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Sustainable transportation planning on college campuses

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Abstract

In the last decade, campus planners in the US have been struggling to provide access and mobility without destroying campus qualities as distinct communities. The purpose of this paper is to reflect on how college campuses have encouraged a modal shift from cars to other modes, and in particular to bicycling and walking. I report the results of a survey of eight pre-selected bicycle and pedestrian friendly campuses. My argument is that due to their pro-active educational milieu, college campuses are privileged places to communicate sustainability and to help reshape society's transportation patterns.

Keywords: Campus; Transportation; Planning; Sustainability

1. Introduction

The United States has an extremely high automobile dependence. Automobiles not only are the focus of transportation systems but they very often push the planning decision making processes (Newman and Kenworthy, 1999). It is extensively accepted that trends in motorization on college campuses equate those experienced by society at large. In the last decade, campus planners have struggled to provide access and mobility without destroying campus qualities as distinct communities. Due to federal requirements concerning air quality, increasing congestion, lack of land for parking, the high cost of constructing parking structures, pressures to reduce traffic's impact on surrounding neighborhoods, and constraints on financial resources, many universities are exploring a range of environmentally appealing solutions to alleviate congestion and improve safety for all campus users (Poinsatte and Toor, 2001). Many of these solutions are based on the concept of transportation demand management (TDM), which include market prices for parking, expanded transit access, park and ride lots complemented by bus shuttles, rideshare programs, bicycle and pedestrian facilities and traffic-calming schemes, among others.

Although published literature on sustainable transportation is increasing, it focuses mostly on automobile dependence and its impacts (Whitelegg, 1997; Newman and Kenworthy, 1999; Vuchic, 1999), parking provisions (Shoup, 1997), TDM (CUTR, 1996; Poinsatte and Toor, 2001; Litman, 2001), cross-country comparisons, and best-practice analyses (Hodgson and Tight, 1999; Pucher, 1997; Pucher and Dijkstra, 2000; Beatley, 2000). Research on nonmotorized transportation planning is still meager if compared with research on other modes (e.g. Hanson and Hanson, 1976; Forester, 1994; Schimeck, 1996; Tolley, 1997; Gardner, 1998; Pucher et al., 1999; Clarke, 1997, 2000; Cleary and McClintock, 2000; Forester, 2001; Balsas, 2002). This literature does not fully address the unique context in which universities function, such as mix of population, irregular schedules, and continual movement of people throughout the day. While some research has been found on mass transit on college campuses (Farris and Radwan, 1989; Carter, 1996; Brown et al., 2001), with the exception of Tolley (1996), who has examined bicycling on college campuses in the UK, I have not found published research specifically on bicycle and pedestrian planning on American college campuses.

This paper is guided by one major research question: How have college campuses encouraged a modal shift from cars to other modes, in particular to bicycling and walking; its main purpose is to reflect on the opportunity to create sustainable campuses from a bicycle and pedestrian planning viewpoint. This paper attempts to answer the call for more research on ways to create more sustainable communities (Litman, 1999; Taylor and Davis, 1999), and

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on the links between transport use and activity patterns (Preston, 2001). My argument is that, due to their pro-active educational milieu, college campuses are privileged places to communicate sustainability and to help reshape society's transportation patterns. This argument was constructed based on the results of a survey of eight bicycle and pedestrian friendly campuses. The pre-selection of well-known campuses was motivated by Keniry (1995) and Filho (2000) who highlight the considerable demand for case studies of success when soliciting staff and administration support for new projects. My key findings emphasize that college administrators rarely consider bicycle and pedestrian planning to its full extent, and that more can be done to integrate nonmotorized modes in the alternative transportation package.

This paper should be of interest to transportation, city planning and landscape architecture academic departments, campus planners, TDM coordinators, environmental advocates, and professionals engaged in implementing alternative transportation strategies. My reflections should also be relevant to other campus environments such as hospitals, science and research parks, and office complexes. This paper is structured in four parts. The first part discusses how changes in transportation patterns can affect campus planning and community life, and vice versa; emphasis is given to the recent movement towards 'greening' university campuses and to the palette of TDM options. The second part presents the research methods and introduces the transportation patterns at the eight campuses. The third part discusses the survey results. Finally, the last part gives some concluding comments.

2. Transportation on college campuses

2.1. Campus—a unique place

A community, in the words of Checkoway (1997, p. 308), may be defined as

> A process of people acting collectively with others who share some common concern, whether on the basis of a place where they live, of interests or interest groups that are similar, or of relationships that have some cohesion or continuity

College campuses are very distinct communities. They are places where people of different backgrounds, incomes, lifestyles and attitudes do come together to live, study, work, and recreate. College campuses build societies that are at once transitory and lasting, and have an ideal human scale (Ojeda and Yudell, 1997). The traditional campus adheres to the basic principles of the neotraditional town, since it concentrates a variety of functions within reach of pedestrians (Dulken, 1992; Turner, 1995). Campuses are usually self-contained neighborhoods where classrooms, offices, apartments, students centers, child care facilities, performance halls, art galleries, gymnasiums, swimming pools, sports arenas and shopping places are all in close proximity. They have their own streets, squares and open spaces, where people can stroll and get together.

College campuses may be located in rural or urban areas; their layouts vary according to their locations. A rural campus tends to present horizontal connectivity, while an urban campus tends toward vertical connectivity. Rural campuses are normally more automobile dependent than urban ones. Although most campuses do not totally exclude the automobile, walking is the expected way to get around even though other ways of transportation may also be possible. College campuses are a good example of a 'people's place' (Engwicht, 1993).

2.2. Transportation and the greening of the campus movement

In many communities, college campuses are very often among the area's largest employers. They have their own energy plants and water treatment facilities. Besides energy, water and waste, college campuses are also major traffic generators, which require extensive parking areas. Tolley (1996) argues that the major environmental impacts of transportation on college campuses include disturbance to teaching, loss of natural environment and greenery, despoliation of the visual environment by parking provision, and health effects on staff and students.

