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Integrating Indigenous Knowledge and Western Science into Forestry, Natural Resources, and Environmental Programs

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A new minor titled "Indigenous Studies in Natural Resources and the Environment" (INRE) became available to students at California Polytechnic State University in San Luis Obispo, California, in the fall of 2013. This minor aims to bring together the principles of both Indigenous ecological knowledge and western science. Instruction in these two approaches provides students with practical knowledge, research, and critical thinking skills to address complex environmental issues and natural resources management problems facing both Indigenous and non-Indigenous communities around the world today. The INRE minor seeks to prepare students by providing a balanced education in the arts, sciences, and technology, while encouraging interdisciplinary and co-curricular activities. This article reports on the need for the INRE minor, learning outcomes, curriculum, approval process, student interest surveys, and enrolled INRE students' focus group comments. This program may serve as a model for other academic institutions to bridge the gap between western and Indigenous science regarding the environment.

Keywords: Indigenous, western science, educational programs, sustainability, land ethic, traditional ecological knowledge

The world population is expected to increase to 9.725 billion people by the year 2050 (United Nations, Department of Economic and Social Affairs, Population Division 2015), or approximately 8 billion more people than were present in 1800. Sustainable management in relation to this population increase has and will have different meanings to those involved with management of natural resources, wildland, and forested areas. These different viewpoints will lead to discussion of and debate on a wide range of questions such as the following: How will we solve difficult environmental issues and natural resource utilization dilemmas with demands to feed, house, and provide energy for this global population increase? How do we arrive at logical, sustainable land management decisions? How can we maintain working farms, ranches, and forests with increasing pressure to develop land? How should we manage for wilderness and other natural resources? Will we make our decisions to meet our growing needs based only on higher and best use principles or on alternatives that provide a balance between respecting earth ecosystems and the life they sustain?

These questions illustrate that there are many current and continuing issues involving management of land, economics, natural resources, and ecosystems. Using natural resources does have impacts, but perhaps there are alternative approaches that foster discussion, integration, and appreciation for a wide variety of viewpoints with the ultimate goal of achieving "better decisions" that are more widely supported. Faculty at California Polytechnic State University, San Luis Obispo (Cal Poly) see some of these issues being resolved with better communication and integration of Indigenous knowledge and western science into the curriculum.[1] This suggests that a more collaborative, integrated approach to resolving these issues

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may be warranted. Communication in this context means to seek insights into the short- and long-term consequences of our proposed land management actions. As Oren Lyons (2008, p. 22) has cogently suggested, "We need to take a more responsible direction and begin dealing with the realities of the future to ensure that there *is* a future for the children, for the nation." Ultimately, an "intimate relationship and connection to the land supports the notion that when responsibilities are fulfilled, humans will be taken care of and thrive, and so will the land. Maintaining biological diversity and complex reciprocal relations are key ideas" (Martin 2012, p. 201).

Aldo Leopold and other conservationists also have beseeched us to develop a land ethic built on a biotic systems approach (Leopold 1949), and these calls echo Indigenous aspirations that focus on respect and responsibility for the land and associated living ecosystems. As Snively (2006, p. 195) notes, "…increasingly, in a postcolonial world beset with ecological and social crises, scientists and science educators are showing interest in traditional cultural approaches that have been used to achieve and maintain sustainable relations between human communities and environments." Indigenous communities have practiced long-term observation of the environment, often recorded as oral narratives, and environmental knowledge specific to homelands. Traditional ecological knowledge (TEK) "is born of long intimacy and attentiveness to a homeland and can arise wherever people are materially and spiritually integrated with their landscape" (Kimmerer 2002, p. 433). This intimacy and attentiveness is knowledge directly tied to the numerous diverse cultures, beliefs, places, and experiences of Indigenous populations throughout the world. For example, Indigenous peoples have been calling for attention to climate change as they observe changes in the Arctic (Martello 2008); fisheries impacts and the loss of habitat (Dupris et al. 2006); oversight and regulation of natural gas wells, mining, and the pollution/destruction of waterways (Lawson 2010, Southwest Research and Information Center 2015); and a host of other impacts on the natural world (Anderson 2005, LaDuke 2005, Menzies 2006, Nelson 2008, Dowie 2009, Middleton 2011, Schilling 2011). For some, like the Indigenous Sami in Lapland, natural resources issues affect their survival as they work to protect their culture, forests, reindeer, natural ecosystems, and food sources (Helle and Kojola 2006, Kyllönen et al. 2006, Tuulentie and Meriruoho 2008, Hyppönen 2011, Mustajoki et al. 2011).

Since the 1980s, much has been written regarding traditional knowledge systems and methods for utilizing both TEK and western science in college and university research and educational programs. However, this has not been an easy collaboration, as indicated by Berkes (2012, p. xxiii): "Scholars have wasted too much time and effort on a science versus traditional knowledge debate; we should reframe it instead as a science *and* traditional dialogue and partnership." We suggest that these two viewpoints, Indigenous TEK and western science, are in powerful agreement yet the debate and rancor associated with them and their implied economic considerations have interfered with communication and collaborative partnerships (Deloria 1995, Harkin and Lewis 2007, Bussey et al. 2016). "The question then becomes one of how to use both TEK and Western science in a sustainable resource management planning and learning process" (McGregor, 2008, p. 140). For those of us at Cal Poly, this has been a long process and is still ongoing as we endeavor to integrate TEK and western science more effectively. It has become apparent that a better integration and understanding of these fields from multiple perspectives would benefit our students, faculty, and communities in their studies and careers. To address these issues, Cal Poly's "Indigenous Studies in Natural Resources and the Environment" (INRE) minor was designed to bridge the gap between Indigenous TEK and western science. This article addresses the (1) purpose and need for the INRE minor, (2) the development of the INRE minor, (3) the INRE curriculum, and (4) current student support for the INRE minor.

