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Are We Producing Society-Ready Foresters? A Quantitative Content Analysis of Graduate-Level Forestry Curriculum

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Are We Producing Society-Ready Foresters? A Quantitative Content Analysis of Graduate-Level Forestry Curriculum

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ABSTRACT: Forestry education in the United States has been hailed for its ability to provide students with the scientific and technical skills needed for a career in forestry as much as it has been criticized for ignoring social dimensions of the discipline. Its inability to adapt curriculum to the increasingly multidisciplinary nature of the forestry profession has led to stagnant or decreasing enrollment and lack of student diversity in recent years. While forestry education and curriculum has been thoroughly analyzed at the undergraduate level, no such analysis exists for graduate curriculum. This study analyzes the course content of 40 graduate-level forestry programs across 31 public and private institutions in the United States, using a quantitative content analysis to determine what curriculum disparities exist and how future course content can be improved. We classified courses into three categories: Science/Technology, Economic, and Social courses through a dictionary of key words to search institutions' curriculum documents, excluding special topics, directed studies, thesis, and independent research credits with non-descriptive course titles and/or course descriptions. We conclude that graduate curriculum across universities is composed disproportionately of scientific and economic courses, fostering understanding of these forestry topics, while social curriculum is persistently lacking. Analysis and suggestions for improvement follow.

KEYWORDS: forestry; education; social science; curriculum; content analysis

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INTRODUCTION

Once a technical discipline primarily dedicated to extractive resource management, the forestry profession has evolved and broadened throughout the twentieth and twenty-first centuries in response to local and global changes, such as population growth, urbanization, climate change, evolving silvicultural markets, ecological damage from pests, invasive species, and intensive land use (Bullard *et al.* 2014, Sample & Bixler 2014, Sample *et al.* 2015). In order to meet the changing needs of modern society, forestry professionals must possess in-depth knowledge of the ecological, economic, and social values of forests in addition to the technical competencies traditional to the discipline. To meet these evolving needs, forestry education must also evolve to reflect changes in the profession (O'Hara & Salwasser 2015, Sample *et al.* 2015).

Thus, one goal of forestry education has been to produce "society-ready" foresters, or ones who are adequately prepared to address the changing ecological, economic, and social landscape of the profession as described above (Bullard *et al.* 2014, Sample *et al.* 2015). Modern foresters face myriad challenges, such as increasing ecological pressures due to population growth, changing growth patterns and forest health due to climate change, evolving markets for forest products, and working with a variety of stakeholders with different visions and goals for forest management. A society-ready forester is one who is trained in social and political competencies — such as effective communication, working with diverse stakeholders, knowledge of forest policies, and the societal impacts of the pressures and changes mentioned above so that they can effectively approach these challenges (Bullard *et al.* 2014). This study investigates the degree to which forestry Masters programs are working toward this goal in the curriculum by analyzing the content of curriculum for scientific, economic, and social themes.

LITERATURE REVIEW

Although the discipline has evolved over time, forestry curriculum at the undergraduate level consistently lags in adapting to include social competencies, and thus in producing society-ready foresters. These social competencies are diverse and are equally paramount as technical competencies to successful forestry. Specific social competencies include active listening, effective communication, understanding stakeholder goals, knowledge of current forest policies, forestry at the urban-rural interface, and international forestry (Sample *et al.* 2015). As the world's forests, which cover about a third of the globe, face increasing pressure from a growing population, foresters must be trained to collaborate with diverse populations, solve complex issues, and understand and shape future forest policy (Sharik *et al.* 2015).

Yet, forestry, more than any other natural resource discipline, severely lags in teaching social competencies (Bullard 2015). This disparity in forestry curriculum is sorely felt by employers, who take notice that their recently graduated employees, while adept at traditional technical skills, are lacking skills in communication, leadership, and policy analysis. Furthermore, while academic institutions are aware of these shortcomings and have taken measures to remedy them, bureaucratic obstacles have rendered efforts largely ineffective. The resulting impacts are felt by forestry programs and the forestry profession as a whole, as explained in greater detail below.

Social Competencies: What Employers Want

In a 1949 survey, U.S. foresters ranked 57 general and technical competencies by importance, and the competencies with the highest ranking involved speaking and writing skills (Barrett 1953). Surveys in 1993 and 1994 reaffirmed the importance of personal competencies as well as knowledge of forest policies and foreign language skills (Brown and Lassoie 1998, Gilbert *et al.* 1993). In a 1998 survey by the Pinchot Institute, forestry employers were surveyed on recent graduate performance in a number of skills and competencies. Employers consistently mentioned a significant gap between curriculum and graduate preparedness in social skills, such as communication and leadership (Sample *et al.* 1999, 2000). In the latest survey by Sample *et al.* (2015) administered as a follow up to the 1998 survey, employers cited social skills, communication, and other human dimensions of natural resource management as among the greatest disparities between importance and graduate preparedness.

