SRM Society for Range Management

Lessons given and learned from rangeland monitoring courses

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On the Ground

- Monitoring courses, offered at universities and through professional training, are critical to successfully collecting and applying rangeland monitoring data.
- Instructors can meet course objectives by carefully considering course content, the target audience, delivery approaches, evaluation mechanisms, and training for new instructors.
- Shared principles and practices taught in monitoring courses facilitate the rangeland management community in achieving desired outcomes through adaptive management.

Keywords: academia, active learning, hybrid courses, learning style, teaching style, training.

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Introduction

Assessing and monitoring natural resources supports achievement of desired outcomes in rangeland management. Monitoring data provide land managers (federal, state, tribal, and private landowners) with information to understand ecosystem structure and function,[1] thus empowering managers to adjust their actions to meet management goals and objectives. Monitoring data are most useful when they are collected using standard methods across space and time and of sufficient quality to be used for multiple applications.[2,3] Successful rangeland monitoring requires a significant investment in time and human resources, including adequate training in the monitoring process. Large numbers of academic students at universities and colleges, as well as rangeland professionals, must be trained to collect, manage, and use monitoring data for rangeland management on a regular basis. Thus, evaluating and sharing information and techniques across academic and professional monitoring courses is crucial to ensure that students and technicians are properly trained in standard monitoring methods to apply them across rangelands.

Accredited rangeland ecology and management degree programs require undergraduate students to take a rangeland inventory, monitoring, and assessment course in order to qualify for the federal Rangeland Management 0454 job series. For simplicity, we combine this suite of courses under monitoring in this paper. Additionally, other undergraduate degrees, including those associated with ecology, conservation biology, and wildlife, require or recommend that undergraduates take a monitoring course. Course content is often not standardized and may include quantitative and/or qualitative methods. The data collection and analytical skills gained in these undergraduate courses can also be valuable for graduate students conducting research. Academic monitoring courses provide the foundations for professionals, who can continue their education through employer training opportunities.

Professional training courses enable technicians and land managers to assess rangeland ecosystem structure and function as part of their job. Training is typically organized by the monitoring program or method used, often agency-specific, and targeted to particular job duties.[4] For example, the Bureau of Land Management (BLM) offers quantitative courses in the Assessment, Inventory, and Monitoring (AIM) core methods, as well as Measuring and Monitoring Plant Populations. Additionally, the Natural Resources Conservation Service (NRCS) has a quantitative course on the National Resources Inventory (NRI) monitoring methods, which are consistent with AIM. The BLM and NRCS also offer qualitative monitoring courses, including Interpreting Indicators of Rangeland Health (IIRH) and Proper Functioning Condition (PFC). Although the same methods are increasingly adopted across agencies, particular policies, regulations, and goals may be agency specific.[4] Course participants in professional training courses include federal government employees, as well as employees from state agencies, contractors, landowners, and other nongovernmental organizations.

Well-designed and executed monitoring courses can be valuable for academic students and professionals, as well as highly rewarding for instructors. However, professors, agency employees, and/or contractors asked to teach these courses rarely receive formal training or education on effective teach-

Figure 1. The CADET model provides a framework for monitoring course development for academic and professional settings. Instructors 1) determine appropriate course content, 2) assess who the audience is, 3) select suitable materials and delivery methods, 4) develop evaluation metrics, and 5) teach future instructors, who ultimately will play a role in teaching and improving future monitoring courses. CADET indicates Content, Audience, Delivery, Evaluation, Training.

ing. Instead, instructors often develop teaching skills in an ad hoc manner and must be self-motivated to advance their teaching skills. Our objective is to provide a framework for those embarking on developing and teaching a monitoring course, drawing upon our shared experience with academic and professional courses (primarily from BLM and NRCS). We propose the CADET model (CADET = Content, Audience, Delivery, Evaluation, Training; Fig. 1) as a framework for building monitoring courses, which provides advice on how to 1) determine appropriate course content, 2) assess the audience and their needs, 3) select suitable materials and delivery methods, 4) develop evaluation metrics, and 5) teach future instructors. We couple teaching research with practical experience to provide a framework that anyone teaching a monitoring course could adapt. Hereafter, we refer to both academic students and professionals in training courses as "students" unless otherwise specifically stated.

Content: What do students need to know?