Universities also impact neighboring communities in many ways, such as parking, traffic, service access and off-campus housing. While communities deal with these impacts through the implementation of neighborhood residential parking permits and prohibition of nonresident parking during school hours, colleges also are minimizing their own impacts in order to become more sustainable communities. This is in fact the result of a legal requirement to implement employer trip reduction programs. Companies of a certain size (usually employing 100 or more people) are required to reduce the number of employees commuting alone in their cars each day. This is seen as a way to reduce auto-related air pollution, energy consumption and traffic congestion. When combined with other environmental strategies, such as recycling, this is many times referred to as the 'greening of the ivory tower' or the development of academic environmental stewardship (Orr, 1992b; Creighton, 1998; Mansfield, 1998; Griffen, 2000), and it is closely related to the sustainable development movement (Beatley, 2000; Jepson, 2001). According to Weenen (2000, p. 28) sustainable development is about dealing with 'material concerns, acknowledging the relationship between humanity and nature, being committed to addressing fundamental causes and considering ethical values'.

On the other hand, Orr (1992a, p. 5) has argued that "colleges and universities must learn to act responsibly not only because it is right to be responsible, but also because it

is in their self-interest". This self-interest was formally realized with the 1990 signing of the 'Talloires Declaration' by the Association of University Leaders for a Sustainable Future. The Talloires Declaration spells out key actions that institutions of higher education must take to create a more sustainable future. It was initially signed by 31 university leaders and international environmental experts representing 15 nations worldwide and since then more than 275 universities in over 40 countries worldwide have subscribed its sustainability principles.

The 'Campus Earth Summit' held at Yale University in 1994 has also been important in the greening of the campus movement. This congress ended with the 'Blueprint for a Green Campus', a document which makes recommendations on conducting environmental audits, integrating coursework with campus stewardship projects, researching campus and local environmental issues, reducing wastes, promoting energy efficiency, determining sustainable land use, developing clean and safe transportation systems, constructing efficient buildings, finding environmental careers, and networking with similar domestic and international programs (The Heinz Family Foundation, 1995; Mansfield, 1998). This paper complies with the spirit of both documents in the sense that it shows commitment to the formulation of more effective and innovative approaches to campus and local environmental issues, and to make environmental sustainability a top priority in campus transportation planning.

2.3. Sustainable transportation and TDM

A sustainable transportation system has been defined as one that satisfies current transport and mobility needs without compromising the ability of future generations to meet their own (Black, 1997; Richardson, 1999). Other authors have written about the emergence of new goals for transportation decision-making and for mainstreaming alternative practices by retrofitting existing networks and creating healthier communities (Dittmar, 1995; Newman, 1998). On campus grounds sustainable transportation planning can be seen as providing incentives for walking, bicycling, taking mass transit, ridesharing, discouraging the use of single-occupancy cars by passing on the full costs of parking to drivers, and linking transportation planning to land-use planning.

University campuses can constitute a laboratory for testing and implementing various alternative transportation strategies, reducing infrastructure costs and minimizing their impacts on surrounding areas.

One aspect often overlooked by campus administrators and planners is the college's potential to affect not only the transportation behavior of the campus population in the present but also the transportation habits and the environmental awareness that students can develop in the long term, as "they will progress to occupy influential roles in government, companies or other organizations" (Tolley, 1996, p. 214). In this way, innovative transportation approaches are likely to diffuse from higher education to other parts of society. One of the main problems is that campus planners and administrators were trained when the 'automobile was king' and 'are reluctant to embrace change' (Poinsatte and Toor, 2001). However, since students are more open-minded and have the potential to become 'movers and shakers' if properly motivated, they can become powerful forces for the establishment of bicycle and pedestrian friendly communities (Weerts, 1992).

Bicycling and walking are two components of more global TDM strategies. In fact, TDM can be defined as a package of planning strategies, incentives and disincentives, which emphasize alternatives to single occupant vehicle traveling (see CUTR, 1996; Meyer, 1999; Ewing, 1999). TDM includes not only traffic engineering such as traffic-calming schemes, but also multimodal solutions. The most widely implemented solutions are parking management, carsharing, park and ride schemes, mass transit, vehicle technology and alternative fuels, and the use of the internet and video to provide online classes and transportation information (Markowitz and Estrella, 1998).

Car-based transportation has many hidden costs (Balsas, 2001). It is expensive and inefficient over short distances and is a major contributor to global warming. The major problem with automobility, however, is the amount of parking it requires (Shoup, 1997; Dober, 2000). Planning laws require parking minimums, which very often make it expensive to build. Shoup (1997) has argued that eliminating minimum parking requirements and free parking would substantially reduce the cost of urban development, improve urban design and reduce automobile dependency, and restrain urban sprawl. On college campuses parking is a common problem with different slants. Keniry (1995) playfully states that a "University is a group of administrators, faculty and students held together by a common grievance over parking". In fact, under-priced parking subsidizes students who drive to campus, while students who walk, bike, or ride transit to campus rarely receive any subsidy (Brown et al., 2001). These different treatments are being realized by a growing number of campuses, which are not only restricting parking in the campus core, but are also implementing parking management programs which charge higher fees and are coupled with innovative ways to promote alternative modes—transit, bicycle and walking.

Universities are also working in collaboration with transit agencies across the country to provide innovative transit pass programs. For instance, free transit passes are being funded with student fees or through innovative partnerships with local municipalities. This has become known as 'Unlimited Access'. It not only reduces the demand for parking, increases student's access to housing and employment, helps universities recruit and retain students, reduces the cost of attending college, but also increases transportation equity (Brown et al., 2001, p. 235). In order to reverse transit's negative image, transportation

agencies are decreasing headways and increasing service amenities such as providing passengers with real time schedule information through Intelligent Transportation Systems.