Academic Response & Shortcomings

In response to trends in the forestry profession and to meet employer demand, many meetings and symposia over the years have been convened to address changes in the forestry profession and resulting changes in curriculum. In the 1969 National Symposium on Forestry Education conference sponsored by the Society

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of American Foresters (SAF), a growing need for leadership and emphasis on the human dimensions of forestry were consistently emphasized (Greeley 1969). In another SAF sponsored conference in 1991 titled "Forest Resource Management in the 21st Century: Will Forestry Education Meet the Challenges?" the following recommendations were made: placing forest resource management in an international context, broadening the curriculum to include sociopolitical processes, and expanding diversity. (Cortner 1992, Gilbert *et al.* 1993). Most recently in 2014, the University of California, Berkeley hosted the North American Summit on Forest Science and Education. This conference echoed concerns that evolving societal needs require adaptations in the profession and, ultimately, the curriculum, and made suggestions consistent with those above, including greater integration of general and personal competencies and creation of a curriculum in which these skills hold equal importance with technical competencies (Gilless 2015, Sample *et al.* 2015). Other recommendations of the Summit included adding social sciences to accreditation standards and emphasizing sustainable problem solving in the curriculum (Bullard 2015).

Although the need for inclusion of social sciences in forestry curriculum is echoed in every major forestry education study, there are several factors that prevent forestry curriculum from keeping pace with the changing needs of society (Graves and Guise 1932, Chapman 1935, Dana and Johnson 1963, Bullard *et al.* 2014, Bullard 2015). In a survey by Sample *et al.* (2015), departmental deans and directors noted the difficulty in maintaining a rigorous technical curriculum while broadening the discipline to include social competencies. Faculty cited communication issues, resistance to change, and lack of faculty skills as the top barriers to adjusting forestry curriculum (Sample *et al.* 2015). Furthermore, "curriculum inertia" or institutional bias for the status quo prevents changes in curriculum. This inertia prevents social competencies from being developed (Bullard *et al.* 2014, Bullard 2015). In addition, forestry programs have been conslidated from their own college into broader academic units within the heading of Natural Resources. This consolidation may lead to non-forestry faculty and staff, who are not aware of the modern demands and challenges of forestry education, being the key decision makers in developing forestry curriculum (O'Hara & Salwasser 2015).

Resulting Impacts on Academia and Profession

Forestry curriculum's resistance to change is the cause of many modern shortcomings in both forestry education and the profession. When compared to forestry programs in the United States, general environmental science and natural resource programs have been much more responsive in adapting to the changing needs of society and incorporating sociopolitical curriculum (Bullard 2015, Gilless 2015). In addition, undergraduate forestry programs suffer from declining or static enrollment and lack of student retention. From 1980 to 2009, forestry enrollment declined the most out of every natural resources discipline, with a staggering 58% decline in enrollment, from nearly half of total natural resources enrollment to 15.7% (Sharik *et al.* 2015). There has also been a significant decline in the number of undergraduate forestry programs offered, although this decline is offset by other natural resource programs, where enrollment is on the rise. Meanwhile, demand from forestry employers for qualified employees continues to increase (Innes 2015).

Forestry programs also have a marked diversity problem, with the majority of students being white males and attracting the lowest number of women of all natural resource degree programs (Bragg & Tappe 2015, Gilless 2015, McGown 2015). While the average female enrollment across all other undergraduate natural resource disciplines was 41% in 2012, female students constituted only 18% of total enrollment in forestry programs in the same year. In addition, minority enrollment in undergraduate forestry programs was below the natural resources average of 12%, resting at 10.5% (Sharik *et al.* 2015). If forestry curriculum does not adapt to the changing needs of society and attract students that reflect the demographics of society as a whole, forestry degrees may lose legitimacy in the job market, and the forestry profession may decline (Gilless 2015).

The solution, then, to the shortcomings described above is an overhaul of the forestry curriculum to include social science competencies with equal emphasis on scientific, technical, and economic competencies. While forestry curriculum has been analyzed for disparities at the undergraduate level, no such analysis exists for graduate curriculum. Furthermore, many state and federal government agencies, such as the USDA Forest Service, one of the United States largest employers of foresters, require a graduate degree for hire and

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advancement to senior level positions (Innes 2015). Thus, an understanding of the composition of and disparities within graduate-level forestry curriculum in the United States is imperative to making the appropriate curriculum adjustments and to producing society-ready foresters.

METHODS

We conducted a quantitative content analysis of graduate level forestry curricula in the United States in the following sequence: identifying universities and programs, compiling curriculum from each institution as the data source upon which the content analysis was conducted, developing a dictionary, and conducting the computer-aided quantitative content analysis. These methods are explained in detail below.

Study Area and Data Set

In this study, we analyzed the graduate forestry curricula of all public and private institutions in the United States offering Masters degrees in forestry. We did not analyze graduate programs in a more general subject (such as biology or ecology) with a concentration in forestry. Institutions were identified from "Institutions with Society of American Foresters Accredited Curricula" (The Entomology and Forest Resources Digital Information Work Group 1999), the Society of American Foresters' "Guide to Forestry and Natural Resource Programs" (2012), and ForestryUSA's list of Colleges and Universities (2016) for those that still offered these degrees as of Fall 2016. The resulting 31 universities and 40 programs appear in Table 1.

Masters programs are the subject of this study, opposed to both Masters and Doctoral programs, because of their growing prevalence in the forestry profession. To compensate for the contraction of undergraduate forestry programs as mentioned above, Masters degrees are being identified as a viable option to produce trained foresters in lieu of an undergraduate degree specific to the field (Innes 2015). In addition, those who completed a Masters-level forestry program are more employable and see higher grades of pay. The USDA, one of the biggest forestry employers in the United States, requires employees to have at least a Masters degree to be eligible for senior positions. In addition, government agencies at the state level often feature higher pay and promote faster those employees with a graduate education (Innes 2015). In comparison, doctoral programs in forestry are regarded as unnecessary outside of a career in academia and may not offer the same degree of financial return as a Masters degree (Theodosiou 2012).

