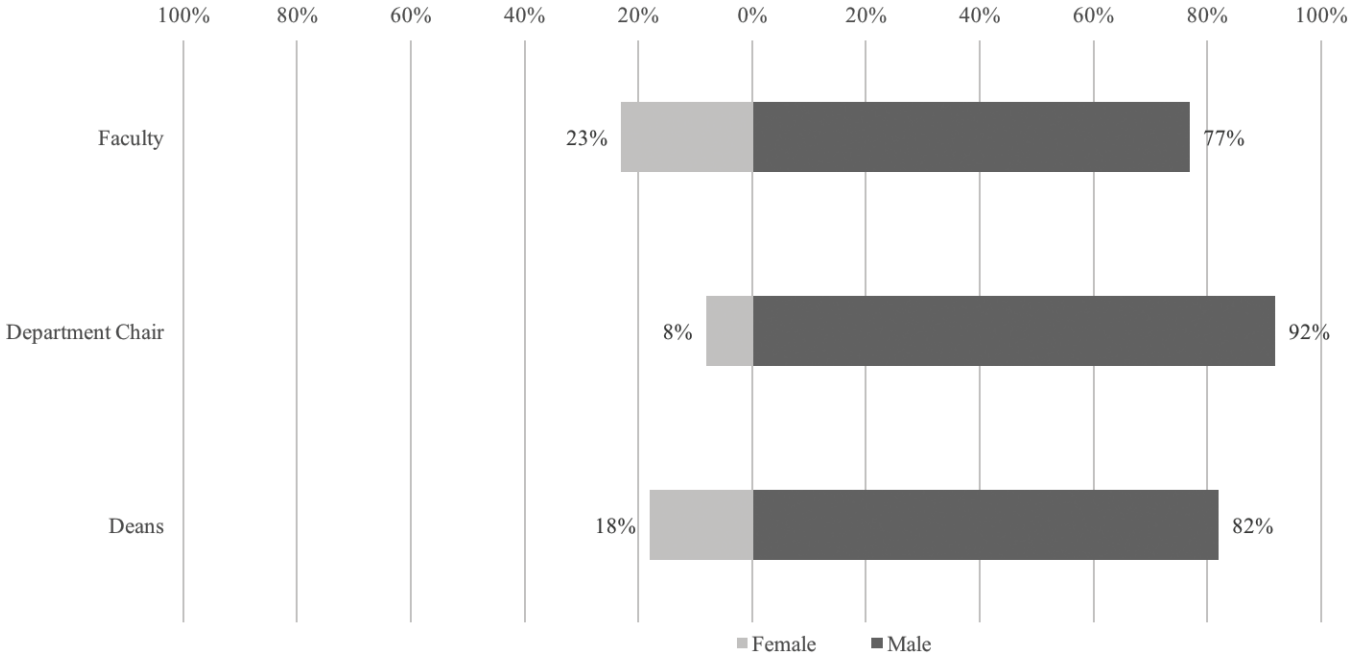

Fig. 1. Gender representation among faculty, department chairs, and deans of agricultural sciences from the land grant institutions (LGIs) of the United States.