The partial replacement of university fleets with alternative fuel vehicles and technologies such as compressed natural gas or electricity is also being attempted by a growing number of universities, as well as the recycling of operation fluids (Keniry, 1995). Telecommuting, flextime and distance learning are 'soft' approaches that may also positively impact the campus environment and reduce congestion. Telecommuting is a technique that allows an employee to work at home one or more days a week. Flextime more than reducing automobile use, can decrease rush hour congestion and replace traditional workweeks with more flexible schedules. On the other hand, distance learning and the use of new technologies can decrease the need for additional parking. Delivering classes to students in dormitories and even off-campus through the use of the Internet, CD-Rom, fiber-optic networks is likely to reduce commuting peaks as well (Markowitz and Estrella, 1998).

A truly integrated TDM program may bring many environmental and societal benefits by enhancing the use of existing transportation systems. If fewer cars are traveling to campus, then fewer parking spaces are required, lower maintenance costs are incurred, and the land currently used for parking can be converted to other, more rewarding uses such as open space or new environmentally sound research buildings. This can only happen if, in addition to a comprehensive approach to promote alternative transportation modes, car use is restrained or charged at full cost and the funds redistributed to improve those alternative options (Tolley, 1996).

3. Bicycle and pedestrian friendly campuses

As Weerts (1992) recognizes bicycling is often seen as the 'poor step-child' of other alternative modes; however, bicycling and walking have evolved from being the 'forgotten modes' to emblems of a high quality of life (Wilkinson, 1997; Clarke, 2000). In recent years more bicycles have been sold annually than automobiles, with total bicycle ownership in 1999 at over 120 million units in the United States (Dober, 2000). Bicycling and walking increased their visibility with the ISTEA legislation in the beginning of the 1990s. As Clarke (1997, p. 340) puts it, "the simple mention of bicycling and walking throughout the legislation has helped to legitimize these modes and make them an acceptable activity for transportation agencies to include in their regular operations". Federal funding also increased substantially in the last decade and pedestrian and bicycle safety at the USDOT has become a priority.

Walking and bicycling are complementary modes of transportation to get to and around campus. At many colleges a high percentage of students live on campus, and another considerable percentage of students and staff live within a reasonable walking and cycling distance. The bicycle offers riders speed and flexibility over short distances. It produces no pollution, uses no energy, is silent, can be accommodated with relatively little space, is fast and cheap, and is also accessible to many people who cannot drive, especially the young (Tolley, 1996, p. 215). On some campuses biking is deeply rooted in local culture. On the other hand, walking is the primary mode of transportation for many people, although few of us may realize how it is a big part of our trip (Blomberg et al., 2000). Walking is fast, direct, and has no costs involved. In addition, these two modes have many health benefits.

It is also well known that college students cycle at much higher rates than the general population (Pucher et al., 1999). Students are usually more environmentally conscious and receptive to new ideas. They are physically more fit, have restricted budgets, live close to campus and already own a bicycle. Staff and faculty members share some of these characteristics and many are influential members of the local community, as potential bicycle advocates, they can help persuade city officials and campus administrators to implement policy geared towards cycling (Tolley, 1996, p. 215). Despite the fact that not everyone can use bicycles, the problem is that growing levels of automobility have catered more to the car than to these two modes.

On campus, walking is affected by safety concerns at intersections, when pedestrians must cross roadways used by motor traffic and bicycles, or walk along improperly built or maintained corridors. Comfort is a characteristic that can encourage more walking. Examples range from protection from the weather and good illumination, to visual appearance and amenities (litter containers, benches, etc.). Despite the Americans with disabilities act (ADA) of 1990, which requires transportation systems to offer equal access to disabled people, the disabled still have problems with stairs, narrow passageways, long distances, slippery surfaces and poor-illuminated areas. The need to provide parking lots in close proximity to buildings also contributes to unfriendly land use development and long walking distance between locations, which can increase the fear of assault, especially after dark or when there are few others around.

Regarding bicycling, many college campuses lack proper and adequate bicycle facilities, including bicycle paths and lanes, intersection treatments, signage and parking. Many times bicycling on campus can be dangerous. Accidents can occur because of speeding, mixing types of traffic, poor right-of-way design, and college-age youth's propensity to ride outside the routes designated for bicycles and to ignore traffic rules and regulations (Dober, 2000). Because bicycles are not considered as 'design vehicles', in many of the cases engineers and campus planners have not considered the special needs of bicyclists on their precincts (Schimeck, 1996). The lack of secure bicycle parking increases

the possibilities for bicycle theft, which at the same time acts as a major deterrent to bicycle use. On the other hand, many bicyclists are accused of not obeying the rules of the road. This can cause resentment towards cyclists among other road users, which can cause accidents. One way to solve this problem is to combine education and enforcement programs to help bicyclists ride safely and other users to share the road with them.

However, the campus population with the characteristics described above presents many opportunities. Nelson and Allen (1997) have argued that there is a latent demand for bicycle facilities that can only be tapped by providing those facilities. On the other hand, Pendakur et al., 1995 claim that when the many benefits of nonmotorized modes are considered it makes sense to promote them as much as possible. In the US, several campuses already have realized this opportunity and have undertaken many actions to provide safe cycling and walking conditions to their campus communities. In the UK, large city employers also have reported more cycling awareness and activity due to the implementation of the government funded Cycle Challenge program (Cleary and McClintock, 2000). It is my argument that valuable lessons can be learned by examining successful cases.

