Commuting at the University of Michigan

A Report Developed for and Supported by the U-M President's Commission on Carbon Neutrality

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EXECUTIVE SUMMARY

Purpose
The commuting team has developed an approach to measure the carbon impact of commuting at the University of Michigan and studied peer institutions to determine best practices for reducing those emissions as well as the effectiveness of those practices. The team adapted those approaches and developed prioritized recommendations to help reduce emissions at the University of Michigan based on lowering existing incentives for reliance on solo car travel and removing obstacles to its alternatives. In tandem, policies proposed here will help the University of Michigan reduce its commute carbon emissions through practices that will also ensure fairer campus access for all.

Policies
We researched five families of policies: land use and housing; parking permit structure; motorized transportation; cycling; and telecommuting. These main categories were supplemented by research analyzing how commuter schools implement these policies (with an eye to adaptation to Dearborn and Flint) and how the Sustainability Cultural Indicators Program (SCIP) can be repurposed to help develop metrics measuring the impact of these policies. These policies are built around practices already occurring at the University of Michigan and best practices implemented with success at peer universities.

While the commute will not be carbon neutral in the foreseeable future, policies to reduce vehicle-miles traveled commuting should reduce the carbon impact by 20% to 35% from a current estimated baseline of 171,000 metric tons of carbon dioxide equivalent per year.

Arguments
Principal proposals include:

1) Provide housing programs for students, faculty, and staff tailored to the specific campus and prioritize central locations for Ann Arbor campus expansion.
2) Eliminate the annual parking pass and gear parking fees to an employee's salary.
3) Invest in rideshare, extend universal-transit-access policies to the Dearborn and Flint campuses, and ensure that Ann Arbor campus transit upgrades are integrated with the broader public transportation environment.
4) Upgrade cycling infrastructure.
5) Develop data to gauge the potential carbon impact of broad telecommuting policies.

FINAL REPORT

Overview of the Challenge: The commute to the University of Michigan, representing a scope 3 category of emissions, emits carbon dioxide equivalent to 49% of the University's scope 1 emissions and 21% of the sum of scope 1 and scope 2 emissions.[1] While these impacts are not under the direct control of the University, its policies and practices in parking, public transit, housing, land-use planning, and telecommuting all shape the decisions of faculty, students, and staff regarding how far to travel, how frequently to travel, and which transportation modes to use when commuting to the campus. For these reasons, the decision of the President's Commission on Carbon Neutrality (PCCN) to incorporate the commute into its recommendations for tracking and mitigating the University's carbon impact was a vital step toward campus carbon neutrality. The Commuting Internal Analysis Team focused on University actions that shape commute vehicle-miles traveled, analyzing policies on the origin of the commute trip (housing), the destination (land-use planning), the trip itself (parking, transit, cycling), and alternatives to travel (telecommuting). [2]

Key Findings: Estimates of the carbon impact of commuting at the University of Michigan are presented in Appendix B, tables 2.3.2 to 2.3.4. Several observations emerge from these tables. First, the per capita carbon impact of an individual's commute grows more rapidly than the commute's distance because walking, cycling, and transit are much more common from nearby areas than from more remote locations, from which commutes are almost exclusively by single-occupancy automobiles. Second, the campus destination is highly relevant to the carbon impact of the commute. For example, an average employee on Central Campus has a commute carbon impact less than two-thirds that of an East Medical Campus employee, with much of the difference due to the very large share of automobile use in the East Medical commute. The high share of automobile use in the Dearborn and Flint commutes lead these campuses to have relatively high commute emissions per employee as well. Third, the portion of the commute that exceeds 20 miles contributes a particularly large share of the campus's total commute carbon, particularly the long-distance commutes to the Central and Medical Campuses. Finally, whereas faculty and staff represent the largest share of the carbon impact of the Ann Arbor commute, the impact of the Flint and Dearborn commutes is dominantly from student travel.

Tracking commute carbon reductions will require systematic and regular surveys of the travel behavior of students, faculty, and staff. These are discussed relative to all of the recommendations below in Appendix A, and the topic is only mentioned in an individual section below if the issue presents unique needs or opportunities for tracking and monitoring.

Estimates presented here are in comparison to a 2020 baseline. Future growth of the campus will move that baseline; it may be assumed that the carbon-reducing impact of policies recommended here will affect the growth increment in the same proportion as the 2020 base. Our land-use policy recommendation pertains to (an unknown) future increment of growth, recommending that it be focused in central locations, which provide the best alternatives to single-occupancy driving.

Prioritized Recommendations Summary: Recommendations below center on housing, parking, transportation, and telecommuting, and the considerations behind their ranking, based on cost, effectiveness, revenue-generation potential, timeframe, and equity, are presented in Appendix L. The highest priority recommendations include immediate-term actions in parking policy reform and a longer-term strategy of development of student, faculty, and staff housing on University land. The transportation system recommendations are ranked next in importance,

particularly as they are needed complements to reforms geared at reducing the incentives for exclusive reliance on solo driving. The next tier of priority is telecommuting policies, the effects of which are uncertain after household location decisions and daily travel behavior are taken into account.

Priority #1 Recommendation: Housing Development and Land-Use Policy

Description: The University owns hundreds of acres of well-located developable land in Ann Arbor. We recommend that a significant share of this land be dedicated to housing development for students, faculty, and staff. Giving more students, faculty, and staff the opportunity to choose short-distance commutes will reduce the carbon impact of the commute by facilitating walking, cycling, transit use, and short automobile trips and can be accomplished while guaranteeing territory for academic-function expansion. At Flint and Dearborn, we recommend additional student housing as well as a financial program to incentivize employees to live closer to campus. Importantly, when housing is developed on University land, the University retains control as to who is qualified to occupy it. Generally, employment or enrollment in the University—or retiree status from the University—is required. This has the benefit of ensuring that such housing will have the greatest possible commute-reducing impact for both existing residents and new students and employees.

Numerous universities have significant programs of housing development or support. For example, Stanford, UC Irvine, and UC Santa Cruz all provide faculty and staff housing through a land lease. The University of Chicago and Purdue are expanding their undergraduate housing as housing markets become more restrictive and enrollment increases. Depending on the land selected and the density of development, we estimate that between 10,000 and 22,000 new student beds could be added, together with between 3,000 and 12,000 faculty and staff housing units, which could provide a mix of rental and ownership offerings.

We further recommend that future Ann Arbor campus academic expansion focus on central locations, which offer the best alternatives for non-automotive commuting and hence the best potential for University growth while minimizing the increase in carbon emissions. For example, both the Church Street and Catherine Street parking structures will reach the end of their useful lives within ten years. The land on which they sit should be considered prime territory for expansion of academic functions. The Ann Street and Hill Street structures will provide similar opportunities in the longer term. The recent acquisition of the Fingerle property in central Ann Arbor provides a unique opportunity for residential development. This approach to campus expansion is compelled by the observation that commute emissions per capita increase with greater peripheral location of campus destinations (Appendix B, Table 2.3.2).

Carbon emissions reduction potential: Estimates of direct effects of housing development on the carbon impact of the commute are presented Table 1.[3] The emissions-growth-mitigating impact of focusing future Ann Arbor campus expansion in central locations is estimated at 900 metric tons per year for each 1,000 employees located in central, rather than peripheral, locations.

Financial costs, savings, and considerations: Consistent with past practice, the cost of student housing should be net zero to keep education as affordable as possible.[4] Housing development on University-owned land in Ann Arbor can be a revenue-generating endeavor.

Table 1. Emissions Reduction from Housing Policies on the Ann Arbor, Flint, and Dearborn Campuses

Campus	Housing Development Scenario	Number of Employee Housing Units	Additional On-Campus Students	Emissions Reduction (Metric tons CO_2 e/year)		% Reduction in Employee Emissions by Campus	% Reduction in Student Emissions by Campus
				Faculty & Staff	Students		
Ann Arbor	Low	3,133	6,007	7,150	7,471	7	27
	Medium	7,740	9,231	17,665	11,480	17	42
	High	11,812	9,679	26,958	12,038	26	44
Dearborn		100[5]	400	258	602	8	5
Flint		100	400	287	835	8	4

Organizational structure considerations: The University currently has housing offices for the Ann Arbor and Flint campuses, which manage on-campus student housing, and a real estate office in Ann Arbor that handles land acquisition and a handful of rental properties. These could form the basis for a housing development operation, or a separate entity, akin to the public-benefit nonprofit Irvine Housing Development Authority, could serve as both developer and incentive-system manager. The model proposed for housing development on campus land is a land lease to enable policies to maintain housing affordability.

Campus culture and individual accountability considerations: The University of Michigan has avoided faculty and staff housing provision, at least in part because housing provision is seen as remote from the University's core missions. Yet the University has embraced a number of ancillary missions, from operating transit and parking systems to running a power plant. Housing provision promises benefits in a number of vital realms, including sustainability, affordability, equity, and recruitment and retention. The University's freedom from Ann Arbor zoning means that it is uniquely placed to expand housing supplies locally without the constraints of local politics. A range of housing types can serve different household types and lifestyle preferences (Appendix C).

Equity and justice considerations: Housing programs promote equity differently in the three campuses. Housing expansion in Ann Arbor can help expand affordable options locally even as it sharply reduces commuting costs for residents. In Flint, policies to encourage local residence can be a force for urban revitalization. And in Dearborn, policies to encourage nearby residence can significantly lower the cost of living for employees and students through reduced commute costs. Some units can be set aside for leasing or renting at affordable rates. For example, UC Santa Cruz groups employees based on income and ensures each group receives a certain percentage of on-campus housing.[6] UC Irvine and UC Santa Cruz ensure that the appreciation on a property does not make it unaffordable in the future.[7]

Timeline for implementation: Housing development will need to occur over many years and will depend in part on market acceptance of initial offerings. We assess that University-owned land is adequate to the provision of housing proposed here together with all academic needs at least until 2050 (Appendix C).

Potential implementation challenges: The scale of effort implied in Table 1—even the "low" development scenario—is very large. Development will necessarily be incremental, providing plenty of opportunity for feedback on market acceptance.

Unknowns, gaps, and/or additional analysis required: Market studies will be needed to assess demand for such housing and the desirable mix of housing types.

Critical next steps to catalyze work: Begin housing surveys and select areas to redevelop for housing mixed with academic, research, commercial, and parking. For example, the Northwood apartments are a highly suitable area, and the North Campus plan from the mid-2000s highlights their ability to become a mixed-use development.

Priority #2 Recommendation: Parking Policy Reform

Description: The central tool the University has to shape the commute in the immediate term is its policy toward parking. We recommend that the University reform the structures by which it charges for parking in five ways:

1) Eliminate the $172 per year mandated University contribution to faculty and staff parking passes (Ann Arbor). This represents a direct subsidy to carbon emissions in the commute and, ironically, one from which commuters who make the lowest-carbon choices are unable to benefit.
2) Eliminate annual and monthly parking passes in favor of daily parking payment (Ann Arbor, Dearborn, Flint). Commuters who have purchased an annual or monthly pass lack incentive to walk, cycle, carpool, or use public transportation. In contrast, daily payment ensures that while the commuter remains able to park, they have incentives to consider alternatives to driving alone, even if on an occasional basis.
3) Link parking charges to an employee's salary (Ann Arbor, Dearborn, Flint). This policy, which has been implemented at campuses including Rutgers, Rochester Institute of Technology, and University of Indiana Bloomington, is designed to ensure that the changes described here affect commuters based on their ability to pay.
4) Set parking charges with the goal of utilizing available parking throughout campus (Ann Arbor). Currently, while parking in central locations is at or beyond capacity, about 1,300 spots in peripheral locations in southern and northeastern Ann Arbor go vacant at peak periods (Appendix D, Figure 3.2). This inefficient utilization of existing parking leads to pressure to expand parking capacity in central locations, with its inevitable carbon impacts.
5) On the Dearborn and Flint campuses, separate parking charges that are currently incorporated into mandatory per term registration fees and make parking fees optional to offer cost savings to students who opt to reach campus by different modes.

At least two variants of annual pass elimination are possible. The Massachusetts Institute of Technology (MIT) capped individual parkers' payments at the previous cost of the annual pass, meaning that once cumulative daily expenditures reached the cost of the pass, parking charges were waived for the rest of the year. This approach would lead to reduced parking system revenues, however. The alternative approach would be a fee structure geared at maintaining parking system revenues but shifting the burden on whom the payments fall: low-salaried employees, remote parkers, and occasional parkers would pay less while high-salaried employees would pay more if they park regularly at central locations.

Carbon emissions reduction potential: A conservative estimate of the Ann Arbor component of this policy is a carbon reduction of 6,300 metric tons per year, or 6% of the carbon impact of the faculty and staff commute to Ann Arbor. In the two years following MIT's 2016 switch, the

number of people driving to campus dropped by 13%, and the frequency with which people drove to campus per week declined by 8.7%. (They were accompanied by a switch to a universal access policy to public transit, something that the Ann Arbor campus has had for years.[8]) The extent of reduction at the University of Michigan would depend on which variant of the policy would be selected. Elimination of the $172 annual subsidy to parkers would imply an increase in the average daily cost of parking overall. This was not the case for MIT's implementation, and the subsidy elimination, as well as other policies recommended in this report, could augment the policy's effectiveness.

Financial costs, savings, and considerations: Depending on the implementation selected, the policy could have either a neutral or negative effect on parking system revenue. Elimination of the University contribution would represent annual cost savings of over $5 million to the units currently subsidizing driving in this way.[9]

Metrics and tracking: Usage can be tracked through the number of system participants and via automated counts of daily parkers.

Campus culture and individual accountability considerations: Faculty and staff frequently expect available parking within an easy walk of their workplace, an expectation that pushes toward parking system expansion. This policy represents a shift toward alternatives to parking and toward efficient parking system management.

Equity and justice considerations: Linking parking charges to the parker's income is necessary to ensure that the impact of the changes does not fall on those least able to afford them.

Scalability, transferability, and external engagement: The policy could be phased according to lot infrastructure, with automatic-gate-controlled structures implemented first.

Timeline for implementation: The policy can be phased in by steps: elimination of the parking subsidy; gearing parking fees to an individual's salary; phased elimination of the annual pass.

Potential implementation challenges: Full implementation of the policy could entail the infrastructure costs of installing automated gates at all parking lots that currently lack them, which would cost several hundred thousand dollars.[10] An alternative to this infrastructure investment could be reliance on daily scratch-off hang tags for lots not controlled by automated gates, an option that already exists for some commuters.

Unknowns, gaps, and/or additional analysis required: The fee levels to achieve goals stated here, and their variation by income and parking location, require further study.

Priority #3 Recommendation: Motorized-Transportation Improvements

Description: Despite its highly performing vanpool system, the University of Michigan lags behind its peer institutions in support of ridesharing for affiliates; less than 1% of University affiliates currently commute by rideshare.[11] Rideshare is particularly relevant for longer-distance commutes, which account for an outsized share of the carbon impact of the commute as a whole (Appendix B, Table 2.3.3). We recommend that the University 1) create a carpool system with perks and matchmaking as described in Appendix F, section 1.0; and 2) extend our excellent vanpool system to students, faculty, and staff at the Dearborn and Flint campuses. Recent analysis by UM-Dearborn students has found lack of transit access constitutes a significant barrier to attendance, which can be alleviated with strong vanpool service.[12]

In the realm of public transportation, the University provides free access to Ann Arbor Area Transportation Authority buses for all students, faculty, and staff. The University should extend universal access transit agreements to all students, faculty, and staff at the Dearborn and Flint campuses through cooperative agreements with the Suburban Mobility Authority for Regional Transportation (SMART) and the Mass Transportation Authority (MTA), respectively. Increased bus service to campus, including a higher number of accessible bus stops and campus-based routes, should be included in the agreements of both UM-Dearborn and UM-Flint. In the case of Dearborn, the University should negotiate with SMART for a stop and regular service directly to campus.

On the Ann Arbor campus, the University should plan the U-M Connector, a contemplated high-capacity transit corridor (Appendix E, Figure 1), for integration with the municipal and regional transit systems to aid in transit movements to campus in addition to serving as an intercampus shuttle. Steps include:

1) Seek partnership with the City of Ann Arbor, Ann Arbor Township, and the Michigan Department of Transportation to extend the transit system to US 23 in the east (1.4 miles) and Blake Transit Center in the west (0.7 miles). The easterly extension should allow for parking expansion at the Plymouth Road/US 23 interchange rather than at the North Campus Research Complex (NCRC), whose valuable nearby location should be reserved for housing and academic uses.
2) To start, extend the U-M Connector from the Central Campus Transit Center to the edge of campus territory at State Street.
3) Link the U-M Connector with the site of the potential rail station at Fuller Road adjacent to the hospital.
4) Design capacity under the assumption that the U-M Connector will ultimately be a link in a larger municipal system.
5) Consider designing the system as a bus rapid transit, accommodating buses of Ann Arbor Area Transportation Authority as well as those of the University. Such integration could accelerate transit service between town and a range of campus destinations and, as a shared community benefit, could also form the basis of a funding application to the Federal Transit Administration.

Carbon emissions reduction potential: We analyzed the change in emissions that would result from University of Michigan affiliates utilizing rideshare at the same rate as Indiana University, an institution with an exemplary rate of rideshare utilization: 11% for faculty and staff and 10% for students.[13] This would result in an estimated 8,200 metric ton reduction in annual carbon emissions associated with commuting, or 5% of the total faculty, student, and staff emissions from the three campuses. Appendix F, Section 2.0 contains tabulations of change in emissions by campus location as a result of adopting this policy.

A comprehensive survey of University-led universal-transit-access programs found a sustained 1% to 13% annual increase in transit over baseline levels after introducing a universal access program.[14] Using the University of Indiana's 6% annual increase as a benchmark, we expect to see a modest decrease in emissions of 6.6 metric tons in the first year and 66 metric tons in the tenth year of operation. Integration of the U-M Connector is estimated to reduce 1,400 metric tons per year.

Financial considerations: The primary cost of ridesharing programs comes from the loss of parking revenue. The new expenses are low as most matchmaking services are ad supported while fringe benefits to participants, such as raffles and reduced parking permits, can be tailored

to budgetary constraints. The main costs for the vanpool program are the purchase of and insurance for vehicles. Additionally, vanpool user fees will offset the costs of operating this service. Universal access agreements in Flint and Dearborn can be modeled on the agreement the University has with the Ann Arbor Area Transportation Authority, with a total program cost of under $28 per student, faculty, and staff member per year.[15]

Metrics and tracking: In addition to the surveys described in Appendix A, usage of a universal access system can be tracked automatically via farebox card swipes.

Campus culture and individual accountability considerations: A focus group and survey at Dearborn found 1) a prevalent campus culture of driving to work, 2) an interest in using the bus, and 3) significant barriers to riding the bus (Appendix I). Ongoing marketing campaigns are needed to help overcome these barriers.

Equity and justice considerations: Increasing the accessibility of ridesharing will reduce the necessity of owning or operating an automobile and can lower expenses for those who must drive. Given that our proposed parking policy lowers incentives to drive, improving rideshare is a necessity, particularly for students, faculty, and staff living remotely for whom few alternatives to commuting by car exist.