Following the distinction made in Innes (2015), we identified universities as offering either Master of Science (M.S.), Master of Forestry (M.F.), or both degree options. The M.S. program is typically marked by its basis in research and the students' creation of an original academic thesis, while the M.F. program has a heavier basis in coursework and may or may not require a research component. While the M.S. degree prepares students for further education such as a Ph.D. or a career in forest research, the M.F. is meant for either mid-career foresters or those wishing to enter the forestry profession directly following completion of the program. In either case, the M.F. is a terminal degree program (Innes 2015).

We assume that course titles and descriptions present in the official curriculum documents of each institution are representative of the learning objectives and topics to be covered in each course and are thus indicative of the content of forestry curriculum. From this line of logic, we assume that a course title or course description that contains social keywords will emphasize social values and themes in the curriculum, with this logic extending to scientific and economic keywords, values, and themes. These curriculum documents consisted of course catalogs specific to forestry programs and institution-wide catalogs that were edited to include only courses specific to forestry programs; these documents are readily available at each institution's website. We searched for keywords in the course titles and course descriptions of graduate-level forestry courses for the 2016-2017 catalog year; however, these documents were pre-processed to exclude special topics, directed studies, thesis, and independent research credits with non-descriptive course titles or course descriptions.

Dictionary and Quantitative Content Analysis

We utilized an automated thematic quantitative content analysis in this study. A thematic content analysis "aims at an assessment of the (frequency of the) presence of specified themes, issues, actors, state of affairs, words or ideas in the texts or visuals to be analyzed" (Pennings *et al.* 2006). Before performing the automated analysis, we used the dictionary to code each course into one of the three categories by hand and without the aid of software. By performing this manual coding, we wanted to see whether the results would be different, more informative, or more accurate than an automated method.

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Nevertheless, we found the results of the manual coding to be similar to those of the automated coding reported below. Furthermore, the automated analysis benefits from being able to analyze several themes occurring within one course by analyzing every word in a course description, while the manual content analysis simply places each course in one of the three categories. Therefore, the automated analysis reflects greater nuances present in the curriculum documents. Furthermore, an automated analysis benefits from a quick display of additional metrics, such as total words analyzed and average word counts. The automated technique is one of the most established research techniques in the social and political sciences (IEEE 2016). Thus, we chose this technique to analyze the composition of forestry curriculum.

We developed a dictionary following Bengston & Xu (1995, 1997) and modified it for use in forestry curriculum. The original dictionary published by the aforementioned authors consisted of 612 words and phrases and categorized forest values into four categories: economic/utilitarian, life support, aesthetic, and moral/spiritual. For our dictionary, we combined aesthetic and moral/spiritual into one category, changed life support to science/technology, and added our own terms to each category to make the dictionary more applicable to values in forestry curriculum. Thus, our resulting dictionary consists of 854 words and phrases and categorizes terms into three categories: economic/utilitarian, science/technology, and social/political. We did not stem terms, but rather included all words that we thought captured the desired inflection. For example, "govern," "governance," and "government" are all included terms.

The economic/utilitarian category consists of 189 terms and captures those words that indicate a curriculum focus on forest *use*, especially use for profit. This category contains words that are forest products, such as "biocomposites", "lumber", "paper", and "entity"; it also contains words that signal a focus on economic principles of forestry, such accounting, business, and taxation.

The science/technology category consists of 373 terms and is drawn from the life support category of Bengston & Xu (1995, 1997). Based on the words placed in this category by the original authors, as well as their descriptions of this category, we deemed that this category best represents the ecological values of the forestry profession as it contains words that are ecosystem services or things all life depends on to function, such as climate, biodiversity, and soil. Because we tailored this category for the forestry curriculum, we added words that signaled scientific understanding of forest ecology, such as biogeochemistry, dendrology, and genetics. Finally, this category also contains words that incorporate the research process and the technology used in this process, such as Bayesian, data, GIS, and statistics. This category reflects both traditional scientific knowledge of forestry as well as the modern technological tools we use to obtain and analyze this knowledge.

Our last category—social/political—contains 292 terms and combines the aesthetic and moral/spiritual categories of Bengston & Xu (1995, 1997), which we effectively synonymize with social values. In addition, we added words that reflect the shifting social and political dimensions of the forestry discipline described above. Our additions include words that would signal curriculum on the sociopolitical context of forestry, such as "global," "policy," and "urban." Furthermore, we also added words that contribute to the essential communication and general skills that employers often identify as deficiencies in recent graduates. These additions include the words "communication," "leadership," and "writing."

Our choices in which words were added to the original categories depended on which words were present in the course documents. In making these additions, all course documents were pre-screened (manually), and words detected that informed the values present in curricula were added to the dictionary. Simply put, the dictionary cannot capture all words that reflect economic, ecological, and social values, respectively; therefore, words that were found to be present in the curriculum documents through the pre-screening process were added to one of the three categories. Words that are missing from our dictionary were left out because of their absence from the curriculum documents being analyzed. Future curriculum documents will contain new or different courses with entirely new course descriptions, so future additions to this dictionary to include greater variety in words are expected and welcomed.