4. Survey research

From a pool of more than 3000 college campuses nationwide, I pre-selected eight bicycle and pedestrian friendly campuses. These campuses are: Cornell University, University of Wisconsin at Madison, University of Colorado at Boulder, University of California at Santa Barbara, Sanford University, University of California at Davis, University of Oregon at Eugene, and University of Washington at Seattle. This selection was reached by what Babbie (1995) calls snowball sampling and deviant cases. Initially, I started with only four campuses and then, through peer-review referral and literature analysis, I expanded the sample to eight campuses. The criteria used in the selection was three-fold: (1) bicycling and walking as part of a larger TDM program, (2) known bicycle and walking levels and existence of well publicized nonmotorized planning pro-activity, and (3) expedite access to up-to-date and accurate information. This research is mainly based on a survey and on several semi-structured interviews with campus and transportation planners and TDM coordinators at the eight campuses. In addition, I also observed and participated in bicycle and pedestrian committee meetings, conducted extensive Internet searches of campus webpages, reviewed pertinent literature, analyzed campus plans, and collected local and college newspaper articles. All these constitute my key data sources. The survey was designed based on the National Bicycling and Walking Study's chapter on Actions Plans and Programs at the local level (USDOT, 1994); and it was administered during the first two weeks of October 2001.

4.1. Transportation patterns at the eight campuses

Table 1 provides contextual information about the eight campuses. Although data on bicycle commuting is scarce and few statistics are available (Moritz, 1997), I was able to collect or to estimate modal shares for the eight campuses. The chosen campuses are necessarily different and face different challenges as a consequence of their respective locations, such as weather and terrain, total population, area, budget constraints, historical administration, and programs in place. Modal shares are also dependent upon campus bicycle facilities and, probably most important of all, the existence of a local bicycle culture.

The selected campuses are located in six different States. Although almost all are located in urban settings, Cornell University is located in the small college town of Ithaca in upstate New York. Downtown locations or in more peripheral neighborhoods also affects how much land is available for automobile parking, and the possibility of walking, bicycling or taking public transportation to campus. For instance, the University of Wisconsin at Madison is located downtown. In part, this may explain its relatively high walking and bicycling levels. With the exception of the three campuses in the State of California, all other campuses experience harsh or particularly rainy weather. Cornell's rural setting and steep slopes probably explain its low bicycle ridership levels.

The selected case studies have total populations ranging from about 21,000 for the University of Oregon at Eugene, to about 50,000 people for the University of Washington at Seattle. Table 1 also shows the modal shares by campus users. Fig. 1 shows extreme contrasting values for undergraduate trips and for staff trips regarding walking and driving alone at the University of Colorado at Boulder. Surrounding community support for bicycling also influences campus ridership levels.

Table 2 compares bicycle commute values in four selected cities with their respective shares on campuses. Madison has the highest percentage on campus and the lowest commute percentage for the city, while Boulder shows the highest percentage citywide. Seattle has very humid weather and hilly terrain, and although bicycling is strongly encouraged by city government and the city has been rated twice by Bicycling Magazine as the best bicycling city (Richardson, 1999). According to Table 2 only 1.55% of trips in Seattle are done by bicycle—the lowest percentage for the four cities sample.

It is estimated that approximately 14,000 people commute to UC Santa Barbara by bicycle on a given day during school time. Davis, a small city 12 miles from Sacramento, hosts another campus of the University of California where estimates indicate that between 15,000 and 18,000 bicycles can be found on its grounds everyday

(Weerts, personal communication, October 2001). Although mild weather and flat topography probably contribute to high levels of bicycling on these two campuses, Davis' more than 50 miles of city bicycle paths and the campus' extensive network of bicycle paths and roadways make Davis 'the Bicycle Capital of the US'. Pucher et al. (1999) argue that Davis and its UC campus are unique in America for their high levels of bicycling, the quality and completeness of their cycling infrastructure, and the extent to which cycling is ingrained in their identity.

5. Discussion

5.1. TDM strategies

All eight selected campuses have TDM strategies in place. For instance, the University of Washington at Seattle's UPASS program has been a national model in transportation management. In fact, the UW Seattle has seen its population increase by 7% since 1991, while vehicle trips to and from campus have decreased by 5% (Toor, 1999). At UC Boulder it is important to emphasize a recent fleet of small buses, and a specific program called 'Ecopass'. This program allows employers to buy passes for their employees and pass holders to ride the buses for free with a valid ID. Due to efforts among the transit agency, the city of Boulder, and the University of Colorado, the community has seen a 400% increase in total transit use in the last 5 years (Toor, 1999). At the UW Madison, the Campus Transportation Committee has approved free rides for a one-year trial period effective as of September 2001, with the possibility of continuing the no-fare policy beyond this period (Martin, personal communication, October 2001).

Regarding parking, college campuses are providing limited additional free parking, while they are also strongly enforcing existing spaces. Table 1 shows that UO Eugene has the lowest number of parking spaces per thousand people. Stanford, on the other hand, presents the highest number but, based on economic feasibility considerations, it has stopped providing more parking. Rideshare programs include carpooling and vanpooling incentives, normally incorporated into parking policies. Carpool parking permits allow members of a 'club' to share the cost of a single permit, sometimes in privileged lots. Some universities do not have their own rideshare programs but do encourage their employees and students to use city or countywide services. Economic incentives are also being used to discourage driving. For instance, Stanford pays 2500 employees who do not purchase a parking permit during the year through its 'Clean Air Cash' program.

Alternative work hours and telecommuting are determined and negotiated within each department, based upon business needs. For instance, the UW Seattle has a telework policy that recognizes it as an important tool to address space concerns, decrease absenteeism and retain quality

Table 1
Contextual information about the selected campuses

	Cornell University	UW Madison	UC Boulder	UC Santa Barbara	Stanford University	UC Davis	UO Eugene	UW Seattle
Location	Rural	Urban	Urban	Sub-urban	Urban	Urban	Urban	Urban
Total student population	19,500	43,000	26,000	19,000	14,200	27,000	17,300	31,000
Total faculty and staff	12,300	16,000	5000	10,100	8600	10,000	3500	18,200
Weather conditions	Three seasons	Three seasons	Three seasons	All year	All year	All year	Three seasons	Three seasons
Terrain	Slopes	Gentle	Moderate	Moderate	Gentle	Gentle	Gentle	Moderate
Area (acres)	745	933	306	989	8180	5200	230	694
% Bicycle trips[a]	6	15	12	37	24	48[b]	12	5
% Walking trips[a]	45	49	28	8	8	48[b]	27	25
% Bus trips[a]	9	12	24	4	4	12	16	31
% Car trips[a]	40	23	36	51	64	38	45	38
Total number of car parking spaces	11,000	12,600	10,500	6500	21,000	14,000	3300	11,800
Car parking spaces/1000 persons	345.9	213.6	338.7	223.4	921.1	378.4	158.7	239.8

[a] Weighted percentages based on data received from the surveys and/or found on universities' web sites.
[b] Aggregate bicycling and walking percentage.