Universal access is a privilege that is already afforded to the Ann Arbor campus, which serves wealthier students.[16] Universal access in UM-Flint and UM-Dearborn will increase equity across U-M's three campuses (Appendix E). And integration of major planned improvements in campus transit with the broader public transportation environment can significantly reduce transportation costs for people for whom driving and parking is a burden.

Scalability, transferability, and external engagement: The value of a universal access agreement can grow over time if the University pursues the development of park and ride services that specifically serve hubs where students, faculty, and staff live. Integration of the U-M Connector with the broader public transit environment can occur in phases, with the U-M Connector potentially beginning on U-M land as an exclusively University project.

Timeline for implementation: To start, U-M can reach out to carpool matching services like iCarpool and RideAmigos, which also provide platforms for green commuter reward programs that would complement the overall mission of the PCCN. Parking policy redesign can emphasize carpooling incentives, for example, through semester-long passes or discounts that scale with carpool size. To aid adoption, the University should tap currently idle resources like Planet Blue Ambassadors to create a marketing campaign for carpooling and vanpooling.

Universal access agreements can be set up within a year. Longer-term efforts over several years, in terms of public information and park and ride development, will enhance the value of the initial agreements. Deployment of the U-M Connector and its adaptation to the broader municipal public transportation environment is a longer-term prospect of several years.

Potential implementation challenges: The U-M Connector, which is currently under consideration, will entail very high capital costs and will likely be postponed because of financial challenges associated with the COVID-19 pandemic. However, integration with the municipal public transit environment holds potential savings in two forms: 1) As a shared community resource, an integrated system could form the basis of a joint Ann Arbor/University of Michigan application for federal capital funding. 2) Bus rapid transit is a lower-cost technology for high-volume public transportation than any of its rail-based competitors.[17]

Unknowns, gaps, and/or additional analysis required: Additional analysis is required to determine optimal placement of bus stops on campus as well as current travel behavior to UM-Flint and UM-Dearborn. Regarding integration of the U-M Connector, the funding environment at the federal level is uncertain and is likely to be strongly influenced by both the response to the current public health crisis and the outcome of the November 2020 election.

Critical next steps to catalyze work: In order to move forward, UM-Dearborn and UM-Flint must first reach out to SMART and MTA Flint, respectively, in order to assess the feasibility of universal access collaborations. Regarding the U-M Connector, the University should quickly make public its intent to develop it for integration with the broader transit environment as it develops its plans.

Priority #4 Recommendation: Cycling Improvements

Description: Currently, the University of Michigan lags behind comparison institutions in cycling use (Appendix J, Figure 3.1). The University should take four steps to improve the cycling environment on and to its campuses:

1) Provide the City of Ann Arbor the necessary easement across University property in southern Ann Arbor for the route of the Treeline Trail, a proposed north-south pedestrian-cycle path that can provide access directly to the Diag.
2) Create a workable Central-to-North Campus bike route.
3) Establish an on-campus bike service center on the Ann Arbor campus.
4) Work with the City of Dearborn to fund and complete the bikeways to campus proposed in the City of Dearborn Multimodal Plan (CDMP).

Full descriptions of each policy may be found in Appendix G.

Carbon emissions reduction potential: This recommendation has the potential to reduce emissions by 1,500 metric tons of carbon dioxide equivalent per year, or around 1% of campus emissions. This estimate is based on a scenario in which the University's cycling mode share goes from roughly 3.5% for faculty and staff and 12% for students to 8% and 20%, respectively, numbers based on results achieved by the University of Wisconsin–Madison.[18]

Financial costs, savings, and considerations: With the exception of the on-campus bike service center, no recommended policies require ongoing investments. The City of Dearborn estimates the cost of protected bike lanes and associated street alterations to be $50,000–$500,000 per mile, meaning the proposed trails would cost $150,000–$1,500,000. The city estimates its entire Strategic Improvement Plan (Appendix G, Figure 1.3.1) to cost $6.3 million. Comparable estimates for the proposed campus-to-campus trail in Ann Arbor would require about $1 million to complete. The easement for the Treeline Trail would cost the University no money and only marginal opportunity cost as the University would still retain ownership of the land. Operation of the bike service center would be largely self-supporting. See Appendix G, Section 3.0 for more information.

Equity and justice considerations: Increasing opportunities for safe and convenient cycling allows more University affiliates to forgo automobile ownership or use, which constitutes a significant burden for low-income students, faculty, and staff.

Scalability, transferability, and external engagement: These policies will help build a strong working relationship between the Cities of Ann Arbor and Dearborn and the University around

bike infrastructure, which may be mobilized for further improvements, such as a bikeway between Ann Arbor and Ypsilanti.

Timeline for implementation: For the bike service center, the institutional capacity already exists in the form of the Common Cycle Cooperative. Concerning the lane construction, bike lanes could be built in as few as four months in Dearborn given the prior planning effort and strong political will.[19]

Potential implementation challenges: The campus-to-campus bike lane in Ann Arbor will likely take longer as formal planning efforts have yet to begin, and more substantial construction is necessary to build the ramps to access the Fuller-Maiden Lane underpass.

Unknowns, gaps, and/or additional analysis required: Cycle planning will be enhanced with reliable and regular travel behavior data across the three campuses (Appendix A).

Critical next steps to catalyze work: The University should convey its intention to the City of Ann Arbor to grant an easement for alignment of the Treeline Trail and to the City of Dearborn to work toward completion of the campus bike lanes.

Priority #5 Recommendation: Telecommuting

Description of recommendation: At present, telecommuting is practiced to only a small degree at U-M. Relatively few schools and colleges have a formal telecommuting program, and even among those that do, in some, only a small proportion of employees take advantage of these programs, notwithstanding that nearly one-quarter of all jobs in the United States can be done from home.[20]

While telecommuting has taken place at U-M for some time—mostly informally—the last two years have nevertheless seen a marked increase in schools and colleges developing telecommuting programs. Several units[21] have already established telecommuting programs, and others[22] are considering or reviewing draft policies. Typically, schools and colleges have implemented these programs for benefits unrelated to carbon emissions reductions. Regarding students, policies to facilitate scheduling classes on fewer days can encourage telecommuting on days in which the student does not have classes.

The main type of telecommuting under consideration here is regular telecommuting—that is, on a fixed schedule over a substantial length of time. More irregular telecommuting often does not require a formal policy. Recommendations presented here pertain to U-M staff, whose schedules are more regular and needs more predictable than those of faculty and students.

Carbon emissions reduction potential: At face value, telecommuting seems promising as a means of reducing carbon emissions. However, recent research has suggested that telecommuting may paradoxically increase rather than decrease carbon emissions among telecommuters, a so-called rebound effect stemming from three sources: telecommuters' non-work trips on telecommuting days,[23] telecommuters' willingness to live farther from work,[24] and telecommuters' high use of low-carbon transportation modes, which sharply reduces their savings on telecommuting days.[25] For these reasons, the jury is still out on the carbon reduction potential of U-M telecommuting. Available data show that the average one-way commuting distance of 14 telecommuting employees at U-M's Dearborn campus was 24.1 miles, and among the 248 telecommuting staff at the College of Engineering (Ann Arbor), the distance was 16.8 miles, suggesting that telecommuting was replacing at least some driving to work on telecommuting days (see Appendix K).

Financial costs, savings, and considerations: The financial costs of telecommuting are typically minimal.[26] Where the equipment required is not already on hand at the remote working location, and particularly where this equipment is highly specialized (e.g., secure servers, specialized software, etc.), employers may in some cases cover this cost.

There are substantial benefits to telecommuting apart from those related to carbon emissions.[27] In existing telecommuting programs at U-M, both managers and telecommuting employees regularly report increased productivity while telecommuting. Managers also report telecommuting as an effective tool for both recruitment and retention of talent, and telecommuting employees often report improved morale and general satisfaction with their employment.

For a telecommuting program to be successful, the importance of a clear and strong policy cannot be overemphasized. Managers should evaluate carefully the suitability of employees for telecommuting, including their overall performance, whether their tasks can be accomplished remotely, and whether they have the equipment necessary to telecommute.

Metrics and tracking: Effective tracking of telecommuting would benefit from centralized University data collection on the number of employees telecommuting, number of miles typically commuted, normal commuting mode of transportation, and number of days per week or month telecommuted. These data can be augmented by survey data on non-work vehicle-miles traveled and commute-related attitudes and experiences.

Organizational structure considerations: Typically, telecommuting employees are expected to perform the same duties that they would were they not telecommuting; it is only the working location that changes.

Campus culture and individual accountability considerations: The wholesale change of U-M operations to exclusively remote working during the current public health crisis will contribute significantly to the broader acceptance of telecommuting and increased awareness of its potential benefits.

Equity and justice considerations: In certain cases, telecommuting could be implemented by way of an accommodation for an employee with a disability covered under the Americans with Disabilities Act (ADA). Telecommuting would, however, benefit only classes of employees whose work can be adapted for remote interaction; employees whose work involves physical contact would generally be excluded.

Scalability, transferability, and external engagement: One of the virtues of existing telecommuting programs at U-M is that while schools and colleges articulate a general telecommuting policy, it is up to individual units to determine the details of and implement this policy according to their normal operations. This model speeds up the application and approval processes for telecommuting and ensures that the policy suits the unit in question. In reviewing various existing telecommuting policies, both in U-M schools and colleges and those of other comparable institutions, we have observed significant consistencies between policies, which in turn suggest that the general structure of strong telecommuting policies and best practices are highly transferable.

Timeline for implementation: The time required for a school or college to develop, review, and approve a policy is around 6 months; for individual units to in turn determine the specifics of this

policy for their own operations is around 2 months; for several units at a school or college to pilot telecommuting programs is 6 to 12 months; and for broad implementation across a school is another 6 to 12 months.

Potential implementation challenges: Few obstacles impede the broad adoption of telecommuting policies; the biggest challenge is developing the information needed to gauge their impacts on commute carbon.

Unknowns, gaps, and/or additional analysis required: As explained above, the most significant outstanding question regarding the further development of telecommuting at U-M is the degree to which telecommuting reduces carbon emissions, if at all.

Critical next steps to catalyze work: Given that a fundamental question as to whether telecommuting by U-M employees in fact may reduce carbon emissions remains outstanding, the next step is to gather further information from existing telecommuting programs on this question, as outlined above. In this regard, the telecommuting programs of the School of Engineering and UM-Dearborn Information Technology Services may serve as models, as both programs have developed means of tracking this information. In the meantime, while we lack a basis for encouraging schools and colleges to develop telecommuting programs, there is no basis for discouraging them either, particularly in light of shifts that will continue to occur due to the current global public health crisis.

Appendix A: SCIP Methodology and Questionnaire

1.0 Background

Since 2012, the Sustainability Cultural Indicators Program (SCIP) has been a successful, multi-year effort at understanding the critical environmental issues within the University and the behaviors of its core groups of faculty, staff, and students to measure and track the culture of sustainability at the Ann Arbor campus. The questionnaire was built around the U-M sustainability goals of climate action, waste prevention, healthy environments, and community awareness. The SCIP has been a crucial piece for the understanding of both commuting and other student, faculty, and staff behavior relevant to the University's sustainability goals. However, with the integration of the President's Commission on Carbon Neutrality and the University's commitment to carbon neutrality, a similar sustainability goal should be integrated with the other goals: commuting's carbon impact.

While the commuting team relied heavily on the SCIP survey for travel behavior, the survey is not currently providing reliable estimates of the carbon impact of the commute (and was not designed with that purpose in mind). This is due to the sample having notable geographic under-sampling and over-sampling. In particular, short commutes are under-sampled and longer commutes are oversampled. Furthermore, the survey instrument, sampling procedure, and sampling frame will need to be adapted to the purpose of commute-based carbon monitoring.

To aid in implementing this new survey, this report looks at two of the leaders in transportation surveying for guidance: University of Washington (UW)-Seattle and Yale University. As the landscape of this transportation environment set to change within the coming years, it is imperative that the University continues to track and analyze the behaviors the University's understanding of its populace's commuting behaviors must be prioritized; the introduction of a Transportation Survey will be essential.

2.0 Considerations

The University will have to make considerations regarding data collection and survey administration when deciding to implement a Transportation Survey.

Campus expansion: Currently, the SCIP survey has sampled only the Ann Arbor campus. In order to capture the entirety of the University's commuting behaviors and environmental impact, the Transportation Survey will need to be expanded to the Dearborn and Flint campuses as well. This expansion will require SCIP to work in tandem with each other campus to successfully implement a new survey.

Data acquisition: To ensure spatial representativeness of the campus population, SCIP will need a geographically reliable sampling universe from which to draw. A major roadblock in estimating the University's current carbon impact from commuting is the lack of clean, useable data on home and work locations for students, faculty, and staff. The current available information is gathered using Wolverine Access which requests students and employees enter a "Current Local" address (i.e., residence during the school year), and a "Permanent" address, if different from the "Current Local". Upon spatial analysis of this data, it became evident that students were placing their parents'/home address in the permanent address while not filling out the "Current Local" address because a very large number of addresses for students were not

located in and around Ann Arbor. As a result, the analysis of distance travelled to class/campus was highly erroneous and biased for students. To improve the estimates from this data, it is vital to *require* all students and employees to fill out a "Current Local" address. If the "Current Local" is identical to "Permanent", an option should be included to state "Same as Permanent". This requirement will also improve the ease of future analysis.

3.0 Methodology

The following survey and questionnaire recommendations have been developed with reference to the current SCIP survey and transportation surveys from UW-Seattle and Yale whom are leaders in tracking the environmental impact of their commute. Beyond their leadership, their campuses are similar in population, land size, and accessibility to alternative forms of transportation when compared to the University of Michigan.

3.1 Stratification

With regards to student/employee status, the U-M population should be proportionally stratified into three major subgroups: students, faculty, and staff. Each of these strata should be further divided into four subgroups based on location from campus: 0-1 mile, 1-6 miles, 6-20 miles, and 20+ miles from campus. This is to ensure that a) each stratum has adequate sample size, and b) the distance of the commute, a primary determinant of its carbon impact, is accurately represented in the sample.

The current SCIP survey sampling method is randomly distributed among three different groups: faculty & staff, students, and a panel. This has resulted in geographic under-sampling of students (especially graduate students) and employees further from campus and an over-sampling of those near campus. The extent of this sampling bias is documented in Tables 5.1 and 5.2, after comparing location information from SCIP with University personnel records on a proportional basis. Therefore, the future transportation survey should use random sampling methods with the true population proportions of these double-stratified populations. These stratification methods will account for the variabilities and reduce geographic and transportation biases from under- and over-sampling of certain groups. In order to properly place survey respondents into these stratifications, current student and employee home addresses will be needed from Wolverine Access.

3.2 Sampling

In the most recent SCIP, the survey was emailed to 15,231 (includes panel respondents) employees and students from the Ann Arbor campus, 6,184 participants successfully completed the survey (51.3% faculty and staff, and 36.5% student)[28]. The passive sample design led to a low response rate of 40.6% overall, that over-sampled faculty and staff while it under-sampled students, as demonstrated in the Table 3.2.1 below.

Table 3.2.1 2018 SCIP Survey Population[29]

Category	Population (%)	Sample Size	Response (%)	Response Rate
Faculty/Staff*	57,944 (54.6%)	8,008	4,108 (65.0%)	51.3%
Students	48,090 (45.4%)	5,934	2,166 (35.0%)	36.5%
Total	**106,034**	**13,942**	**6,184**	

Note: Numbers in this table do not include panel respondents
*Includes Michigan Medicine

In order to resolve this problem, one can turn towards the sampling procedures utilized with Yale's Transportation Survey. Yale's survey methods followed guidelines developed by the U.S. Environmental Protection Agency (EPA) for evaluating commuter benefit programs pursuant to air quality regulatory requirements for institutions larger than 20,000 in population size[30]. As a result, Yale achieved survey response rates among each of its population strata roughly proportional to the true population percentages of these same strata with a much smaller sample of 1170 students and employees, as demonstrated in Table 5.3. The smaller sample size allowed more intensive follow-up procedures to reduce non-response among certain groups. U-M should employ the exact same strategy to ensure that true proportions of its populations are accurately represented within the distribution of these groups in the new Transportation Survey, and this will in turn aid in ensuring higher response rates.

3.3 Means of Surveying

Providing new means of administration of the new survey would also increase response and completion of the survey. Currently, sampling of possible future participants is done through email invitation. This method overlooks students who are not accustomed to/tend against using University email as well as a fair proportion of employees that do not often use/check their email for their job (e.g. food service, clerks). Oftentimes, these are also the jobs that are on the lower end of the salary spectrum across U-M employees, which could in turn contribute to the under-sample of people who commute a greater distance to and from campus. To better encapsulate these populations and keep in the equity framework of the PCCN, the Transportation Survey should utilize other existing means (e.g. departmental announcements, chain of command, etc.) to notify potential participants of the survey as well as new means (e.g. phone and paper surveys) for administering the survey to these people. The University could follow the methods of UW-Seattle and Yale, by developing phone based and paper-based versions for distribution beyond the digitally based survey to further reach and more holistically sample the University population[31].

On average, the online survey takes roughly 15 minutes to complete across various platforms (PC, Tablet, and iPhone)[32]. To make sure that potential telephone participants are kept engaged and complete the survey, a stripped-down survey lasting around 5-10 minutes could be developed, consisting of key questions regarding carbon monitoring. The same survey available to those completing the online survey could be made available in hard copy and administered on-campus for the participants.

Qualitative data collected across the Commuting Town Halls held on the Ann Arbor and Dearborn campuses indicate that while much of the U-M population follows regular habits when it comes to its commuting behavior, there is also a fair proportion of students and employees who use a wide variety of transportation modes throughout the week to get to and from campus. A transportation survey will need to be able to collect and quantify this range of behaviors. One integral way to do this is by incorporating a "daily log" for each participant to fill out over the course of one typical, seven-day week (Monday through Sunday) in which they simply log what type of transportation and the time in which they took it during their commute in a day. This is modelled on UW-Seattle's retrospective daily survey in which they ask participants to fill in their commuting behavior for the past seven days[33]. While this does aid in understanding the nuances of a commute, there is plenty of room for error; incorporating a prospective daily log which would take a couple of minutes a day would be more accurate and lead to a better understanding of how daily decisions affect one's commuting behaviors.

4.0 Questionnaire

The SCIP questionnaire (Section 6.0 below) requires modifications in order to serve as a tool for carbon accounting. First, categories such as "Never/Rarely/Sometimes/Always/Most of the Time" are difficult to translate into numerical frequencies. The same applies to "most-often" questions, such as "during the Fall Semester, how did you most often travel to and from campus." Second, retrospective questions about what one did in the past can lead to over- and underestimates on the part of the respondent. A prospective travel diary would be a more reliable approach. Third, carbon accounting demands more specific knowledge of the vehicle used in the commute.

The set of questions posed below encompass questions adapted from the 2018 SCIP Questionnaire, UW-Seattle 2018 Transportation Survey, Yale 2018 Transportation Survey, and new questions to fill the gaps of carbon-monitoring between these surveys. Questions which have been modelled from an existing survey will list the institution which asked this question.

Commuting behaviors for those who live on/around one of the U-M campuses can change depending on the seasons; lower temperatures result in less sustainable means of transportations (e.g. less walking, biking). Therefore, it is recommended to alternate between a fall-focused and winter-focused transportation surveys year-by-year to address the issue of seasonality differences of one's commute.

