

Strategies for Incorporating Long-Term, Distributed-Network Research Projects into the Undergraduate Curriculum: Lessons from the Ecological Research as Education Network's Decomposition Project

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ABSTRACT

Increasingly, undergraduate institutions are incorporating original research into the curriculum as a matter of best practice. However, while the practice of science has grown more collaborative, undergraduate research has remained largely confined to single-institution studies. Incorporating long-term, distributed research projects into the undergraduate research experience can better prepare students to interpret and engage in science of the future. The Decomposition in Aquatic and Terrestrial Invaded Systems (DATIS) project within the Ecological Research as Education Network (EREN) offers a good model for examining how to minimize challenges and maximize opportunities associated with classroom use of long-term, collaborative research projects. Eleven key challenges are identified, and practical solutions are provided for each. By modeling this scientific approach in primarily undergraduate institutions, we are preparing graduates who will have the tools and knowledge to work collaboratively and create their own distributed research networks. Our goal is that the decomposition project we describe here can inform and inspire others seeking to engage in research at the undergraduate level, either as potential research coordinators or as collaborators in an existing network.

Key Words: collaborative research projects; EREN; decomposition; undergraduate research experience; course-based undergraduate research.

○ Introduction

There is broad consensus that research experience is a vital part of undergraduate STEM education (Brewer & Smith, 2011), and the American Association of Colleges and Universities includes undergraduate research as one of its 10 “High Impact Practices” (Kuh, 2008). Undergraduate research aims to give students an opportunity to participate in scientific inquiry in the way science is actually practiced. However, while the actual practice of science has grown increasingly collaborative across institutions, undergraduate research projects have typically

been confined to a single institution (Simmons et al., 2016). This means that most undergraduate research experiences are not introducing students to key components of modern scientific practice.

One approach to addressing this deficit is to incorporate opportunities for collaborative research into the undergraduate experience, through which faculty and undergraduates from different institutions work on broad-scale questions using shared protocols and shared data. The Ecological Research as Education Network (EREN), founded in 2010, pioneered this approach in ecology education by establishing a network of ecological researchers at primarily undergraduate institutions (PUIs) with the goal of producing high-quality, publishable research (Bowne et al., 2011; Lindquist et al., 2011; Simmons et al., 2016). While many other distributed networks exist (e.g., the Nutrient Network or the North American Invasive Species Network, among others), most tend to be narrowly focused on a single topic. By contrast, EREN includes a wide variety of research specialties and has an explicit focus on the under-

graduate level, with projects that are appropriate for students at two- and four-year institutions. Active projects that are accepting new participants are listed on the EREN website (<http://erenweb.org>), along with guidelines and policies for faculty interested in proposing their own projects. In the EREN model, members become lead scientists and project coordinators by proposing research projects that are collaborative and appropriate for undergraduates at diverse institutions. As project coordinators, they recruit participants, provide the methodology and data templates, answer questions along the way, compile data, and have primary responsibility for data analysis and synthesis.

Participating faculty (collaborators) at individual schools incorporate the projects into the curriculum, either as course-embedded activities or as independent study/senior research projects. These project collaborators contribute data to the project,

“Research conducted by distributed networks of researchers is becoming more common and will play a major role in ecology in the future.”

participate in data analysis or manuscript presentation tasks as delegated by the project coordinator, and remain in regular communication with the project coordinator throughout the project.

The strength of this model is that it connects faculty across widely dispersed locations and leverages diverse faculty expertise in order to tackle broader ecological questions than are typically addressed by investigators working alone. Project collaborators have reported that participation in EREN leads to increased professional contacts, research in new areas, increased research opportunities, and enhanced undergraduate research at their home institution (Simmons et al., 2016). Undergraduates also benefit measurably. Assessment data collected on student competencies taken before and after participation in EREN research projects showed a measurable increase in student knowledge and skills (Simmons et al., 2016).

While collaborative research networks like EREN offer faculty and students enhanced research opportunities, there are significant challenges – such as issues of quality control, logistics, faculty commitment, and resource availability – to successfully implementing large-scale, long-term projects in a single science course. Furthermore, implementation as a senior research project may look very different than implementation in a first-year introductory class. Here, we present an EREN project on leaf decomposition as a model for successful collaboration in such networks. Decomposition in Aquatic and Terrestrial and Invaded Systems (DATIS) is a large-scale, multiyear project that examined decomposition rates from native and nonnative species in paired terrestrial and aquatic sites. We report the challenges encountered, outline strategies used to overcome those challenges, and discuss educational benefits of using such projects in the classroom. Our goal is that the decomposition project we describe here can inform and inspire others seeking to engage in research at the undergraduate level, either as potential research coordinators or as collaborators in an existing network.