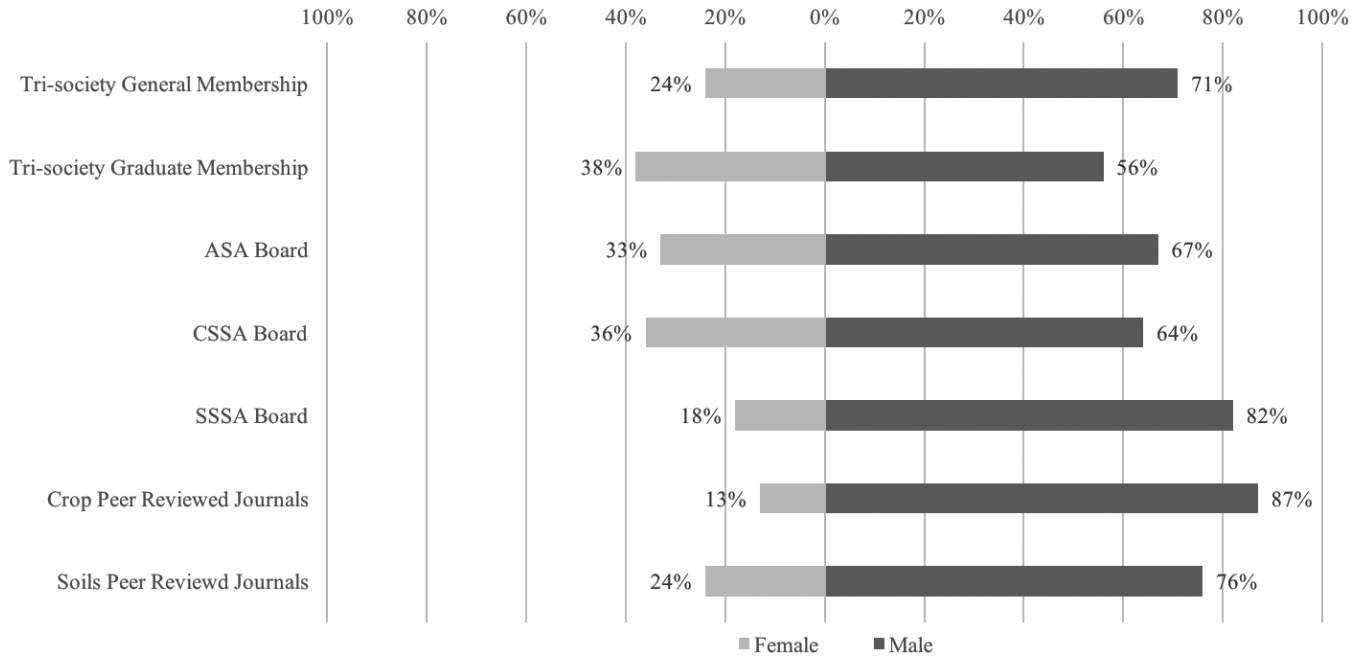

Fig. 2. Gender representation among society membership and leadership and editorial leadership of crop and soil science journals in 2014.

in the study by Buttel and Goldberger (2002) who found no difference in the numbers of Ph.D. degrees conferred between men and women at top tier LGIs. But this has not necessarily translated into equal gender representation among faculty, industry, or government career, or within leadership positions, according to our findings (Fig. 1–3). The numbers of women that have doctoral degrees and are in the employable pool for a given STEM discipline is not always a reliable predictor of the gender representation within that discipline (Kulis et al., 2002), and this appears to apply specifically to the crop and soil sciences.

Gender Representation at the Land Grant Institutions

Gender representation among faculty at the LGIs in the crop and soil sciences was 23% female and 77% male with a significant chi-square (Fig. 1, Table 4) when this evaluation was conducted in 2014. These figures represent an increase from the numbers reported in 1972 (8%) (Buttel and Goldberger, 2002) and again in 2010 (12%) (Goldberger and Crowe, 2010) of women in agricultural science. In fact, the percentage of women faculty members recorded in this study represents nearly double the 12% female scientists reported by Goldberger and Crowe (2010) for soil and crop sciences. The results of Goldberger and