Development of the INRE Minor

Recent articles in the *Journal of Forestry* and elsewhere (e.g., Mason et al. 2012, Sharik 2015, Bussey et al. 2016) support the development of curricular programs that provide cross-cultural problem-solving opportunities.

The INRE minor came out of a shared history of relationship between the department of Ethnic Studies (ES) in the College of Liberal Arts and the department of Natural Resources Management and Environmental Sciences (NRES), formally known as the Natural Resources Management (NRM) Department, in the College of Agriculture, Food and Environmental Sciences. This relationship began in 1995 with the development of two cross-listed courses, "Fire and Society," now taught in the NRES Department and "Ethnicity and the Land—Indigenous Studies," taught in the ES Department. These two courses were designed to offer students the opportunity to integrate and study traditional, cultural, and ethnic variations in managing fire, in conjunction with the ways culture shapes landscapes and social hierarchies allocate natural resource use. The ES and NRM Departments forged this unique and important relationship initially under the leadership of Dr. Robert Gish (ES) and Dr. Norm Pillsbury (NRM) followed later by Dr. Kathleen Martin (ES) and Dr. Douglas D. Piirto (NRES). Both courses fulfill degree requirements and are popular with students in a range of majors at Cal Poly.

In May 2012, a casual conversation among faculty members Piirto, Martin, and Dr. Lynn Moody about the success of these courses led to the idea for a minor program. Moody and Martin along with Dr. James

Management and Policy Implications

Society of American Foresters members are called to abide by a Code of Ethics[10] whose first Principle and Pledge states: "Foresters have a responsibility to manage land for current and future generations. We pledge to practice and advocate management that will maintain the long-term capacity of the land to provide the variety of materials, uses, and values desired by landowners and society." How can foresters and land managers achieve this pledge? Integration of Indigenous and western science into university curricula and professional disciplines could lead to enhanced collaboration and stewardship of public and tribal lands. Cal Poly's new Indigenous Studies in Natural Resources and the Environment (INRE) minor works to foster communication and collaboration across academic disciplines and programs by helping people better understand and respect the land, natural resources, and ecosystems. By presenting the INRE minor design and its learn-by-doing approach to resolving land, forest, and natural resource conflicts, we hope other academic institutions will use this program as a model to bridge the gap between western science and Indigenous knowledge of the environment, as well as to instill in the next generations of foresters a broader resource and land ethic.

Garrett took students from Cal Poly on a field trip in 2008 to Cankdeska Cikana Community College, a tribal college in North Dakota. This event enabled students from Cal Poly and Cankdeska to work together on a native plant garden utilizing Native and Indigenous ethics of land use. The successful completion of this field trip, like the two courses, and the experience of working collaboratively led to further discussions of ways to increase students' professional land management knowledge with the ultimate goal of fostering increased respect for diverse points of view. For a discussion of this field trip experience refer to Martin and Garrett (2010).

In the fall of 2012, the idea for a new minor was presented to the faculty of the ES and NRES Departments. The presentation, titled "Interdisciplinary Innovation and Indigenous Studies," provided an overview of topics and majors and posed four questions to guide the development of the INRE minor:

- In what ways is knowledge of Native/Indigenous peoples significant for our students now and in the future?
- How can we interpret or understand Native/Indigenous life as we seek to solve problems that all humans face?
- What experiences might help our students as they complete their majors and prepare for work in their professional disciplines after graduation?
- How might we conceptualize and strengthen the link between western and traditional Indigenous knowledge?

From discussions with faculty, a committee of five Cal Poly faculty members (Martin [Committee Chair], Piirto, Pulitano, Vaughan, and Verma) from NRES and ES worked throughout the 2012–2013 academic year to develop the INRE minor. The minor was approved and formally offered to students in fall 2013. A launch event featured presentations by Dr. Enrique Salmón from California State University, East Bay, and Serra Hoagland (Laguna Pueblo), PhD candidate in Forestry from Northern Arizona University.

The committee sought to address the goals of the Cal Poly Diversity Statement regarding recruitment, retention, and promotion of diversity. The Statement on Diversity (2015, p. 1) asserts: "For students preparing to embark on work and life in the 21st century, a critical element of a well-rounded education is the ability to understand and to function effectively in a diverse and increasingly interdependent global society…. Thus, diversity serves as a fundamental means to enhance both the quality and value of education." Viewed as more complex than simply diversity of individuals, the idea behind developing the INRE minor was to provide multiple ways of engaging diversity of thought, worldviews, and ideas. The committee's discussions centered on the need for solving complex problems within an ecological management system considering diverse cultural perspectives, science, economics, sustainability, resource utilization, and associated environmental issues. More specifically, discussion focused on ways to do the following:

- Foster improved communication and collaboration across disciplines and programs, promote understanding of diversity and its importance, and enhance recruitment and retention of Native/Indigenous students.
- Support innovative, interdisciplinary programs that provide educational opportunities across the humanities, natural resources management, and the environmental sciences and integrate western and Indigenous thought.
- Provide advanced coursework and research opportunities that incorporate Indigenous environmental knowledge into existing programs of conservation biology, environmental biology, wildlife and fisheries sciences, forest resources management, and environmental studies and science.