It should also be noted that each category in our dictionary does not contain the same number of terms. Like the dictionary of Bengston & Xu (1995, 1997), the science/technology category (based on Life Support in the aforementioned study) contains the greatest number of terms. We found that the number of terms in each category has little impact on results because of the low frequency of occurrence for many words in the dictionary. In fact, if this dictionary were limited to an equal number of the most

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frequently used terms in each category, the results would be much the same (Bengston & Xu 1995, 1997).

QDAMiner 5 and WordStat 7 were used in conjunction with this dictionary to search the course titles and descriptions in each institutions' curriculum documents for presence of key words. Our new dictionary is presented alphabetically and by category in Table 2.

RESULTS

We completed a content analysis of each institutions' curriculum documents using a dictionary altered for use in forestry curriculum from Bengston & Xu (1995, 1997). Figure 1 displays the results by each institution, and Figure 2 shows the results for the combined documents of every institution analyzed. The results are shown as a percentage of occurrences across all three categories. For example, 66% of words detected across all schools' curriculum documents were from the science/technology category. The remainder of occurrences fell into the economic/utilitarian category at 18% and the social/political category at 16%. In total, 69,292 words were analyzed across 31 curriculum documents. We excluded certain words from analysis due to their uninformative nature. Examples of excluded words include "about," "not," "since," "such," "under," and "yes." A total of 23,445 words were excluded across all curriculum documents, equating to 33.8% of total words excluded. In all, out of words placed into one of the three categories, 7023 words were detected from the science/technology category, 1951 were detected in economic/utilitarian, and 1766 were detected in social/political.

"Environmental" was the word with the highest frequency, with 382 total occurrences. Out of the 854 words and phrases present in the dictionary, 300 were detected in the text. Interestingly, the leftover, uncategorized words with the highest frequency in descending order are "credit," "students," "spring," "offered," "fall," "hours," and "graduate." While it makes sense that these would be high frequency words in curriculum documents, they are uninformative in forest values and curriculum composition. Word clouds of the most frequently detected categorized and uncategorized words can be found in Figures 3 and 4, respectively.

Previous studies and Symposia, including the most recent Berkeley Summit, recommend that forestry curriculum should equally emphasize each of the curriculum categories, but this is not the case for undergraduate curriculum (Bullard *et al.* 2014, Sample *et al.* 1999, Sample *et al.* 2000, Sample *et al.* 2015). Our results show that these same curriculum disparities are consistent at the graduate level. Across all institutions, science/technology had the greatest percentages of occurrences by far, with 66% across all institutions and with no institution falling below 52%. The highest occurrence occurred at California Polytechnic at 89%, where social/political occurrences were only 4% at this institution. Science curriculum continuing to dominate across institutions is indicative of curriculum inertia, and the traditional technical emphases of the discipline persist and show resistance to change.

Likewise, social/political occurrences lagged far behind the science/technology category. This category accounted for 16% of occurrences across all institutions, which is far below the goal of 33%. What is more, social/political words accounted for less 10% of total occurrences in seven out of the 31 institutions analyzed, and this score was less than 20% in all but three institutions. The school with the greatest occurrence in the social/political category was Yale University at 29% followed closely by the University of California, Berkeley at 26%. Thus, while scientific and technical curriculum continues to dominate at the graduate level, the discipline demonstrates that it is slow to adapt in incorporating social curriculum.

Results were mixed in the economic/utilitarian category. This category accounted for 18% of total occurrences across all institutions, which is nearly equal to the 16% for social/political occurrences across all institutions. However, results are more variable among individual institutions. Six out of the 31 institutions had scores of under 10% in this category, 16 institutions had scores between 10% and 19%, and nine institutions were at 20% or above. The scores spread from 6% at the University of Wisconsin to 33% at the University of Maine, Mississippi State University, and Auburn University. A higher score in this category would indicate a curriculum emphasis on extractive resource management and the study of forestry for its profitable utilization. While these scores establish an important baseline, it would be more interesting to measure their change over time. In this way, we could gather a better idea if the economic and utilitarian aspects of the curriculum had experienced a change over time.

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DISCUSSION

The forestry profession in the United States has evolved significantly throughout our country's history of resource management. Once a discipline primarily concerned with extractive resource management, economic activity, and the technical expertise necessary for these activities, forestry has evolved and broadened as a discipline. Forests are now being managed for a plethora of purposes, some for their instrumental value and others for their non-instrumental, inherent worth (Xu & Bengston 1997). Forest professionals and the general public alike recognize the value of social strategies in managing forests. Society depends on the world's forests, which are increasingly stressed to meet changing global needs and adapt to changing conditions from climate, pests, invasive species, and population growth. As such, the forestry profession now requires understanding of sustainability, urban forestry, forest law and political science, and cross-cultural collaboration in successfully managing forests for the public good (McGown 2015).

While the profession has evolved to reflect these changes by incorporating social concepts, forestry education at the undergraduate level has not, threatening the success of forestry higher education. As our study shows, graduate curriculum is similarly deficient in social and political topics. It is recommended that the curriculum be split evenly between scientific, economic, and social subjects (1/3 each) to produce a well-rounded curriculum and "society-ready" foresters. Yale is close to meeting this goal, as 29% of detected language in their curriculum documents fell into the social/political category. The University of California, Berkeley is not far behind at 26%. Overall, however, graduate programs across the country have more work to do and must dramatically restructure their curriculum to remain viable.