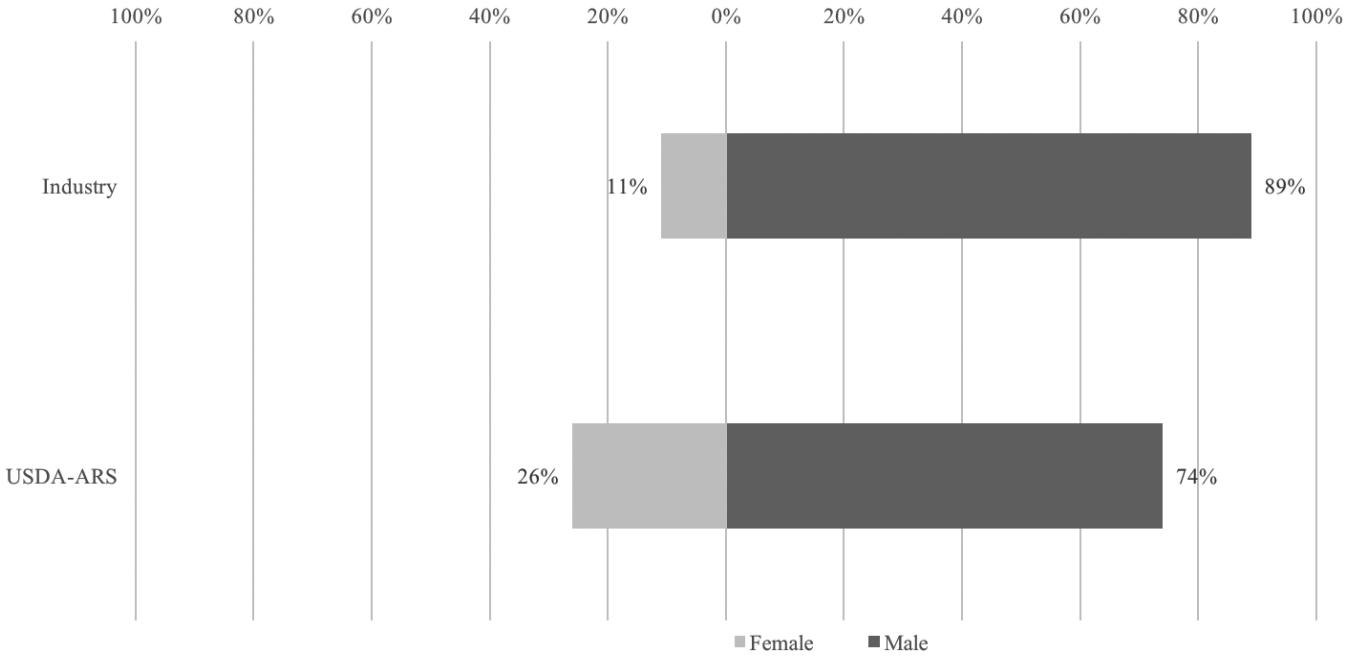

Fig. 3. Industry leadership roles and USDA-ARS research scientist positions by gender from 2014.

Crowe (2010) cannot be taken as a direct comparison with our current study, due to possible differences in how institutions were defined in that prior study, but certainly do indicate an improvement in the numbers of women moving into careers in agricultural sciences after attainment of the Ph.D.

Despite the increase in women faculty members, it does not seem to translate to leadership positions at the LGIs. Considering that department chairs and further administrative leadership roles are typically filled from within the college level, it is likely that starting out with a lack of representation of women in faculty could possibly be magnified at higher levels of leadership. The department chairs of the crop and soil science departments at each LGI were primarily male (92%) with the proportion of men to women being significantly different (Fig. 1, Table 4). Out of the 50 universities surveyed in this study in 2014, only four universities had a female department chair for the crop and soil science departments: the University of Wyoming, the University of Vermont, the University of Alaska-Fairbanks, and the University of Maine. Similarly, there were very few female deans for Colleges of Agriculture at LGIs. Out of the 50 universities considered in this study, only nine had female deans (Fig. 1, Table 4): the University of Florida, Iowa State University, the University of Kentucky, the University of Hawaii at Manoa, the University of Tennessee, Cornell University, Pennsylvania State University, the University of California-Davis, and the University of Wisconsin-Madison.