The INRE minor was envisioned to "fulfill the ethics of reciprocity and responsibility vital to communities and student educational success" (Martin and Garrett 2010, p. 294).

The committee wanted to bring together principles of both Indigenous knowledge and western science (Mason et al. 2012) and believed that instruction in these approaches would provide students with the necessary skills, practical research methods, and critical thinking abilities for addressing complex environmental and health issues and resource management problems facing both Indigenous and non-Indigenous communities around the world today. Creating opportunities for "cross-cultural problem solving founded on openness and trust" is recommended by Mason et al. (2012, p. 192) and supported by Sharik (2015). The INRE minor specifically addresses Cal Poly's learn-by-doing motto by helping students apply the knowledge they gain in the disciplines through practical experiences and fieldwork in an interdisciplinary applied format. Thus, the INRE minor would provide students with a balanced education in the arts, sciences, and technology, while encouraging cross-disciplinary and co-curricular experiences. The principal learning outcomes for students on completion of the minor are presented in Table 1 with applicable coursework designed to develop cross-culturally competent professionals.

Other major universities, including State University of New York, Syracuse; Montana State University; University of Minnesota, Twin Cities; University of Oregon; and California State Universities, Humboldt and San Marcos campuses, have moved ahead on similar collaborations between Indigenous knowledge and western science as part of "cutting edge" developments in the professional fields. In 2014, the University of Oregon hosted an international conference focused on "Climate Change and Indigenous Peoples" with "Environment, Culture and Indigenous Sovereignty in the Americas" as a conference theme.[2] Today, an increasing number of students in a broad range of professional fields will benefit from a combination of studies in Indigenous and western science. Examples include negotiations with Indigenous and Native peoples on the use of natural resources; the protection of sensitive cultural, physical, and natural environments; issues of climate change; maintenance of working farms and forests; and negotiations among organizations such as the United Nations, United States Bureau of Land Management, US Department of the Interior (USDI), US Department of Agriculture (USDA), Indigenous peoples, corporations, and other entities working in the areas of human rights, law, and policy. Interest, experience, and expertise in these areas are becoming more readily recognized in university education programs and more specifically in the professions. In an investigation of interest by federal agencies and nongovernmental organizations (NGOs) in combining TEK with their current environmental management practices, Hoagland (2014) found the following examples of emerging collaborative efforts:

- The US Fish and Wildlife Service (USFWS) created a TEK fact sheet and identified tribal liaisons within their department.[3]
- The USDA Forest Service and Natural Resources Conservation Service have recognized the value of TEK in various agency-sponsored documents such as "A Tribal Engagement Roadmap" created by the USDA Forest Service Research and Development branch. It states that TEK can help the USDA Forest Service understand and solve current and future natural resource management challenges.[4]

Table 1. Learning outcomes for the INRE minor with applicable required coursework.

Learning outcomes	Courses
Classify, distinguish, and illustrate information regarding Indigenous environmental knowledge and the range of management approaches that have and are employed with reference to forestry, natural resources, and the environment here in the United States and throughout the world.	NR 141, NR 142, ERSC/GEOG 325, ES/NR 360
Apply and evaluate legal requirements and responsibilities in seeking, constructing, and responding to Indigenous viewpoints and perspectives.	ES 241, NR 323, NR 335, ES/NR 360
Compare, contrast, interpret, and evaluate cultural, social, political, and economic self-determination, self-representation, and human rights issues that promote social, economic, and environmental sustainability.	ES 241, PHIL 340, NR/ES 308, ES/NR 406
Interpret and analyze ecosystem management principles as a process to improve collaboration and associated decisionmaking.	NR 335, PHIL 340, ES 450
Synthesize the appropriate inclusion of Indigenous traditional knowledge in environmental assessment and the planning and implementation of development projects.	NR/ES 308, ES/NR 360, ES/NR 406
Evaluate and critique the scope of tribal sovereignty in the United States as it relates to tribal, federal, and international laws (legislative and judicial), including the structure of federal/tribal relationships and Indigenous autonomy and self-determination, particularly regarding management of US tribal and nontribal lands.	ES 241, ES/NR 360, ES 410, ES/NR 406
Interpret and appraise the viewpoints of Indigenous and government organizations in the planning, design, and construction of projects and management systems.	NR 335, ES/NR 406, ES 450
Develop proficiency in the formulation, analysis, and synthesis of research for successful integration of science and traditional Indigenous knowledge through conference and poster presentations, publications, and/or web-based services.	NR 323, ES/NR 406, ES 450

See Table 2 for the full course name. Course descriptions can be found in the Cal Poly catalog (http://www.catalog.calpoly.edu/collegesandprograms/collegeofagriculturefoodenvironmentalsciences/naturalresourcesmanagementenvironmentalsciences/indigenousstudiesnaturalresourcesandtheenvironmentminor/). The level of detail regarding the integration of learning objectives to specific courses is addressed in the Cal Poly, 2012, INRE curriculum package available from the authors by request.