Our study did not find a spatial trend in the prevalence of social curriculum. That is to say, location of a school is not a predictor of prevalence of social curriculum. For example, the University of California, Berkeley at 26% is spatially proximal to California Polytechnic at 4%. However, it is noteworthy that over half (5/9) of schools with 10% or less occurrence of social curriculum are in southern states.

Advantages & Limitations

While a survey or interview allows for a snapshot of the study question at a particular moment, a quantitative content analysis is more accurately replicated, allowing for the study of trends in data over time (Bengston & Xu 1995). Furthermore, a content analysis is an unobtrusive form of research in that the subject does not know it is being analyzed. While a subject's response may be different under the setting of a survey, the contents of the curriculum documents that we analyzed will remain the same whether they are under analysis or not.

For our analysis, we chose the word as the unit of text. Thus, instead of analyzing a sentence or an entire course description as one unit, our dictionary classified individual words into one of the three categories. This choice allows us to detect nuances and multi-disciplinarity within a single course. For example, the following course title contains words from multiple dictionary categories: "Research Processes in Forest **Resources**". While the underlined words are coded in the science/technology category, the boldface word is coded in the economic/utilitarian category. This example brings to light some level of multi-disciplinarity in the course that would otherwise go undetected if our unit of text was larger than the word.

Nevertheless, this method does have limitations. We recognize that the meaning of a word changes based on its context. For example, we coded "community" into the social/political category. While it is true that this word is correctly coded under the context of *community organization*, *global community*, and *community involvement*, it may be coded incorrectly in the context of *ecological community*, *genetic community*, and *biological community*. Under the latter example, "community" indicates a scientific topic. While we did attempt to code words based upon the context in which they are used most of the time in the curriculum documents, we cannot control for context-based coding in this analysis.

We recognize another limitation based on the typical structure of most graduate programs. While undergraduate programs are primarily curriculum based, many graduate programs are research based, centered around independent research with light coursework. The amount of research varies by institutional requirements and program. As previously mentioned, the M.S. has a heavier research emphasis, while the M.F. contains more coursework. Thus, the curriculum in research-based programs may not be as indicative of student learning outcomes depending on their independent research, faculty research, and faculty backgrounds. We recognize this limitation in our data source and use curriculum

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documents as a proxy for these other indicators in our analysis.

These limitations and insights leave us with some interesting future research directions. Our analysis looked at the curriculum documents of a single catalog year, establishing an important baseline for future curriculum improvement. However, enrollment and curriculum data is historically limited for natural resources programs, at both undergraduate and graduate levels but particularly for the latter. Indeed, it would be more informative to analyze curriculum documents over time to ascertain if curriculum disparities have improved from the past and to set attainable goals for future adjustments. While setting a baseline is important, this study should be taken in the context of the broader subject of forestry curriculum and continuing education at the graduate level. It is our hope that others will continue to research this topic and generate improvements in forestry curriculum and the profession as a whole.

Furthermore, we are left with the following questions: Why are curriculum disparities greater at some institutions than at others? How can we identify the factors hindering curriculum development and make improvements? Curriculum recommendations will be addressed in the following section, but we are left pondering the first of these questions. We found that the reasons underlying curriculum differences among institutions is another topic that deserves its own in-depth analysis to draw any fruitful conclusions. Thus, this topic was outside the scope of this particular project, and we hope that future research may analyze faculty background, faculty research, student research, and funding sources to answer this question and discern the reasons for persistent curriculum disparities.

CONCLUSION: CURRICULUM RECOMMENDATIONS

In order to produce society-ready foresters, forestry curriculum must continue to emphasize scientific and technical competencies while broadening to include social and political skills with equal emphasis. Gilless (2015) perfectly summarizes this idea:

> Although the traditional emphasis on extractive resource management in the forestry curriculum may have been quite appropriate at one point in time, the trend in many forestry programs toward deemphasizing this [extractive focus] to make space for political science, sociology, law, conflict resolution, cultural studies, and others, will arguably produce graduates possessing skill sets that make them more, not less, valuable even to 'traditional' employers in forest industry or land management agencies.

The following are recommendations to help achieve this expansion of social curriculum while still maintaining technical competencies.

Incorporate additional course components. Maintaining depth in scientific and technical competencies while expanding curriculum to include essential social and political expertise is one of the most challenging obstacles to improving forestry curriculum (Sample *et al.* 2015). Universities have found success in weaving experiences that facilitate social competencies into scientific curriculum. Without adding courses or credit hours, the addition of field components, service learning projects, group assignments, and cornerstone and capstone projects can transform a technical course into a multidisciplinary one that teaches both scientific and social competencies (Bullard 2015). These additions transform the learning process from task-oriented to process-oriented and facilitate cooperative learning, enhancing students' ability to work with people and take on leadership roles (Thompson *et al.* 2003).