Clearly stating course objectives and learning outcomes allows the instructor to select what content is appropriate and informs students of what they will gain from the course. Objectives for a rangeland monitoring course may include developing knowledge and skills about 1) planning and designing monitoring efforts, 2) data collection and data management, and/or 3) analyzing and using data (Fig. 2). Professional training courses often focus the limited instruction time available on data collection because it is required by the largest number of people; planning and design, as well as data analysis and use, are usually the responsibility of fewer individuals and may be more project specific. With an extended semester or quarter, academic instructors are able to include material on the planning and designing phase, as well as data analysis and use. Covering this first and last step in the monitoring process provides a foundation for academic students to bring to the professional setting where they can gain skills for specific protocols used in the workplace.

The planning and designing phase of a monitoring program requires knowledge of background concepts in rangeland ecology. Landscapes are spatially and temporally heterogeneous, which requires monitoring efforts to identify ecological sites. State and transitions models describe various community phases and any state shifts in an ecological site, which are valuable for interpreting monitoring data.[5] These concepts are important in both quantitative and qualitative monitoring courses. In addition, the qualitative IIRH course requires students to understand reference states because rangeland health evaluations are based on ecological site reference conditions.[1] These ecological concepts help students understand monitoring efforts in a management context, allow them to develop appropriate management and/or research questions, develop monitoring objectives, and design monitoring appropriately.

Data collection methods and data management procedures are crucial to enable rangeland managers to collect and manage high-quality data. It is often assumed or required that students have basic geospatial skills and already know how to identify plant species; however, knowledge about soils and ecological sites is less common and should be included in monitoring courses. Many monitoring courses focus on methods for measuring rangeland vegetation indicators, such as plant cover, structure, frequency, density, and/or biomass; some courses also describe soil methods, including soil texture, horizons, and aggregate stability. Additionally, monitoring courses may include standardized ways of recording the data manually and/or electronically. It is important that students use the latest techniques, equipment, and technology for data collection and practice using these tools to assure up-to-date data collection protocols. Finally, monitoring courses should provide the groundwork for data collectors to conduct data quality assurance and control (e.g., calibration, data management, and error checking), as well as how to properly document and store data with appropriate metadata.[6]

Land managers, lead technicians, and graduate students may analyze monitoring data. Sometimes analysis only requires an understanding of descriptive statistics, which allows the user to examine conditions within a measured sample using means, medians, and standard deviations. However, inferential statistics can allow the user to draw conclusions about a broader population and most often include t tests, χ^2 tests, and analysis of variance. The Herrick et al.[7] technical reference, Landscape Toolbox (https://www.landscapetoolbox.org/data-analysis-reporting-tools), and Elzinga et al.[8] provide information on descriptive statistics relevant to monitor-

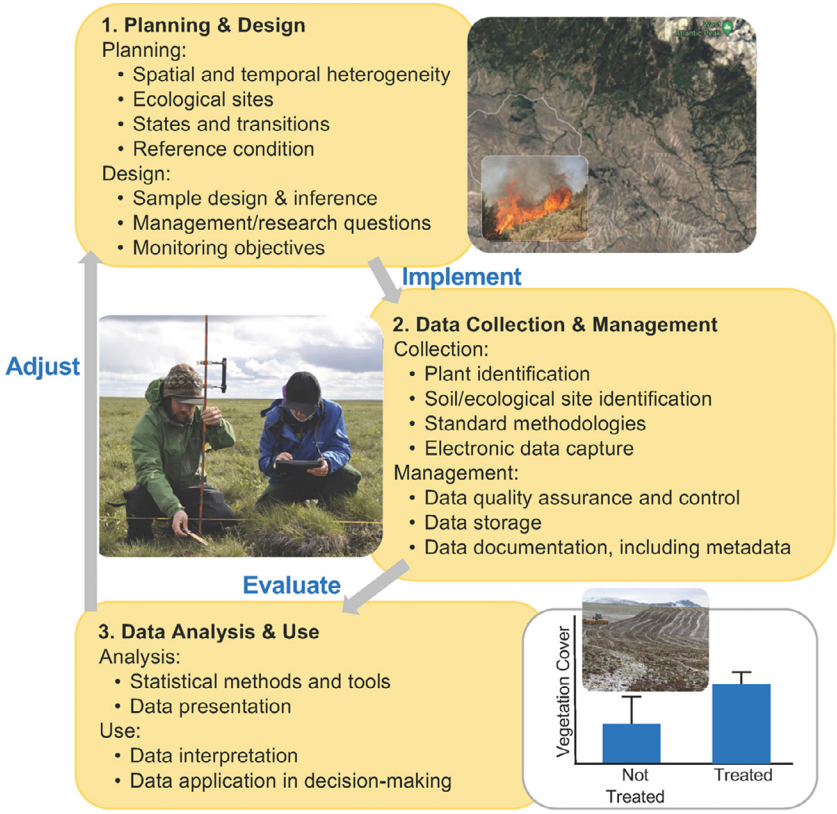


Figure 2. Example of monitoring course content that forms the basis for clearly stated course objectives and learning outcomes. Monitoring planning and design, data collection and management, as well as data analysis and use, form an adaptive management cycle (implement, evaluate, and adjust). Each step informs the next and improves efficiency and effectiveness of monitoring efforts.

