Understanding and advancing campus sustainability using a systems framework

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Abstract

Purpose – University campuses behave as complex systems, and sustainability in higher education is best seen as an emergent quality that arises from interactions both within an institution and between the institution and the environmental and social contexts in which it operates. A framework for strategically prioritizing campus sustainability work is needed. This paper seeks to address these issues.

Design/methodology/approach – First, a conceptual model is developed for understanding institutions of higher education as systems. Second, a leverage points framework is applied to experiences at the University of Vermont in order to evaluate campus sustainability efforts. Finally, real-world examples are used to analyze and prioritize campus sustainability leverage points for advancing organizational change.

Findings – This systems thinking approach identifies key leverage points for actions to improve sustainability on campus. The leverage points framework is found to be valuable for: evaluating the potential of individual programs or actions to produce system-wide change; coordinating individual programs into a strategic effort to improve the system; and making connections between campus and the surrounding social and environmental contexts. Advancing campus sustainability is found to be strengthened by particular ways of thinking and an organizational culture committed to continuous improvements and learning improved ways of doing business based on environmental and social, as well as institutional, benefits.

Originality/value – Campus sustainability workers must develop a prioritization process for evaluating which ideas to move forward on first. Systems thinking can cultivate our ability to consciously redesign and work with the systems that are in place, to intentionally pursue organizational improvements, and to plan and coordinate sustainability programs with potential for big changes.

Keywords Campus sustainability, Leverage points, Systems, Organizational change, Complexity, Universities

1. Introduction

As they have grown, universities have become increasingly interested in understanding and tracking their full social and environmental impacts in order to enhance their long-term institutional sustainability. An indicator of this trend is a recent survey at a National Association of College and University Business Officers conference, which found that institutional emphasis on environmental sustainability is expected to

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increase in the near future compared to other academic initiatives (Fogel and House, 2010). Understanding how universities depend on and impact ecosystems is a central part of this interest in institutional sustainability and can be used as a tool to help manage long-term risks and opportunities for the institution. Underlying motives for this interest in campus sustainability are the need for strategies to:

- understand environmental aspects of the institution in a changing regulatory landscape;
- manage financial risks posed by unpredictable and rising energy prices and operational costs; and
- establish and maintain a positive public reputation for social responsibility.

The unique role of higher education in society gives added importance to this effort, as academic institutions are seen as thought leaders in addressing emerging issues. At the same time, universities are businesses, places of learning and research, and major parts of a community (Johnston et al., 2003). As a business, a university provides a source of local employment and interacts daily with its environment by consuming resources and generating wastes that must eventually be assimilated into the environment (Merkel and Litten, 2007). As a place of learning and research, a university prepares future leaders in understanding environmental problems and developing techniques and strategies to solve them. Universities also provide the basis for a network of community members and help to shift societal norms through the focus of their educational, research, and service enterprises (Rowe, 2007). The focus on university sustainability could set examples for behaviors and policies that affect other sectors of society (Jenks-Jay, 2004).

Hopkinson et al. (2004) organizes these functions of higher education into three types of university impacts: direct impacts from operations and campus activities, indirect impacts from research, and indirect impacts in the form of student knowledge and behavior as they graduate from a university. Universities can foster environmental sustainability with respect to these impacts by minimizing ecological footprints, focusing research on sustainability-related issues, and fostering eco-literacy and an environmental ethic among graduating students. The long-term success of sustainability programs designed to manage impacts in these areas depends on the degree to which programs influence changes at a deep, systemic level (Sharp, 2002; Elder, 2008).

The problem is that campus sustainability efforts on the ground often develop in the form of programs aimed at individual issues such as recycling, transportation alternatives, or support for local food producers, with little broad coordination across the university system. While such piece-meal approaches have been successful in improving particular aspects of campus operations, they have fallen short of catalyzing the organizational change and curriculum reform required for universities to develop systemic sustainability. Instead, institutional policies and practices often rely on financial growth as a primary strategy for dealing with these challenges. We believe that change efforts based on a systems view of higher education are essential to meet the important and urgent challenge of the “triple bottom line” of campus sustainability (i.e. economic, as well as environmental and social sustainability).