Establishing international connections. There is also a recognized need to internationalize the context of forestry education. This move will improve forestry education from multiple angles. While forest management regimes are typically focused on the local ecosystem and political context in which they exist, the consequences of forest management are global in scale and typically require a level of international understanding. Simply incorporating international angles into curriculum will generate multicultural awareness and produce foresters that are global problem solvers (Kanowski 2015). At the Berkeley Summit, student participants noted that international field components were often the best way to gain an international perspective of forest management (Kanowski 2015). In addition to incorporating international management concepts into the curriculum, international connections with other institutions can lead to joint projects and even bring in new faculty (Bragg & Tappe 2015). Forestry programs benefit from fresh faculty perspectives and novel faculty expertise, which is often the basis of curriculum development and student learning. Furthermore, connections with international institutions can lead to student exchanges, diversifying the student body and bringing international perspective to the student population (Bragg & Tappe 2015).

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Host communal meetings, discuss the issues. In addition to these improvements, symposia and summits, such as the North American Summit on Forest Science Education at Berkeley in 2014, may hold a valuable place in bringing about change in the realm of forestry education. The host, University of California Berkeley, facilitated a summit that centered on many of the themes discussed above, such as maintaining breadth of curriculum, internationalizing perspectives, and incorporating collaborative field experiences (McGown 2015). In addition, the University of California, Berkeley had the second highest occurrence of social themes in curriculum at 26%. As such, perhaps the hosting of a curriculum conference may accelerate changes in an institution's curriculum.

Further studies are necessary to provide further recommendations, elucidate the root cause of these issues, and continue progress in improving forestry higher education and producing society-ready foresters.

APPENDIX A

Table 1. Institutions and degree programs analyzed are organized alphabetically by state.

Institution	MS	MF	Program(s) Offered	State
Auburn University	X		Forestry	Alabama
Northern Arizona University	X	X	Forestry	Arizona
University of Arkansas, Monticello	X		Forest Resources	Arkansas
University of California, Berkeley		X	Forestry	California
California Polytechnic	X		Forestry Science	California
Colorado State University	X		Forest Sciences	Colorado
Yale University	X	X	Forestry, Forest Science	Connecticut
University of Florida	X	X	Forest Resources and Conservation	Florida
University of Georgia	X	X	Forest Resources and Conservation	Georgia
Southern Illinois University	X		Forestry	Illinois
Purdue	X		Forestry	Indiana
Iowa State University	X		Forestry	Iowa
University of Kentucky	X		Forestry	Kentucky
University of Maine	X	X	Forest Resources; Forestry	Maine
Michigan Technological University	X	X	Forestry; Forest Ecology and Management; Forest Molecular Genetics and Biotechnology	Michigan
Michigan State University	X		Forestry	Michigan
Mississippi State University	X		Forestry	Mississippi
University of Montana	X		Forestry	Montana
State University of New York	X	X	Forest Pathology and Mycology; Forest Management and Operations	New York
Duke University		X	Forestry	North Carolina
North Carolina State University	X	X	Forestry	North Carolina
Oregon State University	X	X	Forest Ecosystems and Society; Sustainable Forest Management	Oregon
Pennsylvania State University	X		Forest Resources	Pennsylvania
Clemson University	X	X	Forest Resources	South Carolina
University of Tennessee	X		Forestry	Tennessee
Stephen F. Austin State University	X	X	Forestry	Texas
Utah State University	X		Forestry	Utah
Virginia Tech	X	X	Forestry; Forest Products	Virginia
University of Washington	X	X	Forest Ecology; Forest Soils; Forest Resources	Washington
West Virginia University	X		Forest Resources Managament	West Virginia
University of Wisconsin	X		Forestry	Wisconsin

Table 2. Our additions to the published dictionary of Bengston & Xu (1995) are organized alphabetically by category.

Science/Technology	Economic/Utility	Social/Political
absorb air pollutants	accounting	adorn
absorption of pollutants	adhesives	adorned
acid drainage	administration	aesthetic
acid precipitation	agricultural	aesthetically
acid rain	agriculture	affective
air	agroforestry	ancient forest
air and water	benefits of timber	ancient tree
air purifier	bid price	anthropocentric
air purify	biocomposites	architect
air purifying	bioenergy	architecture
air quality	biomass	artist
analysis	biomaterial	artist's
analytic	bioproducts	artistic
animal	biotechnology	attitude
aquatic life	breeding	attitudes
aquatic zone	business	awe
assimilative capacity	certification	awe -inspiring
bayesian	chain saw	awesome
binding of soil	commercial	beauteous
bio - diversity	commodities	beautiful
biodiversity	commodity	beautifully
biogeochemistry	composite	beauty
bioinformatics	composites	biocentric
biological	consulting	bioethics
biological health	crop	breathtaking
biological diversity	crops of tree	breathtakingly
biological integrity	design	captivate
biological legacies	dollars in timber	captivating
biological legacy	earning	cathedral
biological processes	earnings	cathedrals
biological systems	econometric	charming
biological wealth	economic	cherish
biology	economic analysis	cherished
biometeorology	economic development	cherishing
biometrics	economic effect	cities
biometry	economic growth	collective
bioscience	economic impact	communication
biosphere	economic sense	communities
biospheric	economical	community
biota	economically	conflict
biotic	economics	consecrate
biotic diversity	economies	consecrated
breakdown of pollutants	economy	consecration
buffer strip	embankment	consensus
buffer zone	energy	cooperation
C02 fixation	entity	crisis
C02 sequestration	entrepreneur	cultural
C02 sink	entrepreneurship	culture
C02 storage	estate	dazzling
carbon cycle	expenditure	delight
carbon dioxide	exploited for timber	delighted
carbon fixation	exporter	delightful
carbon sequestration	exporting	delights
carbon sink	exports	desecrate
carbon storage	facilities	desecration
chemistry	facility	development
climate	finance	dignity
climate ameliorate	firewood	divine
climate ameliorating	fisheries	divinity
climate amelioration	fishery	documentary
climate buffer	forest product	duties and obligations
climate stabilization	goods and services	ecocentric
climate stabilizer	grazing fee	ecotourism
climatic change	harvest	ecstasy
climatic regulation	harvest level	ecstatic