• The Ecological Society of America hosts a TEK section at its annual meeting designed to support students, promote multiple approaches to ecology, and increase the diversity of ecologists.[5]

Another such USDA Forest Service example is specifically focused on TEK in the context of climate change (Vinyeta and Lynn 2013). We see the efforts in these agencies and NGOs as an indication of the importance of the INRE minor in the preparation and education of students after graduation, and these are only four examples. Other degree programs including those in anthropology, archaeology, social services, education, political science, law, engineering, and a host of others are finding the benefit and usefulness of some preparation in Indigenous knowledge.

Most notably, tribal colleges, as members of the American Indian Higher Education Consortium, have been at the forefront of programs to address environmental concerns, natural resources management, tribal forests, and other related issues with their students. Phil Duran (Tiwa Pueblo), who has advanced degrees in physics and computer science, stated, "Many threads weave the tapestry of Native American science. Tribal science is linked to the needs and goals of the tribal community; it understands Indian ways and recognizes the treaty relationship. Native science incorporates traditional knowledge and perspectives" (Lambert 2003, p. 1). Examples of important collaborative efforts that could serve as case studies in the preparation of INRE minor students across disciplines include the following:

• Salish Kootenai College in Pablo, Montana explores how Native science is tied to ecological values in an environmental science class.[6]

• Northwest Hudson Bay residents examine caribou migration and feeding in chemically contaminated areas and how it relates to the high rate of cancer deaths among elders who eat caribou (Lambert 2003).

• The Navajo Land Use Planning Project secured funding for the AR5 Fifth Assessment Report of the Intergovernmental Panel on Climate Change with Margaret Redsteer, member of the Crow Nation and geologist, as lead author.[7]

• The USDI's Partners in Conservation award was given to the Klamath Youth Program after nomination by the USFWS for its use of traditional knowledge in conjunction with modern science (Woodbridge 2013).

• Students in the Klamath Basin worked with tribal elders to restore and manage native fish populations (Indian Country Today 2014).

INRE Curriculum

The INRE curriculum provides innovative coursework, cross-disciplinary study, fieldwork, and research opportunities that incorporate Indigenous TEK in areas such as wildlife and fisheries sciences, forest resources management, environmental studies, ethnic studies, education, geography/anthropology, political science, wildland recreation management, and agriculture. Most of the courses in the minor were already being taught at Cal Poly; however, they had not been combined into a program across the university colleges.

The minor consists of 27 quarter units (Table 2). Eleven units are required core courses, 8 units are emphasis courses chosen from a list of 7 courses, and 8 units are selected from a list of approved electives. Students choose electives with adviser recommendations from a wide variety of 63 courses offered by the NRES, ES, and other university departments. Consultation with the INRE minor faculty advisors is required when students select courses.

In developing the curriculum, the INRE committee noted subject areas that needed strengthening and further development to provide students with advanced study and address the learning outcomes, particularly in the areas of Indigenous and Native Studies. Out of these discussions, two courses were developed and added to the INRE curriculum: the cross-listed ES/NR 406 to address international and policy issues and a special topics course, ES 410, to address issues of federal Indian law in the United States. These courses have added significant depth and breadth regarding government relations, history, and legal precedent to the curriculum across the areas of forestry, natural resources, environmental

Table 2. INRE curriculum.

Course	Course units
Required core courses (11 units)	
NR 141–Introduction to Forest Ecosystem Management (3) or	
NR 142–Environmental Management (3)	3
ES 241–Survey of Indigenous Peoples (4) (D3, UCSP)	4
ES/NR 360–Ethnicity & the Land (4) (C4, USCP)	4
Emphasis courses—choose two (8 units)	8
NR/ES 308–Fire & Society (4) (D5)	
NR 323–Human Dimensions in NR Management (4) (D5)	
ERSC/GEOG 325–Climate and Humanity (4)	
NR 335–Conflict Management in Natural Resources (4)	
PHIL 340–Environmental Ethics (4) (C4)	
ES/NR 406–Indigenous Peoples and International Law & Policy (4)	
ES 410–Advanced Topics in Comparative Ethnic Studies-American Indian Natural Resources Law, Culture, and Environment (4)	
ES 450–Fieldwork in Comparative Ethnic Studies (4)	
Approved electives (8 units)	8
At least 4 of these units must be upper division (300–400)	
Refer to Cal Poly 2015/17 catalog for a complete listing of INRE elective courses	
Total units	27

Table 3. Comparison of Cal Poly university student enrollment by college to Survey Monkey respondents.

College	Cal Poly University enrollment (N = 18,679)		Survey Monkey respondents (n = 132)	
	No.	%	No.	%
College of Agriculture Food and Environmental Science	3,728	20.0	71	53.8
College of Architecture and Environmental Design	1,533	8.2	10	7.6
College of Business	2,334	12.5	5	3.8
College of Engineering	5,411	29.0	18	13.6
College of Liberal Arts	2,731	14.6	19	14.4
College of Science and Mathematics	2,848	15.2	8	6.1
Unknown	94	0.5	1	0.8

sciences, public policy, political science, and ethnic studies. In addition, the ES 450 Fieldwork in Comparative Ethnic Studies course was added to the INRE minor. A description of these three courses is provided in the supplemental data (see Course Descriptions S1[S]).

Assessing Student Interest

As part of the California State University approval process for a new minor in the curriculum, surveys of Cal Poly students were conducted to gauge student interest in and support of the proposed INRE minor in the 2012/2013 academic year. A copy of the survey instrument is provided in the supplemental data (see Student Interest Survey S2). After university approval, a focus group discussion with some of the students enrolled in the minor was conducted in May 2015.