ing plants and soils. Elzinga et al.[8] also includes information on inferential statistics, but these advanced skills may be more easily learned from statistical references, online resources, and at academic institutions. Teaching students basic data analysis facilitates their understanding of the importance of high-quality data and increases their ability to make independent decisions about field-collected data.[9]

Presenting the results of data analysis and ensuring appropriate data use in decision-making are also advanced skills that complete the monitoring process. Unfortunately, these skills are not often taught in professional monitoring courses but sometimes are found in other professional courses. For example, the BLM has an AIM Project Leads training, which enables professional students to work through several BLM-specific land management examples, and a Habitat Assessment Framework training for completing greater sage-grouse habitat assessments. Both courses build off of technical guidance, which describes specific workflows for using data in decision-making[10,11] in compliance with agency policy. In contrast, data presentation and use are often included in academic monitoring courses and/or are covered in other courses, but the decision contexts vary. Because data presentation and use are the final products in the monitoring process, we encourage instructors and institutions to develop courses for data users to acquire these skills. Including real-world examples of management decisions that students may face as rangeland professionals may enhance students' ability to apply information to decision-making in the future.[3]

Audience: Who are the students?

Students of monitoring courses have diverse backgrounds, including varying levels of education and work experience, as well as approaches to learning (Fig. 3) and learning styles or preferences (Fig. 4). Taking time to understand the audience enables instructors to design and teach a more effective monitoring course by tailoring activities to diverse classrooms. One way to achieve this is to conduct precourse surveys. Questions may include 1) personal background, 2) reason for taking the course, 3) previous related courses, 4) existing knowledge and skill sets, 5) familiarity with protocols, 5) goals for the course, and 6) desired material to be covered (Table 1). While the instructor should adhere to the course objectives, understanding student backgrounds can help an instructor make valuable adjustments to course content and delivery.

Academic students are usually from various natural resource, biology, or environmental science degrees and are generally inexperienced in the workplace. However, there are an increasing number of professionals going back for additional academic coursework. Professional training courses are equally diverse with recent academic graduates of various degree programs, as well as professionals working in federal,

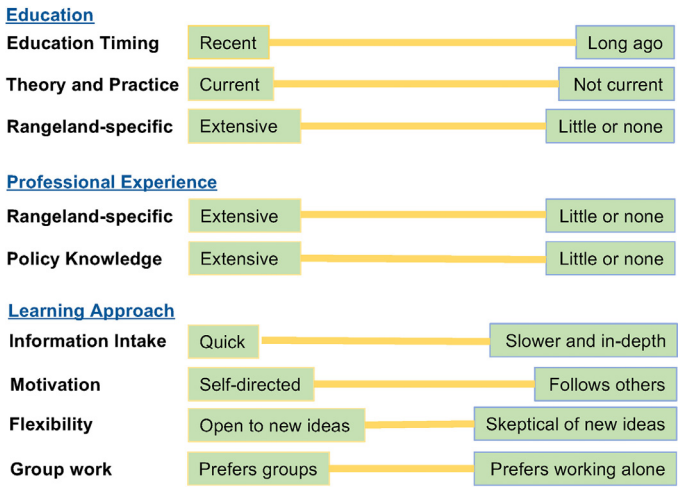


Figure 3. Each student falls along a continuum of characteristics, including education, professional experience, and learning approaches. Taking time to understand the audience and designing the course accordingly can result in a more effective monitoring course.

Table 1
Example of a precourse questionnaire used in current Bureau of Land Management courses

1. Name:
2. Employer:
3. State:
4. Current Job Title:
5. Years in Position:
6. Why are you taking this course?
7. Have you taken other monitoring or assessment courses from the government, universities, etc.? If so, what course(s) and where?
8. Have you taken this particular course before? If so, when?
9. Have you hand-textured soils before?
10. Do you have experience describing soil pits?
11. Do you have other experience working with soils?
12. Do you have other experience identifying plants?
13. Have you previously conducted monitoring using AIM, NRI, FIA, IIRH or other protocols in the field?
14. What is/are your major goal(s) for this course?
15. Is there any particular subject matter you would like covered in this course?
16. What are your career goals?
17. Is there any other experience you have related to monitoring or assessment you wish us to know about?