2. Universities as complex systems
Our experience suggests that university campuses are best understood as complex systems composed of many individual elements that interact dynamically across space
and time. This perspective clarifies our experience with the ongoing increase in interest in campus environmental impacts since 1985. For example, at University of Vermont (UVM), recycling programs were initiated in the late 1980s, largely due to student activism around this issue. However, it is important to realize this student interest coincided with solid waste management problems identified in this time frame as many Vermont municipal disposal facilities were closed, creating a significant financial incentive for the institution to reduce the amount of solid waste disposed of as trash. By 1990, this combination of factors resulted in the establishment of a permanent office tasked with managing a campus-wide solid waste management program. Since that time, this office has continuously worked to decrease the amount of trash associated with campus operations and to divert unwanted materials into productive reuses, such as materials recycling, product deconstruction, and composting. Without the combination of student interest and financial incentive, it is unlikely that this program would have been able to continue operating as the market prices associated with its efforts over time have risen and fallen based on events external to the institution.

This example demonstrates how:
- campus unsustainability is a “wicked problem” as defined by Rittel (1973), with changing contexts and stakeholders and no obvious, objective policy solutions; and
- campus sustainability is an emergent quality that arises from interactions among elements within an institution, as well as relationships between the institution and the environmental and social contexts in which it operates.

These relationships are also historical and institutionally-based, so that similar programs in different institutional settings may result in different levels of success. The changing nature of these flows and interactions between internal elements, processes, and other systems create complex behaviors that are often surprising.

Another example of a university’s systemic behavior is its research efforts, which lead to the development of new understandings. For example, areas of inquiry such as ecological economics have fostered a better understanding of how systems analysis can be applied to real-world economic patterns in general. The ecological footprint concept has been used to measure patterns of resource consumption and waste generation on campus relative to supporting ecosystems (Venetoulis, 2001; Swahn, 2004; San Jose State University, 2009; Carnegie Mellon University, 2011). This perspective looks beyond the physical campus itself to consider supporting ecosystems that provide inputs and receive wastes at different scales. At the same time, this campus-based research supports local efforts to implement more sustainable institutional practices by attracting students interested in testing these ideas to campus.

Making use of this work, Figure 1 shows how over time, a university that is growing in population, economic size, and ecological footprint can become significantly larger with respect to containing local and global ecosystems. At the planetary scale, this phenomenon is observed in the depletion of nonrenewable resources and the changing budget of the Earth’s radiation balance due to increased concentrations of greenhouse gases (GHGs) in the atmosphere. At a university scale, this can be observed in institutional food and energy consumption that exceeds the production of regional ecosystems. Dependence on global systems raises threats of institutional unsustainability if global food markets (or the underlying energy systems upon which modern agriculture is based) change in a way that increases the financial costs of importing enough food to support the
campus population. Similar problems of environmental sustainability will arise as the scale of institutional operations grows with respect to finite ecosystems.

The boundaries of any system can be drawn by the observer according to the purpose and questions at hand. Within a university system defined by its spatial extent, many different elements interact. Individual elements may be defined in terms of institutional branches (i.e. operations, academics, administration, as in broad STARS categories), stakeholder subcultures (i.e. faculty, students, administrators, as in Sharp, 2002), or aspects of sustainability (i.e. energy use, buildings, food and dining service as in STARS credits and environmental management systems), for example. Elements of a university interact in complex ways to give rise to persistent organizational behaviors. The programmatic responses that universities often create to address issues of sustainability have been inadequate for the deeply-embedded problems they face, but coordination of programs based on a systems framework can reach strategic leverage points for organizational change.

A systems understanding of institutions of higher education can enhance the effectiveness of programs that manage campus sustainability by helping to identify key leverage points for action to improve the system. Viewing a university as a whole system can allow actions to be taken with the goal of having the institutional elements and interactions evolve in more sustainable directions while illuminating opportunities to advance sustainability with targeted campaigns aimed at key leverage points (Koester et al., 2006). Using the UVM as a case study, approaches to enabling campus sustainability are described below to determine key leverage points and areas of influence in the university system. A framework based on leverage points for change is used to organize the discussion.