4.1 Public Transit

4.1.1 What is your access to public transportation (select all that apply)? (Seattle)

1. No service
2. Service with Park and Ride
3. Service with AAATA (Ann Arbor Area Transportation Authority)
4. Service with U-M Buses

4.1.2 Are there any barriers to your use of public transportation (AAATA or U-M Buses) with regards to the following criteria?

1. Cost – is the cost of public transportation too high?
2. Accessibility – are the locations of bus stops accessible for your commute?
3. Speed – is public transportation rapid enough for your commute?
4. Other (fillable)

4.1.3 Are there any barriers to your use of biking with regards to the following criteria?

1. Cost – is the cost of biking too high?
2. Parking – is there a lack of safe and convenient parking?
3. Speed – would cycling to your job take too long?
4. Ability – do you lack the physical or cognitive ability to cycle?
5. Comfort – are you sncomfortable with rules of biking/no knowledge of how
6. Other (fillable)

4.2 Participant Commute

4.2.1 In a typical week, how often are you on campus?

1. Zero days
2. One day
3. Two days

4. Three days
5. Four days
6. Five days
7. Six days
8. Seven days

Note: seven days are included to encompass those employees and students who don't simply commute to campus the typical Monday to Friday.

4.2.2 (Excluding campus housing) Do you spend more than half of your time in one particular campus? (U-M SCIP)

1. Yes
2. No

4.2.3 On which campus is that particular building? (U-M SCIP)

1. Central Campus
2. North Campus
3. Medical Campus
4. The Hill Area of Central/Medical campuses
5. Ross Athletic Campus
6. Elsewhere

Note: The question above is one which is taken from the 2018 SCIP Survey but it can be applied to both the Dearborn and Flint campuses by altering the campus choice selection.

4.2.4 How far is your current residential location from the campus on which you spend more than half of your time?

1. 0-1 mile
2. 1-2 miles
3. 2-4 miles
4. 4-6 miles
5. 6-10 miles
6. 10-15 miles
7. 15-20 miles
8. 20+ miles

4.2.5 In the past year, how often did you use the following modes of transportation to travel between where you live and campus? (U-M SCIP)[2]

	Never	Rarely	Sometimes	Most of the time	Always
Car (drive alone)					

Park & Ride					
Walk					
Bike					
AAATA Bus					
UM Bus					
Carpool					
Vanpool					
UM Greenride Connect					
Motorcycle/Moped/Scooter					
Work from home (telecommute)					
On-demand transportation (Uber, Lyft. etc.)					

Note: the option to work from home was not available for the student survey. This option should be added as students often telecommute into class or watch recorded lectures.

4.2.6 (For each mode of transportation frequency answered "Rarely" to "Always")

How many days in a typical week do you use _____ (mode)?

1. Zero days
2. One day
3. Two days
4. Three days
5. Four days
6. Five days
7. Six days
8. Seven days

4.2.7 (For each mode of transportation answered "Never")

For _____ (mode), why have you never used this mode of transportation?

1. Cost to use is too high
2. Haven't heard of it
3. Do not own it
4. Inconvenient
5. Other (fillable)

Note: these responses may not encompass all possible/likely responses among all different forms of transportation but are general reasons to not use a mode of transportation.

4.2.8 How long is your one-way commute (in minutes)?

1. _____ (open-ended)

The following questions are aimed towards those with a vehicle (any of car, carpool, rideshare, park and ride answered "Rarely" to "Always")

4.2.9 What is the year that the vehicle was built?

1. (participant enters YYYY)

4.2.10 What is your vehicle type? (Yale)

1. Small/Economy
2. Mid-sized
3. Sport Utility/Truck
4. Hybrid/Alternative Fuel
5. Full-sized/Luxury
6. Plug-in electric

4.2.11 (If carpool used “Rarely” to “Always”)

What is your role in the carpool? (Seattle)

1. Driver
2. Passenger
3. Both equally

4.2.12 (If carpool used “Rarely” to “Always”)

With how many people do you carpool?

1. ____ (open-ended)

Note: The purpose of these questions above is to obtain better estimates of the miles per gallon (mpg) of the vehicle which a participant drives, their shared emissions impact, and to get a better understanding of the fleet composition by vehicle type.

4.3 Daily log questions

4.3.1 What was your mode of transportation today?

1. Car (drive alone)
2. Park & Ride
3. Walk/Run
4. Bike
5. AAATA Bus
6. UM Bus
7. Carpool
8. Vanpool
9. UM Greenride Connect
10. Motorcycle/Moped/Scooter
11. Work from home (telecommute)
12. On-demand transportation

4.3.2 When did you depart for campus?

1. Departure time: _ _:_ _ (AM/PM)
2. Arrival time: _ _:_ _ (AM/PM)

4.3.3 When did you depart for home?

1. Departure time: _ _:_ _ (AM/PM)
2. Arrival time: _ _:_ _ (AM/PM)

Note: We want information on when people are traveling to and leaving campus to understand if participants are commuting during peak times versus non-peak times, as well as understand what form of transportation they are using. Linking this data with information collected from the baseline will achieve less biased estimates on a participant's emissions each day.

5.0 Tables

Table 5.1 Faculty/Staff Population Proportions based on SCIP and actual address data

Zone	SCIP Proportion	True Proportion	Weight
< 1 mile	0.00068	0.00262	3.84089
1 - 1.99 miles	0.12875	0.09431	0.73255
2 - 3.99 miles	0.12125	0.11267	0.92920
4 - 5.99 miles	0.05790	0.05173	0.89350
6 - 9.99 miles	0.32016	0.26438	0.82577
10 - 14.99 miles	0.14782	0.15663	1.05965
15 - 19.99 miles	0.08174	0.10496	1.28405
≥20 miles	0.13556	0.21268	1.56896

Table 5.2 Student Population Proportions based on SCIP and actual address data

Zone	SCIP Proportion	True Proportion	Weight
< 1 mile	0.00130	0.00061	0.47058
1 - 1.99 miles	0.75196	0.54634	0.72656
2 - 3.99 miles	0.11271	0.15916	1.41218
4 - 5.99 miles	0.01654	0.01810	1.09440
6 - 9.99 miles	0.07137	0.07257	1.01683
10 - 14.99 miles	0.01349	0.02296	1.70204
15 - 19.99 miles	0.00566	0.01380	2.43885
≥20 miles	0.02089	0.10408	4.98272

Table 5.3 Yale 2017 Transportation Survey[34]

Category	Population	Population (%)	Sample Size (Rounded)	Survey Responses	Survey Responses (%)
Faculty	4503	20.58%	241	187*	15.98%
Postdoc	1244	5.69%	67	67	5.73%
C&T Employee	3593	16.42%	192	192	16.41%
M&P Employee	4366	19.96%	233	287*	24.53%
S&M Employee	921	4.21%	49	49	4.19%
Graduate Student	7250	33.14%	388	388	33.16%
Total	**21877**	**100.00%**	**1170**	**1170**	**100.00%**

6.0 SCIP Questionnaire Discussion

The section below provides all the SCIP questions which relate to a survey respondent's commute along with comments about the adequacy of groups of questions.

6.1 2018 Cross-section Student Questionnaire

We begin by looking at questions found within the student questionnaire.

6.1.1 Questions Regarding Modes of Transportation

How much do you know about the following?

	A lot	A fair amount	A little	Not much/nothing
Bus, AAATA/"The Ride" (Ann Arbor Area Transportation Authority schedules, routes, etc.)	○	○	○	○
Bus, U-M	○	○	○	○
Biking in Ann Arbor (bike lanes, rules of the road, etc.)	○	○	○	○
Renting a car by the hour - Zipcar	○	○	○	○
Renting a car by the hour - Maven	○	○	○	○
U-M GreenRide Connect	○	○	○	○
Arbor Bike	○	○	○	○
U-M After Hours & Emergency Transit/TapRide	○	○	○	○
On-demand transportation (e.g. Uber or Lyft)	○	○	○	○

During the past year, how often did you do the following to travel between where you lived and campus?

	Never	Rarely	Sometimes	Always/ Most of the time
Drive a car and park on campus	○	○	○	○
Park and Ride (the bus)	○	○	○	○
Walk	○	○	○	○
Bike	○	○	○	○
Bus, AAATA/"The Ride" (Ann Arbor Area Transportation Authority schedules, routes, etc.)	○	○	○	○
Bus, U-M	○	○	○	○
Carpool (self-organized with friends or coworkers)	○	○	○	○
U-M GreenRide Connect	○	○	○	○
Vanpool	○	○	○	○
Motorcycle, moped, or scooter	○	○	○	○
On-demand transportation (e.g. Uber or Lyft)	○	○	○	○

In the past week, how often did you ride the bus?

- ○ One day
- ○ Two days
- ○ Three days
- ○ Four days
- ○ Five days

Page Break

During the fall semester, how did you most often travel to and from campus?

- ○ Drive a car
- ○ Park and Ride (the bus)
- ○ Walk
- ○ Bike
- ○ Ride the bus
- ○ Ride the bus and bike
- ○ Ride share (i.e. van/car pool, dropped off, etc.)
- ○ Motorcycle, moped, or scooter
- ○ On-demand transportation (e.g. Uber or Lyft)
- ○ Other *(please specify):*

Page Break

Do you have a car of your own at your local residence this semester?

- ○ Yes
- ○ No

Should the updated survey contain a dairy log, the trip diary will take into account only 7 days of a participant's commute, which may be a week that is abnormal and inconsistent with their overall commuting patterns. For example, the week that a participant fills out the survey may be

a week in which they telecommute to work, but in general, they would be driving to work alone. Therefore, both general questions about typical commute behaviors and a diary would be useful in tandem, but not separately. Questions regarding awareness can be substituted out for questions regarding barriers to different modes of transportation.

6.1.2 Questions Regarding Campus Location

Excluding campus housing, do you spend more than half of your time in one particular campus building?

- ○ Yes
- ○ No

On which campus is that one particular building?

- ○ Central Campus
- ○ The Hill Area of Central/Medical campuses
- ○ Medical Campus
- ○ North Campus
- ○ Ross Athletic Campus - between Packard & Stadium
- ○ Elsewhere

Listed below are several buildings on Central Campus. Sometimes buildings are known by more than one name. Please review the list of building names to find the one in which you spend more than half of your time (for activity such as work, classes, or studying). If you do not see the name of your building, select "Other" and type in the name of the building.

Please select the name of the building in which you spend more than half of your time:

- ○ Angell Hall
- ○ Central Campus Recreation Building
- ○ Chemistry
- ○ Clarence Cook Little Building
- ○ Dana Building (SEAS)
- ○ David M. Dennison Building
- ○ Dental Building
- ○ East Hall
- ○ East Quad
- ○ Harlan Hatcher Graduate Library
- ○ Health Services
- ○ Hutchins Hall
- ○ Law School (including South Hall)
- ○ Lorch Hall
- ○ Mason Hall
- ○ Michigan Union
- ○ Modern Languages Building
- ○ Munger Graduate Residences
- ○ North Quad
- ○ Ross School of Business
- ○ School of Education
- ○ School of Public Health I or II
- ○ School of Social Work
- ○ Shapiro Undergraduate Library
- ○ South Quad
- ○ Weill Hall
- ○ West Hall

Listed below are several buildings on the Medical Campus. Sometimes buildings are known by more than one name. Please review the list of building names to find the one in which you spend more than half of your time (for activity such as work, classes, or studying). If you do not see the name of your building, select "Other" and type in the name of the building.

Please select the name of the building in which you spend more than half of your time:

- ○ Biomedical Science Research Building
- ○ C. S. Mott Children's Hospital
- ○ Children's Psychiatric Hospital
- ○ Kellogg Eye Center
- ○ Kresge Hearing Research Institute
- ○ Learning Resource Center, Taubman Medical Library
- ○ Medical Science Research, Building III
- ○ Medical Science Research, Building I
- ○ Medical Science Research, Building II
- ○ Mental Health Research Institute
- ○ North Ingalls Building
- ○ School of Nursing (North Ingalls Building)
- ○ School of Public Health I or II
- ○ University Hospital
- ○ Women's Hospital
- ○ Other *(please specify):*

Listed below are several buildings on North Campus. Sometimes buildings are known by more than one name. Please review the list of building names to find the one in which you spend more than half of your time (for activity such as work, classes, or studying). If you do not see the name of your building, select "Other" and type in the name of the building.

Please select the name of the building in which you spend more than half of your time:

- ○ Art & Architecture Building
- ○ Blanch Anderson Moore Hall, School of Music
- ○ Bob and Betty Beyster Building (formerly CSE)
- ○ Bursley Hall
- ○ Charles R. Walgreen, Jr. Drama Center
- ○ Chrysler Center
- ○ Cooley Building
- ○ Dow Engineering Building
- ○ Duderstadt Center
- ○ Earl V. Moore Building, School of Music
- ○ Electrical Engineering and Computer Science Building
- ○ Engineering Research Building 1
- ○ Engineering Research Building 2
- ○ Environmental & Water Resources Engineering Building
- ○ Ford Library
- ○ Francois-Xavier Bagnoud Building
- ○ G. G. Brown Laboratory
- ○ Gorguze Family Laboratory (formerly EPB)
- ○ Industrial and Operations Engineering Building
- ○ Lurie Biomedical Engineering Building
- ○ Lurie Engineering Center
- ○ Naval Architecture and Marine Engineering Building
- ○ North Campus Recreation Building
- ○ Phoenix Memorial Laboratory
- ○ Pierpont Commons
- ○ Space Research Building
- ○ Stamps Auditorium
- ○ Sterns Building
- ○ Walter E. Lay Automotive Lab
- ○ Other *(please specify):*

Listed below are several buildings in the Hill Area of the Central and Medical Campuses. Sometimes buildings are known by more than one name. Please review the list of building names to find the one in which you spend more than half of your time (for activity such as work, classes, or studying). If you do not see the name of your building, select "Other" and type in the name of the building.

Please select the name of the building in which you spend more than half of your time:

- ○ Alice Lloyd Hall
- ○ Central Campus Recreation Building (including Margaret Bell Pool)
- ○ Couzens Hall
- ○ Dance Building, 1310 N University Court
- ○ Henry Vaughan Building, School of Public Health I
- ○ Margaret Bell Pool, Central Campus Recreation Building
- ○ Mary Markley Hall
- ○ Mosher Jordan Hall
- ○ Observatory Lodge, 1402 Washington Heights
- ○ Stockwell Hall
- ○ Thomas Francis, Jr Building, School of Public Health II
- ○ School of Public Health I or II
- ○ Other *(please specify):*

Listed below are several buildings on the Ross Athletic Campus. Sometimes buildings are known by more than one name. Please review the list of building names to find the one in which you spend more than half of your time (for activity such as work, classes, or studying). If you do not see the name of your building, select "Other" and type in the name of the building.

Please select the name of the building in which you spend more than half of your time:

- ○ Campus Safety Services Building
- ○ Crisler Center
- ○ Donald B. Canham Natatorium
- ○ Institute of Continuing Legal Ed
- ○ Intramural Sports Building
- ○ John P. Weidenbach Hall
- ○ Schembechler Hall
- ○ Stephen M. Ross Academic Center
- ○ William D. Revelli Hall
- ○ William Davidson Player Development Center
- ○ Yost Ice Arena
- ○ Other *(please specify):*

Question: STUDQUES56_OTHER
Show if: (STUDQUES56_CAMPUS = 3:[Elsewhere])

Please type the name of the building on campus in which you spend more than half of your time (for activity such as work, classes, or studying).

Name of Building:

The above questions regarding the campus and building at which a participant spends more than half of their time is useful for where the participant commutes every day. If it is necessary to shorten the length of the survey, keeping questions of campus and getting rid of questions regarding a specific building can be utilized as the information regarding campus is more important when it comes to carbon monitoring.

6.2 2018 Faculty and Staff Questionnaire

We now look at questions found within the faculty and staff questionnaire.

6.2.1 Questions Regarding Modes of Transportation

How much do you know about travel by:

	A lot	A fair amount	A little	Not much/ nothing
Bus, AAATA/"The Ride" (Ann Arbor Area Transportation Authority schedules, routes, etc.)	○	○	○	○
U-M buses (schedules, routes, etc.)	○	○	○	○
Biking in Ann Arbor (bike lanes, rules of the road, etc.)	○	○	○	○
Renting a car by the hour - Zipcar	○	○	○	○
Renting a car by the hour - Maven	○	○	○	○
U-M Vanpools (VanRide)	○	○	○	○
U-M Greenride Connect	○	○	○	○
Arbor Bike	○	○	○	○
U-M After Hours & Emergency	○	○	○	○

Transit/TapRide				
On-demand transportation (e.g. Uber or Lyft)	○	○	○	○

During the past year, how often did you do the following to travel between your home and your U-M workplace?

	Never	Rarely	Sometimes	Always/ Most of the time
Drive a car (alone or with family members) and park on campus	○	○	○	○
Park and Ride (the bus)	○	○	○	○
Walk	○	○	○	○
Bike	○	○	○	○
Bus, AAATA/"The Ride" (Ann Arbor Area Transportation Authority schedules, routes, etc.)	○	○	○	○
Bus, U-M	○	○	○	○
Carpool (self-organized with friends or coworkers)	○	○	○	○
U-M Greenride Connect	○	○	○	○
U-M Vanpools (VanRide)	○	○	○	○
Motorcycle, moped, or scooter	○	○	○	○

Did not travel (worked from home/telecommuted)	○	○	○	○
On-demand transportation (e.g. Uber or Lyft)	○	○	○	○

In the past week, how often did you ride the bus?

- ○ One day
- ○ Two days
- ○ Three days
- ○ Four days
- ○ Five days

How do you most often travel to and from home to your work place?

- ○ Drive a car
- ○ Park and ride (the bus)
- ○ Walk
- ○ Bike
- ○ Ride the bus
- ○ Ride the bus and bike
- ○ Ride share (e.g. vanpool, car pool, dropped off, etc.)
- ○ Motorcycle, moped, or scooter
- ○ On-demand transportation (e.g. Uber or Lyft)
- ○ Other *(please specify:)*

Questions need to be posed about exactly why participants are “rarely” or “never” using certain forms of transportation. The SCIP survey dives into barriers for carpooling below, but these types of questions should be expanded to every form of transportation.

6.2.2 Parking Questions

Where do you most often park?

- ○ U-M gold/blue parking lot or structure
- ○ U-M yellow parking lot
- ○ U-M orange parking lot
- ○ U-M free Park & Ride lot
- ○ AAATA Park & Ride lot
- ○ Other *(please specify:)*

On a typical day, how easy it is for you to find a parking space?

- ○ Very easy
- ○ Somewhat easy
- ○ Not very easy
- ○ Not at all easy

While informative, the two questions above regarding parking aren’t exactly linked to monitoring carbon and can be removed to save time for other questions.

6.2.3 Time of Travel Questions

On a typical workday, when do you usually leave home for campus?

- ○ Midnight-5:59AM
- ○ 6:00-6:59AM
- ○ 7:00-7:59AM
- ○ 8:00-8:59AM
- ○ 9:00-9:59AM
- ○ 10:00AM-11:59PM

If you were to use the U-M carpooling service, would you be willing to leave home earlier or later than when you now leave?