Note: Questions are put in a Google Form that students are asked to fill out before attending class, which can be adapted to academic situations.
AIM indicates Assessment, Inventory, and Monitoring; FIA, Forest Inventory and Analysis, IIRH, Interpreting Indicators of Rangeland Health; NRI, National Resources Inventory.

state, and nongovernmental organizations holding positions with varying responsibilities and levels of authority. Academic cohorts and employer field crews have high turnover; frequently, early career or seasonal staff are assigned to complete monitoring data collection but move on to other positions once they gain experience. More experienced staff benefit when they periodically update their knowledge via refresher training. Consequently, instructors should remember that the student body will vary each time the course is taught.

Students fall along a continuum in regard to their education, work experience, and approaches to learning (Fig. 3). For example, some students with recent education and current knowledge of theories and practices may also have a rangeland ecology or similarly specific degree; in contrast, other students will have taken relevant courses long ago and/or focused on other educational fields, such as environmental sciences or biology. Some professional students may understand workplace policy in order to effectively apply monitoring programs to land management, but some will not. Students may also vary in their approaches to learning by 1) how fast they intake information, 2) whether they are self-motivated or follow others, 3) their openness to new ideas, and 4) their preference to work alone or in groups. Students may even vary their learning approaches depending on the lesson topic and from day-to-day.

Students may also have various learning styles or preferences. These learning styles or preferences relate to how an instructor presents material, which may be through kinesthetic (K), reading/writing (R), visual (V), or verbal (V) means (KRVV; Fig. 4; adapted from Fleming and Mills[12]). Students may be unimodal, bimodal, trimodal, or quadrimodal in their preferences, meaning they have one or more preferences. Al-

Figure 4. The KRVV model illustrates the four primary modes of information transfer: kinesthetic, reading/writing, visual, and verbal. Structuring learning using multiple modes of learning will allow for greater knowledge retention.

though some have questioned if focusing on learning styles increases learning,[13,14] at a minimum it breaks up the monotony of a unimodal delivery method and reinforces concepts.

The variation in student backgrounds and approaches to learning provides excellent opportunities for students to learn and teach each other. In monitoring courses, there is great value in the information exchange between those academic students who can share the latest ideas on ecological theories, whereas professional students share their experiences of implementing monitoring protocols and programs. Students who tend to follow others may learn from those more self-directed and be more open-minded to new ideas than the self-directed student. Instructors can use this diversity in background, as well as learning approaches and styles, in group work. We encourage instructors to group students with different experience levels to maximize peer teaching and learning opportunities.

Delivery: How do I facilitate learning?

The diversity of students in monitoring courses necessitates that instructors use diverse materials and methods for course delivery to facilitate participation and engagement with course content (i.e., active learning). Monitoring information can be relayed via manuals, websites, and apps or software (Table 2). Instructors are encouraged to use common sources of monitoring information, which include 1) extensive background on monitoring plants, including setting objectives and basic data analysis (Elzinga et al.[8]); 2) monitoring design, as well as standardized plant and soil sampling methods used in AIM and NRI (Herrick et al.[7,9]); and 3) qualitative rangeland health monitoring (Pellant et al.[1]). These manuals may be supplemented by websites, apps, and software that help determine soils, plant identification, and ecological sites, as well as conduct vegetation analysis. An online "Vegetation Measurement and Monitoring" course was also developed by a group of professors teaching monitoring courses across the western United States (see Table 2 and additional resources may be found in Appendix 10 of Pellant et al.[1]).

Using multiple teaching methods (or modalities) to achieve blended or hybrid learning may be most effective for achieving learning outcomes, especially when the focus is on active learning. Today's learning environment is full of options for teaching monitoring in-person and remotely, including in the classroom, online, and in the field. Classroom and online activities can cover concepts critical to a monitoring program, including planning, design, data analysis and data use. Online and remote learning gained popularity due to travel budget restrictions, student/employee life and job commitments, and the COVID-19 pandemic. Online instruction can be done live; however, prerecorded material allows students the flexibility of when they view course material. Field trips provide students with the invaluable skill to practice data collection and management, including instructor feedback. Illustrating monitoring concepts recurrently using multiple modalities promotes consistent data collection and increases repeatability.

We provide an example using numerous teaching modalities to illustrate concepts, reinforce learning, and build cognitive skills (Fig. 5). Professional courses provide the opportunity for participants to do precoursework, which is done online via lectures and/or demonstration videos, to give students an overview of the course; the participants can then be quizzed on the material before coming to the classroom. Classroom lectures and online modules may focus on key skills and concepts on planning and design, which can be interspersed with periodic instructor–student interactions (guiding brainstorming sessions, asking students questions) and student–student interactions (pair-sharing, group projects and presentations, debates) that facilitate active learning. Another way to engage students is to present material using games—like bingo, matching cards, and trivia.