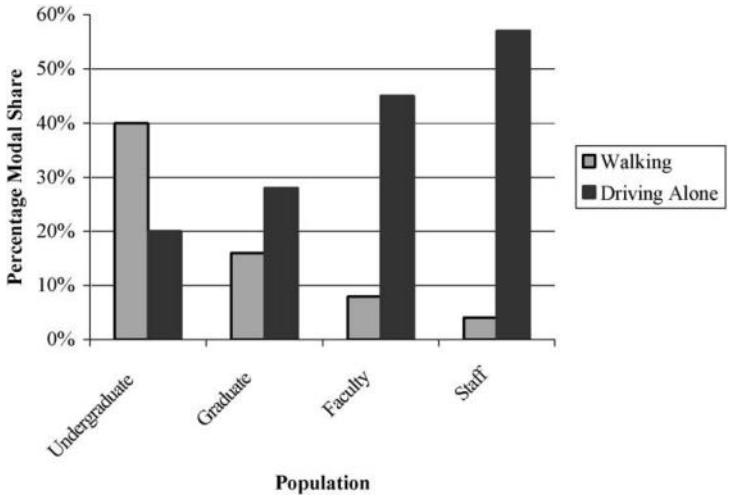

Fig. 1. Percentages of walking and driving alone trips by population for the university of Colorado at Boulder. Source: Exhibit IVE2—UC Boulder (2001).

employees. Several campuses reported having guarantied ride home programs that provide faculty and staff who use alternate modes with a free taxi ride home in the event of an emergency. Intelligent transportation systems are also being used on some of these eight campuses. Since many buses already have ITS technology, transit information at stops on campus is provided in real time. Furthermore, Seattle is considering SMART cards capable of proximity reading, while UC Santa Barbara and UW Madison are experimenting with in-vehicle parking meters.

5.2. Organizational aspects

Table 3 shows the organizational aspects regarding nonmotorized transportation. Six of the eight campuses have bicycle and pedestrian committees; the other two campuses only have transportation advisory committees. The advantage of having a specific bicycle committee is that bicyclist's interests have more possibilities of being considered in the transportation planning process. It is important to have students in the committee since many times students are the ones asking campus administrators to make the settings of their education more sustainable. Also local user groups have a very important role in monitoring and revising campus sustainable transportation policies. UC Boulder, home of one of the nation's largest student run environmental resource center, has no formal bicycle committee, but the UC Environmental Center lobbies for alternative transportation very often. Cornell's first efforts with bicycle planning started in 1990 with the constitution of an ad hoc bicycle committee and with the completion of a bicycle plan for the campus. At present there is a formal bicycle and pedestrian safety committee. At the UO Eugene the bicycle group was part of the Environmental Issues Committee. Stanford has a Bicycle Coalition and UC Santa Barbara has a student funded bicycle committee.

Four campuses currently have a full time bicycle and pedestrian coordinator. In general, his responsibilities are assessing needs, identifying opportunities, formulating and implementing plans, coordinating events and maintaining the campus bicycle and pedestrian facilities. At UC Davis, David Weerts has been the bicycle coordinator for more than 10 years. Stanford has a second person holding the post of bicycle coordinator since August 2001. The university's first coordinator was able to complete about $1 million in bicycle capital improvements between 1995 and 2000. Four campuses conduct regular user surveys. UW Madison and UW Seattle reported to conduct yearly and biennial surveys, respectively. Keniry (1995) has identified that campuses with a strong commitment to bicycling also tend to evaluate bicycle needs as carefully as automobile use and safety. Regular surveys can reveal changes in use over the years and across the seasons. The latest bicycle rack survey at UW Seattle showed a 33% occupation rate.

Table 2
Comparison of bicycling in four selected cities and on their respective campuses sources: Nelson and Allen (1997, p. 81)

	Mean high temperature	Rain days	Bicycle pathway miles per 100,000 residents	Bicycle commute percent for the city	Bicycle commute percent for the campus[a]
Boulder	65.3	51	48.75	7.34	12
Eugene	63.3	123	56.6	6.04	12
Madison	56.1	18	17.37	3.44	15
Seattle	59.7	158	10.47	1.55	5

[a] Weighted percentages based on data received from the surveys and/or found on universities' web sites.

Table 3
Organizational aspects regarding nonmotorized transportation sources: information received from the surveys and/or found on universities' web sites

	Cornell University	UW Madison	UC Boulder	UC Santa Barbara	Stanford University	UC Davis	UO Eugene	UW Seattle
Bicycle/pedestrian committee	✓	✓		✓	✓	✓		✓
Full time coordinator		✓		✓	✓	✓		
Conduct regular user surveys		✓	✓		✓			✓
Identify major funding sources		✓	✓	✓	✓	✓		✓
Communicate bicycle and pedestrian planning knowledge	✓	✓	✓	✓	✓	✓	✓	✓

Campuses with bicycle committees and coordinators tend to conduct surveys more often and to attract more funding. Funding is needed to fund bicycle facilities such as paths, lanes, parking racks and lockers, and to pay a bicycle coordinator. Revenues may come from student fees, bicycle registration fees and fines for traffic and parking violations but also from foundations, alumni associations, state and federal sources. ISTEA and TEA 21 have funded bicycle racks, lanes and other alternative transportation measures. To qualify for federal funding, campus transportation planners need to work closely with surrounding planning agencies in the development and implementation of local and regional plans. The UC Davis was able to buy 24 lockers with a grant from the Federal Congestion Mitigation/Air Quality Program (Weerts, personal communication, October 2001). Another area of intervention for the committee and the coordinator is the communication of transportation practices with the campus and with the surrounding communities. Accordingly to the survey respondents, all campuses undertake this practice to a certain extent.