- ○ Willing to leave home earlier
- ○ Willing to leave home later
- ○ Willing to leave home either earlier or later
- ○ I am not willing to leave home earlier or later

How much earlier would you be willing to leave home?

- ○ Up to 10 minutes earlier
- ○ 10-20 minutes earlier
- ○ 20-30 minutes earlier

How much later would you be willing to leave home?

- ○ Up to 10 minutes later
- ○ 10-20 minutes later
- ○ 20-30 minutes later

How much earlier or later would you be willing to leave home?

	Up to 10 minutes	10-20 minutes	20-30 minutes
Earlier	○	○	○
Later	○	○	○

The questions above can aid in adding in information of if participants are travelling in peak vs. non-peak times, but the questions can be coalesced together more to aid in shortening the number of questions.

6.2.4 Ridesharing and Carpooling Questions

This next set of questions is about *ridesharing or carpooling*, that is driving to/from work with others who live/work close to you. U-M currently supports and promotes carpool, vanpool and other ride sharing programs.

What do you think is the most important benefit of carpooling?

- ○ Save money (e.g. fuel, car repair, parking, etc.)
- ○ Reduce impact on the environment
- ○ Enjoy the company of others while commuting
- ○ Get some added sleep/rest
- ○ Other *(please specify:)* _____

If U-M were to expand and improve a carpool service and incentivize its use, how likely would you be to use it?

- ○ Very likely
- ○ Somewhat likely
- ○ Unsure/Don't know
- ○ Not very likely
- ○ Not at all likely

How much do you agree or disagree with each of the follow statements about carpool riders and drivers.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Would prefer same group of riders each day	○	○	○	○	○
Wouldn't mind changing riders once in a while	○	○	○	○	○
Wouldn't mind changing riders if driver was the same.	○	○	○	○	○
Wouldn't mind different drivers if riders were the same.	○	○	○	○	○
Wouldn't mind having different riders and drivers all the time.	○	○	○	○	○

Number of cars and trucks (passenger vehicles) owned/leased by your household:

- ○ None
- ○ 1
- ○ 2
- ○ 3
- ○ 4 or more

What is the primary reason you drive a car to work?

- ○ Convenience
- ○ Work schedule
- ○ Home/family schedule
- ○ Length of commute
- ○ Other *(please specify):*

If you don't currently carpool to campus, what are the obstacles to carpooling?

(Select All That Apply)

- ☐ Takes extra time
- ☐ Difficult to coordinate schedules
- ☐ Lack of privacy/comfort
- ☐ Lack of flexibility/freedom
- ☐ Safety issues
- ☐ Not knowing who my fellow passengers might be
- ☐ Carpooling doesn't make sense from my home location
- ☐ Other *(please specify:)*

The above questions regarding carpooling are very useful in gauging participants' barriers to carpooling and should continue to be asked in future surveys to continue to understand these barriers. However, they should be expanded to all forms of transportation to get better understanding of the different types of barriers to different modes of transportation.

6.2.5 Questions Regarding Campus Location

On which campus do you mainly work?

- ○ Central Campus *(includes the Law School and Diag, among many others)*
- ○ East Medical Campus and Properties *(includes buildings off Plymouth road, among others)*
- ○ Medical Campus *(U-M Hospital and surrounding medical buildings)*
- ○ North Campus *(between Fuller and Plymouth Roads)*
- ○ Ross Athletic Campus *(South of Packard to Stadium)*
- ○ Other *(including Wolverine Tower)*
- ○ *I'm not sure - show me a map*

Listed below are many buildings on Central Campus. Some buildings are known by more than one name. If you do not see the name of the building where you work, please select "Other" and type in the name of the building in which you work.

Please select the name of the building where you mainly work.

- ○ Angell Hall
- ○ Central Campus Recreation Building
- ○ Central Power Plant
- ○ Chemistry
- ○ Clarence Cook Little Building
- ○ Dana Natural Resources Building
- ○ Dental & W.K. Kellogg Institute
- ○ East Hall
- ○ Edward Henry Kraus Building
- ○ Ford School of Public Policy
- ○ Harlan Hatcher Graduate Library
- ○ Haven Hall
- ○ Hutchins Hall
- ○ Institute For Social Research
- ○ Law School (including South Hall)
- ○ Literature Science and the Arts
- ○ Lorch Hall
- ○ Modern Languages Building
- ○ Munger Graduate Residences
- ○ Museum of Natural History
- ○ North Quad
- ○ Palmer Commons
- ○ Randall Laboratory
- ○ Ross School of Business
- ○ School of Education
- ○ School of Public Health I or II
- ○ School of Social Work Building
- ○ Shapiro Harold & Vivian Library
- ○ Student Activities Building
- ○ Tisch Hall
- ○ Undergraduate Science Building
- ○ University Health Services
- ○ West Hall
- ○ 202 S. Thayer
- ○ Other *(name of building):*

Listed below are buildings on East Medical Campus and Properties. Some buildings are known by more than one name. If you do not see the name of the building where you work, please select "Other" and type in the name of the building in which you work.

Please select the name of the building where you mainly work.

- ○ Arbor Lakes Building 1, 2 or 3
- ○ Arbor Lakes Building 2
- ○ Arbor Lakes Building 3
- ○ Domino's Farms
- ○ East Ann Arbor Health & Geriatrics Center
- ○ Matthaei Botanical Gardens or Nichols Arboretum
- ○ Rachel Upjohn Building
- ○ Other *(name of building):*

Listed below are buildings on the Medical Campus. Some buildings are known by more than one name. If you do not see the name of the building where you work, please select "Other" and type in the name of the building in which you work.

Please select the name of the building where you mainly work.

- ○ A. Alfred Taubman Biomedical Science Research Building
- ○ A. Alfred Taubman Health Care
- ○ A. Alfred Taubman Health Sciences Library
- ○ Brehm Tower
- ○ Cancer Center
- ○ Detroit Observatory
- ○ Frankel Cardiovascular Center
- ○ Kellogg Eye Center
- ○ Life Sciences Institute
- ○ Med Inn
- ○ Medical Science Research Building I, II or III

- ○ Medical Science Unit I or II
- ○ Medical Science Unit II
- ○ Medical Science Unit III
- ○ Mott Children's Hospital
- ○ Neuroscience Hospital
- ○ Neuroscience Hospital Unit 2
- ○ Palmer Commons
- ○ School of Nursing
- ○ School of Public Health I or II
- ○ Undergraduate Science Building
- ○ University Hospital
- ○ Von Voigtlander Women's Hospital
- ○ Other *(name of building):*

Listed below are buildings on North Campus. Some buildings are known by more than one name. If you do not see the name of the building where you work, please select "Other" and type in the name of the building in which you work.

Please select the name of the building where you mainly work.

- ○ Art and Architecture Building
- ○ Bentley Historical Library
- ○ Bob and Betty Beyster Building
- ○ Carl A. Gerstacker Building
- ○ Chrysler Center Engineering
- ○ Duderstadt Center
- ○ Electrical Engineering and Computer Science Building
- ○ Engineering Research Building
- ○ Francois-Xavier Bagnoud Building
- ○ GG Brown Laboratory
- ○ Gorguze Family Laboratory
- ○ Herbert H. Dow Building

- ○ Industrial and Operations Engineering Building
- ○ Moore Building
- ○ Naval Architecture and Marine Engineering Building
- ○ North Campus Administrative Complex
- ○ North Campus Facilities Services Building
- ○ North Campus Research Complex
- ○ Space Research Building
- ○ Transportation Research Institute
- ○ Walgreen Drama Center
- ○ Walter E Lay Automotive Laboratory
- ○ Other *(name of building):*

Listed below are buildings on the Ross Athletic Campus. Some buildings are known by more than one name. If you do not see the name of the building where you work, please select "Other" and type in the name of the building in which you work.

Please select the name of the building where you mainly work.

- ○ Administrative Services Building
- ○ Argus Building
- ○ Boyer Building
- ○ Buhr Building
- ○ Campus Safety Services Building
- ○ Donald B. Canham Natatorium
- ○ Facility Services Building A, B or C
- ○ Hoover Annex
- ○ Hoover Heating Plant
- ○ Institute of Continuing Legal Ed
- ○ Intramural Sports Building
- ○ John P. Weidenbach Hall
- ○ Madison Building
- ○ Schembechler Hall
- ○ Transportation Services Building
- ○ William D. Revelli Hall

- ○ William Davidson Player Development Center
- ○ Yost Ice Arena
- ○ Other *(name of building):*

Listed below are other U-M buildings where you may work. Some buildings are known by more than one name. If you do not see the name of the building where you work, please select "Other" and type in the name of the building in which you work.

Please select the name of the building where you mainly work.

- ○ A. Alfred Taubman Biomedical Science Research Building
- ○ Argus Building I or II
- ○ Argus Building II
- ○ Brehm Tower
- ○ Briarwood Medical Group Buildings
- ○ Campus Safety Services Building
- ○ Central Campus Recreation
- ○ Couzens Hall
- ○ Detroit Observatory
- ○ Kellogg Eye Center
- ○ KMS Building
- ○ School of Public Health I and II
- ○ Stockwell Hall
- ○ Wolverine Tower
- ○ Other *(name of building):*

The above questions regarding the campus and building at which a participant spends more than half of their time is useful for where the participant commutes every day. The University

contains data on the work location of U-M employees, so these questions could be removed should access be gained to home/work addresses.

[1] U-M Graham Sustainability Institute, *SCIP Methodology Report (2018)*, 29.

[1] U-M Ann Arbor Population Figures https://umich.edu/facts-figures/

[1] *Guidance for Quantifying and Using Emission Reductions from Best Workplaces for Commuter Programs in State Implementation Plans and Transportation Conformity Determinations*, 42.

[1] University of Washington-Seattle, *2018 Transportation Survey*, 12.

[1] U-M Graham Sustainability Institute, *SCIP Methodology Report (2018)*, 6.

[1] University of Washington-Seattle, *2018 Transportation Survey*, 24.

[1] Yale University,*2017 Transportation Survey Report*, 4

Appendix B: Carbon-Accounting Methodology

1.0 Introduction

This appendix presents the central method that the commuting team used to estimate commute carbon and predict the impact of policy changes. We developed a series of estimates of commuting by commute distance and campus destination on both a per-capita and a total basis. (Table 2.3.2 through 2.3.4) There are three factors that determine a commuter's yearly commute carbon emissions: their distance to work, their mode of travel, and the number of days worked per year. Annual emissions are the product of distance per day, emissions per mile for their mode of travel, and number of commutes per year. Calculating emissions for the entire University involved finding or approximating those data for all University students, faculty, and staff, termed here "affiliates." Finally, different policies were analyzed by varying some or all of these values based on best estimates of the impacts of these policies. Section 2 below describes the methodology for finding or computing the spatial distribution of affiliates, their modeshare, and their emissions. Section 3 describes how estimates for various scenarios were generated.

2.0 Data Collection

2.1 Computing Spatial Distribution of Affiliates

2.1.1 Overview of Method

The goal of this analysis was to assign all affiliates to a campus location as a destination for which mode share data was available as a function of distance. These were Central Campus, North Campus, South Campus, Medical, East Medical, or Other for Ann Arbor; Dearborn or Flint. The 'other' category contained affiliates at outlying locations like the Biological Station or hospitals in Canton or Livonia. It was not feasible to cover these locations in the analysis due to insufficient data. Affiliates at each campus location were then divided into distance bands that corresponded to mode share data available through the Sustainability Cultural Indicators Project (SCIP).

To place affliates within these distance bands, we geocoded anonymized employee and student home and work addresses received from the University HR department, taking steps to maintain data privacy and security. Tables 2.1.1 and 2.1.1 below contain these locational results for students, and faculty and staff respectively.

2.1.2 Steps in the Analysis

Analysis proceeded as follows:

1. Affiliates assigned to a campus location by cross referencing work address to a table of campus buildings by campus location
2. Outstanding addresses from step 1 manually assigned to a campus location after geocoding using ArcGIS Pro

3. For each campus location, network distance (i.e. drive distance) bands were created from a central point with the following cutoffs consistent with SCIP: 1, 2, 4, 6, 10, 15, 20 miles
4. All affiliates within a distance band (e.g. 0-1 miles, 10-15 miles, 20+ miles) were assigned to that distance band

Table 2.1.1 Student Population by Location

Distance (mi)	Ann Arbor		Dearborn		Flint	
0-1	17299	44.2%	112	1.4%	216	2.1%
1-2	3811	9.7%	219	2.7%	152	1.5%
2-4	8173	20.9%	1236	15.0%	566	5.6%
4-6	1220	3.1%	981	11.9%	612	6.1%
6-10	732	1.9%	939	11.4%	2014	19.9%
10-15	486	1.2%	1584	19.2%	964	9.5%
15-20	571	1.5%	1297	15.7%	822	8.1%
20+	6815	17.4%	1873	22.7%	4754	47.1%
Total	39107		8241		10100	

Table 2.1.2 Faculty and Staff Population by Location

Distance (mi)	Central		North		East Medical		Medical		South		Other*	Dearborn		Flint	
0-1	1017	6.4%	386	5.8%	5	0.4%	64	0.3%	67	1.8%		14	1.1%	44	3.5%
1-2	2108	13.2%	783	11.7%	13	1.1%	753	4.0%	175	4.8%		17	1.4%	51	4.1%
2-4	3129	19.6%	1349	20.2%	55	4.5%	2380	12.8%	351	9.6%		145	11.7%	63	5.0%
4-6	1579	9.9%	754	11.3%	92	7.5%	1790	9.6%	269	7.4%		77	6.2%	70	5.6%
6-10	1862	11.7%	723	10.8%	248	20.2%	2269	12.2%	512	14.0%		141	11.3%	265	21.1%
10-15	1259	7.9%	675	10.1%	245	20.0%	2214	11.9%	486	13.3%		260	20.9%	124	9.9%
15-20	1406	8.8%	580	8.7%	180	14.7%	2687	14.4%	607	16.6%		242	19.5%	119	9.5%
20+	3568	22.4%	1438	21.5%	388	31.6%	6490	34.8%	1179	32.3%		347	27.9%	521	41.4%
Total	15928		6688		1226		18647		3646		2590	1243		1257	

*Other contains farflung locations like the biological station and hospitals in Livonia, Canton, etc. where analysis was not possible

2.2 Estimating Mode share

The proportion each transportation mode used to reach each campus based on the distance from faculty, staff, and student's campus location was estimated for further analysis of carbon emissions from the commute. These estimates were derived so that different emissions per mile could be placed upon the distance travelled bands across each campus.

2.2.1 Using SCIP Data

Modeshare estimates were compiled based on data available from the 2018 SCIP survey. Percentages were estimated from two questions located in the faculty and staff survey and the student cross-section survey, each asking the survey participant about the mode of transportation they most often traveled to and from campus; proportions were then estimated. These proportions were then split among each of the campuses in a matrix containing the proportion between the distance bands outlined above and the method of transportation from data on where the survey participants spend most of their time on campus, for work and for class respectively.

2.3 Estimating Emissions per Mile

Emissions per mile were taken from the EPA's Emissions Factors for Greenhouse Gas Inventories[35], and the following assumptions:

1. Walking and cycling produce negligible emissions
2. Rideshares have two participants
3. Park and riders split their commute evenly between driving and transit

In particular assumption 2 is likely to overestimate emissions slightly since vanpools comprise a large share of all rideshares and have at least 3 participants on any given day. Table 2.3.1 contains the emissions per mile by mode used for all commuting team analysis.

Table 2.3.1 Emissions per Passenger Mile (kg of carbon equivalent/mile)

Drive Alone	Walk/Bike	Bus	Park and Ride	Micro	Rideshare
0.347	0	0.056	0.202	0.191	0.173

Table 2.3.2: Current Carbon-Equivalent Impact of the Faculty and Staff Commute Per Capita, by Distance Traveled and Campus Destination (kilograms per person per day)

Commute Distance (mi)	Central Campus	North Campus	Medical Campus	East Medical Campus	South Campus	Total UM Ann Arbor	UM Dear-born	UM Flint
0-1	0.1	0.2	0.1	0.3	0.3	0.2	0.1	0.1
1-2	0.5	0.7	0.6	1.0	0.8	0.6	0.6	0.6
2-4	1.6	1.7	1.6	2.1	2.1	1.6	1.7	1.7
4-6	2.8	3.5	2.8	2.7	3.5	3.0	2.9	2.9
6-10	4.9	5.5	5.0	5.5	5.5	5.1	5.2	5.2
10-15	7.9	8.7	8.1	8.7	8.7	8.2	7.2	7.2
15-20	12.1	12.1	9.8	12.1	12.1	11.0	11.1	11.1
20+	19.6	20.8	19.6	19.5	20.8	19.8	19.4	19.4
All	7.3	7.8	10.3	11.1	11.2	9.0	10.0	11.2

Table 2.3.3: Current Carbon-Equivalent Impact of the Faculty and Staff Commute by Distance Traveled and Campus Destination (metric tons per year)

Commute Distance (mi)	Central Campus	North Campus	Medical Campus	East Medical Campus	South Campus	Total UM Ann Arbor	UM Dearborn	UM Flint	Total UM
0-1	27	27	2	0	6	58	0	2	60
1-2	269	139	122	3	36	568	3	8	579
2-4	1,234	579	940	29	183	2,965	60	26	3,051
4-6	1,121	654	1,240	63	233	3,310	57	52	3,419
6-10	2,289	1,003	2,815	344	710	7,160	182	342	7,684
10-15	2,496	1,463	4,474	531	1,053	10,017	466	222	10,705
15-20	4,266	1,760	6,587	546	1,842	15,001	669	329	15,999
20+	17,505	7,479	31,815	1,891	6,132	64,823	1,683	2,526	69,032
Total	29,207	13,100	47,994	3,408	10,195	103,903	3,119	3,506	110,528

Table 2.3.4: Carbon Equivalent Impact of the Student Commute by Distance Traveled and Campus Location

	Impact per capita (kilograms per student per day)			**Impact total (metric tons per year)**			
Com-mute Distance (mi)	**Ann Arbor**	**Dearborn**	**Flint**	**Ann Arbor**	**Dearborn**	**Flint**	**Total**
0-1	0.1	0.1	0.1	161	1	2	164
1-2	0.2	0.2	0.2	106	6	4	117
2-4	0.6	0.6	0.6	930	141	64	1,135
4-6	1.8	1.8	1.8	386	311	194	891
6-10	2.3	2.3	2.3	308	395	847	1,549
10-15	7.9	7.9	7.9	692	2,254	1,372	4,318
15-20	11.5	11.5	11.5	1,179	2,678	1,697	5,554
20+	19.3	19.3	19.3	23,723	6,520	16,549	46,792
All	3.9	8.3	11.4	27,485	12,305	20,729	60,519

3.0 Policy Modeling

All policies proposed by the commuting team pull on one of two levers: 1) changing mode share and/or 2) altering the distribution of population among the distance bands or campus destinations of the commute. The combination of a distance band and campus destination is referred to below as “buckets.” For each policy, we made assumptions based on results seen at comparable peer institutions upon adopting best practices. The remainder of this appendix details the assumptions made for each policy.