3. Leverage points – places to intervene in a system
Leverage points are specific places within a system where small changes can lead to large shifts in the overall system’s behavior (Meadows, 1999). That is, they are places

Notes: A university’s ecological footprint becomes a more significant issue as material and energy flows grow with respect to finite, supporting ecosystems; efforts to minimize ecological footprints and foster environmental sustainability on campus must address the fundamental issue of uneconomic growth
Source: Based on Daly (1996)
in the system where we can get the most “bang for our buck.” However, it is important to remember that because complex systems are inherently unpredictable, it is often not clear what the results of an action at a specific leverage point might be in terms of system-wide behaviors. For this reason, a variety of system responses to an action must be considered and tracked in order to understand the value of the action. For the purpose of this discussion, the system under consideration includes the UVM built campus, community, and ecological footprint.

Meadows (1999) presented the classification of leverage points in Table I in increasing order of their capacity to produce system-wide change. The lower the number on her list a leverage point has, the deeper the level of change it can produce (in the sense that the changes in the system can be expected to reach farther beyond the point of change), but also the more the system will resist changes at that leverage point. To further clarify Meadows’ classification for people interested in campus sustainability, we have additionally organized the leverage points around three layers of campus systems where an action can result in expected changes at similar points within the system. These three layers are:

1. physical measures;
2. information and control components; and
3. the purposes and contexts of a system.

This is still a tentative, developing framework that acknowledges exceptions, but we believe that it provides an important step to prioritize, plan, and coordinate efforts to improve a university system (Lidgren et al., 2006).

3.1 Physical measures of the system (the plumbing)

Numbers – constants and parameters (subsidies, taxes, standards). “Numbers” include parameters (either constants or variables) that affect material stocks or resource flow rates, either in terms of amounts of materials or speed of their movement within the system. Examples of such parameters that can be expected to impact UVM’s ecological footprint include the amount of fees charged to students to support a clean energy fund, green building standards for specific energy use reductions in new construction, or shifting amounts of spending in UVM’s budget for environmentally related programs. Intervening in the system by changing these numbers can bring about short-term changes, especially for those stakeholders directly affected by the change, but since these numbers do not influence the system’s structure, information flow, or rules and goals, they are less likely to impact long-term, more deeply embedded system behavior.

Buffers – stabilizing stocks relative to their flows. Buffers are places within the system where material or energy stocks are stored thereby providing organizational stability by mitigating the impact of changing flow rates. Examples include a stormwater retention pond that mitigates the downstream impact of surges in water runoff after a storm, or capital savings accrued for building maintenance. Increasing the size of these buffers can produce more system stability, but since this change usually involves significant short-term costs or requires time to accumulate enough money to impact building maintenance practices, it is not a strong leverage point. In addition, systems can become rigid and inflexible if such buffers become too large.

Stock-and-flow structures – physical systems and their nodes of intersection. The connections between stocks and flows determine the plumbing architecture of
a university system. The organization of resources and how they flow between storage points and use points are central to how a university operates, but changing the physical aspects of this structure can be slow and expensive – often, desired conditions will evolve before changes in connections can be put into place. A good example of this leverage point arises in the question of air conditioning dorms on campus. Some dorms at UVM were not designed to be air conditioned, and retro-fitting them with a stock of window air-conditioners would require significantly more electricity flows than the current