○ EREN-DATIS as an Educational Topic & Model for Collaborative Undergraduate Work

Leaf decomposition is a critical process that mediates nutrient availability, accumulation of organic matter, and carbon storage over long time scales. As an example of an integrative ecosystem function, decomposition illustrates the temporal and spatial scales at which ecosystems operate. In both aquatic and terrestrial ecosystems, decomposition is related to other processes, such as carbon sequestration and climate change.

Decomposition rates are influenced by a combination of litter quality and site factors (Swift et al., 1979; Gartner & Cardon, 2006), many of which are driven by regional climate patterns (Aerts, 1997; Moorhead et al., 1999). Human-related influences, such as pollution or introduction of nonnative species, also have the potential to impact decomposition processes. Introductions of nonnative species can result in changes in leaf litter quality and modifications of the soil environment. Often, but not always, decomposition of nonnative species is faster than that of native counterparts (Ehrenfeld, 2003, 2010). However, the generality of this pattern has not been established, and the extent to which a site must be invaded before ecosystem processes are visibly altered is not clear. Because of its widely distributed study sites and its foundation in PUIs, EREN

provides a unique opportunity to address these questions within the context of the undergraduate classroom, across a wide range of species and environments.

Decomposition is an excellent topic for an undergraduate ecology course because it is an integrative, ecosystem-level process that draws on multiple scientific disciplines. Ecology lab curricula, however, rarely investigate ecosystem-level functions because they occur at such long temporal scales (months to years) compared to the typical ecology lab period of two to four hours. Inter- or cross-disciplinary topics, like the study of decomposition, also demonstrate the need for collaboration across many scientific fields such as biogeochemistry, botany, entomology, phycology, soil science, and meteorology. Thus, DATIS (Appendix 1; <http://erenweb.org/new-page/datis/>) provides an opportunity for collaboration and offers an approach for introducing and evaluating long-term ecological processes within the constraints and opportunities present at undergraduate institutions. Because the DATIS decomposition exercise includes both the aquatic and terrestrial processes of decomposition, the linkages between these ecosystems can be emphasized instead of being considered separately as they are in many ecology classes.

Meaningful research experiences are important learning tools because engaged and motivated students develop greater confidence and independence (Graham et al., 2013). The 2011 *Vision and Change* report on biology undergraduate education (Brewer & Smith, 2011) called for improving biology education by integrating undergraduate research into the curriculum, especially in the first or second year of college. This report cites a number of studies that show a link between student research and lasting learning skills in problem solving, quantitative analyses, and management of large data sets. Thus, inquiry-based experiences promote student learning as well as higher-order outcomes such as student retention and graduate school applications (Brewer & Smith, 2011).

Authentic science projects like DATIS enable students to engage in the process of science through a hands-on investigation of complex questions. Students develop hypotheses, collect evidence through observation and experimentation, and evaluate results. Unexpected outcomes often can lead to more questions and further investigation. While working on the project, students also connect with peers, engage in discussion, and develop a sense of community. All are shown to increase a student's commitment to a career in science (Light & Micari, 2013).

○ Challenges & Strategies

Ensuring Data Quality

One main challenge in any distributed project is ensuring data quality and consistency among widespread field sites and among numerous researchers with varying backgrounds and skill levels. Clear and detailed protocols are essential in large-scale projects of this nature (Table 1: strategy 1). Protocols should provide guidance on where flexibility is allowed and where protocols are strict. Ambiguous or incomplete guidelines can create confusion among participants and lead to wasted time and effort. Worse, they can compromise the study. Consequently, project coordinators must take extra care in generating a well-organized study with clear guidelines and protocols.

Protocols for large collaborative studies also have the potential to develop over the course of the project as a result of trial and

Table 1. Strategies for addressing the challenges of (A) data quality, (B) procedural and educational logistics, (C) faculty availability, and (D) resource availability when incorporating long-term research projects into the undergraduate curriculum.