Two different survey modes were used to assess student interest. First, a questionnaire containing 11 questions was developed and made available to Cal Poly students in various majors in the College of Agriculture, Food and Environmental Sciences, College of Liberal Arts, College of Engineering, College of Business, College of Architecture and Environmental Design, and College of Science and Mathematics. The voluntary survey was administered using a Survey Monkey questionnaire through Cal Poly's computer portal.[8] During the 2012–2013 academic year approximately 18,679 students were enrolled at Cal Poly.[9] A total of 132 respondents completed the questionnaire, providing a response rate of 0.7%. The survey provided a random sample of the general university population. Students in the NRES and Ethnic Studies Departments were specifically encouraged by faculty members to participate in the survey.

The second student interest survey was implemented through an in-class survey that provided insights from students in the Environmental Management and Protection and Forestry and Natural Resources majors. These in-class survey questionnaires contained the exact same questions as the Survey Monkey questionnaire; however, they were filled out manually. A total of 48 respondents completed the in-class survey. All students attending class on the day the survey was administered were asked but not required to fill out the survey. Students who had already filled the survey out via Survey Monkey were asked not to fill out the survey twice.

Survey Results and Discussions with INRE Students

Students (n = 132) from 30 different majors from the College of Agriculture, Food and Environmental Sciences, College of Liberal Arts, College of Engineering, College of Business, and College of Science and Mathematics completed the Survey Monkey questionnaire with 25% identified as freshmen, 18.5% as sophomores, 22.6% as juniors, 33.9% as seniors, and 0.6% as other. The largest percentage of respondents were from the Colleges of Agriculture, Food and Environmental Sciences, Liberal Arts, and Engineering. Students in Architecture and Environmental Design, Business, and Science and Mathematics also responded but in lower numbers. The Survey Monkey results are presented by college in Table 3. A comparison between Cal Poly ethnic diversity in 2012 and ethnic diversity of survey respondents is presented in Table 4. The percentages of students responding to the questionnaire display ethnic diversity similar to that of the Cal Poly campus-wide student body, whereas 81% of the in-class respondents were Caucasian.

Survey Monkey results and in-class survey results for responses to Questions 5–11 are provided in Tables 5 and 6. In Question 5, students overwhelmingly identify the importance of being aware of diverse perspectives and philosophies associated with their fields of study (Cal Poly 95% and NRES Department 85%). In response to Question 6, respondents also strongly see the value in learning more about Indigenous peo-

[S] Supplementary data are available with this article at http://dx.doi.org/10.5849/forsci.15-090.

ples and how they work with and view the environment (Survey Monkey 84% and in-class 79%). Question 9 asked students if they would take additional classes in the INRE minor if it were offered; 48% chose agree/strongly agree, whereas 25% felt neutral about the choice. In addition, survey respondents had the opportunity to add any additional written comments, and we gained insight from these comments. Examples of student responses to Question 9 include the following:

• "This is a really great collaboration. If the minor existed 4 years ago, I would have been very interested. I would like to see this minor expanded to the civil engineering department to see if they are interested."

• "I wish I had more time at Cal Poly to do this [minor]. But I graduate in June."

• "After taking a 'Survey of Indigenous Peoples' course at Cal Poly, I really saw a great connection that could be made between my major and the philosophies, respect, and treatments toward the environment that the various studied groups of Indigenous peoples' displayed."

• "I enjoy the science aspect of my major but ethnic studies courses and learning have always been a big interest too."

• "Having this option as a minor or more preferably a concentration would be in my mind a perfect ideal for what I want to study and find a career in."

There is support for the INRE minor as reflected in student responses to the questions. Currently, 11 students are enrolled in the minor, and 6 more are in the process of adding the minor to their degree plans (2014–2015 academic year). This is encouraging, given the

Table 4. Comparison between Cal Poly University ethnic diversity in 2012 with ethnic diversity of survey respondents.

Ethnicity	Cal Poly University enrollment (N = 18,679)	Survey Monkey respondents (n = 132)	In-class respondents (n = 48)
	(%)		
African American	0.7	0.6	0
Asian/Asian American	11.0	9.7	10.0
Caucasian	61.8	61.7	81.0
Latino/Hispanic	13.8	14.9	3.0
Native American	0.3	1.3	3.0
Other/unknown	12.4	11.7	3.0

Table 5. Student Survey Monkey results for all majors (n = 132).

Question no.	Survey question	Agree and strongly agree	Neutral	Disagree and strongly disagree
		(%)		
5	Do you recognize the importance of being aware of diverse perspectives and philosophies in your field of study?	95	3	2
6	Do you see value in learning more about Indigenous peoples and how they work with and view the environment?	84	11	4
7	Would you be interested in a minor that presented current issues regarding Native/Indigenous peoples and the environment?	41	32	26
8	Are you interested in working with teams of students and professors in order to increase the diversity of your education at Cal Poly?	74	15	7
9	Would you take additional classes in Indigenous studies in Natural Resources and the Environment (INRE) if Cal Poly offered more of these courses?	48	25	21
10	Would you be interested in a program, summer institute, internship, or field trip that connected your assignments and experiences with the natural world and agencies working with Indigenous peoples?	61	19	17
11	Would you consider choosing the INRE minor in Ethnic Studies and Natural Resource Management if Cal Poly offered such a program?	37	27	33

Table 6. Student in-class survey results for Environmental Management and Protection and Forestry and Natural Resources majors (n = 48).