### Table 1. Places to intervene in a university system (in increasing order of effectiveness) from Meadows (1999)

<table>
<thead>
<tr>
<th>Leverage point</th>
<th>Examples of related university programs</th>
<th>Campus constituencies with access to leverage point&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Numbers</td>
<td>Green building standards for new construction, Student green fees</td>
<td>✓</td>
</tr>
<tr>
<td>11. Buffers</td>
<td>Stormwater retention pond, Capital savings accrued for building maintenance</td>
<td>✓</td>
</tr>
<tr>
<td>10. Stock-and-flow structures</td>
<td>Presence of air conditioning units in residential building windows</td>
<td>✓</td>
</tr>
<tr>
<td>9. Delays</td>
<td>Pace of academic reform for sustainability-related course content, Real-time information about energy use</td>
<td>✓</td>
</tr>
<tr>
<td><strong>System information and control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Balancing feedback loops</td>
<td>Co-curricular educational opportunities such as Eco-Reps that reinforce behaviors and choices</td>
<td>✓</td>
</tr>
<tr>
<td>7. Reinforcing feedback loops</td>
<td>College spending patterns and tuition growth</td>
<td>✓</td>
</tr>
<tr>
<td>6. Information flow</td>
<td>Personal solid waste management practices, Tracking and charging for steam use in each building</td>
<td>✓</td>
</tr>
<tr>
<td>5. Rules</td>
<td>Regulatory agency rule regarding GHG emissions, Equipment purchasing practices</td>
<td>✓</td>
</tr>
<tr>
<td>4. Self-organization</td>
<td>Campus grassroots, bottom-up efforts, Support for student and faculty sustainability initiatives</td>
<td>✓</td>
</tr>
<tr>
<td><strong>System purpose and context</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Goals</td>
<td>Commitment to climate neutrality, signing of ACUPCC</td>
<td>✓</td>
</tr>
<tr>
<td>2. Paradigms</td>
<td>Growth, Equitable access to education, Faculty reward and promotion system</td>
<td>✓</td>
</tr>
<tr>
<td>1. Transcending paradigms</td>
<td>Due to their long-term stability in society, institutions of higher education themselves rarely transcend cultural paradigms, even while they provide educational and research settings for individuals to do so</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Based on three predominant organizational constituencies within universities – faculty, administration, and students – defined by Sharp (2002); constituency “access” refers to relatively immediate ability to apply pressure to the leverage point

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building wiring can carry. Understanding this system limitation could lead to alternative solutions for effective heating and cooling of dorms through the seasons.

Delays – the lengths of time relative to the rates of system changes. Optimizing the length of time delays, such as delays in information about conditions, can improve our ability to respond to problems. Short delays can lead to jumpy responses that overreact. Long delays can produce irrelevant responses or sustained, unpredictable swings in behavior. Consider an example at UVM: eco-literacy among graduates may be identified by an institutional goal, but there is a significant time delay in the process of curriculum reform to support this goal. Multiple levels of review by decision-making bodies, and student expectations for consistent educational requirements over their four-year tenure slow the pace of curricular change. As an alternative, rather than relying on changing general education requirements to move forward on this goal, UVM developed a Sustainability Faculty Fellows Program to foster peer support and advance eco-literacy efforts relatively quickly.

Real-time information about energy use is another example of how adjusting a time delay can provide a leverage point for changing the university system. If information about energy use is provided to building occupants only periodically, it is less clear to occupants how their choices have an immediate impact. Shortening the delay to provide real-time feedback allows for greater impact on energy use, and increased understanding of how behavior choices impact resource use and associated generation of pollution (Petersen et al., 2007).

3.2 Information and control parts of the system

Balancing feedback loops – the strength of the feedbacks relative to the impacts they are trying to correct. Well-balanced feedback loops are critical to a system’s ability to remain stable under changing environmental conditions and impacts. An example from UVM’s solid waste management program is the loop including students living on campus, the institutional waste management system (including trash cans, hauling services, etc.), and an Eco-Reps Program which has the goal of promoting environmentally responsible behavior. To influence the behavior of this system, waste sort events are conducted to identify systematic deviations from the goal of proper waste disposal, and a response mechanism is developed in the form of a targeted behavior change campaign to shift these behaviors of the population as a whole. If the feedback loop in this situation functions well, it can bring about the desired conditions (proper waste disposal behaviors), at least on a short-term basis.