3.1 Housing Policy

1. New housing units will be distributed randomly throughout the population living more than 1 mile from campus. That is, no preference is given to affiliates living farther away over those living closer.
2. Mode share for each bucket will not change as a result of moving population

3.2 Transit Policy

1. Bus mode share in response to a universal access agreement will increase as described in table 3.2.1

Table 3.2.1 Change in Mode Share in Dearborn from Transit Policy

Distance (mi)	Drive Alone	Bus
0-1	-0.1	0.1
1-2	-0.1	0.1
2-4	-0.08	0.08
4-6	-0.06	0.06
6-10	-0.04	0.04
10-15	-0.01	0.01
15-20	-0.01	0.01
20+		

3.3 Parking Policy

1. Decreases in parking are equivalent to MIT’s value of 13% on the Ann Arbor campus and half that on the Dearborn and Flint campuses due to much easier parking environment
    a. See body of report ‘Parking Policy’

2. Decrease in drive alone is distributed between walking/biking, bus, and rideshare along in the shares given in table 3.3.1
3. Decrease in drive alone concentrated around 1-4 miles due to ease of alternatives

Table 3.2.1 Distribution of decrease in drive alone share

Distance (mi)	Walk/Bike	Bus	Rideshare
0-1	100%	0%	0%
1-2	50%	50%	0%
2-4	50%	50%	0%
4-6	33%	67%	0%
6-10	0%	100%	0%
10-15	0%	83%	17%
15-20	0%	50%	50%
20+	0%	0%	100%

3.4 Cycling Policy

1. Cycling rates will see comparable improvements to those seen at the University of Wisconsin Madison following comparable improvements: mode share at the Ann Arbor campus: 12% for faculty and staff and 22% for students.
    a. See body of report 'Climate Impacts'
2. Change in cycling rates in Dearborn will be half those in Ann Arbor
3. Increased cycling only detracts from drive alone mode share

3.5 Rideshare Policy

1. Rideshare rates will reach University of Indiana mode share on all campuses: 11% for faculty and staff, and 10% for students
    a. See body of report 'Climate Impacts'
2. Increased rideshare detracts from drive alone mode share
3. Rideshare utilization will not be a function of distance
    a. i.e. all bands will have the modeshare for their demographic

Appendix C: Housing and Land Use Detailed Analysis

1.0 Introduction

This appendix provides background information on the commuting team's recommendations regarding housing. The University of Michigan increased its student housing stock twice in the past 15 years,[36] yet the percentage of students housed on campus at the University of Michigan is lower than many peer institutions of a similar caliber.[37] U-M does not currently actively pursue the provision of housing to faculty and staff. UC Irvine, the University of Chicago, UC Santa Cruz, and Stanford are examples of peer institutions that all provide faculty and staff housing.[38] UC Santa Cruz, UC Irvine, and Stanford build and provide housing to faculty and staff for rent or purchase though a land lease. These universities and Syracuse University provide financial assistance to faculty and staff who purchase a home near campus.[39] Additionally, universities such as the University of Chicago and Purdue are expanding their undergraduate housing as housing markets become more restrictive and enrollment increases.

The proposed solution would require a multiphase process that would take many years to implement. The proposed strategy comprehensively brings students, faculty and staff closer to campus. It consists of two parts:

- Develop student, faculty, and staff housing on the Ann Arbor campus
- Provide financial incentive programs that meet the context of each campus and encourage employees to live closer to their work.

Housing development can be phased in to allow the university to evaluate resource availability and current needs. The cost of these programs should be net zero or positive as university housing in the past has been a net zero endeavor.[40] The inclusion of faculty and staff housing and a housing proximity incentives program should allow the university to generate revenue from housing. On-campus faculty and staff housing will also bring non-monetary benefits to the university through a stronger sense of community, attracting and retaining new talent, and financial stability of the employees. In fact, recruitment and community development were the original motivation behind employee housing at UC Irvine, UC Santa Cruz, and Stanford.[41]

2.0 UC Santa Cruz, UC Irvine, and Stanford - Models for Land Leasing & Renting

UC Santa Cruz, UC Irvine, and Stanford are examples of peer institutions with robust for-sale and for-rent housing programs.[42] These institutions were selected due to the history of their housing programs, availability of information, positioning in constrained housing markets, and peer institutional rankings by US World News Report.[43] UC Santa Cruz views its housing as a tool to meet "institutional goals for the recruitment and retention of long-term qualified faculty and staff, and support creation of communities of learning." Stanford and UC Irvine view their faculty and staff housing in a similar manner.[44]

Each institution has a set of qualification criteria to evaluate faculty and staff members in efforts to manage their limited supply. UC Santa Cruz uses their system in an effort to ensure no group is excluded by being outpriced for a home.[45] Employees are ranked into Senate (academic senate), non-senate academics (except for visiting appointees, post-doctoral, and academic student titles), and Staff. An allocated amount of housing is assigned to each ranking group. UC Irvine's for-rent and for-sale functions on a waiting list based on a ranking system however, no specific numbers of units are allocated to each group.[46] New members of the academic senate and senior management are the highest priority, followed by existing academic senate and senior management, then newly recruited non-senate academic staff, management and professionals, and finally current academic staff, management, professionals, and university staff as the lowest priority. Stanford's for rent and for sale appears to function on a first-come, first-served basis.[47]

The housing policy of UC Santa Cruz was revisited in 2002 and completed in 2008 in order to bolster its ability to help with recruitment and align with the University's Long Range Development Plan (LRDP).[48] The LRDP evaluates sites for new housing based on infrastructure, neighborhood opposition, location to the coastal zone, and if part of the City of Santa Cruz, environmental issues. As of 2008 the university had 6 active housing sites with 188 for sale units and 38 rental units.[49]

UC Irvine's Campus Housing Authority has been in operation since 1983 and is the nation's largest on-campus, for-sale workforce housing.[50] It currently has 300 acres with 1,482 households (1,122 for-sale homes & 360 rental units). Approximately 4,000 people reside in the on-campus faculty and staff housing. This living arrangement even works for a variety of families as 40% of households have school age children or younger.[51]

Stanford currently has over 700 on- and off-campus rental units and an additional 900 residential on-campus leaseholds.[52] The most recent housing expansion was the University Terrace and Cardinal Apartments.[53] At University Terrace, there are 112 condominium homes and 68 single-family homes in the complex. The development is advertised to be within walking distance of the campus and downtown.

2.1 For Sale Programs - Land Leasing

These universities use what is known as a ground lease or land lease when selling a property on their campus. The university owns the land, leasing it to the employee who is given ownership of the structure.[54] Such a system is attractive to the employee because they can accrue equity as the value of the home appreciates. When they decide to move and sell the home, they have the ability to make money from the sale, though in most cases the contract restricts appreciation to ensure affordability. The university benefits by making money from the lease payments while retaining ownership of the land. Retaining ownership ensures the university will always be able to use the property for employee housing. Land leases between Stanford, UC Irvine, and UC Santa Cruz are extremely similar yet each offers nuances in the control, sales, and affordability. Each of these has different effects on aspects of equity and management of their properties.

For those that qualify for housing, additional criteria must be met to qualify for the leasing program. UC Santa Cruz employees must have a full-time position and a minimum of a 1-year appointment; however, longer term commitments are preferred. UC Irvine requires full-time employment with their for purchase program.[55] Stanford requires 50% time employment for faculty, 75% for clinician educators, and 100% for staff.[56] Faculty and clinician educators are

typically required to have a three-year appointment or continuous appointment while only upper level staff are eligible for the purchase programs.

Universities must account for numerous circumstances in their land leasing contracts. At Stanford, the leaseholder of the property is legally the employee.[57] If the employee were to die during employment, the spouse is eligible to become the leaseholder of the property.[58] If the employee retires, they can remain in the residence for 10 years. The property must always be the primary residence of the employee. If the employee no longer qualifies for university housing, or there is a divorce in which the principal owner becomes the spouse, the tenant will have one or two years to move out of the property. If the employee is allowed to sublet the residence for a maximum of one year if they are away from the property.

University contracts account for other homeownership behaviors such as structural improvements. All three universities allow for home improvements, but these must be reviewed. UC Irvine uses an architectural review board. Homeowners must submit an application for review before beginning their projects.[59] UC Santa Cruz uses deed restrictions to ensure the building is not altered in counterproductive ways to its long term viability for future faculty and staff, with changes allowed only when approved by the architecture committee or housing staff.[60] Stanford has a similar program.[61] Each area has different requirements to suit its purpose and architectural president.

UC Irvine restricts sales of the homes to the University, faculty, and staff. There are provisions in the contract that allow sales to the general public if the home doesn't sell to any one of these three groups.[62] Stanford does not appear to allow sales to the general public.[63] UC Irvine and Stanford list the available properties on their website for current and future employees to find.

Practices to ensure equitable access to housing are carried out differently between UC Irvine, UC Santa Cruz, and Stanford. UC Irvine and Stanford use different leasing structures. UC Santa Cruz stands out with its allocation program. These strategies are meant to ensure affordability to purchasers or access to different groups as faculty and staff typically have different ability to pay.

UC Irvine has three lease payment plans which differ in payment for the first 5 years, adjustment factor for every subsequent 5 years, and the percentage value home improvements can bring when sold back to the Irvine Campus Housing Authority (See Table 8.1).[64]

Stanford has two different lease contracts available. The residential ground lease is the standard lease used for qualified university employees while the restricted ground lease was created to ensure affordability.[65] The restricted ground lease only allows faculty and staff to use the Stanford financing programs. Additionally, the sale of the property can only be to the University. The value will be the lower of either the original sale price plus a previously agreed - upon appreciation rate or an adjusted value based on residential homes in the area. UC Santa Cruz also places appreciation restrictions on portions of its housing stock to ensure affordability.[66] Limiting the appreciation of the home limits the possible future resale value, therefore ensuring affordability by preventing sudden spikes in sale price

2.2 Rental Programs

Stanford, UC Irvine, and UC Santa Cruz provide rental housing to their faculty and staff members. Rental programs benefit employees with lower incomes or who may be expecting to stay for shorter periods of time.

The rental program at Santa Cruz is focused on transitional housing for new employees. Stanford's is focused on those who did not qualify or chose not to participate in the purchase program.[67] At UC Santa Cruz, hired employees must be at full time to qualify and are preferred to stay at full time employment, although exceptions are possible if reduced to 50% employment. The employee must have been hired within the past two years to be eligible.

The criteria at Stanford are more complicated. Renters qualify based criteria such as the location of the property itself, appointment intensity and length, and location of employment.[68] Stanford also has the highest number of rental units with over 700 on and off campus.[69] Each property is operated by professional property managers.

UC Irvine prioritizes full-time employees in its rental program.[70] Despite such a high criteria, Irvine has a number of program features making it as accessible as possible, including furnished rentals that can range from one week to one year.[71] The housing authority also offers furnished or unfurnished units in their more traditional program.

3.0 Financial Support & Incentives for On and Near Campus Housing

In addition to the provision of living space through rent or purchase arrangements, many universities provide assistance to encourage employees to live on or near campus through financial programs like mortgage assistance or one-time payments to assist with the cost of purchasing a home. The purpose of these programs varies. For example, Stanford's program aims to increase the attractiveness of working at the university by reducing barriers associated with moving while helping employees live closer to campus, where they work, while the program at Washington University in St. Louis cites revitalization of historic urban neighborhoods and reduction of carbon footprints as motivating factors.[72]

Stanford provides four types of loan programs: Mortgage Assistance Program, Deferred Interest Program, Reduced Interest Program, and Zero Interest program.[73] There is also a Housing Allowance Program (see Table 8.2). These programs are applicable to all within a large area around Stanford, going as far north as San Francisco (at least 40 miles) to as far south as San Jose (at least 20 miles, see Figure 9.1).[74] The programs incentivize the selection of housing within these areas. If an employee were to leave Stanford while under a payment program, that employee can choose to refinance the loan or sell their property.[75]

The University of California's Office of the President offers four loan programs to help incentivize employees to live closer to employment locations.[76] These programs are the Mortgage Origination Program, the Graduated Payment Mortgage Origination Program (GP-MOP), 5/1 Mortgage Origination Program, and Supplemental Home Loan Program (See Table 8.3). As of 2005, the regents of UC Santa Cruz had allocated $92.5 for the Mortgage Origination Program and 254,000 for the Supplemental Home Loan Program.[77] The popularity of these programs is best demonstrated by UC Irvine and the University of Santa Barbara above 90% utilization rate for these funds.

Syracuse's Guaranteed Mortgage Program is administered by the Real Estate and Asset Management Department.[78] The loan is guaranteed by the university, eligible to full-time and regular part-time employees, is administered in cooperation with four lenders, and is eligible for

dwellings ranging from single-family homes to condominiums. Similar to Stanford, the program is only eligible for those who live within certain areas around campus (see Figure 9.2).

Forgivable loans are offered by Washington University in St. Louis, the University of Maryland, and the Ohio State University.[79] In all cases, the forgivable loans are to be used for the down payment and closing costs. Washington offers $8,500 to $12,500 (depending on the neighborhood), the Ohio State offers 6% of the appraised value capped at $15,000, and Maryland offers $15,000 10-year forgivable loans with no interest. The universities require the home to be the primary residence and only if the property is in certain neighborhoods. Eligibility for Washington and the Ohio State includes part time workers with 50% or greater employment while Maryland requires full time employment.[80]

The University of Maryland Baltimore, Johns Hopkins University, and the University of Rochester provide grants to cover the costs of home ownership, such as down payment and closing costs.[81] The University of Maryland Baltimore's grant program is similar to the program at the University of Washington St. Louis as they both hope to increase home ownership in the area will help with community revitalization and stabilization in the selected neighborhoods. Maryland Baltimore program contributes $16,000 and Johns Hopkins offers $17,000. Johns Hopkins requires full time employment, while Maryland Baltimore requires a minimum of 50% full time employment. Both require homeownership counseling and a purchase within a designated neighborhood. Rochester's University Home Ownership Incentive Program provides $3,000 from the University, $3,000 from the City of Rochester, and $3,000 from a participating bank/credit union for employees who purchase homes within designated communities and commit to five-year occupancy and employment.

4.0 On-Campus Housing Expansion for Undergraduates

Universities across the country have come under pressure to expand not only their faculty and staff housing, but their student housing as well.[82] The growth in the student population has outpaced the growth in supply, constraining the market and putting financial pressure on residents in the surrounding neighborhoods. On-campus housing benefits the university by enabling students to accomplish more and potentially save money by reducing time to graduation.[83] Across the country, various universities have begun expanding their on campus stocks of student housing.[84] In some instances, enrollment of incoming students overshot the local on- and off-campus housing supply, necessitating emergency dorms.[85]

The housing crisis in the Boston area has led the City to work with universities to expand their on-campus housing.[86] In 2015, the City set a goal of creating 18,500 new beds by 2030 in order to help ease the strain on housing supply. MIT alone has expanded its share of graduate students housing on campus from 27 to 38 percent in the past thirty years, an era of growth in the graduate-student population.[87] Their most recent commitment to graduate student housing was in 2017, with plans to construct apartments that would house 950 beds.

On the west coast, Stanford students, like employees, have also struggled to find housing.[88] This is especially true for graduate students. While the University provides 93% of all students with housing, only 75% of the graduate students find on-campus housing.[89]

The University of California created the President's Student Housing Initiative in 2016, setting a goal for 14,000 new affordable student beds to be available systemwide by fall 2020.[90] Seven projects are planned for completion in 2024 and will add 8,500 new beds. Between the announcement in 2016 and the fall of 2018, 9,845 new student beds were constructed. This

resulted in the percentage of students living in on-campus student housing across all its campuses was 33.9% in 2015 and 35.2% in 2018, even with enrollment growing by 15,000. Approximately 5,100 of the new beds came from new construction while 4,700 beds came from increased density in older buildings.

The University of Chicago continues to expand its on-campus housing supply as the faculty finds the housing quality to be instrumental in student well-being and therefore necessary for higher education.[91] The newest facility, Woodlawn Residents, will house an additional 1,200 students.

Purdue University is one of many universities forced to expand its undergraduate housing after there were not enough dorms to house incoming Freshman students in 2018.[92] Since the incident, Purdue has committed to expanding its on-campus student housing. Two residence halls were recently built to house 1,300 additional students. The construction was completed through a partnership between Purdue, West Lafayette, and Plenary Properties Purdue LLC. The agreement will last 22 years; upon conclusion, Purdue and West Lafayette will retain ownership. Since 2018, roughly 42% of undergraduates at Purdue live on campus, and the University had the lowest room and board rates in the entire Big Ten.[93]

5.0 Current University of Michigan Housing Programs & Context

In the fall of 2019, the University of Michigan housed 12,048 students, 87 employees (despite no formal program), and 727 family members on the Ann Arbor campus. Flint houses approximately 800 students in two apartment-style buildings.[94] Dearborn does not have a formal housing program. Instead it has a public-private-partnership with 605 beds in the Union, [95] not owned or operated by the University. There is currently a capacity for 12,242 students and employees on the Ann Arbor campus. Undergraduates, specifically freshmen, fill the majority of on campus housing (see table 8.4). Approximately 25% of the student body is currently housed on campus, specifically 31% of all undergraduate students and 14% of all graduate students (see table 8.5).

An on-campus student population of 25% is low compared to other institutions of a similar caliber and compared to those included in this housing analysis (see table 8.5).[96] While the University of Michigan is a public institution and has a greater student enrollment than many on the list, their percentage of students in on campus housing is still lower.[97] Within the list, New York University, The University of Illinois Urbana Champaign, and The Ohio State University each have higher student enrollment, larger share of students in on campus housing, and therefore a greater number of students in on campus housing. On-campus housing at Michigan, however, has only expanded twice in the past 15 years and was primarily meant to meet the growing number of incoming students.[98] This means the housing was not intended to increase the share of students living on campus.

Currently, the University of Michigan has a loan discount through Quicken Loans with $1250 in mortgage savings but no mortgage or incentive program on the scale of the previously listed universities.[99] The current program offers $500 cash back after closing, $750 closing cost credit, and a personalized mortgage review. This is the only financial incentive, and there are no restrictions on where qualifying homes can be located in relation to the campus of employment. These are the only loan programs, and none are tied to distance from campus.

The Ann Arbor, Flint, and Dearborn campuses face different challenges from one another. Ann Arbor and Ypsilanti are housing markets facing housing shortages and rising

prices. This shortage has led to an inability for many staff and some faculty to live close to the Ann Arbor campus, resulting in higher commuter emissions per capita. The housing markets in Flint and Dearborn are less competitive than the housing market in Ann Arbor. Faculty and staff on these campuses have much more flexibility in deciding where to live.

6.0 Proposed Programs

Lessons from the previously mentioned universities create the potential for an integrated housing system at the University of Michigan that lowers commuter emissions; attracts and retains talent; increases student performance; fosters a stronger sense of community; and treats students, employees, and neighbors equitably all while increasing the value in the experience of being a Michigan Wolverine. Each strategy must fit the local context of each campus. The adoption of these housing strategies is an essential piece of reducing commuter emissions and will interact with the other programs in this report to reduce commuter emissions.