Challenge	Strategy	Examples from the DATIS Project
A.	1. Provide clear research protocols and data templates.	<ul style="list-style-type: none"> • Clear written materials with revision history • Training workshops or videos • Website or listserv for communication • Frequently updated FAQ
A.	2. Use standardized database to collect data.	<ul style="list-style-type: none"> • Standardized Excel templates for data entry • Online databases (e.g., Project REDCap)
A.	3. Perform QAQC at many levels.	<ul style="list-style-type: none"> • Quality checks by students in the field • Quality checks by faculty and PIs • Computer programs for quality control
B.	4. Incorporate flexibility into the research design.	<ul style="list-style-type: none"> • Choices within broader specifications (e.g., harvest time, species selection) • Some site variables optional
B.	5. Engage students in a variety of ways.	<ul style="list-style-type: none"> • Combination of traditional class work and independent study student projects • Cross-class or cross-college communication
B.	6. Scaffold learning elements across multiple classes.	<ul style="list-style-type: none"> • Range of work offers varied skill development • Teach different core concepts for each class • Students from past classes can mentor at entry level
B.	7. Illustrate all stages of the project in a single semester.	<ul style="list-style-type: none"> • Use data from multiple years • Analyze previous year's data while setting up and processing current year
C.	8. Allow different levels of commitment.	<ul style="list-style-type: none"> • Multiple faculty per institution divide labor • Some institutions work in only one habitat
C.	9. Outsource some of the labor.	<ul style="list-style-type: none"> • Order key supplies • Some aspects processed at central location
D.	10. Use available resources.	<ul style="list-style-type: none"> • Capitalize on vertical space • Collaborate with neighboring colleges
D.	11. Solicit administrative support.	<ul style="list-style-type: none"> • Publicize your work within the institution • Apply for small grants/fellowships from college or local foundations • Add curricular fees to support labs

error and user feedback. Where such modifications occur mid-stream, special care by project coordinators is needed to ensure that all collaborators are updated on the changes. A history of such revisions can be useful for distinguishing new from old. Project coordinators may benefit from the use of small-scale pilot studies to work out potential problems with protocols and methodology. Such a two-phase approach was used in DATIS, which led to refinements and improvements in the methods used before launching the full-scale project.

We found that our participants in DATIS generally preferred enumerated steps in the written protocols rather than detailed narratives. It was also helpful to use what we learned from the pilot experience to alert researchers less experienced with decomposition projects to potential pitfalls in order to prevent mistakes. Where particular or unique items were necessary, DATIS project coordinators provided

vendor information and specifications; in some cases, they purchased, in bulk, items (i.e., litterbags) to be distributed to participants.

At the data collection stage, we recommend using common data sheets or templates in an accessible spreadsheet program so that data are collected using consistent format and units of measure (Table 1: strategy 2). This approach generates a centralized database, in which all project data are accessible to project collaborators. For the DATIS project, we accomplished this using a shared but protected website on which we uploaded individual datasets. Online document sharing sites, such as Google Docs, provide a versatile (and no-cost) platform for storing, updating, and delivering protocols to collaborators. Other models might include the use of secure web applications for building and managing online surveys or databases, such as REDCap (<https://projectredcap.org>) or similar programs.

Quality assurance and quality control (QAQC) checks are important throughout the process of data gathering so that the reliability and accuracy of the data submitted by various participants can be assessed (Table 1: strategy 3). Simple actions that should be performed by students, contributing faculty, and the project leaders include proofreading of data sets from each site to detect data-entry errors and to check for “impossible” values. More involved data assurance could include duplicated measurements in which multiple individuals take measurements of the same sample. In DATIS, once data were recorded, macros in Microsoft Excel were created to automatically check the large data sets to detect matching of duplicate measurements where applicable, and to detect values outside a reasonable range. Other software, such as SAS, Talend, or Informatica, can perform similar functions.