5.3. Planning aspects

As in many other planning strategies it is important not only to have a plan but also to pay close attention to planning processes and implementation. Three campuses are known to have bicycle plans. Others are reformulating their master, sustainable development, and long-range development plans. Cornell's plan was developed in the early 1990s by an ad hoc bicycle committee. 'Cornell Cycles: New Call for Transportation Alternatives' highlights the circulation network, the improvements to recommended bicycle routes and parking facilities, and a set of actions in terms of regulations and enforcement, education and promotion. The UO's Planning Office developed a sustainability plan, which was approved in October 2000. The UC Boulder has developed a similar plan called 'Blueprint for a Green Campus', and the UW Seattle has developed a Campus Master Plan for the period 2002–2012 that strongly encourages nonmotorized transportation.

The advantages of having a bicycle committee and a bicycle coordinator include the ability to make changes to existing policies more expeditiously. Nonmotorized traveling can only be maximized by thoroughly integrating bicycling and walking needs and desirable circulation patterns in all transportation, and housing and environmental policies. It is important to make nonmotorized traveling compatible with land-uses and to establish linkages between the different elements of the transportation system on campus and in the surrounding communities. On campus it is important to institutionalize TDM policies in the planning routines of the university and to incorporate campus-wide nonmotorized urban design guidelines with site and master planning. For instance, bicycle storage rooms and shower facilities should be accommodated in

new buildings, and corridors for greenways or walkways that represent desirable lines of travel should be reserved. Finally, it is also important to integrate and coordinate planning efforts with the surrounding communities. Table 4 shows that these aspects are reasonably well taken into consideration in the planning processes at the eight campuses.

5.4. Bicycle and pedestrian facilities

Although walking and bicycling can take advantage of complementary planning strategies, it is important to separately consider the needs of the two groups in order to reduce modal conflicts (Untermann, 1984). Pedestrians' facilities include a network of sidewalks and dedicated zones. Regarding bicyclists McClintock (1992) argues that special facilities can offer important contributions to improving bicyclists' safety but only if they offer some distinct advantages to cyclists, in terms of safety, convenience, comfort, directness, and general attractiveness.

Despite the need to make every road cycleable, a logical and well-identified bicycle network composed of different types of bikeways should be implemented with identifiable links to off-campus facilities (Huang and Ye, 1995). The selected campuses show a variety of bicycle facilities (Table 5). The bicycle paths at UC Davis extend the farthest among campuses in the US. UC Boulder has multiuse paths with separate lanes for bicyclists and pedestrians; about thirty bicycle paths, lanes and routes connect the campus with the community.

Where pedestrians share the space with bicyclists it is important to implement a dismount zone policy. All campuses in the research reported to have dismount zones and pedestrians only precincts. UC Davis has 1.5 miles of roadway from which all motor traffic is prohibited except service, delivery and emergency vehicles. In four campuses traffic-calming measures are also being implemented. Proper facility maintenance and bicycle parking are aspects of the bicycle network that cannot be overlooked. Bicycle theft on campus can be a major deterrent to bicycle use as well, thus secure bicycle-parking racks and lockers are required. Five of the eight campuses reported having bicycle lockers for rent in their precincts. The UW Seattle has 362 lockers-more than any other college in the country. At UO Eugene, in addition to bicycle lockers, there are also locked bicycle cages to deter vandalism and theft more effectively.

Bicycle racks should also be installed on buses that serve campus locations. This type of synergy has the potential to encourage more people to use these two complementary modes of transportation by extending their commuting distance. Campuses are ideal locations to implement bicycle-lending programs as well. These types of programs allow for use of 'public' bicycles for free (or for a refundable deposit) from on-campus bike racks which may be ridden to classes or to other campus locations. Although five survey respondents reported that showers, clothing lockers and changing rooms are available in some buildings in their campuses, it is important that they become more widespread and are offered in more locations than just sports facilities.

Careful attention should also be paid to the redesign of intersections and crossings to more safely accommodate bicyclists and pedestrians. Weerts (1998) describes a situation in Davis where an intersection with over one thousand bicycle crossings per hour at peak times was redesigned and equipped with bicycle traffic lights to provide cyclists a separate phase during which only they may cross a busy arterial. Appropriate use of signs and markings is required to create safe networks. Finally, off-campus infrastructures can positively impact on-campus ridership levels as well. An example of an apparent successful case seems to be Stanford's neighboring Palo Alto Bicycle Station which includes free valet bicycle parking, commuter and recreational rentals, bicycle repairs, basic bicycle accessory sales, changing room and an outdoor seating area with concessions. This parallels some of the finest examples of trip chains in the Netherlands (Priemus, 1995; Rietveld, 2000).

5.5. Promotional measures

There are many promotional measures that can be taken to advertise alternative transportation. These include maps, brochures, news in the local and regional mass media, special discounts at local bicycle stores, and networking with other transportation professionals and interest groups. Table 6 shows respondents answers about universities' promotional measures. Clear and informative bicycle maps should be a priority on every campus. At UW Madison, the TDM program makes use of a biannual newsletter to provide the university community with up to-date information about transportation alternatives.

The Internet is an outstanding way to promote non-motorized traveling (Blickstein and Hanson, 2001). Most campuses have well-designed and informative web pages with links to other online resources. On campus, bicycle shops provide quick repairs and tire inflation centers. These shops are often located in the student or campus center buildings, and many provide discounts on parts or services. At UW Seattle, the local bicycle shop gives students a free helmet with tune-ups, while offering staff and faculty other discounts. All campuses reported having and celebrating events such as 'Bike to Work Week' and 'Earth Day'. Davis has an annual citywide celebration of bicycling called 'Cyclebration'.