6.1 Strategy 1: On Campus Housing - Students, Faculty, and Staff

The University of Michigan should begin to provide faculty and staff housing on the Ann Arbor campus while increasing the amount of student housing on all three campuses. Faculty and staff create more emissions per capita in their commute than students. The University has the ability to provide a guaranteed supply of housing to faculty and staff beyond that which local private markets are able to provide, particularly since they are constrained by Ann Arbor zoning. Student housing can be provided as significantly higher densities. Additionally, drawing students into on campus housing vacates units in Ann Arbor for employees and others, magnifying its carbon-reduction effect. Student housing supports transit improvements as they are more likely to use the public transit system, cycle, or walk. This helps to justify the cost savings for these strategies.

On-campus housing for faculty and staff is possible to implement on Dearborn and Flint campuses however it is more suited to Ann Arbor's campus. Dearborn and Flint's housing supply does not appear to be under the same pressure as Ann Arbor's housing supply.

In context of the Ann Arbor campus, faculty and staff are more likely to live further from the Ann Arbor campus than students. Nearly 75% of Ann Arbor campus students live within 4 miles of campus while this is true for roughly 27% of faculty and staff. "Drive a car" was the most used form of transportation for 76.4% of employees while it was the 3rd most common form of transportation for students, making up 12% of trips. There are differences in between the faculty and staff commutes as well. Faculty are more likely to live close to campus than staff. This is in part due to the high cost of housing in Ann Arbor.

The primary justification for student housing is the same as that for employee housing. Closer locations reduce the intensity of the commute and facilitate less intensive mode shares. Increasing the amount of on campus student housing does more than reduce commuting emissions. Some of the housing units in Ann Arbor previously used for student housing will become vacant with fewer students seeking off campus student housing. Landlords will repurpose this housing. It is possible that the changes may meet the needs of some faculty and staff. While it is possible that faculty and staff currently living in Ann Arbor will move into campus housing, on campus student housing will have a larger impact on the local market. Students are generally willing to accept higher densities than faculty and staff, thus more student units can be built, and more units of campus be freed up. More students live within 4 miles of campus than faculty and staff as well.

The increase in student, faculty, and staff housing on campus has an extra benefit of decreasing the strain on the daily parking supply. An increase in housing close to campus would decrease the share of students and employees who drive to campus and require temporary on campus parking services for work or attending class. Current SCIP data shows that of the employees who live within two miles of their work location, more than 50% walk, ride a bike, or use public transportation. More than 50% of students within four miles of campus walk, bike or use transit. The University has a robust transit system that is likely to improve with the implementation of the UM Connector and better coordination with the Ann Arbor Area Transportation Authority busses. One could expect the mode shares for walking, cycling, and public transportation to increase in a future with more on campus housing that places students, faculty, and staff within four miles of where they work and study.

We developed scenarios of housing development based on development elsewhere. The densities of on campus faculty and staff housing at UC Santa Cruz are between 7 and 13 dwelling units per acre.[100] Stanford's campus plan was adopted in 2000 with low density residential areas with up to 8 units per acre and medium density areas which allow 8-15 units per acre.[101] Stanford currently has numerous townhome and condo developments with higher densities than 15 units per acre. Stanford has been increasing the densities of its developments.

Higher densities of employee housing on the Ann Arbor campus at a net density of 14 to 41 units per acre would have a stronger impact on commuter emissions. Densities could also be tailored to fit neighborhood context within Ann Arbor while also matching up with employee preferences, needs, and price ranges. Higher density buildings compound other sustainable practices such as the thermal effect of shared walls, reduced infrastructure costs per capita, and more adequately encourage the use of public transit. (For density examples see figures 9.3 though 9.13; for financial savings of multi-story vs single family see figures 9.14, for relationship between density and transit see figures 9.15 through 9.16)

To ensure equitable access to faculty and staff housing, three potential strategies stand out. First, some units should be set aside for leasing or renting at affordable rates. In the case of a lease, restrictions on the appreciation of the home and land following either the UC Irvine or Santa Cruz model will help ensure affordability. Second, the University could establish groups of faculty and staff based on income, similar to UC Santa Cruz. Each group would be allocated a certain amount of housing. This would ensure that no income group within the university is priced out of the ability to participate in the on-campus housing market. The third and final strategy is based around mortgage policies. A variety of mortgage policies should be available. This ensures faculty and staff of different income groups are able to pick the one that minimizes their risks.

Student housing in the Ann Arbor area ranges from repurposed single-family homes to 13-story residential buildings. The highest population structures on campus are Mary Markley, West Quad, East Quadrangle, and South Quadrangle, which all have over 1,000 beds. Upperclassmen do not appear attracted to living in dorms and during interviews expressed the desire for a more independent and self-reliant lifestyle. Typologies appropriate for student housing were a net density between 66 and 250 units per acre. In the development our student housing scenarios, we assumed densities of under 90 units per acre, and two bedrooms per unit. Only on central campus were densities of 250 units per acre deemed appropriate. Student housing estimations were not able to be carried out on the Dearborn and Flint campus.

Estimations of 200, 400, and 600 beds were used, as they are similar to existing facilities on the Dearborn and Flint campuses.

6.2 Strategy 2: Off Campus Housing - Financing & Incentives

The University of Michigan could implement a housing assistance program on all three campuses to encourage employees to live closer to where they work. At Dearborn and Flint, such a program would apply to homes purchased within a specified distance to campus or within certain regions in order to effect reductions to carbon emissions due to commuting. For example, a program might be structured to include homes within a reasonable biking distance to work (5-6 miles) or located on a direct bus or cycling route to campus. At the Ann Arbor Campus, these incentives would only apply to the proposed-on campus housing. As discussed earlier, “live near where you work” incentives are motivated for various reasons other than sustainability, however, and are important to consider in the context of a university-wide plan.

In the case of Ann Arbor, where housing is in high demand, direct housing assistance could help address commuting issues, housing affordability concerns, and attract employees to live in the on-campus housing. This strategy should not be adopted to incentivize the purchase of off campus housing, however. There is already a shortage of available and affordable housing in Ann Arbor, especially in locations within walking and biking distance to the university and urban core. University-subsidies for off campus housing in this situation could limit the supply to non-university individuals, deepening already existing housing tensions in Ann Arbor.\

Areas around the Dearborn and Flint campuses do not have a constrained housing supply. An employer-assisted financial housing incentive program could help Dearborn compete with the many nearby communities in southeastern Michigan, attracting its employees to settle within a short commute to work. In Flint, such a program could also further revitalization efforts, similar to the goals of the University of Baltimore, Maryland.

The university’s incentive program can consist of mortgages, forgivable loans, and/or a benefits package or grant funding to assist with covering down payments and closing costs for qualifying homes. The mortgage programs from Stanford and the University of California could serve as reference points. (See tables 8.2 to 8.3) These peer institutions focus on down payments and closing costs with incentives between $7,000 and $15,000, which could be restricted by a percentage of the appraised value. Premium incentives could be offered for homes with access to transit services that connect to campus, are close to campus, and limit on-campus parking. Lower-paid employees could be offered more premium benefits, since this demographic has historically been unable to purchase close homes with transit access to campus.

6.3 Equity Considerations

The two campus housing programs address equity in a number of ways. Each policy reduces the cost of transportation, the cost of housing, and increases access to education. These housing policies can also help to serve the communities surrounding campus, where many students, faculty, and staff reside.

Housing should generally never account for more than 30% of a household's income as this is considered a housing burden.[102] Students, faculty, and staff will benefit from living closer

to campus due to the reduced costs of transportation. Progressive affordability indexes look at the cumulative cost of transportation and housing, which is recommended at 45% a household's monthly income. Walking, cycling, and transit costs are less than the cost of car ownership and maintenance, translating to savings for those who can reduce vehicle usage and ownership.[103] Living in more dense areas has been shown to result in lower cumulative housing transit costs.[104]

Housing affordability can be a barrier for seeking an education, limiting both the diversity and talent that can afford to attend the University of Michigan on all campuses.[105] Student housing at the University has been an at-cost endeavor for the University to ensure affordability. This trend should continue to help keep the cost of higher education as low as possible.

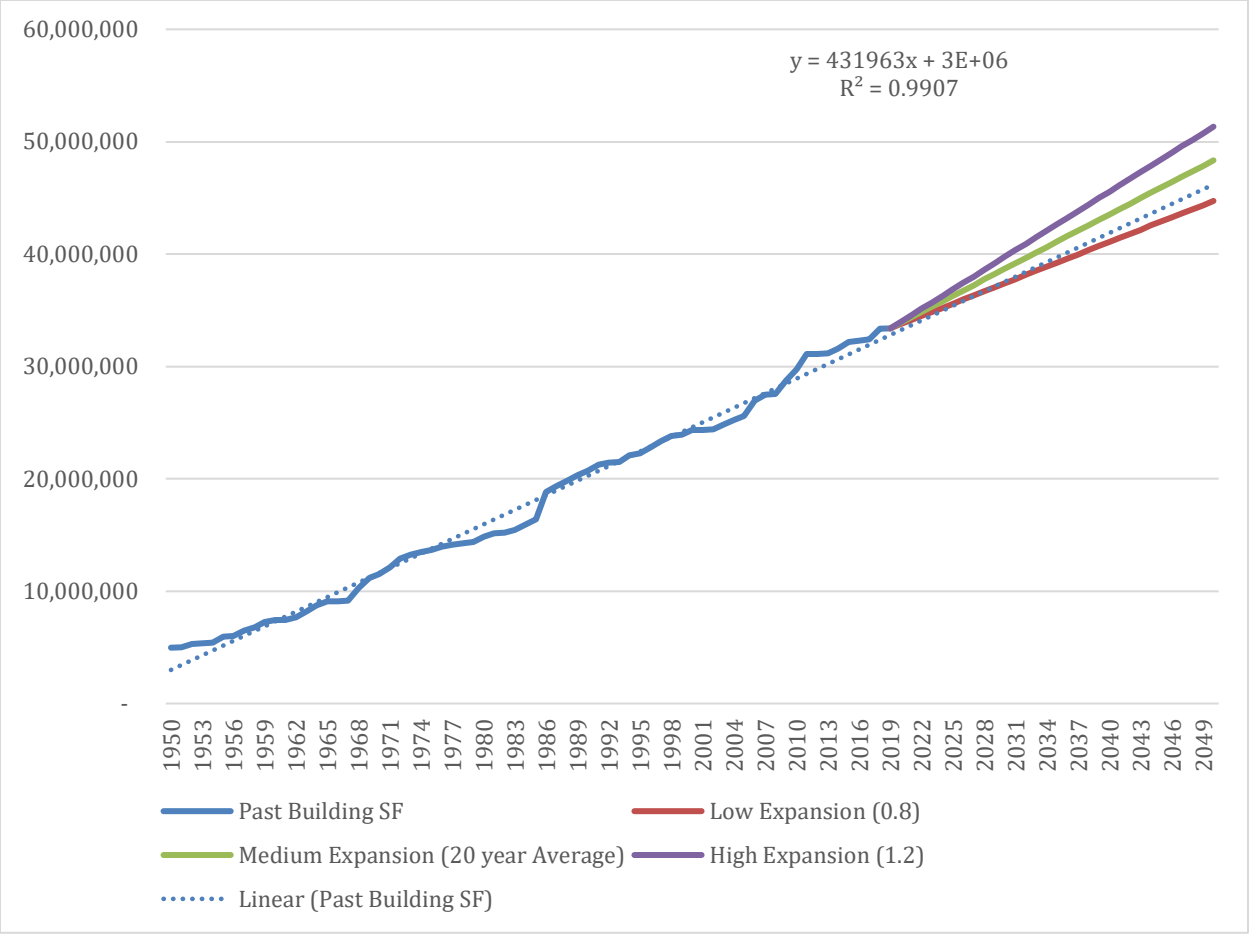
The housing strategies for the Ann Arbor, Flint, and Dearborn campuses are tailored in a way that supports the housing needs of the area. The Ann Arbor housing market is suffering from a lack of supply. The University of Michigan will be increasing its housing supply for students, faculty, and staff and in turn, decreasing the demand for the housing not on campus as it creates a separate market. Around the Flint campus, the mortgage program will serve as a tool for urban revitalization by attracting University employees to the area, similar to the University of Maryland, Baltimore. The area around the Dearborn campus, will benefit from the increased utilization and returns on the investment in their alternative transportation systems.

6.4 Location, Planning, Models. Emission Reduction Potential

The University of Michigan can greatly expand its housing stock without compromising its ability to expand academic and research programs or provide parking for faculty and staff. To account for changes to the land use of the university, two models were developed. To ensure that housing scenarios do not constrain core campus functions, we estimated models of campus growth. The first model used past construction and expansions of the Ann Arbor campus's buildings to forecast the square footage of building space that the university will operate in 2050. The second model predicted how much of the University's available land could be devoted to four categories: student housing; faculty and staff housing; parking; and academic, Research, and Commercial Space.

The forecast model relied on data provided by the University of Michigan Buildings department. It was edited to remove buildings on Flint, Dearborn, the biological station, and housing on Ann Arbor's campus. Four potential forecasts were projected to the year 2050. The first was a linear forecast based on expansion since the year 1950. The second was an average of the 20-year average expansions since 1999. Both the linear forecast and 20-year average forecasts provide middle-of-the-road predictions, with a range created by adding or subtracting 20 percent. This model's prediction for the 2050 sq. ft. needs of the University to be 51,335,851 sq. ft. at the high end and 44,729,142 sq. ft. at the low end.

Figure 6.4.1 Forecast of sq ft. of Buildings for Academic, Research, and Supportive Functions on the Ann Arbor Campus



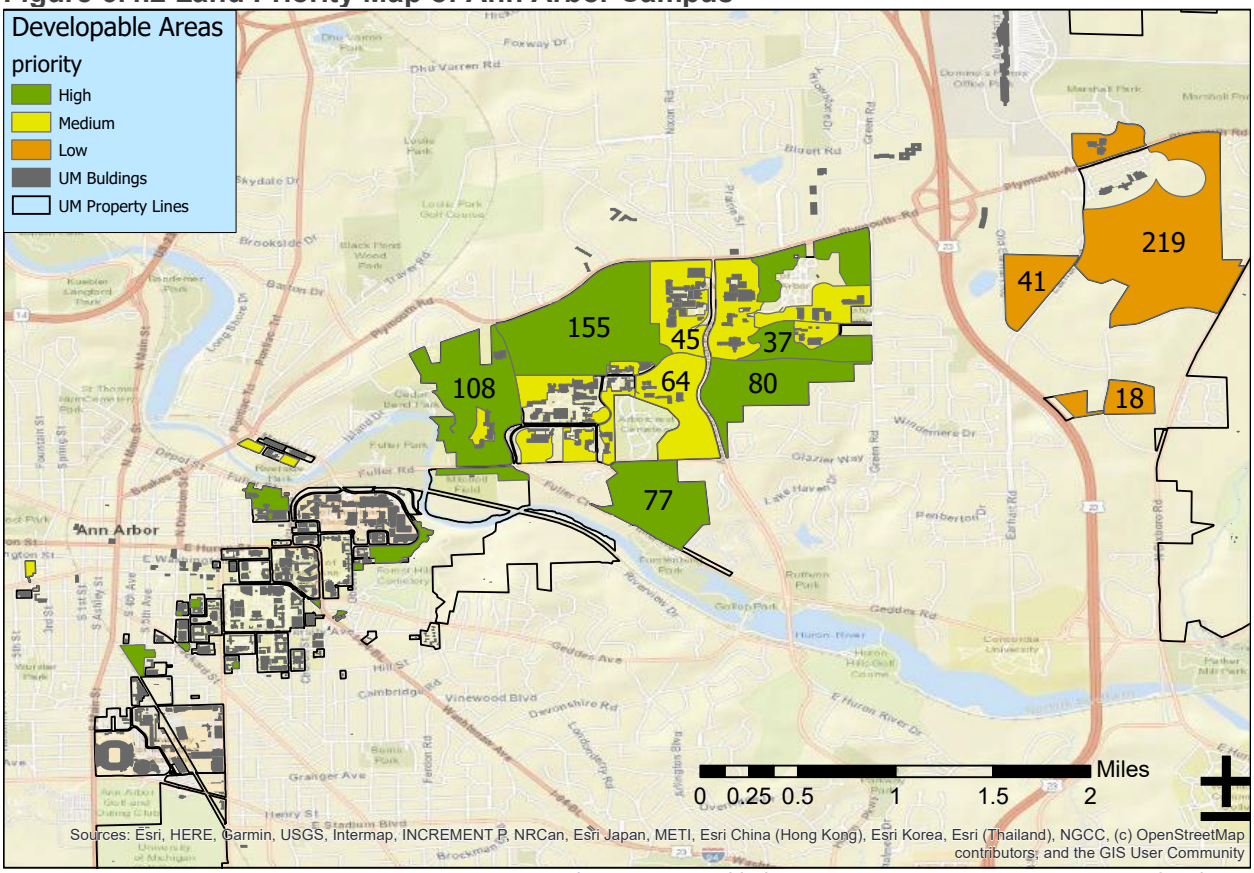
Source: University of Michigan Buildings Department

The second model provided a method of systematically predicting the campus expansion. The model relied on information gathered from various campus plans and interviews with different faculty and staff members on campus. (for assumptions in model see Table 8.6) The model is divided into three different intensities of expansion for housing and parking: low, medium, and high. Academic, research, and commercial space was kept constant in all the models as it more than satisfied the predicted expansion.

Additionally, the model breaks land into priorities to hypothetically simulate phasing. It is the recommendation of the team that the housing developments be phased in over time with highly applicable locations being developed first. Such a development process will allow the University to judge market conditions without making large commitments. The criteria of this potential framework includes distance to campus, presence and use of existing structures/ parking, and establishment of development plans. Areas labeled as having a high priority included locations include the Northwood apartment area, vacant locations on north or central campus, and locations on central campus with surface parking lots or redevelopment plans. (Figure 6.4.2) Medium priority locations were those on north campus that would require buildings, landscapes, or parking lots to be changed. Parking lots were deemed to present a logistical challenge to replacing the old parking before it is no longer available due to construction. Changes in these areas would require more planning to ensure the functions of demolished areas are transferred to new locations. Low priority locations included those that

were past the freeway. Despite there being no revealed development plans in this area, it was labeled as a lower priority in an effort to discourage sprawl.

Figure 6.4.2 Land Priority Map of Ann Arbor Campus



Cartographer: James Wooldridge Data Source: University of Michigan

Table 6.4.2 Summary of Land Use Analysis

Acres				
Development Priority of Land	High	Medium	Low	Total
	540.5	253.2	307.4	1,101.1
Additional Students on Campus				
Density / Priority	High	Medium	Development Scenario: High + Medium Priority	Total Students (Existing + New) on Campus
Low	4,999	1,008	*6,007	18,249
Medium	7,872	1,359	**9,231	21,473
High	8,321	1,359	***9,679	21,921
Employee Units on Campus				
Density/ Priority	High	Medium	Low	
Low	3,133	456	1,110	
Medium	6,918	822	1,110	
High	7,575	988	3,249	
Development Scenarios				
Density/ Scenarios	Low: High Priority Land Only	Medium: High + Medium Priority Land	High: High + Medium + Low Priority Land	
Low	*3,133	3,589	4,699	
Med	6,918	**7,740	8,850	
High	7,575	8,563	***11,812	

* Corresponds to the “low development scenario,” Table 1, report.
** Corresponds to the “medium development scenario,” Table 1, main report.
*** Corresponds to the “high development scenario,” Table 1, main report.