Leadership in Professional Societies

Female membership in the tri-societies represented 24% of the general membership (Fig. 2). The higher proportion of male to female members in all three societies was significant (Table 4). This pattern could be due to the lower proportions of women at the faculty level, the most common population holding membership in the societies. Interestingly, the percentages of women was higher among the graduate student membership in comparison to the general membership: membership for female graduate students was similar across all three societies with 38% female (Fig. 2, Table 4). These graduate student membership numbers still do not represent fully the 44% of graduates earning PhDs. in agricultural science who are women (NSF, 2012), so there is concern about the lack of participation by Ph.D. and other graduate students in their professional societies. A drop in representation and involvement of women graduate students in professional societies is an important harbinger, as lack of involvement in professional societies could translate into lost opportunities that otherwise might lead to further career advancement.

Going beyond society membership and serving as a leader on the board of the society or as a member of an editorial board often reflects a much deeper level of involvement of the faculty member. By not holding leadership roles in societies or journal editorships, women could potentially experience detrimental impacts on research productivity and success since these positions often expose scientists to emerging and transformative research topics (Goldberger and Crowe, 2010). Our results suggest female involvement in the society leadership as board members was slightly higher in ASA (33%) and CSSA (36%) than the female general membership rates, but was lower in SSSA with only 18% females represented on the board (Fig. 2) (Chi-square tests not calculated for tri-society leadership due to cell values < 5). While this shows increased numbers of women in the tri-societies, editorial leadership across agricultural science journals in general did not reflect these trends, with only 13 and 24% female editorial board membership for the crop and soil science journals, respectively (Fig. 2, Table 4).

Non-Academic Careers in Agricultural Sciences

If women who are obtaining Ph.D.'s in crop and soil sciences are not going into academia, as is indicated by the decrease from 44% females receiving Ph.D.'s (NSF, 2012) to 23% female faculty members found in our study (Fig. 1), it is possible that these women are choosing careers outside academia. Therefore,

we also evaluated the leadership roles in two sectors of possible employment: industry and the governmental agricultural science sector. Private agricultural industries are not as public about their scientific staff, therefore obtaining data from public sources on current employees was not feasible for this study. Rather, the leadership positions at the top agricultural companies were used as indicators for the status of gender representation. Upon investigation, we found that within leadership roles in top agricultural companies, there were 11% females and 89% males (Fig. 3, Table 4). While the overall leadership of these agricultural companies may not accurately reflect the total number of women entering into industry positions, it does indicate that there are similar disparities at the leadership level within industry as in the academic realm and suggests similar lack of representation of women in leadership roles.

A possible overall weaker link to industry of women than men can be seen by relatively fewer agreements, consulting arrangements, and ties to industry that women faculty have in comparison to men faculty at LGIs (Crowe and Goldberger, 2009); however, this same study found the lower number of links to industry by women was not due to an inherent bias of women against industry per se, but primarily due to a lack of women in disciplines that typically have more relationships with industry. For example, they found women represented 52% of nutrition faculty but only 5 and 13% of soil science and agronomy/crop science, respectively (Crowe and Goldberger, 2009). This is a case of horizontal segregation, where some disciplines within science itself are gender skewed (Rosser, 2004). With weak ties to industry, this would likely decrease the overall number of women entering industry careers, and thus leadership positions in agricultural companies, as we observed. It would be expected, therefore, that the percent of women in industry leadership positions should improve as more women enter into careers in agricultural disciplines (such as agronomy and soil science) with stronger linkages to industry.

An additional sector for employment as a researcher in crop and soil sciences includes public service positions such as within the USDA-ARS. Of the positions evaluated in the current study at the GS13-15 level for 2014 (representing research scientist level positions), 26% were female and 74% were male (USDA-ARS, 2014) (Fig. 3, Table 4). This is similar to the representation in faculty and leadership positions at LGIs and indicates that while 44% of Ph.D.'s in agricultural science were awarded to women, the number of women entering into the public sector via governmental research positions after attaining their Ph.D.'s was only 26%. This lack of women entering into careers after their Ph.D. can be described by the phenomenon known as vertical segregation, which occurs as the number of women decreases up the hierarchical career progression; that is, the number of women decreases from B.S., M.S., and Ph.D. degrees and eventually into faculty, administration, and other leadership positions (Rosser, 2004). Results from this study support that the vertical segregation phenomenon is still ongoing in many career paths in agricultural science.