The situation shown in Figure 2 provides a second good example of system-wide feedback. In Fall 2011 at UVM, an initiative was developed to improve waste sorting in the student center building. Early in the design process, it was recognized that focus on students and waste bins (for recyclables, compostables, and land-fill) alone was insufficient: the items being turned into waste originated further upstream. It was decided that dining services, as a purchaser of what eventually becomes waste products (i.e. cups, utensils, to-go containers), needs to be part of the change process. In this way, waste management and sorting can begin with the institutional purchase of standardized, compostable or recyclable products. This could change a steady stream of materials on campus destined for the landfill into balancing feedback loops that make waste sorting and re-use more effective.
Reinforcing feedback loops – the strength of the gain of driving loops. Reinforcing feedback loops drive system behavior in the same direction it is already moving. They are often sources of important system-wide changes, such as growth, explosion, erosion, or collapse. An example of this leverage point involves college tuition growth, which is fed by things like college spending that requires increased amounts of revenue, monetary inflation, or a college reaching its maximum borrowing capacity and thus needing to shore up an imbalanced budget. A balancing loop will eventually intervene in tuition growth – for instance, fewer enrollments due to unreasonably expensive tuition may force reductions in tuition growth – but a balancing loop may not kick in until after the system exhibits undesirable behavior (i.e. a drop in enrollment, which could be triggered by a shrinking target market as well as pricing issues). Reducing the gain around a reinforcing loop is usually a more powerful leverage point than strengthening a balancing loop.

Information flows – the structure of who does and does not have access to information. This leverage point involves creating a new information loop so that feedback is delivered to a place where it was not going before. This strategy is usually easier and cheaper than rebuilding physical infrastructure, but it can be unpopular with those who are accustomed to current information flows, and so cooperation in generating and moving information in new ways can prove difficult. One example of this concern is the challenge many campuses have faced in staying abreast of internet-based computer systems as rapid technology changes have taken place over the last decade.

Examples of using this insight as a leverage point include requiring students to spend a week carrying around a bag for all the trash they generate, or making steam and energy use data visible to building users. The new information provided could bolster changes in individual behaviors – generating less waste per person or accepting wider building temperature ranges – as well as enable university managers to charge different classes of energy users depending on how much energy their activities require.

Rules – incentives, punishments, constraints. Rules define a system’s boundaries, scope, and degrees of freedom. They are high leverage points because they indicate
political power within the system. The following are examples of questions that change agents might address to influence the rules and to create a different educational system. What if students graded the teachers or each other? What if a professor’s productivity was measured by, and tenure decisions based on, their ability to solve real-world social and environmental problems rather than publish academic papers? What if co-curricular sustainability education experiences that take place outside the classroom were eligible for course credit or included as program requirements? Such changes in rules may compete with the basic higher education paradigm that faculty are expected to be subject matter experts to the extent that they can only be assessed by their subject matter peers – thus, existing power structures within a campus system can be a significant obstacle to changing the rules.

Experience at UVM indicates that resistance to changing the rules can be greater for academic reform than for operational improvements. In a relatively short time frame, a high-level manager can implement new rules for how the university operates with respect to waste, utilities, or campus transportation. To change rules regarding teaching and research, on the other hand, requires multiple layers of decision-making from various campus stakeholders, including governing bodies for faculty, students, and administration. The power structures that determine university operations versus university academics are very different, and thus leverage points for changing the rules may be more effective at improving operations.

Self-organization – the power to add, change, or evolve system structure. Self-organization refers to a system’s ability to change itself internally by creating new structures and behaviors. These changes at a university are often expressed as “grassroots movements” wherein people mutually agree to change their behaviors without authorities changing the rules. In biological systems, self-organization is a fundamental process through which living things arrange themselves into patterns; in human economies, it can be observed as technological innovation or social revolution. Self-organization leads to system resilience – the ability to adapt in the face of changing conditions or new realizations. Self-organization can be an unpopular intervention point for both individuals in authority and the group because it involves variability, diversity, and experimentation that may produce threatening levels of uncertainty or perceived lack of control about what is next.

A recent example from UVM is the effort among students to learn, organize, and campaign to bring about a different university beverage system perceived to be more sustainable. While new rules about a beverage vendor contract can change the system, people self-organizing to realize that buying bottled water is unnecessary and undesirable is an even more powerful and lasting leverage point. Self-organization of the campus around the purchase of bottled beverages could significantly reduce waste and energy impacts associated with this issue.