Through strategic planning and implementation, the University could provide housing to an additional 6,000 to 10,000 students. At the same time, it could provide housing to between 4,700 and 11,800 faculty and staff members. These expansions would leave room for 19.2 million square feet of expansion of academic research and commercial space, 1.3 million square feet above the high estimate of growth by 2050. (Figure 6.4.1)

6.5 Emission Reduction Potential

The emissions reduction potential for housing can account for 24% of the current emissions with 9,679 additional students and 11,812 faculty and staff on the Ann Arbor campus, 600 additional students on the Dearborn and Flint campuses while 100 faculty and staff follow the incentive program on this campus.

Table 6.5.1 Emissions Reduction Potential

		Reductions per	% local emission	Metric tons per year
Faculty and Staff	AA	100 units	0.2%	228
	Dearborn	100 units	8.3%	258
	Flint	100 units	8.3%	287
Students	AA	100 beds	0.5%	124
	Flint	100 beds	1.2%	150
	Dearborn	100 beds	1.0%	209

Table 6.5.2 Emissions Reduction on Ann Arbor Campus

Emissions Reduction, New Student Development (metric tons per year)	
Density/ Priority	***Development Scenario: High + Medium Priority***
Low	7,474
Medium	11,484
High	12,039
% Student Emissions Reduction	
Density/ Priority	***Development Scenario: High + Medium Priority***
Low	27.2%
Medium	41.8%
High	43.8%

Emissions Reduction, Employee Housing development (metric tons per year)			
Density/ Priority	***Low Development Scenario: High Priority Only***	***Medium Development Scenario: High + Medium Priority***	***High Development Scenario: High + Medium + Low Priority***
Low	7,150	8,122	10,655
Med	15,788	17,664	20,198
High	17,288.0	19,542	*26,958
% Employee Reduction			
Density/ Priority	***Low Development Scenario: High Priority Only***	***Medium Development Scenario: High + Medium Priority***	***High Development Scenario: High + Medium + Low Priority***
Low	6.9%	7.8%	10.2%
Med	15.2%	17.0%	19.4%
High	16.6%	18.8%	25.9%

Table 6.5.3 Emissions Reduction on the Flint and Dearborn Campuses

		Dearborn		Flint	
	Units or Bds	Mt/year	% reduction in campus emissions	Mt/year	% reduction in campus emissions
New Student Beds	200	301	2.5%	418	2.0%
	400	602	4.9%	835	4.0%
	600	903	7.3%	1253	6.0%
Employees Incentivized	100	358	8.3%	287	8.2%
	200	516	16.5%	574	16.4%

6.6 Emissions Model for Housing

Emissions modeling for housing follows the methodology described in Appendix B. In particular, the variables permuted were the distribution of faculty and staff, and student population. To model the change in emissions, we made three assumptions: 1) all new housing

would be within 0–1 miles of the campus location of the faculty moving into that housing, 2) the mode share of relocated affiliates would match that of the people living within that band, 3) new housing units were assigned randomly to all affiliates living more than a mile away from their work location.

6.7 Cost

The proposed housing strategies should result in a revenue generating endeavor for the University. Past university housing has been neutral profitability.[106] This is because current on campus housing has been solely focused on students. The addition of faculty and staff housing may allow on-campus housing to turn a profit.

Building additional on campus housing will require an upfront cost to construction and planning. Once constructed, rental units will require some level of upkeep. The leased units to faculty and staff should not require upkeep costs as the owners of the units will be responsible for upkeep. The leasing program will require staff for monitoring and maintaining the program.

The various possibilities of the benefits programs offer differing levels of cost and revenue generating possibilities. Any mortgage loan programs should result in a net positive investment for the university. they will require upfront money to loan and a team to manage. A positive aspect for loaning money to university employees is their higher level of job security, translating into a lower risk investment. The benefits, forgivable loans, and/ or grants to help cover down payments and closing costs are not likely to be revenue generating as there is no stream of revenues. The down payment and closing costs strategies may help to make on campus housing more profitable by increasing its appeal.

8.0 Tables

Table 8.1 Irvine Campus Housing Authority Land Lease Payment Plans

	Payment for the First 5 Years	Adjustment Factor Every 5 Years	Percentage of Appreciation to ICHA at Resale
Plan 1	4% of land value	Increase by 4% of any incremental increase in land value	10%
Plan 2	2% of land value	Increase by 4% of any incremental increase in land value	20%
Plan 3	None	Increase by 4% of any incremental increase in land value	30%

Table 8.2 Stanford Purchase Programs

Program	Description
Mortgage Assistance Program (MAP)	"A non-amortizing, interest-only mortgage loan with a low current interest rate and deferred interest due at payoff"
Deferred Interest Program (DIP)	"A non-amortizing loan with no payments until the principal and deferred interest are due"
Reduced Interest Program (RIP)	"A non-amortizing interest only loan with a low interest rate. The loan has low or no payments until the principal is due."
Zero Interest Program (ZIP)	"A non-amortizing loan with no payments until the principle is due. The ZIP loan may have a forgivable feature."
Housing Allowance Program (HAP)	"A taxable fringe benefit that supplements income upon purchase of a home"

Source: "For New Homebuyers." Stanford Faculty Staff Housing. https://fsh.stanford.edu/homebuyers/index.shtml.

Table 8.3 University of California Loan Programs

Program	Description

Mortgage Origination Program	“Provides adjustable rate loans with repayment terms of up to 30 years. Loans may have a maximum loan-to-value ratio of 80 to 90 percent, depending on overall qualifying documentation.”
Graduated Payment Mortgage Origination Program	“Loan featuring an initial interest rate that is a specified percentage lower than the Standard Rate in effect at the time of loan commitment”
5/1 Mortgage Origination Program	“Loan featuring a temporary fixed interest rate for the first 5 years of the loan after which it converts to an adjustable rate mortgage for the remaining loan term. The maximum overall loan term is 30 years.”
Supplemental Home Loan Program	“Provides primary secondary mortgage financing with variable fixed rate options”

Source: “Office of Loan Programs.” University of California Office of the President. https://www.ucop.edu/loan-programs/loan-programs/index.html.

Table 8.4 Fall 2019 Housing Statistics at the University of Michigan

	Freshmen	Sophomores	Juniors	Seniors	Undergraduate
Number in Housing	5,303	2,817	944	561	9,625
% of Housing Population	44%	23%	8%	5%	80%
Campus Totals					31,255
% of Population among Peers					31%
	Undergraduate	Graduate	All Students	Faculty & Staff	Total Active Wolverines
Number in Housing	9625	2,423	12,048	87	12,135
% of Housing Population	80%	20%	100%	<.01%	
Campus Totals	31,255	16,824	48,079	52,042	100,121
% of Population among Peers	31%	14%	25%	0.17%	12%

Sources: “Master Planning.” Architecture Engineering and Construction, October 31, 2019. https://umaec.umich.edu/master-planning/.

Table 8.5 On Campus Housing in US News & World Report Top 50

Institution	National Rank	Public Rank	Location	Status	Student Population	Percent in on Campus Housing	Students in on Campus Housing
Princeton	1		Princeton, NJ	Private	8,374	94%	7,872
Harvard	2		Cambridge, MA	Private	20,739		
MIT	3		Cambridge, MA	Private	11,574	92%	10,648
Columbia	3		New York, NY	Private	26,338	92%	24,231
Yale	3		New Haven, CT	Private	13,433	84%	11,284
Stanford	6		Stanford, CA	Private	17,381	93%	16,164
University of Chicago	6		Chicago, IL	Private	14,347	55%	7,891
University of Pennsylvania	6		Philadelphia, PA	Private	22,376	51%	11,412
Northwestern University	9		Evanston, IL	Private	21,591	60%	12,955
Duke University	10		Durham, NC	Private	16,606		
Johns Hopkins University	10		Baltimore, MD	Private	26,152	49%	12,814
California Institute of Technology	12		Pasadena, CA	Private	2,233	86%	1,920
Dartmouth College	12		Hanover, NH	Private	6,571	87%	5,717
Brown University	14		Providence, RI	Private	10,257	72%	7,385
University of Notre Dame	15		Notre Dame, IN	Private	12,607	74%	9,329
Vanderbilt University	15		Nashville, TN	Private	12,824	94%	12,055
Cornell University	17		Ithaca, NY	Private	23,600	52%	12,272
Rice University	17		Huston, TX	Private	7,124	71%	5,058
Washington University in St. Louis	19		St. Louis, MO	Private	15,852	74%	11,730
UC Los Angeles	20	1	Los Angeles, CA	Public	45,930		
Emory University	21		Atlanta, GA	Private	14,459	63%	9,109

UC Berkeley	22	2	Berkeley, CA	Public	42,501	27%	11,475
University of Southern California	22		Los Angeles, CA	Private	47,310	30%	14,193
Georgetown University	24		Washington, DC	Private	19,204	77%	14,787
Carnegie Mellon University	25		Pittsburgh, PA	Private	14,625	58%	8,483
University of Michigan	25	3	Ann Arbor, MI	Public	47,716	31%	14,792
Data from UM Housing and Registrar. Student Enrollment & Maximum Student Beds as of Fall 2019.					48,090	25%	Max: 12,242
Wake Forest University	27		Winston-Salem, NC	Private	8,401	75%	6,301
University of Virginia	28	4	Charlottesville, VA	Public	24,639	38%	9,363
Georgia Institute of Technology	29	5	Atlanta, GA	Public	32,723	43%	14,071
New York University	29		New York, NY	Private	51,847	42%	21,776
Tufts University	29		Medford, MA	Private	11,586		
University of North Carolina Chapel Hill	29	5	Chapel Hill, NC	Public	30,011	51%	15,306
University of Rochester	29		Rochester, NY	Private	11,817	78%	9,217
UC Santa Barbara	34	7	Santa Barbara, CA	Public	25,976	38%	9,871
University of Florida	34	7	Gainesville, FL	Public	52,218	22%	11,488
UC Irvine	36	9	Irvine, CA	Public	36,032	38%	13,692
Boston College	37		Chestnut Hill, MA	Private	14,107	84%	11,850
UC San Diego	37	10	La Jolla, CA	Public	37,887	38%	14,397
UC Davis	39	11	Davis, CA	Public	38,097	25%	9,524
Boston University	40		Boston, MA	Private	34,657	75%	25,993
Brandeis University	40		Waltham, MA	Private	5,801	76%	4,409
Case Western Reserve University	40		Cleveland, OH	Private	11,891	80%	9,513
College of William and Mary	40	12	Williamsburg, VA	Public	8,817	71%	6,260
Northeastern University	40		Boston, MA	Private	21,627	49%	10,597

Tulane University	40		New Orleans, LA	Private	11,722	48%	5,627
University of Wisconsin - Madison	46	13	Madison, WI	Public	44,411	25%	11,103
Villanova University	46		Villanova, PA	Private	11,023	67%	7,385
University of Illinois - Urbana-Champaign	48	14	Champaign, IL	Public	49,702	50%	24,851
University of Texas - Austin	48	14	Austin, TX	Public	51,832	18%	9,330
Lehigh University	50		Bethlehem, PA	Private	6,849	63%	4,315
Pepperdine University	50		Malibu, CA	Private	7,961	57%	4,538
Rensselaer Polytechnic Institute	50		Troy, NY	Private	7,962	57%	4,538
University of Georgia	50	16	Athens, GA	Public	38,652	34%	13,142
The Ohio State University	54	17	Columbus, OH	Public	61,170	32%	19,574
				Average	23,540	59%	11,232
				Median	18,293	58%	10,875

Source: The Best Colleges in America, Ranked." U.S. News & World Report. U.S. News & World Report. https://www.usnews.com/best-colleges., University of Michigan Office of Registrar, University of Michigan Housing

Notes: Higher Housing values than the University of Michigan are colored Green
Higher or close housing values when compared to the University of Michigan are colored orange. Data discrepancy between exists as US News & World Report values were different than those obtained from University Housing.
Average and Median values excludes UM actual values
Numbers were not provided for Harvard however 97% of undergraduates live on campus and freshmen are required to live on campus.[107]

Table 8.6 Assumptions Embedded in Land Use Planning Model

Assumption 1)	Carbon reduction potentials are only for UM Employees that move into on campus housing. This does not include students who move onto campus or employees who move into previously student units (newly renovated) in Ann Arbor.
Assumption 2)	UM will grow at its average previous rate per year for Academic, Research, and Commercial space.
Assumption 3)	SF expansion of Academic, Research, and Commercial space will not occur on top of currently operation buildings. This translates to a conservative estimate for the ability to expand academic, research, and commercial space.
Assumption 5)	Students would be more willing to accept higher densities

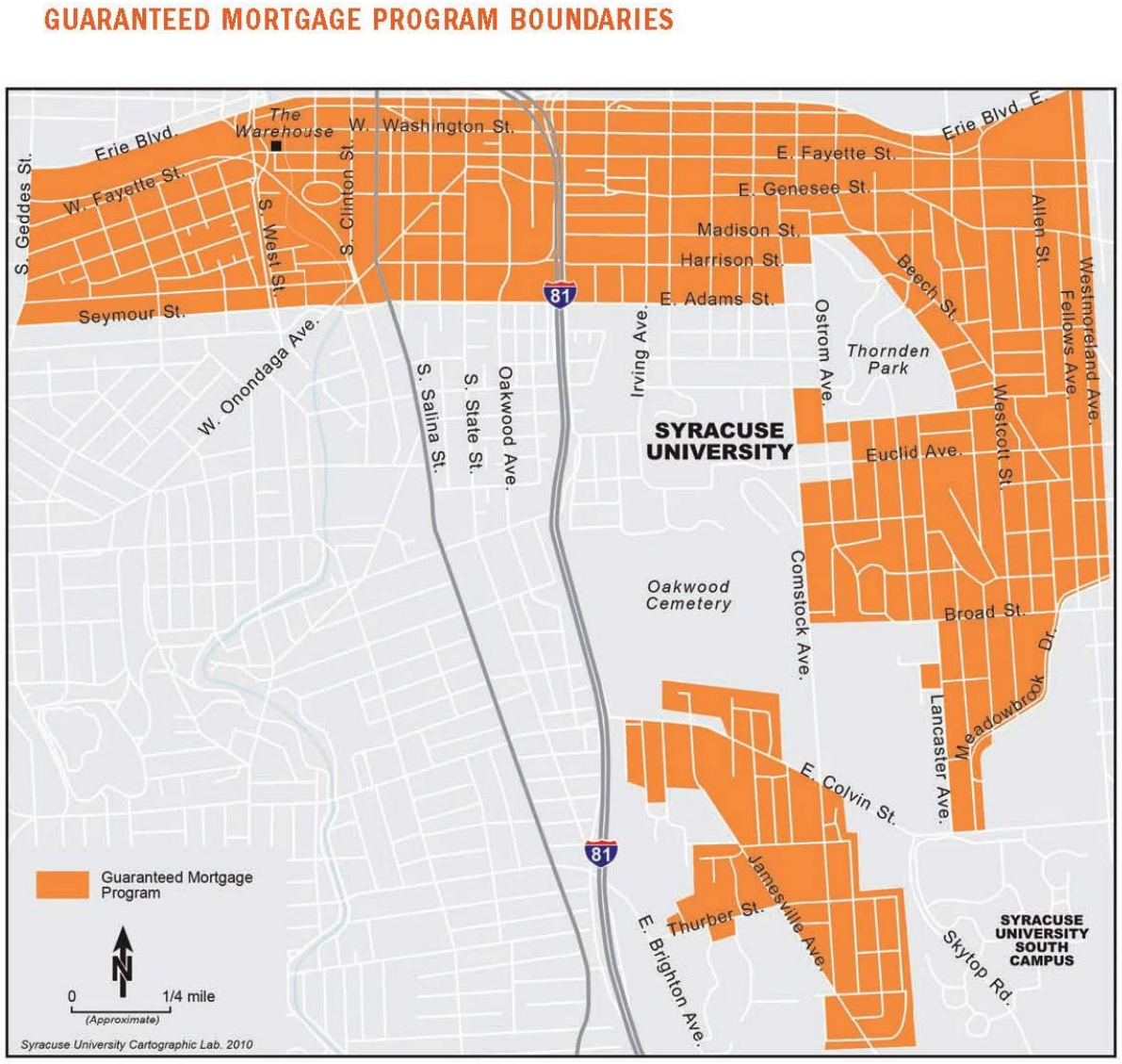
Assumption 6)	Faculty and Staff would have a preference for lower densities than students
Assumption 7)	25% of all area would be needed for green space, open space, and green infrastructure
Assumption 8)	35% of all space would be needed for streets and paths impervious surfaces
Assumption 9)	Density Estimations will rely on Net Density as assumptions 7 & 8 manage assumptions about spaces not used for housing.
Assumption 10)	Town homes will come with 1 parking space per home, parking space not counted. (Densities lower than 41 DU per acre).
Assumption 11)	Employee housing will function off of roughly 1 car per household. Accounted for in parking predictions.
Assumption 12)	Development will be done in phases, not all at once
Assumption 13)	Parking decks function off of 1 space per 400 sf of area. This is on the high (inefficient) estimation end on sf required per parking space, providing a conservative estimate.
Assumption 14)	Students parking spaces for upperclassmen .5 per student above 9,000
Assumption 15)	Floodplains on the property were small properly manage with landscape architecture and therefore accounted by assumption 7 or buildings were elevated with only parking on the first floor (Fingerle Lumber and Parking Lots by Huron River)

9.0 Figures

Figure 9.1 Eligible area for Stanford Purchase Programs

Source: "Qualifying Limit." Stanford Faculty Staff Housing. https://fsh.stanford.edu/homebuyers/limit.shtml.

Figure 9.2 Syracuse University Eligibility Map



Source: "Guaranteed Mortgage Program." Syracuse University Business, Finance, and Administrative Service. https://bfas.syr.edu/real-estate/guaranteed-mortgage-program/.