Question no.	Survey questions	Agree and strongly agree	Neutral	Disagree and strongly disagree
		(%)		
5	Do you recognize the importance of being aware of diverse perspectives and philosophies in your field of study?	85	10	4
6	Do you see value in learning more about Indigenous peoples and how they work with and view the environment?	79	15	6
7	Would you be interested in a minor that presented current issues regarding Native/Indigenous peoples and the environment?	27	29	44
8	Are you interested in working with teams of students and professors in order to increase the diversity of your education at Cal Poly?	65	31	4
9	Would you take additional classes in Indigenous studies in Natural Resources and the Environment (INRE) if Cal Poly offered more of these courses?	40	21	40
10	Would you be interested in a program, summer institute, internship, or field trip that connected your assignments and experiences with the natural world and agencies working with Indigenous peoples?	48	31	21
11	Would you consider choosing the INRE minor in Ethnic Studies and Natural Resource Management if Cal Poly offered such a program?	27	25	48

extensive number of programs from which students can choose and the importance of making students aware of the minor early enough in their college careers to take advantage of it.

In a small initial focus group discussion with 7 of 17 interested and enrolled students in the minor, a preliminary review of the comments indicates that students feel that the minor "provides a more complex way of thinking with more breadth of knowledge" than in their major classes alone. They indicate that the minor coursework challenges students in INRE classes to consider different perspectives other than their own. Several students in the focus group that were also enrolled in the ES 410 course indicated, "Native American law is an area that is overlooked." More succinctly, students identified key terms that describe their feelings about the minor program in terms of their development. These include cogent responses such as "crucially contextualizing, ambitious, integrating, informing, passionate, inspiring, and empowering, as well as discouraging/frightening, exciting, and necessary." All of the students in the focus group viewed the minor as an important connection to their future career paths. They did enumerate a variety of areas such as forestry, agriculture, equine science, law, public policy, anthropology/geography, environmental sciences, and natural resource management. Student focus group participants' commitment to the importance of the minor was evident in their responses.

Conclusions and Future Considerations

There is notable purpose, need, and current support for the new INRE minor at Cal Poly as indicated by the written and verbal responses received from students, faculty, and professionals who serve on supporting department advisory councils. Combining TEK and western science can provide a more rounded preparation for students in forestry, natural resources, and other professional areas. Further, programs such as the INRE minor provide students the opportunity to study and gain experience in diversity learning and understanding of other perspectives (Kimmerer 2002, 2013, Mason et al. 2012, Sharik 2015). We envision the INRE minor as an opportunity to address Cal Poly's diversity learning objectives, as well as to help in the recruitment and preparation of our students. We perceive the INRE minor at Cal Poly as a complementary program for any major at Cal Poly or at other universities.

Tribal colleges have been incorporating TEK into the curriculum with demonstrated success for a number of years. In fact, as Hoagland and Gervais (2014, p. 38) report, tribal colleges engage in recruitment and retention of Indian students in natural resources-related fields. Cal Poly, with the addition of the INRE minor, joins other colleges and universities in efforts to integrate Indigenous traditional ecological knowledge into the curriculum since the acceptance of the United Nations Declaration of the Rights of Indigenous Peoples in 2007 and by the United States in 2011. We see threats to natural resources and environmental quality increasing in the future. Kimmerer (2002, p. 434) states, "The complex issues of environmental sustainability require a diversity of intellectual approaches and can benefit from thoughtful consideration and incorporation of traditional ecological knowledge." The opportunity to educate the next generation to address/investigate critical issues and raise awareness should be done with the collaboration of effectively led and managed groups working respectfully together (Piirto 2014). Our goal is to prepare students with an INRE minor to face the many challenges of the future with more than one worldview and with more than one set of solutions.

The INRE minor will without a doubt face challenges in the future. The first and foremost challenge will be to maintain and enhance student, faculty, and administrative support over time. At universities, things change with time. Faculty retire. Funding increases. Funding decreases. University priorities change with a change of key personnel. Can we be certain that the INRE minor will prevail? If a sufficient number of students enroll in the INRE minor then, hopefully, continued university and college support in terms of funding, faculty, and suitable class scheduling of required courses will be provided. As indicated by students in the survey and focus group responses, they perceive merit in the INRE minor. If that perception remains for current and future students, we will see enrollments in the minor continue. The second set of challenges for any program includes maintaining relevance given emerging science, varied cultural perspectives, technological innovations, legal, and economic realities. Will the INRE minor persist? This will require faculty keeping courses relevant.

One thing is certain, land-use conflicts in relation to population growth, urbanization, and resource utilization will require effectively led people working collaboratively to find innovative sustainable solutions for today's and tomorrow's generations. A contemporary vision of our forestry future, particularly in relation to finding viable and supported forest management decisions, must include the preparation of cross-culturally competent foresters and resource managers. As participants in a forest health and wildfire workshop noted, traditional knowledge and science education knowledge could produce a resource management approach that is stronger than either can provide alone (Mason et al. 2012, p. 192). We think that the Cal Poly INRE minor is one small educational step in the right direction in terms of (1) living sustainably (i.e., an integrative holistic approach) while protecting the earth (Gordon et al. 2013), (2) responding to Kimmerer's (2002) call to action to integrate traditional ecological knowledge with scientific ecological knowledge, (3) responding to the Bullard et al. (2014) findings that the Society of American Foresters (SAF) accredited forestry programs (e.g., Cal Poly, San Luis Obispo Forestry and Natural Resources program) continue to emphasize greater preparation and general competencies in people-related areas, and (4) helping students in our programs to gain knowledge and experience in areas largely missing in the curriculum. We believe that the INRE minor will help our students who are or will become SAF members meet their ethical responsibilities to manage the land and maintain its long-term capacity to provide desired materials, uses, and values for current and future generations. We owe it to our past, present, and future generations to find better, shared approaches to living sustainably here on earth.