Field experiences allow students experiential learning opportunities through live demonstrations of field methods and hands-on practice. These field exercises benefit the kinesthetic learners by providing practical instruction and experience, as well as feedback on data collection. Practicing field methods also allows students to become familiar with commonly used field equipment. Many students are less familiar with soil measurements; thus, field trips help students acquire skills in determining soil texture, horizons, and aggregate stability, which is difficult to do in a classroom.

While some courses may stop at teaching field methods, crucial steps for monitoring courses include giving students feedback and sharing examples of data analysis and use. We encourage instructor–student interactions in the field to provide immediate feedback on data collection techniques. If these in-person interactions are not possible (e.g., online-only course delivery), instructors may have students do live video or videotape themselves conducting the data collection for subsequent feedback. The rapid shift to online delivery of academic courses worldwide during the COVID-19 pandemic fueled innovation in creating meaningful experiential learning opportunities.[15] Although this shift came out

Table 2
Examples of general references, tools, and government planning documents useful in monitoring courses

Type	Name	Source
General references	Measuring and Monitoring Plant Populations, Elzinga et al.[8]	https://www.ntc.blm.gov/krc/uploads/265/technical%20reference.pdf
	Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems, 2nd edition (AIM, NRI)	https://www.landscapetoolbox.org/wp-content/uploads/2016/02/MMGSSE_20170614.pdf
	Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems, Vol. II	https://www.landscapetoolbox.org/wp-content/uploads/2015/01/Volume_II.pdf
	Interpreting Indicators of Rangeland Health	https://www.blm.gov/documents/national-office/blm-library/technical-reference/interpreting-indicators-rangeland-health-0
	Lotic Field Protocol for Wadeable Systems (AIM)	http://aim.landscapetoolbox.org/wp-content/uploads/2020/05/Lotic_FieldProtocolForWadeableSystems_TR1735-2.pdf
	Landscape Toolbox and AIM Landscape Toolbox websites (USDA-ARS)	https://landscapetoolbox.orghttps://aim.landscapetoolbox.org
	Online Vegetation Measurement and Monitoring Course	https://learn.landscapetoolbox.org/course/vegetation-measurement-and-monitoring/
Tools	LandPKS app	https://landpotential.org/
	Web Soil Survey	https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
	Ecosystem Dynamics Interpretive Tool (EDIT)	https://edit.jornada.nmsu.edu
	USDA PLANTS Database	https://plants.sc.egov.usda.gov/java/
	iNaturalist	https://www.inaturalist.org/
	GrassSnap	https://extension.unl.edu/statewide/centralsandhills/grasssnap/
	Rangelands Analysis Platform (RAP)	https://rangelands.app
	Western Regional Climate Center (WRCC)	https://wrcc.dri.edu
	PRISM Climate Group	https://prism.oregonstate.edu
	Climate Engine	http://climateengine.org
Government planning	Greater Sage-Grouse Habitat Assessment Framework	https://www.blm.gov/documents/noc/blm-library/technical-note/guide-using-aim-and-lmf-data-land-health-evaluations-and
	Land management policy and plans	https://www.ntc.blm.gov/krc/uploads/923/TR_6710-01_HAF.pdf
		e.g., FLPMA, Local Land Use Plans or Allotment Management Plans

Note: Some materials may not be widely available, particularly outside the United States.
AIM indicates Assessment, Inventory, and Monitoring; FLPMA, Federal Land Policy and Management Act, NRI, National Resources Inventory; USDA-ARS, USDA-Agricultural Research Service.

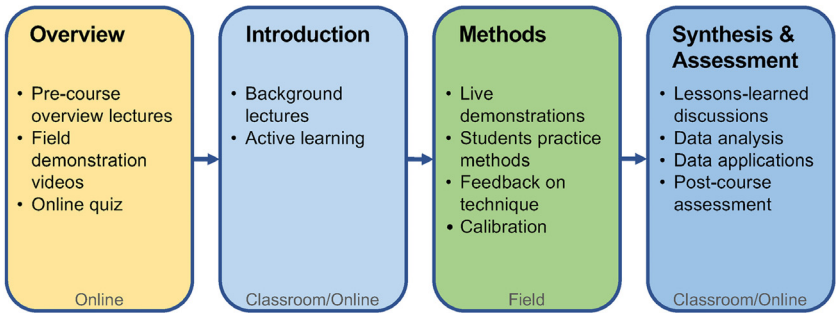


Figure 5. Example activities and associated teaching modalities in a monitoring course: 1) introductory background concepts and methods may be introduced online; 2) concepts and methods can be further explored in the classroom with active learning; 3) students can see live demonstrations, practice, and get feedback on field methods and apply previously learned concepts; and 4) the class can discuss lessons learned, data applications, and do postcourse assessments related to concepts and methods learned after the field.