DISCUSSION

What are the reasons behind the reduction in the number of women from attaining their Ph.D.'s to professional and leadership positions in agricultural science? It appears that the lack of women in faculty and leadership positions has nothing to do with differences in qualifications, such as the educational requirement of a Ph.D., but rather some disconnect after the degree program. Buttel and Goldberger (2002) found several reasons for this disconnect including: prevalence of more women in post-doc positions prior to faculty careers; spending a larger percentage of job time on teaching than on research, with teaching being less valued for promotion; women having fewer graduate students than men which has the potential to hamper promotion progress; and women having fewer consulting or research agreements with industry. Other reasons postulated include: hostility overtly or clandestinely expressed from colleagues or campus infrastructure once placed in a faculty position, thus leading women to leave; and the inability for some women to balance a highly demanding list of faculty demands with a desire for caretaking and family responsibilities (Handelsman et al., 2005; Ceci and Williams, 2010). For leadership and other high-level positions, the low number of women may be linked to the time it takes to move through the professional levels after earning a Ph.D. and parity may be reached in the near future. It appears the disconnect in the career paths of women earning doctorate degrees in agricultural sciences is not unique to academia, but is also observed in industry and public service positions (Fig. 3).

There is evidence that biases against women, perhaps based in historical gender inequities, continue to exist. A recent study surveying life sciences labs across the United States found that male faculty, including "elite" faculty renowned for their scientific programs, employed and trained fewer female graduate students and post-doctoral scientists than their female faculty counterparts (Sheltzer and Smith, 2014). Another study found that male and female faculty were equally biased against prospective female laboratory applicants, such that both men and women offered a higher starting salary and career mentoring to male applicants over female applicants (Moss-Racusin et al., 2012). Regardless of the gender of the employer, the bias against female training and STEM experience has the same result such that women may not have the same opportunities or encouragement for moving into faculty positions at LGIs. There is also potential for gender discrimination to exist at a higher level of hiring–men and women faculty were found to be biased against hiring or tenuring faculty with curricula vitae that indicated an origin from a female applicant nearly two decades ago (Steinpreis et al., 1999). However, one current study shows this may no longer be the case, indicating the lack of a barrier for women at the faculty hiring stage in STEM (Williams and Ceci, 2015).

Oftentimes, biases are formed by repeated exposure to inculcated (historical) cultural stereotypes frequently occurring unconsciously (Moss-Racusin et al., 2012). That makes the bias in our current times often subtle and difficult to overcome. This is because gender bias is so unacceptable in the public eye, that it is often hidden or extremely elusive and challenging to identify (Moss-Racusin et al., 2012). Bias can certainly influence representation, but it can also impact faculty advancement and remuneration. Ginther (2003) explored the reasons behind the continued salary and promotion disparity between male and female faculty, an investigation brought on by the admission of the Massachusetts Institute of Technology in 1999 that their female faculty were under

pervasive but unintentional discrimination and marginalization. The study found that there was a continued existence of gender discrimination for scientists in academic positions and that raising faculty and administrator awareness would be an important first step to combatting this problem (Ginther, 2003).

For some agronomic disciplines, the nature of the work itself–particularly the requirement for fieldwork–may be a deterrent for increasing numbers of women. This has nothing to do with the physical ability of women to carry out field experimental methods, but possibly due to the challenges related to personal safety, harassment, and fair treatment in a physical environment that may allow discriminatory acts to occur with less visibility. The example of women geologists can be used as a likely comparison with the often field-based discipline of agronomy, crop, and soil science. Women geologists through history have suffered difficulties with safe travel to field locations (Burek and Kölbl-Ebert, 2007) without suffering some physical attack. A very recent study that addressed problems for women in all field based science disciplines (those requiring some data collection and experimentation in a field environment as opposed to a lab) found that female students and post-docs had personally experienced sexual harassment (64%) or sexual assault (20%) by senior scientists in a group conducting field research (Clancy et al., 2014). This situation is likely a partial contributor to the lack of women in agricultural science leadership positions.