Endnotes

1. In this article, we use the terms "Native" and "Indigenous" interchangeably. The term Native typically refers to peoples in the United States, whereas the term Indigenous is a term used by the United Nations more globally.
2. For more information, see ccip.uoregon.edu/.
3. For more information, see www.fws.gov/nativeamerican/traditional-knowledge.html.
4. For more information, see www.fs.fed.us/research/tribal-engagement/roadmap.php).
5. For more information, see www.esa.org/esa/about/esa-awards/chaptersections-awards/traditional-ecological-knowledge-section/.
6. For more information, see http://skc.edu/?page_id=2185.

7. For more information, see www.firststewards.org/dr-margaret-hiza-redsteer.html.
8. For more information, see http://www.calpoly.edu.
9. For more information, see http://content-calpoly-edu.s3.amazonaws.com/ir/1/publications_reports/polyview/pv12.pdf.
10. For additional information refer to the Society of American Foresters' website at www.safnet.org/about/codeofethics.cfm.

Literature Cited

ANDERSON, M.K. 2005. *Tending the wild: Native American knowledge and the management of California's natural resources*. Univ. of California Press, Berkeley, CA. 526 p.

BERKES, F. 2012. *Sacred ecology*, 3rd ed. Routledge, New York. 355 p.

BULLARD, S.H., P. STEPHENS WILLIAMS, T. COBLE, D.W. COBLE, R. DARVILLE, AND L. ROGERS. 2014. Producing "society-ready" foresters: A research-based process to revise the Bachelor of Science in forestry curriculum at Stephen F. Austin State University. *J. For.* 112(4):354–360.

BUSSEY, J., M.A. DAVENPORT, M.R. EMERY, AND C. CARROLL. 2016. "A lot of it comes from the heart": The nature and integration of ecological knowledge in tribal and nontribal forest management. *J. For.* 114(2):97–107.

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO. 2015. *Cal Poly statement of diversity.* Available online at www.academicprograms.calpoly.edu/content/academicpolicies/diversity-statement; last accessed May 6, 2015.

DELORIA, V., JR. 1995. *Red earth, white lies, Native Americans and the myth of scientific fact*. Scribner, New York. 288 p.

DOWIE, M. 2009. *Conservation refugees, the hundred-year conflict between global conservation and Native Peoples*. MIT Press. Cambridge, MA. 341 p.

DUPRIS, J.C., K.S. HILL, AND W.H. RODGERS, JR. 2006. *The Si'lailo way: Indians, salmon and law on the Columbia River*. Carolina Academic Press, Durham, NC. 415 p.

GORDON, J., J. SESSIONS, J. BAILEY, D. CLEAVES, V. CORRAO, A. LEIGHTON, L. MASON, M. RASMUSSEN, H. SALWASSER, AND M. STERNER. 2013. *Assessment of Indian forests and forest management in the United States.* Available online at www.itcnet.org/issues_projects/issues_2/forest_management/assessment.html; last accessed Feb. 20, 2015.

HARKIN, M.E., AND D.R. LEWIS. 2007. *Native Americans and the environment: Perspectives on the ecological Indian.* Univ. of Nebraska Press, Lincoln, NE. 367 p.

HELLE, T., AND I. KOJOLA. 2006. Population trends of semi-domesticated reindeer in Fennoscandia—Evaluation of explanations. P. 319–339 in *Reindeer management in northernmost Europe. Linking practical and scientific knowledge in social-ecological systems*, Forbes, B.C., M. Bölter, L. Muller-Wille, J. Hukkinen, and Y. Konstantinov (eds.). Springer-Verlag, Berlin, Germany.

HOAGLAND, S. 2014. *Bridging the traditional ecological knowledge and western science gap to achieve environmental sustainability*. Southwest Regional Conference of the Native American Fish and Wildlife Society, 2014 August 4, Pueblo of Isleta, NM.

HOAGLAND, S., AND B. GERVAIS. 2014. Investing in the next generation of Indian foresters. *Evergreen Mag.* Spring, p. 38–39.

HYPPÖNEN, M. 2011. Sustainable use of forests in Finnish Upper Lapland. P. 25–26 in *Forest management and silviculture in the north—balancing future need, 2011 September 6–8, Stjordal, Norway,* Granhus, A., K.H. Hanssen, and G. Soogard (eds.), Vol. 14. Rapport fra Skog og landskap.

INDIAN COUNTRY TODAY. 2014. *Klamath youth program melding science and traditional knowledge wins national award.* Available online at http://indiancountrytodaymedianetwork.com/2014/01/27/klamath-youth-program-melding-science-and-traditional-knowledge-wins-national-award; last accessed Jan. 28, 2015.

KIMMERER, R.W. 2002. Weaving traditional ecological knowledge into biological education: A call to action. *BioScience* 52(5):432–438.

KIMMERER, R.W. 2013. *Braiding sweetgrass: Indigenous wisdom, scientific knowledge, and the teaching of the plants*. Milkweed Editions, Minneapolis, MN. 408 p.