3.3 Higher-order purpose and context parts of the system

Goals – the purpose or function of the system. The goal of a system will influence the arrangement of everything further down the list – physical stocks and flows, information and feedback loops, and self-organizing behaviors. What is the point of the system – what is it for? The goals may be stated or may lie deeper below the surface of openly acknowledged purposes.
An example is when a leader comes in and describes a new goal that swings an organization into a different direction. For example, a college president could inspire a shared vision for sustainability or set new university goals, and in the process influence institutional investment choices about energy intensive laboratory buildings or the retooling of existing campus infrastructure to best serve the institution’s educational and research needs. The American College & University Presidents’ Climate Commitment (ACUPCC) is an example of an institutional goal oriented toward sustainability. Table II compares the strategies of following a rule versus defining a goal to reduce campus GHG emissions.

Experience at UVM offers insight into system change based upon government regulation and internal goals. The Lab XL project leveraged an internal institutional framework for managing laboratory chemicals that incorporated chemical waste management as part of a larger laboratory chemical safety effort. The results revealed significant reductions in waste generation at UVM when an internal goal and framework was used (with metrics, timelines, etc.), as opposed to when UVM previously operated under traditional hazardous waste regulations (Stuart et al., 2008). In this case, the UVM-adopted goal was more effective than governmental rules at intervening in the system.

Paradigms – the mind-set out of which the system arises. A paradigm refers to shared ideas in the minds that comprise society, or great big unstated assumptions (unstated because everyone already accepts them as true). These deep sets of beliefs about how the world works are the social context out of which universities arise. A paradigm is the source of a higher education system. System goals, feedback, etc. are all created out of a shared social agreement about the nature of higher education. Changing a paradigm can be made more possible by stepping outside the system and seeing it as a whole.

In American culture, a key paradigm is the strategy of “growing out” of system stresses by acquiring or consuming more resources. For example, two typical responses to rising campus operating costs are to increase tuition or enrollment.

<table>
<thead>
<tr>
<th>Approach to reducing GHG emissions</th>
<th>Leverage point(s) addressed</th>
<th>STARS credit(s) earned</th>
<th>University resources and actions required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal law regulating GHG emissions</td>
<td>5. Rule</td>
<td>OP credit 4: GHG emissions inventory</td>
<td>Tracking and reporting emissions, maintaining compliance with law; negotiation of the application of an economy wide rule to a specific, diverse sector of the economy (higher education)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maybe OP credit 5: GHG emissions reduction</td>
<td></td>
</tr>
<tr>
<td>Institutional commitment by signing ACUPCC</td>
<td>3. Goal</td>
<td>OP credit 4: GHG emissions inventory</td>
<td>Defining institutional goal, tracking and reporting emissions, developing internal management guidelines, creating incentives to act</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OP credit 5: GHG emissions reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PAE credit 1: sustainability coordination</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PAE credit 5: climate plan</td>
<td></td>
</tr>
</tbody>
</table>

Note: According to the leverage points framework, an institutional goal such as the ACUPCC may be expected to be more effective than a federal law at intervening in the current system.
Both approaches involve adding more of something and are based in an unlimited growth paradigm that actually serves as a systemic roadblock to sustainability (Beddoe et al., 2009). A different paradigm focused instead on development might involve qualitative improvements to the way the university operates with respect to energy consumption, building maintenance, curriculum design, etc.

A paradigm can become unsettled by highlighting anomalies and failures in the old paradigm, speaking and acting from a new paradigm, and inserting figures that hold a new paradigm into publicly visible positions of power (Kuhn, 1962). Paradigms can shift quickly when a critical mass of participants in the system develop new ways of seeing the world. One example of this happening on a grand scale is the provision of access to higher education in the USA to populations previously excluded based on gender, race, or religion.

Transcending paradigms. Transcending paradigms means realizing and accepting the uncertainty inherent in any worldview:

[... ] to keep oneself unattached in the arena of paradigms, to stay flexible, to realize that no paradigm is “true” [... ] [but] is a tremendously limited understanding of an immense and amazing universe that is far beyond human comprehension (Meadows, 1999).