The lack of women faculty at LGIs may be due to a direct choice of women, a phenomenon known as "self selection" (Schneider, 2000), to avoid such institutions due to a less than welcoming atmosphere and one that discourages a balance with family responsibilities. It may also reflect an attitude held by women that positions at reputable research institutions, like LGIs, are not as achievable a goal for them as for men (Fox and Stephan, 2001). Fox and Stephan (2001) found an inherent preference by women for teaching as opposed to research university positions, likely because of an expectation that women had a higher chance of placement at a teaching university. The greater lifestyle preferences of women than men for structuring some focus of life outside of the career into family, personal development, or community is also linked to the cause of gender disparity at demanding research institutions like LGIs (Robertson et al., 2010). However, other studies do not find this link between increasing family responsibilities and the departure of women from the professoriate in STEM institutions (Xu, 2008). In fact, Xu (2008) found that the lack of general institutional support and "gender-unfriendly" culture in academe that provided fewer resources to women faculty was likely the primary reason for the higher rates of turnover or departure from academics for women.

Global research including 66 nations on the topic of gender disparity in the sciences indicates that, as numbers of women continue to increase at higher education institutions and within the research workforce itself, explicit and implicit national gender stereotypes decrease (Miller and Eagly, 2015). Therefore, clearly the increasing trend of more women being enrolled and completing graduate education in agricultural science will go a long way toward increasing the number of women represented at LGIs.

Kulis et al. (2002) suggest several solutions that could increase the participation of women in certain scientific disciplinary fields, including agriculture. They suggest: remaining vigilant and frequently assessing patterns of sex segregation and bias among disciplines and subdisciplines that are at particular risk for low numbers of women; providing employment policies that allow for a balance between career and family; allowing for hiring academic couples; and increasing the probationary period prior to tenure review (Kulis et al., 2002). No doubt these policies would benefit both women and men seeking a balance in life between personal and professional responsibilities. In addition, Buccheri et al. (2011) suggest the invitation of women scientists from industry or academics to give lectures and participate in other outreach activities would be beneficial to attracting women into STEM, as these individuals can be viewed as role models for young women interested in science.

CONCLUSIONS

Based on the results from this study, female representation has increased certainly since the 1970s and even since 2005 among faculty at the LGIs, but that the parity within other LGI leadership positions, professional societies, industry, or government research positions are predominately male and do not reflect the number of women attaining Ph.D.'s in agricultural science. Although some increases in the numbers of women have been made, representation of women in agricultural science careers and leadership roles that reflect the number of Ph.D.'s being awarded in the field has not been reached. However, there is certainly evidence that these percentages are improving–even within a short 10-yr span. Since women make up 44% of new Ph.D.'s but only 23% of faculty positions, this difference can lead to lower representation of women in leadership positions.

The increase from roughly 12% in 2005 (Goldberger and Crowe, 2010) to our findings of 23% in female faculty representation may signify the result of recruiting and supportive efforts enacted in the 1990s to encourage more women to enter into agricultural science. However, there were other disparities noted in the 2005 study that need to be evaluated further, including the inequality in professoriate rank and salary earnings between men and women (Goldberger and Crowe, 2010). In the 1980s, two studies called for LGI university departments and administrators to commit more support for women in the agricultural sciences to help combat the continued disproportionately low numbers of women at these institutions (Collins and Pesek, 1983; Logan, 1989). Further, it is critical that comprehensive reviews of the status of women in leadership roles in crop and soil sciences be quantified regularly to track gender representation in the LGIs.

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