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Science/Technology	Economic/Utility	Social/Political
community of life	harvest timber	eden
complex web	harvest tree	edenic
conservation	harvesting	education
controlling flooding	harvesting of timber	elegance
cycling of nutrients	harvesting of trees	elegant
damaging stream	harvesting timber	emotive
data	harvesting trees	enshrine
degradation	housing market	enthralling
degrade	hydrocarbons	enthrat
degrading	industrial	environmental ethics
demographic	industrial forest	ethic
demography	industrial forestry	ethics
dendro-ecology	industrial interests	evocation
dendrology	industrial land	evocative
detritus	industry	evocatively
digital	intensive culture	evoke
disease	intensive forest management	exaltation
diseases	intensive forestry	exalted
downstream habitat	intensive management	exaltedly
dynamics	intensively managed	exaltedness
ecohydrology	inventory	exhilarate
ecological	investment	exhilarated
ecological benefits	land-use	exhilarating
ecological communities	livestock	exhilaration
ecological community	log export	expansive
ecological diversity	log price	exquisite
ecological functions	logger	exquisiteness
ecological health	logging	extension
ecological integrity	logs harvested	feminist
ecological processes	lumber	forester
ecological restoration	lumber and pulp	fragrance
ecological services	lumber consumption	fragrant
ecological values	lumber market	future
ecologically complex	lumber price	future generations
ecologically valuable	lumber product	gender
ecology	manufacturing	global
ecophysiology	market price	glories
ecosystem	market system	glorify
ecosystem complexity	market value	glorious
ecosystem diversity	marketing	glory
ecosystem functioning	mechanics	good steward
ecosystem functions	monetary	govern
ecosystem health	monetization	governance
ecosystem integrity	monetizing	government
ecosystem maintenance	non - market	graceful
ecosystem processes	nonmarket	grandeur
ecosystem resilience	operation	harmonious
ecosystem restoration	operations	harmony
ecosystem services	optimization	heart - stopping
ecosystem structure	optimize	heritage
ecosystem sustainability	own	historical
ecosystem values	owner	history
ecotoxicology	paper	holier
endangered species	pastor	holiness
endemic species	pastoralism	holy
energy and material	phytoremediation	hue
energy balance	plantation	human
energy capture	processed timber	identity
energy cycle	processing	immortal
energy cycling	procurement	immortality
energy exchange	product	indigenous
energy flow	production	inherent value
energy flux	products	inspiration
energy transfer	profitable	inspirational
entomology	profits	inspire
entropy	property	inspired

Science/Technology	Economic/Utility	Social/Political
environment	range	inspiring
environmental	rangeland	interest
environmental baseline	raw log	international
environmental benefit	raw materials	interpretation
environmental concern	resource	intrinsic value
environmental cost	road	irreplaceable
environmental degradation	roads	justice
environmental function	scarcity	land ethic
environmental health	sector	landscape
environmental impact	shortage of timber	lavish
environmental processes	stumpage	law
environmental quality	supply	leadership
environmental restoration	supply - demand	legacy
environmental services	supply and demand	lovely
environmental toxin	supply of timber	lush
environmental value	tax	luxuriant
environmentally beneficial	taxation	magnificence
environmentally sensitive	technology	magnificent
environmentally sustainable	timber	majestic
equations	timber - producing	majesty
erode	timber dependent	marvelous
eroded	timber export	meditate
erodible	timber harvest	meditation
eroding	timber industry	meditative
erosion	timber job	morality
eutrophication	timber loss	morals
evolution	timber management	movement
exotic species	timber operation	musical
extinct species	timber plantation	mythic
extinction	timber production	mythical
field	timber sale	mythological
filtration	timber shortage	mythology
fire	timber supplies	narrate
fish habitat	timber supply	narrating
fixation of nitrogen	timber value	national treasure
flood control	timberland	natural
flood mitigating	tourism	natural setting
flood mitigation	trade	natural treasure
flow of energy	transportation	negotiation
food chain	tree crop	noble
food level	tree farmer	nonanthropocentric
food web	tree farming	normative
forest	tree harvest	oral
forest health	tree plantation	orchestral
forestry	underutilized	ornament
fragment	utilization	ornamented
fragmentation	utilize	ornate
fragmented	utilized	panorama
fragmenting	valuation	panoramic
generation of soil	value	paradise
genetic	wage	park
genetic diversity	willing - to - pay	park -like
genetics	willing to pay	parklike
genomics	willingness to pay	partner
geologic	willingness- to - pay	partnership
geomatics	wood	picturesque
geospatial	workforce	picturesqueness
GIS	yield	plaintive
global change		poems
global climate		poetic
global warming		poetical
GPS		poetry
greenhouse effect		policy
greenhouse gases		political
ground water		politics
groundwater		posterity
groundwater contamination		presentation
habitat		pristine