of necessity, it has demonstrated that some barriers to providing experiential learning opportunities (previously considered insurmountable) can be reasonably overcome. Regardless of the delivery mode, having group discussions on lessons learned while collecting field data allows for correction and calibration that is invaluable and increases data quality. Students also benefit from seeing case studies analyzing and using data to ensure appropriate data application and interpretation. In these steps of reinforced learning, the combination of modalities may increase retention by concept repetition, promote problem-solving skills, teach collaboration, and facilitate communication skills.[16]

In addition to using various teaching modalities, instructors can take different approaches via their teaching style. Instructors tend to have a preferred teaching style[17] but are encouraged to include various styles to address student preferences. Grasha[18] proposed the following five teaching styles: 1) Expert - provides expert knowledge and skills to students to increase preparedness and competence, 2) Formal Authority - uses professional status and expert knowledge with a focus on expectations, 3) Personal Model - teaches by example show-

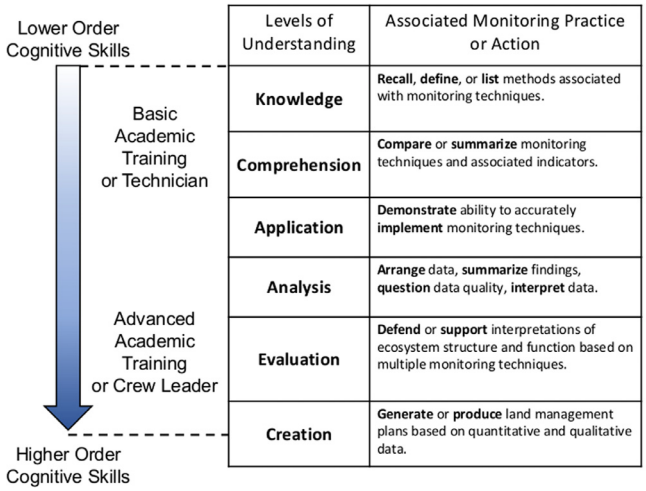
ing students how to think and behave, 4) Facilitator - assists students in critical thinking and exploration, and 5) Delegator - encourages students to learn independently with occasional feedback. Given that each instructor's teaching preference is met by a pool of participants with their own preferred learning styles, incorporating a mix of delivery types facilitates learning of the whole student body.

Some teaching styles may be more useful in academic versus professional monitoring courses, and some teaching styles may lend themselves better to particular material or activities than others. For example, the Expert and Formal Authority may be more effective when used in an academic setting. However, in a professional setting, students may have comparable (but different) experience as the instructor, so the instructor should use caution when using the Expert and Formal Authority approaches. When presenting background concepts and introducing methods, instructors may use the Expert and Formal Authority, while the Personal Model, Facilitator, and Delegator styles may be more appropriate for teaching field methods. For example, a monitoring course may invite a soil scientist as an Expert and a Formal Authority to teach students about soil processes, as well as demonstrate how to dig a soil pit and hand-texture soils. The soil scientist and monitoring instructors may then become Personal Models and Facilitators as students dig their own pits and texture soils. Finding a balance between imparting information as an expert of the material and facilitating independent problem-solving means implementing a blend of information transmission from instructor to student, as well as encouraging students to use resources to answer a question or solve a problem independently.

Evaluation: How do I know they have learned something?

Evaluations that are closely aligned with learning objectives provide critical feedback during and at the conclusion of courses. Because monitoring courses strive to achieve different levels of understanding and skill development, designing assessments that correspond with the spectrum of learning outcomes is important. Using the modified Bloom's taxonomy[19] that classifies different levels of understanding, we provide suggestions for associated monitoring practices or actions to be used in the course to assess various levels of learning (Fig. 6).

During course delivery, formative assessments provide opportunities to gauge students' understanding as they are learning information. Instructors can use this feedback to shift instructional style based on the development of student understanding. Designed to be used in an adaptive manner, formative assessments vary in the time they take or the level of complexity they assess, but fundamentally they serve as an opportunity to redirect instruction to ensure achievement of learning objectives.[20,21] Their adaptive nature allows for greater incorporation of assessment formats (e.g., written, oral, or



Levels of Understanding	Associated Monitoring Practice or Action
Knowledge	**Recall, define,** or **list** methods associated with monitoring techniques.
Comprehension	**Compare** or **summarize** monitoring techniques and associated indicators.
Application	**Demonstrate** ability to accurately **implement** monitoring techniques.
Analysis	**Arrange** data, **summarize** findings, **question** data quality, **interpret** data.
Evaluation	**Defend** or **support** interpretations of ecosystem structure and function based on multiple monitoring techniques.
Creation	**Generate** or **produce** land management plans based on quantitative and qualitative data.