Addressing Procedural & Educational Logistical Challenges

A central issue that had to be overcome in managing DATIS was the mismatch between the academic calendars of our institutions and the seasonal events the DATIS project tracked. Leaves had to be collected, deployed for an adequate period of time, harvested, and processed during locally appropriate seasons. This created both procedural and educational challenges. Procedural issues stemmed from the fact that the individual projects needed to have different start and end dates because (1) decomposition in aquatic sites is considerably faster than decay in terrestrial sites and (2) sites at different institutions are exposed to different climates that influence the timing of leaf fall and the speed of decay. From an educational standpoint, each project also required more than a semester to complete, which meant that in most cases few students would be able to participate in the project for all phases of the work for a particular iteration. Semesters end and students move on to other classes, which creates a set of concomitant educational challenges for faculty using the DATIS project in their courses. How can we engage students and excite them about an ecological process that takes place over a significantly longer time frame than their ecology course?

A primary strategy for addressing the mismatch between the timing of seasonal events, like leaf fall, at different institutions was to build as much flexibility as possible into the timing aspect of the DATIS protocols (Table 1: strategy 4). Leaf packs could be deployed and harvested at times that made sense in the local environment. While this meant that the experiment was not starting and ending at the same date everywhere, it also meant that a broader range of institutions could participate. However, this still left a significant procedural issue: how to manage a project that would take place over multiple terms and potentially involve multiple cohorts of students.

One successful strategy to address this challenge in DATIS was to use different groups of students in different capacities (Table 1: strategies 5 and 6). For example, one class might construct and deploy litterbags as part of their work, while an upper-level student doing an independent study might collect and weigh the leaves the following term. In other cases, students adopted the DATIS protocols as a senior project and worked on the project across multiple terms. Other possibilities might include developing (or having students develop) online modules that could be used to train future

students. These modules could feature all stages of the project, from overall design, to techniques and ethics of data collection, to data analysis and synthesis. Students could then be encouraged to present these modules, as well as their project findings, at their local institutions or at regional poster sessions.

Early on in the planning for DATIS, a key educational challenge became apparent. Even if we can manage the logistics of a project that continues across semesters and involves different cohorts of students, what will students learn from completing only part of the project? One response to this question is to recognize that completing any part of a project has the potential to teach skills and engage students at different levels (Table 1: strategy 7). For example, students who participated in setting up the experiment learned lab and field skills and were prompted with questions that required critical thinking and knowledge of study design. Students who harvested bags also gained lab skills and worked on data management and statistical analysis. Students working on the project in any capacity learned about nutrient cycling and decomposition and were prompted to think about the potential impact of nonnative species beyond just direct competition. Since the DATIS project ran for multiple iterations, students participating in the project one year could serve as mentors for students in subsequent years, so that students had the opportunity to teach as well as learn.

A second response to the problem of students being involved in only part of the project was to combine different elements of the project from multiple years within individual courses – that is, it was possible for students to be involved in the complete process if the project was performed out of sequence within a course. A fall-semester class might set up leaf bags for students to harvest the following year, while also harvesting leaf bags and analyzing the data from bags set up the previous year. This allowed students to set up the experiment, do all the relevant lab and fieldwork, and still benefit from being able to collect and analyze a full data set.

Certainly, student learning outcomes from participation in the DATIS project vary depending on how they engage with the project, whether as part of a course, through an independent research project, or as senior thesis work. However, all DATIS students should become familiar with the role of plant decomposition in nutrient cycling in ecosystems, the influence of relative abundance of native compared to nonnative species in decomposition rates, and how physical factors or geographic location influence the rate of decomposition. Students learn that nitrogen concentration, the carbon to nitrogen ratio, and lignin content affect substrate quality and decomposition (Moorhead et al., 1999), and they are able to observe that similar energy- and nutrient-cycling processes occur in terrestrial and aquatic ecosystems.

In addition to learning about the decomposition process, depending on which aspects of the project they work with, students will learn a variety of field, laboratory, and analytical techniques. In the field, students learn to identify plant species; collect leaves at fall senescence; and assemble, set out, and collect litterbags. They also learn about collecting soil samples for moisture, organic matter, and pH, as well as collection of metadata to describe the sites. In the laboratory, they learn how to carefully wash, dry, and weigh the leaves. Students also learn to manage spreadsheets through data entry and careful review of data. Data analyses include calculation of decay rate constants, analysis of covariance of patterns of decay over time, and possible modeling of decomposition based on data collected.

All of these processes can be applied to other aspects of ecology as students progress in their academic and professional careers. Clearly, sufficient learning outcomes can be achieved despite the mismatch of academic and ecological calendars.