KYLLÖNEN, S., A. CALPAERT, H. HEIKKINEN, M. JOKINEN, J. KUMPULA, M. MARTTUNEN, K. MUJE, AND K. RAITIO. 2006. Conflict management as a means to the sustainable use of natural resources. *Silva Fenn.* 40(4):687–728.

LADUKE, W. 2005. *The power of naming and claiming*. South End Press, Berkeley, CA. 294 p.

LAMBERT, L. 2003. From 'savages' to scientists; mainstream science moves toward recognizing traditional knowledge. *Tribal Coll. J.* 1–2. Available online at web.williams.edu/AnthSoc/native/tribalcolleges last accessed Jan. 28, 2015.

LAWSON, M.L. 2010. *Dammed Indians revisited: The continuing history of the Pick-Sloan Plan and the Missouri River Sioux 1944–1980*. Univ. of Oklahoma Press, Norman, OK. 416 p.

LEOPOLD, A. 1949. *A Sand County almanac and sketches here and there*. Oxford Univ. Press, New York. 228 p.

LYONS, O. 2008. Listening to natural law. In *Original instructions, Indigenous teachings for a sustainable future*, Nelson, M.K. (ed.). Bear & Company, Rochester, VT. 359 p.

MARTELLO, M.L. 2008. Arctic Indigenous peoples as representations and representatives of climate change. *Soc. Stud. Sci.* 38(3):351–376.

MARTIN, K.J. 2012. Traditional responsibility and spiritual relatives: Protection of Indigenous rights to land and sacred places. In *Indigenous rights in the age of the UN declaration,* Pulitano, E. (ed.). Cambridge Univ. Press, Cambridge, UK. 352 p.

MARTIN, K.J., AND J.J. GARRETT. 2010. Teaching and learning with traditional Indigenous knowledge in the tall grass plains. *Can. J. Native Stud.* 30(2):289–314. Available online at works.bepress.com/kamartin/13/; last accessed Feb. 21, 2016.

MASON, L., G. WHITE, G. MORISHIMA, E. ALVARADO, L. ANDREW, F. CLARK, M. DURGLO, ET AL. 2012. Listening and learning from traditional knowledge and western science: A dialogue on contemporary challenges of forest health and wildfire. *J. For.* 110(4):187–193.

MENZIES, C.R. (ED.). 2006. *Traditional ecological knowledge and natural resource management*. Univ. of Nebraska Press, Lincoln, NE. 273 p.

MCGREGOR, D. 2008. Linking traditional ecological knowledge and western science: Aboriginal perspectives from the 2000 state of the lakes ecosystem conference. *Can. J. Native Stud.* 28(1):139–158.

MIDDLETON, B.R. 2011. *Trust in the land: New directions in tribal conservation*. Univ. of Arizona Press, Tucson, AZ. 352 p.

MUSTAJOKI, J., H. SAARIKOSKI, M. MARTTUNEN, A. AHTIKOSKI, V. HALLIKAINEN, T. HELLE, M. HYPPÖNEN, ET AL. 2011. Use of decision analysis interviews to support the sustainable use of the forests in Finnish Upper Lapland. *J. Environ. Manage.* 92(6):1550–1563.

NELSON, M.K. (ED.). 2008. *Original instructions, Indigenous teachings for a sustainable future*. Bear & Company, Rochester, VT. 359 p.

PIIRTO, D.D. 2014. *Leadership, a lifetime quest for excellence.* A publication of Seinajoki University of Applied Sciences, C Series Teaching Materials. Seinajoki Publications, Seinajoki, Finland.

SCHILLING, V. 2011. *Native defenders of the environment (Native trailblazers).* Seventh Generation, Summertown, TN. 128 p.

SHARIK, T. 2015. Diversifying student demographics in forestry and related natural resources disciplines. *J. For.* 113(6):579–580.

SNIVELY, G. 2006. Honoring Aboriginal science knowledge and wisdom in an environmental education graduate program. In *Traditional ecological knowledge and natural resource management*, Menzies, C.R. (ed.). Univ. of Nebraska Press, Lincoln, NE. 273 p.

SOUTHWEST RESEARCH AND INFORMATION CENTER. 2015. *Voices from the earth, a journal of environmental views, news, and reviews.* Available online at www.sric.org/voices/index.php; last accessed Sept. 28, 2015.

TUULENTIE, S., AND A. MERIRUOHO. 2008. Paikallisuuden ja osallisuuden retoriikka keskustelussa Ylä-Lapin luonnon käytöstä [The rhetoric of localness and participation in the debate about the use of nature in the northernmost Lapland]. *Terra* 120(2):83–94.

UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION. 2015. *World population prospects: The 2015 revision, key findings and advance tables*. Working Pap. ESA/P/WP. 241. Available online at esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf; last accessed Feb. 21, 2016.

VINYETA, K., AND K. LYNN. 2013. *Exploring the role of traditional ecological knowledge in climate change initiatives*. USDA For. Serv., Gen. Tech. Rep. PNW-GTR-879, Pacific Northwest Research Station, Portland, OR. 37 p.

WOODBRIDGE, M. 2013. *US Department of the Interior, NASA, and Forest Service inaugurate innovative tribal student education program in the Klamath basin*. US Fish and Wildlife Serv., Pacific Southwest Region, Sacramento, CA. Available online at http://www.fws.gov/cno/restore_022611/press/release.cfm?rid=523; last accessed Jan. 28, 2015.