Three campuses reported participation in or organization of conferences about alternative transportation, or presentation of best practices at transportation conferences. To show the relevance of TDM measures on college campuses, Will Toor—Mayor for the city of Boulder (1998–2001) and

Table 4
Planning aspects regarding nonmotorized transportation sources: information received from the surveys and/or found on universities' web sites

	Cornell University	UW Madison	UC Boulder	UC Santa Barbara	Stanford University	UC Davis	UO Eugene	UW Seattle
Bicycle/pedestrian plan	✓				✓		✓	
Changes to existing policies	✓	✓	✓	✓	✓	✓	✓	✓
Integrate nonmotorized uses into campus transportation planning	✓	✓	✓	✓	✓	✓	✓	✓
Campus-wide nonmotorized urban design guidelines	✓		✓	✓	✓	✓	✓	✓
Reserved corridors/greenways	✓	✓	✓	✓	✓	✓	✓	✓

Table 5
Bicycle and pedestrian facilities sources

	Cornell University	UW Madison	UC Boulder	UC Santa Barbara	Stanford University	UC Davis	UO Eugene	UW Seattle
Bicycle paths (miles)	n/a	2	3	7	n/a	14	n/a	2.5
Bicycle lanes (miles)	2	3	1	1	n/a	12[a]	n/a	1
Bicycle routes		✓	✓		✓	✓	✓	✓
Dismount zones	✓	✓	✓	✓	✓	✓	✓	✓
Bicycle spaces at parking racks[b]	n/a	11,000	7300	9600	12,000	15,000	4700	6100
Bicycle spaces/1000 people	n/a	186.4	235.5	329.9	526.3	405.4	226.0	124.0
Number of bicycle lockers		22			100	36	15	362
Other parking structures					✓	✓	✓	
(Re) Designed intersections and crossings		✓	✓	✓	✓	✓		✓
Traffic—calming measures				✓	✓	✓		✓
Signing and markings	✓	✓	✓	✓	✓	✓	✓	✓
Showers—changing rooms		✓		✓	✓	✓		✓

[a] These 12 miles include bicycle lanes and bicycle routes.
[b] Information received from the surveys and/or found on universities' web sites.

Table 6
Bicycle and pedestrian promotional measures sources: information received from the surveys and/or found on universities' web sites

	Cornell University	UW Madison	UC Boulder	UC Santa Barbara	Stanford University	UC Davis	UO Eugene	UW Seattle
Bicycle maps	✓	✓		✓	✓	✓	✓	✓
Brochures/news in the media	✓	✓	✓	✓	✓	✓		✓
Special events	✓	✓	✓	✓	✓	✓	✓	✓
On campus bicycle shop				✓	✓	✓		✓
Tire inflation centers		✓		✓	✓	✓		✓
Businesses discounts	✓				✓	✓		✓
Bicycle incentives		✓		✓	✓			
Conferences (organization or participation)			✓			✓	✓	
Involvement with bicycling clubs and environmental groups			✓	✓	✓	✓	✓	✓

director of the Environmental Center at the University of Colorado—organized a two-day conference in April 1999. This conference was attended by campus planners from forty-two schools across the US and Canada, and by many towns, municipalities, and transportation sector representatives. It provided an overview of transportation challenges on college campuses and their host communities, and the solutions being implemented at universities across the country. The bicycle coordinator for UC Davis has also presented papers at national and world congresses (Weerts, 1992, 1998). Finally, involvement with the regular activities of other local and regional bicycle and environmental nonprofit associations also helps to increase bicycling and walking levels on campus very effectively.

5.6. Education and enforcement

Pucher and Dijkstra (2000) argue that the neglect of pedestrian and bicycling safety in the United States has made these modes dangerous ways of getting around. In fact, many bicyclists operate their vehicles in a dangerous or unlawful manner (Forester, 1994; Schimeck, 1996), while others do not know how to ride their bicycles with traffic or to use helmets (Weiss, 1996). Many bicyclists feel safer riding on the sidewalk, not bearing in mind eventual collisions with pedestrians. This impasse involves not only enforcement but also education. Table 7 shows that only four campuses reported having regular bicycle safety classes. In addition to Effective Cycling classes, Cornell University has created the Internet based e-learning course, 'Getting Around Cornell'.

Many campuses reported the existence of Police Bicycle Patrols, but a few respondents also confirmed limited law enforcement. The advantages of using bicycle patrols are well known. Police officers can be faster than in patrol cars because they can cut through courtyards and not go on the normal streets a car would have to. They also prevent crime because officers are more accessible to students. UC Santa Barbara has a special community service organization (CSO) that was created as an organization of students to serve as liaisons between the students and the police department. CSOs patrol the campus year-round, reporting crimes in progress, assisting in emergency situations, detecting safety hazards, and warning or enforcing bicycle regulations. Keniry (1995) has argued that the campuses that best accommodate bicyclists also enforce some of the most stringent bicycle regulations. In extreme cases fines and tickets for incorrectly parked bicycles and for those who fail to comply with the bicycle dismount policy are applied. Several campuses impound bicycles and only release them after the payment of a release fee.

The program at UC Davis requires that every bicycle on campus grounds be registered. This helps to locate the bicycle owners in cases of theft and helps to fund the program. In addition, UC Davis also has a bicycle traffic school where violators can eliminate the traffic fine by

Table 7
Bicycle and pedestrian education and enforcement measures sources: information received from the surveys and/or found on universities' web sites

	Cornell University	UW Madison	UC Boulder	UC Santa Barbara	Stanford University	UC Davis	UO Eugene	UW Seattle
Bicycle safety classes	✓	✓	✓	✓	✓	✓	✓	✓
Regulations readily available	✓	✓	✓	✓		✓	✓	✓
Printed materials	✓	✓	✓	✓	✓	✓	✓	✓
Police on bicycles program	✓		✓	✓	✓	✓	✓	✓
Police enforcement		✓	✓	✓		✓	✓	✓

attending classes (TAPS, 2001). Finally, pedestrian safety, especially at night, is a growing concern on many campuses. Respondents reported that their colleges have emergency telephones and escort programs.