This enables one to choose among a variety of paradigms that will help achieve particular purposes. For example, Costa Rica is one of only a few countries to transcend the paradigm that says national governments need to maintain a military in order to be legitimate. This enables Costa Rica to allocate resources to alternative uses. While universities may be able to provide the setting for transformative experiences, or prepare students for transcending paradigms, their institutional mission may be too permanently entrenched in existing cultures to lead this level of change within the greater society.

For example, a great deal of teaching, learning, and research in higher education today occurs within the paradigm of academic silos and disciplinary boundaries. This paradigm compartmentalizes knowledge and erects barriers between areas of academic study. One attempt to transcend this firmly established paradigm at UVM sought to create a meta-college as an integrative source of interdisciplinary research and teaching on campus. For many reasons, including the resistance of a present paradigm, this effort did not come to fruition as envisioned. In this case, the lever itself (the university-wide initiative for an interdisciplinary meta-college) was not strong enough to provide the push that was needed at this high level of change.

4. Conclusions

All campus sustainability efforts face the challenge of having more good ideas than resources available to implement them. Therefore, campus sustainability workers must develop a prioritization process for evaluating which ideas to move forward on first. Universities function as complex systems, and understanding the elements, relationships, and shared persistent behaviors within a particular institution can be used to identify leverage points for system change. Knowledge of the different kinds of leverage points and how to identify them can empower administrators, faculty, and students to select specific policies and actions based on their effectiveness at producing more desirable system-wide behavior. Systems thinking can cultivate our ability to consciously redesign and work with the systems that are in place, to intentionally pursue organizational improvements, and to plan and coordinate sustainability programs with potential for big changes.
The theory of leverage points for intervening in systems is now over 12 years old. Our experiences at the UVM indicate that it is a useful way to understand the successes and failures of attempts to change the university system. Others are encouraged to test their stories of applied campus sustainability work against the framework described by Meadows. In doing so, it is important to consider the unique starting point for each university. Prior to applying pressure on a particular leverage point, a change agent will be more effective if they understand and make use of the existing network on campus. Each university has a different capacity for change, based on unique factors such as institutional priorities, cross-campus relationships, and access to resources.

Still, campus sustainability work is not immune from the unintended side effects and unpredictable outcomes described early in this paper. At UVM, educational campaigns recently took aim at the environmental and human health impacts of bottled soda beverages with high sugar content. Within several semesters, on-campus purchases of these beverages declined, while purchases of flavored teas manufactured “by the same vendor” increased significantly. The economic behavior of individuals is complex, and initial efforts to change behavior on campus can result in surprises. One potential solution is to pilot behavior change strategies on small scales before broad, campus-wide implementation (McKenzie-Mohr, 2011). It is also important to be aware of whole-system dynamics and influences from beyond campus borders. Insights from the study of complex systems and Meadows’ leverage points theory can alert us to surprises soon after they occur.

As tools and frameworks for evaluating campus sustainability continue to develop, some will be more appropriate for systems-level analysis and others will be more useful in guiding the development of programmatic solutions. The leverage points framework described here provides the conceptual big picture that is valuable for:

- evaluating the potential of individual programs or actions to produce system-wide change;
- coordinating individual programs into a strategic effort to improve the higher education system; and
- making the connections between campus and the surrounding social and environmental landscapes that are critical parts of fostering campus sustainability.

Leverage points and tools such as STARS, which assess the degree to which sustainability programs exist, can complement one another. Using them together offers guidance for next steps and promise for shifting institutions of higher education toward sustainability.

It is crucial to monitor and track progress toward sustainability from a whole systems perspective in order to ensure that our institutions are making the necessary changes. Building adaptive processes into management allows strategies to evolve along with changes in the environmental, social, or economic conditions in which higher education operates. But tracking specific information is only a first step – strategies must be designed to communicate information about ecological footprints, ways to manage it, individual behaviors to improve it, and administrative decision-makers with specific management responsibilities. As individuals are held accountable, it becomes someone’s job to help an institution behave in a sustainable manner. And with enough cultural and system-wide change, it can eventually become everyone’s job to enable the integration of sustainability throughout higher education.
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