Figure 6. Associated monitoring practices and actions to assess students' levels of understanding in a monitoring course based on Bloom's taxonomy.

demonstration) that better meet the students' learning styles. Courses structured to promote interaction among students and instructors provide great opportunities for formative assessments, such as small group demonstrations, result sharing, and discussion.

Calibration of monitoring techniques (e.g., soil texturing, plant cover, etc.), where results are compared against known values or against other data collectors, is an especially important type of formative assessment. Calibration ensures that monitoring results are accurate and repeatable, which are critical goals of monitoring work. Calibration is often a form of peer-to-peer feedback, where students can review their results together against a standard and evaluate areas of strength and weakness collaboratively. The ability to share results and have timely discussions regarding data interpretation is crucial to promote skill development and confidence in technique application and data interpretations. Students can continue to use this skill beyond the course to ensure the quality of data collected by themselves or others.[6]

At the conclusion of a course, summative assessments in monitoring courses provide a snapshot of what the student has learned, while also giving them an opportunity to demonstrate their ability to use resources. In courses that span academic semesters, these assessments often come in the form of comprehensive group projects that include data analysis, and evaluation. Professional training courses (e.g., AIM) may use an open-book test focused on manuals and/or other resources to assess learning. Although self-assessments are not truly summative, asking students to rate their knowledge, skills, and abilities associated with monitoring practices or actions before and after a course can also provide great instructional feedback.

Equally important to assessing progress toward achieving learning objectives, instructional evaluation plays a critical role in improving instruction effectiveness. Recognizing every course as a unique assemblage of students with different experiences, ongoing assessment of instructional effective-

ness can inform shifts in instructional strategy. Simple, open-ended questions that allow students to provide feedback on what they like or do not like, or what they find effective or not. The students' answers can inform instructional modification, while demonstrating the investment of instructors to facilitate learning. "Start, Stop, Continue" evaluations can be quickly implemented to receive feedback on what individuals would like instructors to start, stop, and continue doing. The depth of feedback received from this form of evaluation is greater than structured questions,[22] and instructor response to this feedback reinforces the value placed on helping students achieve learning objectives. Instructors can also self-assess the course by journaling and debriefing with other instructors to reflect on what was successful and unsuccessful.

Academic institutions have formalized summative assessments for individual courses that address both content and instructor effectiveness. Additionally, mandated academic program review and accreditation processes require curricular assessments, which link to achievement of core, discipline-specific competencies. Although this level of assessment is not typically required in professional training, data-driven assessment can be useful to justify further investment of resources. Formalized assessment also has its place in trainings (e.g., AIM, NRI) and in certification programs where formal competency assessments are required to demonstrate knowledge, skills, and abilities in specific areas (e.g., Certified Professional in Range Management, Certified Ecological Restoration Practitioner, etc.).

Teaching future instructors: How do I pass this on?

Academia and professional training courses take different approaches to teaching future instructors. Because academic institutions focus on teaching in a broader context, there are numerous resources to help faculty and teaching assistants teach courses. Universities have teaching and learning centers, which provide written material, webinars, and/or workshops. Furthering their instruction capabilities is usually not mandatory for faculty, but an introductory workshop or course is often required for teaching assistants. Teaching assistant training may include general policies, including code of conduct, academic integrity, equity, diversity, and managing behavior in the classroom. Similar to our CADET model, many teaching assistant trainings also cover teaching skills, including developing course content and learning objectives, creating a sense of community in the classroom, classroom and online learning techniques and activities, as well as effective evaluation and assessment. Additionally, teaching assistants are often mentored by the course instructor in informal ways.

Rather than focusing on general teaching skills, professional instructor training usually centers on a specific course. In professional monitoring courses, instructors often learn how to teach via peer-to-peer interactions rather than through academic education. Opportunities for experienced instructors to teach and mentor new instructors, sometimes known as "Train the Trainer," are particularly helpful for expanding the instructor team to meet the demand of teaching a large number of students. The "Train the Trainer" model also instills instructor confidence and knowledge about monitoring skills and concepts, as well as allows peer review.[23] By working through the complexities of instructing together, teaching monitoring becomes a collaborative learning community where instructors can share experiences and best practices. Several federal monitoring programs use a "Train the Trainer" model, including AIM, PFC, and NRI.