6. Conclusion

I started this paper by recognizing that college campuses are distinct communities, in the words of Creighton (1998) 'microcosms of society', and that they have varied and often-large environmental impacts. Then I argued that although transportation in and around university campuses in the United States has always been a challenge (Farris and Radwan, 1989), recent searches to alleviate the transportation problem are part of a broad movement for 'greening the Ivory Tower'.

The purpose of this paper was to understand what could be done to make college campuses more sustainable communities from the bicycle and pedestrian planning point of view. A survey of 8 college campuses showed some of the best practices. Fig. 2 shows the importance of nonmotorized transportation in the selected campuses. Fig. 3 shows a much more balanced and equitable modal share when compared with the national ratio. The key finding is that college campuses are clearly 'de-marketing automobile commuting' (Wright and Egan, 2000) and actively promoting alternative transportation modes. In order to create more bicycle and walking friendly campuses efforts need to focus on the following seven measures: TDM strategies, organization, planning, facilities, promotion, education, and enforcement. Although these measures need to be tailored to local conditions, they should not be implemented alone because only the development of highly integrated strategies have the potential to improve sustainability (Potter and Skinner, 2000).

The implementation of the lessons learned in this research is likely to 'encounter considerable opposition' (Tolley, 1996), which is a normal part of the process of change. One cannot expect swift changes, since 'the extent of what is possible and realistic will change over time as costs rise, technology changes, and awareness and understanding increase' (Creighton, 1998, p. 289). However, universities have the possibility to take a leadership role and promote environmentally sound programs. The need and opportunities for additional research, teaching and service learning on nonmotorized travel are countless. They are bounded only by our creativity and willingness to take risks and improve our way of living. The overriding issue is the way of thinking and the need to change routine decisions, levels of commitment and one's own behavior. Nonetheless, as Weerts (1992, p. 144) recognized so well a decade ago,

> those looking for solutions to worsening air quality, traffic, and parking problems, may well find the resources, expertise and enthusiasm to establish

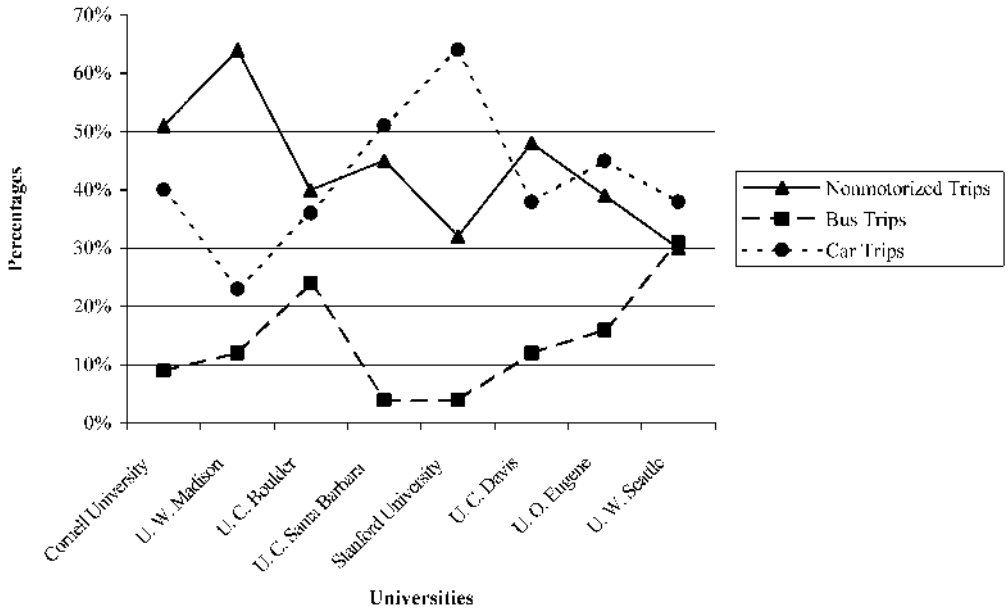

Fig. 2. Comparison of modal shares for the eight campuses. Source: Author's survey. Weighted percentages based on data received from the surveys and/or found on universities' web sites.

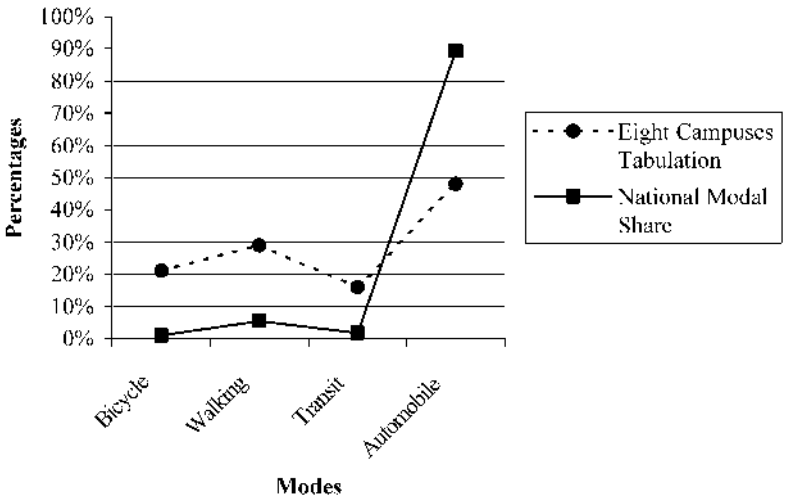

Fig. 3. Comparison of 1995 national modal share with an average for the eight campuses source: Pucher et al. (1999, p. 627) and weighted percentages based on data received from the surveys and/or found on universities' web sites. I assumed that three fourths of the UC Davis 48% walking and bicycling share equals bicycle trips.

workable bicycle programs right in their midst-at their local institutions of higher learning.

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