Managing Faculty Time

Because the time commitment for faculty participating in complex and/or long-term studies like DATIS can be formidable, collaborating with one or more colleagues at your institution is encouraged. Also, faculty availability can change over the course of the experiment, due to changes in family situations and administrative responsibilities, so it is important to provide options that fit a variety of work situations. We have found that flexibility in terms of project scope is essential for maximal faculty participation. For example, faculty at many two-year institutions may not be able to participate in the data collection but could make use of the data in their classes and develop lesson plans to share. Protocols also could allow for flexibility in some but not all aspects of the study (Table 1: strategy 8). In addition to aligning workload with individual faculty needs, this flexibility opens possibilities for side projects, such as analyzing macroinvertebrates or other related variables, that can become additional experiments within or among sites. For instance, because plant distributions varied, DATIS collaborators were allowed to select, from a range of choices, which native and nonnative species were most appropriate for use at their sites. DATIS project collaborators were also given the option of exploring litter decomposition in only one of the two study habitats (terrestrial or aquatic) if they did not have access or time in their academic year to address both habitats; they also did not have to participate every year. Again, when flexibility is allowed, it is especially important to specify in the protocols which aspects can be flexible and which are fixed, and to encourage input from the project leaders in any cases of variation.

Another way to reduce faculty load is to outsource some aspects of the project to third parties (Table 1: strategy 9). Some chemical analyses, for example, involve highly specialized equipment that may not be available at every institution. Outsourcing, in addition to reducing labor, may lead to a greater consistency in methodology when employed across institutions. Outsourcing may increase the overall cost of the project, but the benefits may be worth the investment. The DATIS project outsourced the assembly of mesh litterbags to a commercial entity and centralized nutrient analyses at two of our participating institutions, which increased data consistency and quality.

Finding Resources

Because the emphasis at most PUIs is on teaching, science faculty at these institutions have heavy teaching loads. As a result, less time is available for project and network development, or for research activity and grant writing. Budgets may also be small, with little or no funding available for research, instrumentation, or travel. Moreover, many facilities at PUIs built more than 10 years ago were not designed with research in mind, so research space may be limited. An important strategy here is to leverage networks that already exist and the resources that are available through collaboration (Table 1: strategy 10; see <http://erenweb.org>). For example, one of the collaborators in the DATIS project had the instrumentation to analyze plant tissue samples and another was able to process the soil samples, so together they did all the analyses for all the collaborators.

While certainly not solving fully the very real limitations and pressures on faculty time and resources, flexibility and creativity can be helpful. Researchers must find projects they can conduct on a shoestring budget and with the resources at hand, even if these projects would not be their first choices. Established research networks, like EREN, may have existing projects in which the faculty can engage with relatively smaller individual costs of both time and money. Sometimes, the ideal workspace is not available and so faculty must consider ways to make what they have work. At one of our institutions, for example, vertical wire racks were converted to drying and weighing stations, essentially quadrupling the amount of space available to process, maintain, and store research samples.

Administrative support is, of course, critical for the success of any science program. In some cases, administrators may not have prior awareness of the special needs of science programs, so communication is important (Table 1: strategy 11). Biology faculty see the educational value of research and the positive impact it has on retention and student engagement, but deans may not be aware of these benefits. Faculty should strive to maintain an open dialogue with their dean to increase administrative awareness of the educational value of research as well as the high fiscal and space demands. For example, there is a wealth of literature demonstrating the positive effects of undergraduate research (Nagda et al., 1998; Seymour et al., 2004; Russell et al., 2007). Many institutions also have opportunities for students to showcase their work at internal poster sessions where students could practice communicating science to fellow students, faculty, and administrators. Such poster sessions also provide excellent opportunities to engage administrators with all aspects of classroom-based research.

○ Outcomes

While working on a multisite, multidisciplinary project poses logistical challenges, there are many inherent benefits for faculty development, student learning, and the field of science (Craine et al., 2007). With careful planning, the many challenges of implementing a long-term research project can be overcome, as the DATIS model has demonstrated.

Bringing together scientists with varied backgrounds results in a fertile exchange of ideas. In DATIS, aquatic ecologists work with terrestrial ecologists and train each other in skills of their respective subdisciplines. These more broadly trained faculty are able to take advantage of a wider array of research opportunities and can train their students in a wider range of skills and techniques. Faculty can act as mentors to each other across institutions, which is particularly important when there is only a single ecologist at a college or university.