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habitat fragmentation		profaned
habitat loss		profaning
habitat protection		professional
health		public
healthy ecosystem		race
herpetology		rapture
homeostasis		rapturous
homeostatic		recreation
hydrologic cycle		regulation
hydrological cycle		religion
hydrology		religious
icthyology		resplendent
indicator species		responsible
integrity of ecosystem		restorative
isotope		revered
isotopics		reverence
jeopardized species		reverential
keystone species		reverently
landscape diversity		rights
landscape ecologist		rights and duties
landscape ecology		rustic
lidar		sacred
life - cycle		sacredness
life - support		sanctity
life - supporting		sanctuaries
life - sustaining		sanctuary
life cycle		sanctum
life supporting		savor
life sustaining		savored
limnology		savory
mammology		scenery
management		scenic
marine		scenic beauty
material cycling		scenic value
measure		scenically
measurements		sensibilities
metapopulation		sensibility
meteorological		sensory
meteorology		sensual
micrometeorology		sensually
model		sensualness
modeling		sensuous
mycology		sensuously
mycorrhizae		sensuousness
mycorrhizal		shrine
natural		social
naturalist		society
nature		sociology
nature's services		spectacular
nitrogen - fixation		spiritual
nitrogen - fixing		splendor
nitrogen cycle		splendorous
nitrogen cycling		splendrous
nutrient - cycling		stateliness
nutrient cycle		stately
nutrient export		stewardship
nutrient flux		stunning
nutrient pool		stunningly
nutrient recycling		stupendous
nutrient uptake		sublime
old growth corridor		sublimely
ornithology		sublimeness
oxygen production		sublimity
ozone depletion		sumptuous
ozone hole		sumptuousness
ozone layer		superb
paleoclimate		symphonic
parasitology		symphony
photosynthesis		tabernacle

Science/Technology	Economic/Utility	Social/Political
phylogenetics		teach
phylogeny		teaching
physiology		towering
population		transcendence
potential energy		transcendent
process		transcendental
production of oxygen		transcending
quantitative		transnational
radiation balance		ugly
radiation flux		unspoiled
regression		untrammeled
remote sensing		urban
research		vast expanse
restoration		vast wilderness
restoration ecologist		venerable
restoration ecology		venerate
revegetate		visceral
riparian		vista
riparian area		vistas
riparian boundary		visual
riparian communities		visual quality
riparian system		visual resources
riparian zone		woodland realm
river		writing
sampling		
science		
sediment		
self - maintenance		
self - sustaining		
self maintenance		
self replicating		
self sustaining		
siltation		
silviculture		
soil		
soil - binding		
soil conservation		
soil erosion		
soil formation		
soil maintenance		
soil movement		
soil nutrients		
soil productivity		
soil recovery		
soil stabilization		
soil structure		
solar energy		
solar equivalents		
solar radiation		
space		
species		
species diversity		
species - poor		
species - richness		
species abundance		
species loss		
stand		
statistics		
storm abatement		
stratospheric ozone pollution		
stream sedimentation		
streamside buffers		
structural diversity		
survey		
surveying		
sustainability		
sustainable		
threatened species		
topsoil loss		

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Science/Technology	Economic/Utility	Social/Political
toxicology		
tree		
trophic		
trophic activity		
trophic flow		
trophic functioning		
trophic interactions		
trophic level		
trophic organization		
trophic specialization		
trophic structure		
trophic transfer		
trophic web		
tropical		
unraveling		
unstable soil		
valuable wetland		
waste assimilation		
water		
water cycle		
water- purifier		
water-purification		
water-quality		
watershed		
watershed		
watershed stabilization		
watershed stabilizer		
wetland		
wetland restoration		
wildland		
wildlife		
wildlife habitat		
wildlife habitat		
wildlife population		
wildlife support		
woodland		

APPENDIX B

Figure 1. Category occurrences displayed as percentage of total occurrences were measured for each institution.

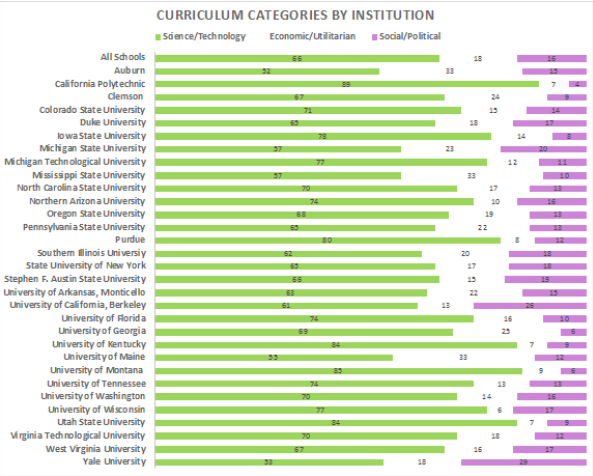

Figure 2. Category occurrences displayed as percentage of total occurrences were measured from the combined curriculum documents of each institution.

Science/Technology	Economic/Utility	Social/Political
66%	18%	16%

Figure 3. Word frequencies for categorized words are visually displayed in a word cloud. Most frequently occurring words (with frequency in parenthesis) are environmental (382), research (371), natural (313), analysis (300), and ecology (284).

Figure 4. Word frequencies for un-categorized words are visually displayed in a word cloud. Most frequently occurring words (with frequency in parenthesis) are credit (384), students (369), spring (362), offered (361), fall (341), and graduate (330).

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