Like the monitoring courses themselves, instructor training for a monitoring course can be designed using the CADET model. Instructor course content should mirror monitoring training but with an additional objective to empower new instructors to teach rangeland monitoring effectively to others. Thus, added content includes course delivery approaches that facilitate student learning. With AIM, we have observed that mirroring the methods course content also allows new instructors to better understand how their students experience and perceive the course. In terms of audience, new instructors are generally recruited from within the monitoring program, although they are experienced monitoring professionals, they may have little or no teaching experience or training. Given that the monitoring courses they will teach have a diverse pool of students, potentially including the instructor's colleagues, it is important that new instructors gain skills in course delivery, including making adjustments as needed to address their audience. Learning to use open-ended questions, directing students to course materials, and managing various classroom challenges will assist future instructors in achieving learning outcomes. The AIM instructor course includes time for new instructors to practice teaching course content and to evaluate themselves and others on delivery effectiveness. This allows new instructors to experience and experiment with different delivery methods to address the diverse student body. In courses that are co-taught with other instructors, working in groups with other new instructors allows participants to learn how to instruct as a team, where instructors can support each other. This provides shared leadership and vision, helping monitoring courses flow seamlessly.

Instructor training courses should be tailored to meet the needs of a program for monitoring data collection and use. Instructors should be encouraged to keep training credentials current so that monitoring and training skills remain relevant, enabling high-quality data collection and robust decision-making. Instructor recruitment on a regular basis is also important for professional courses; AIM instructor training is offered yearly to maintain a robust instructor cadre. Instructor training may be standardized by using a training manual with the monitoring course mapped out in detail, and instructor scripts or lists may be provided to emphasize important points within the course. Once trained, new instructors provide valuable insights that improve future monitoring courses. They also become highly skilled monitoring practitioners who effectively plan, design, collect, manage, and apply monitoring

data to decision-making. Ultimately, monitoring instructors become uniquely empowered to adjust management actions in order to achieve management goals and objectives.

Conclusions

Rangeland monitoring occurs across millions of acres in the United States providing large data sets for broad landscapes. Each monitoring effort may have different research or management objectives necessitating different monitoring choices (e.g., design, methods, and analysis). However, teaching common principles and protocols across agencies and institutions will increase the compatibility among data sets and how we use them to inform land management. Instructors can support compatible data and streamline decision-making by teaching common content, while still considering various audiences, delivery methods, and evaluation techniques. We acknowledge that several concepts in teaching theory and examples in practice have been provided and encourage those leading teaching efforts to further explore the provided references. Additionally, we support others developing teaching manuals that may be specific to their program (e.g., AIM Training Manual).

We also encourage monitoring course instructors to seek out additional training to elevate their teaching skills. This may be achieved with "Train the Trainer" programs and/or academic courses and resources that focus on fundamental teaching skills. Some of the best ideas are obtained from colleagues, who have learned by trial and error. Instructors would substantially benefit from sharing teaching resources, ideas, and materials, which will also assist with consistent data collection. As authors on this paper, we have built a valuable monitoring teaching community across institutions and hope others will join us. Additionally, instructors can revisit educational and training needs with periodic needs assessments by inviting users to determine what the current educational needs are. Other programs have received great insight when conducting participant-based needs assessments, which results in participants who are more invested in their education and training.[24,25]

Building on the successes of data collection courses, we recommend additional focus on developing courses that review monitoring project planning and design, as well as data analysis and use. These skills are essential to ensure that monitoring data provide the intended insights on ecosystem structure and function and improvements in management outcomes. Currently, these skills are less emphasized or not covered in courses. Adequate monitoring design ensures meaningful data to answer management or research questions. Courses that present appropriate analysis techniques for particular data sets and scenarios will assist data users in proper data interpretation and subsequent decision-making.

In addition to technical skills, monitoring courses provide fantastic opportunities for instructors and students to build communities of practice around rangeland monitoring. Monitoring courses can provide students a plethora of student–student and student–instructor contact. Diverse student bodies allow for both instructor- and student-led teaching, which provides new perspectives and allows for continual dialogue. Together, instructors and students develop a shared way of knowing about rangeland ecosystem structure and function. Monitoring courses thus provide an opportunity for the rangeland management community to work together to achieve desired outcomes through adaptive management, now and in the future.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships, which may be considered as potential competing interests: The authors certify that they have no financial interest in the subject matter discussed in the manuscript. Sarah McCord is the Guest Editor for this special issue, but was not involved in the handling, review, or decision for this manuscript. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the US Government. The content of sponsored issues of Rangelands is handled with the same editorial independence and single-blind peer review as that of regular issues.

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