Similarly, student researchers collaborate by participating in data collection and peer-to-peer training both within and among sites. Technology like video conferencing, wikis, and social media make it easy to engage in cross-site collaboration. By participating in collaborative projects like these, undergraduates are prepared to be better collaborators in their careers. Effective collaboration depends on good communication skills, a shared vision, and clear ground rules (Craine et al., 2007; Jackson & Buyuktur, 2014). Discussions about issues of authorship and data ownership, for example, are common

in collaborative research, and collaborative undergraduate experiences expose students to many pertinent ethical aspects of science (Burks & Chumchal, 2009; Strasser & Hampton, 2012). In addition to author guidelines available on the EREN website, there are also a number of ethics modules available elsewhere online that could be useful for discussion among students and faculty (e.g., the Science Education Resource Center at Carleton College, <https://serc.carleton.edu>). We suggest that these discussions are much less likely to occur at the undergraduate level without a collaborative research experience.

Research conducted by distributed networks of researchers is becoming more common and will play a major role in ecology in the future (Hampton et al., 2013). Transdisciplinary research expands the scope of research questions and is being actively promoted by funding agencies such as NSF and NIH (e.g., the Division of Integrative Organismal Systems at NSF). By modeling this collaborative scientific approach in PUIs, we are preparing graduates who will have the tools and knowledge to create their own distributed research networks.

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Appendix 1. The DATIS Protocols

DATIS employs the litterbag technique, which is the most widely used procedure for measuring leaf decomposition. Briefly, mesh bags filled with a known mass of freshly fallen plant leaves are incubated on the soil surface or on the streambed. Subsets of the bags are harvested at discrete intervals and the change in mass of the leaves is determined for each interval. The full protocol can be found at <http://erenweb.org/active-projects/datis/>. The following is an abridged version.

During peak seasonal leaf fall, senesced leaves are collected from two selected species (one native and one nonnative, similar in morphology and life-form) by gently shaking branches and collecting falling leaves on a tarp. Leaf litter is immediately brought to the lab, where leaves are dried at room temperature (~25°C) for 24–48 hours or until constant weight. Sets of 6.0 ± 0.2 g of the air-dried leaves are weighed at the ratios listed below to create five different litter combinations (N = native, I = introduced):

- Litter Combination 1 (LC1): 100%N/0%I (6g/0g)
- Litter Combination 2 (LC2): 75%N/25%I (4.5g/1.5g)
- Litter Combination 3 (LC3): 50%N/50%I (3g/3g)
- Litter Combination 4 (LC4): 25%N/75%I (1.5g/4.5g)
- Litter Combination 5 (LC5): 0%N/100%I (0g/6g)

For each litter combination, mass is recorded to the nearest 0.001 g. Each weighed leaf set is placed in a customized bait bag (1 mm mesh on bottom, 15 mm on top), secured with mason line. Once the litterbags are prepared, one each of the five different treatment litterbags are strung together with mason line, creating a total of 23 strings of litterbags: three travel sets, 10 placed in an aquatic site, and 10 placed in a terrestrial site. Two invaded sites are selected for litterbag placement: a stream placement site and an upland site close to the stream. At each site, the leaf-filled mesh bags are individually staked down with the smaller mesh size down using non-rusting staples. Travel bags are treated the same as all the samples but are harvested immediately and returned to the lab, used to calculate mass loss associated with transport.

Half of the aquatic leaf litterbags are collected 1–1.5 months and 2.5–3 months after deployment, respectively, while the terrestrial leaf litterbags are collected at 2.5–3 months and 12 months after deployment. On each sample date, one string of litterbags is retrieved from each of five replicate block locations and each litterbag separated into its own sealed Ziploc bag for transport back to the lab. In the lab, the litterbag is cut open and roots, insects, label, and other materials are removed. Each leaf is then gently rinsed with deionized water to remove soil that is attached to the leaves. Leaves and the sample ID tag are then transferred into a clean paper mailing envelope, and placed in an oven to dry at 65°C for 48 hours.

After samples have dried, the material is weighed to determine the oven-dry mass of the incubated leaf material. The final leaf mass for each sample is determined, correcting for “25°C to 65°C” drying temperatures. Decomposition rate is calculated as the change in mass over time.