Figure 9.3

Typical Single Family Block

- Gross Density:
  for measuring neighborhoods, districts and cities
- Method:
  total dwelling units divided by overall area, including alley and measured to centerline of adjacent streets
- 6.5 DU/AC

0 100’ 200’ 300’

GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.4

Typical Single Family Block

- Net Density:
  for measuring individual development projects
- Method:
  total dwelling units divided by lot area only (not including right-of-way & other public land)
- 9.7 DU/AC

GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.5


Rainier Vista Townhouses
GGLO
Townhouses
8 DU on 0.6 AC
Net Density = 14 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.6


LionsGate Townhouses
GGLO
2/1 Townhouses
200 DU on 6 AC
Net Density = 34 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.7

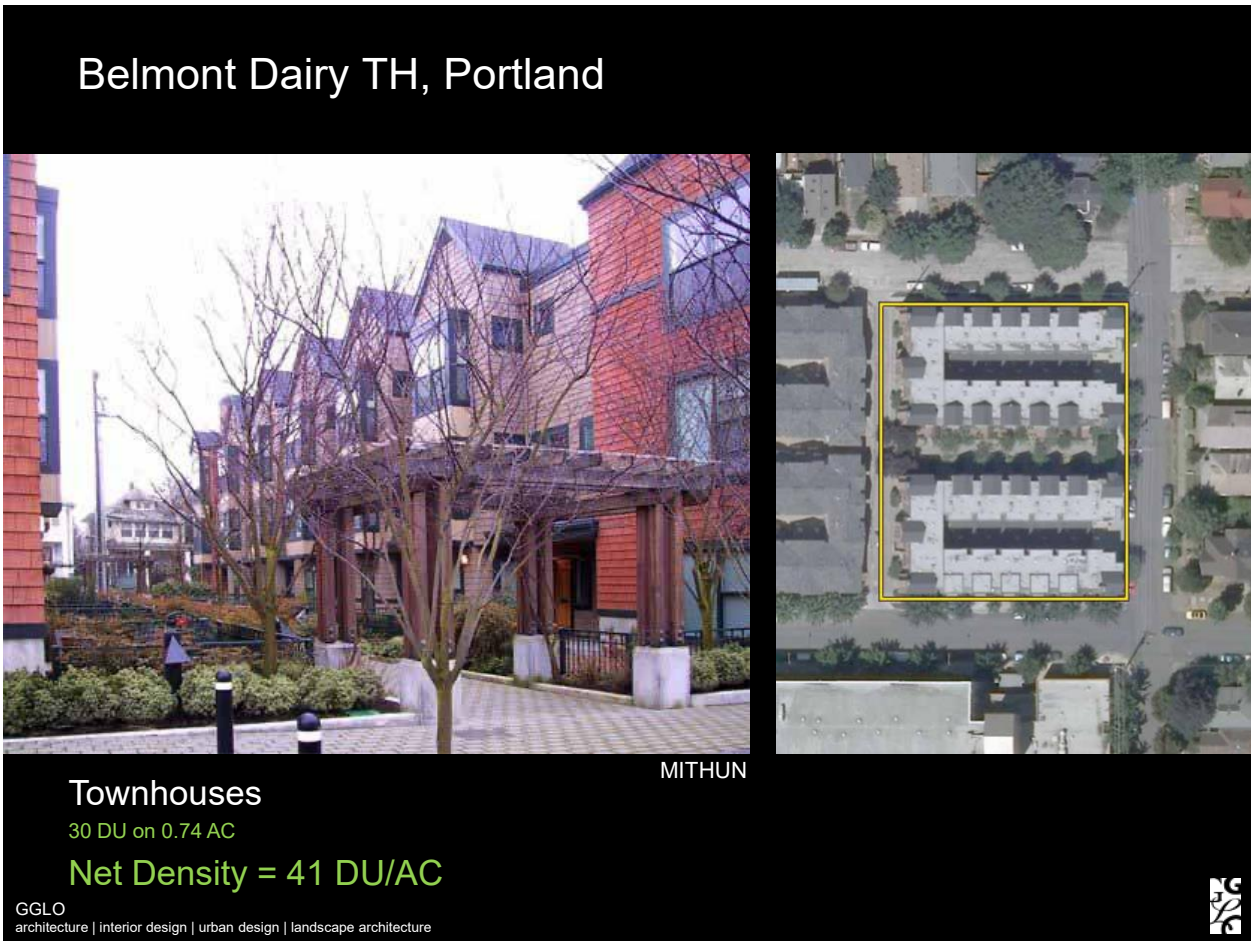

Belmont Dairy TH, Portland
MITHUN
Townhouses
30 DU on 0.74 AC
Net Density = 41 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.8

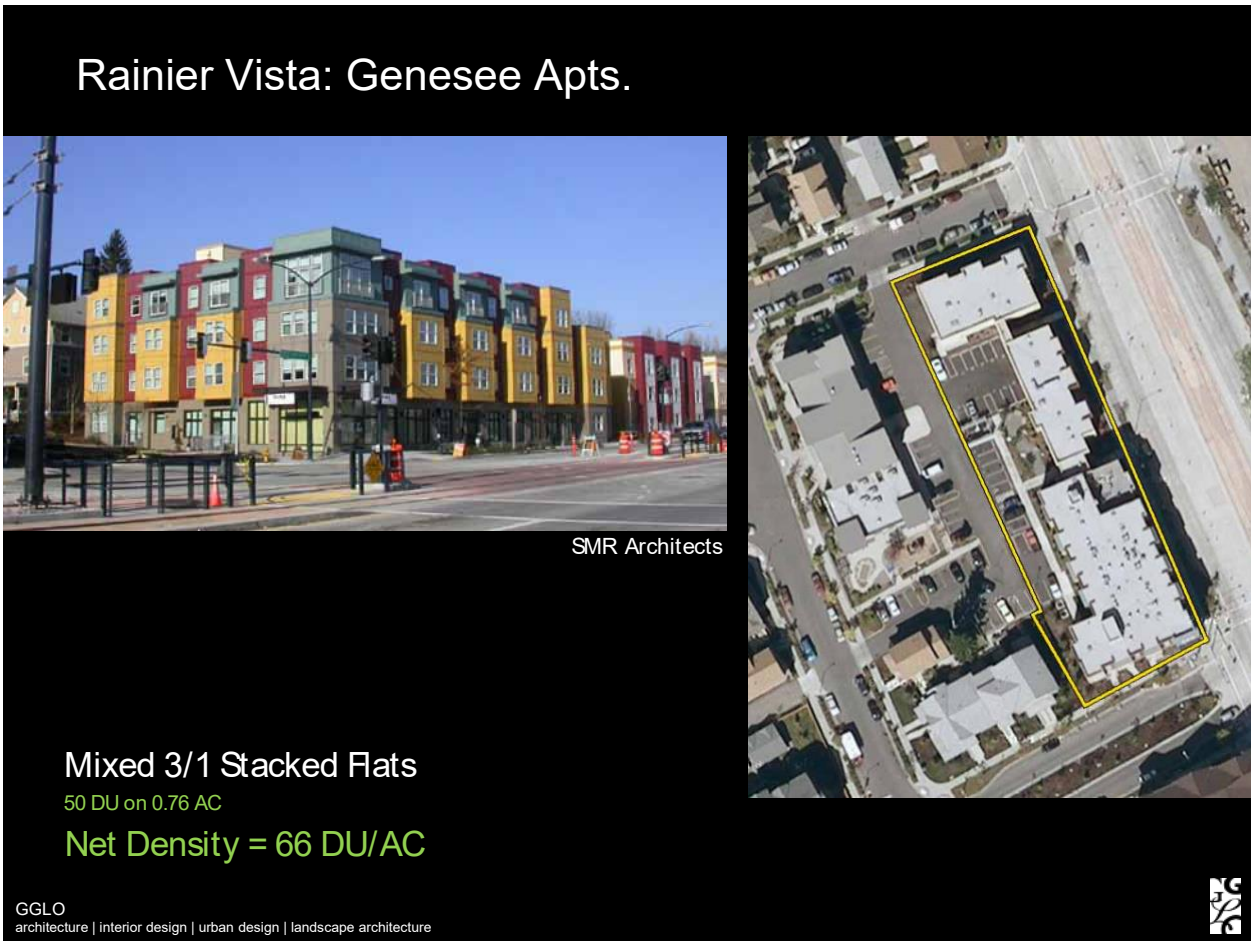

Rainier Vista: Genesee Apts.
SMR Architects
Mixed 3/1 Stacked Flats
50 DU on 0.76 AC
Net Density = 66 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.9

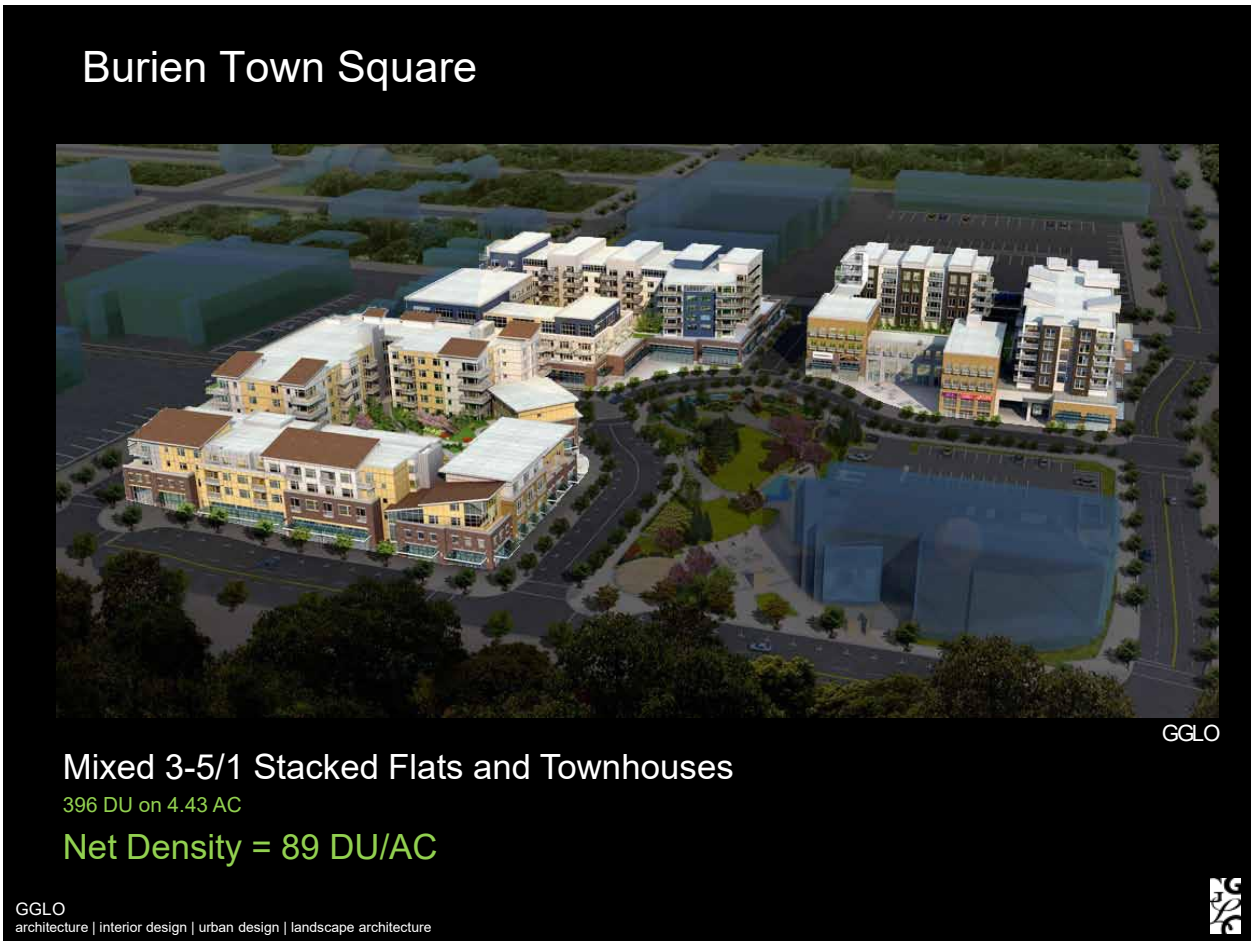

Burien Town Square
GGLO
Mixed 3-5/1 Stacked Flats and Townhouses
396 DU on 4.43 AC
Net Density = 89 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.10

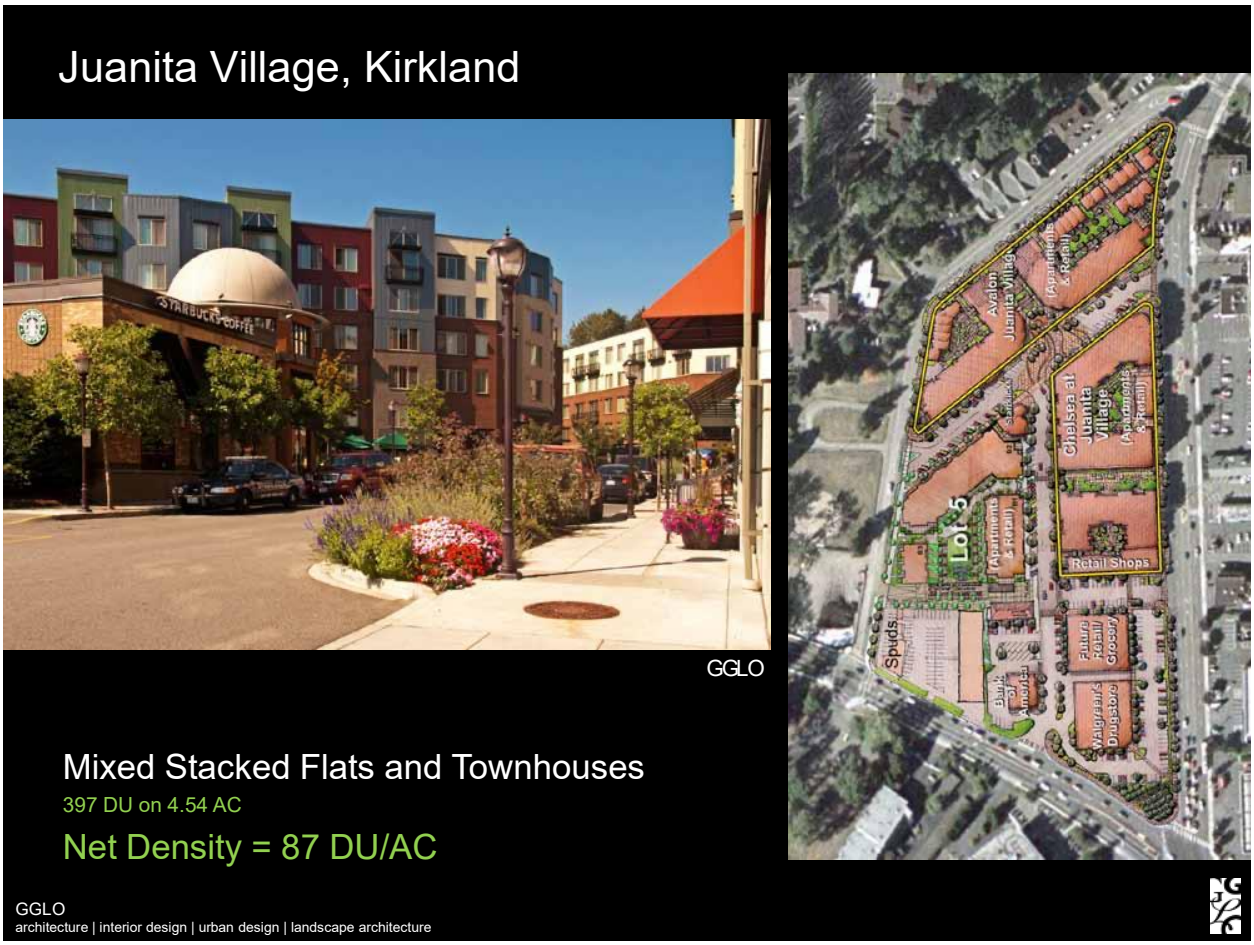

Juanita Village, Kirkland
GGLO
Mixed Stacked Flats and Townhouses
397 DU on 4.54 AC
Net Density = 87 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture
Avalon Juanita Village (Apartments & Retail)
Chelsea at Juanita Village (Apartments & Retail)
Lot 5
(Apartments & Retail)
Retail Shops
Spuds
Future Retail/ Grocery
Bank of America
Walgreens Drugstore

Figure 9.11

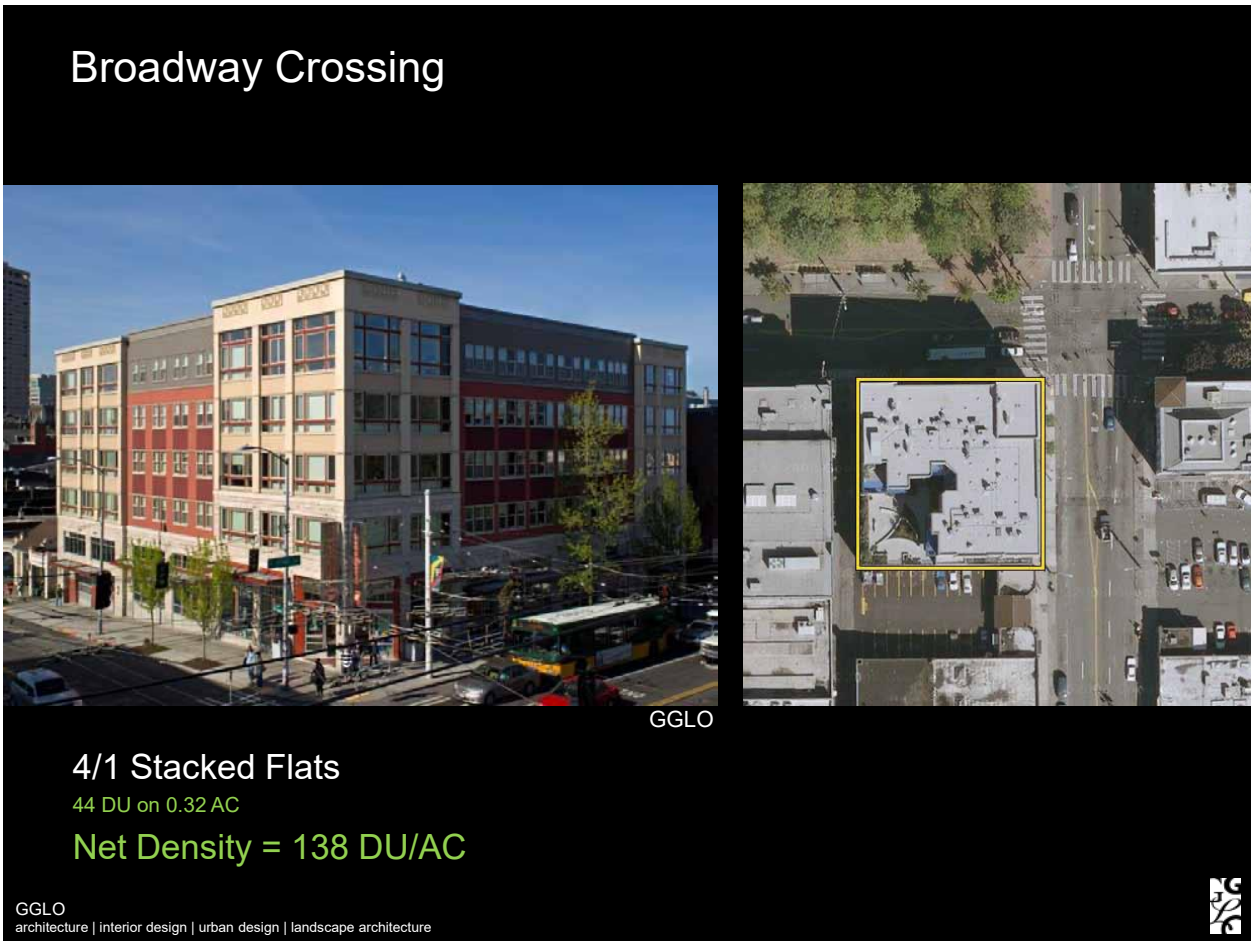

Broadway Crossing
GGLO
4/1 Stacked Flats
44 DU on 0.32 AC
Net Density = 138 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.12

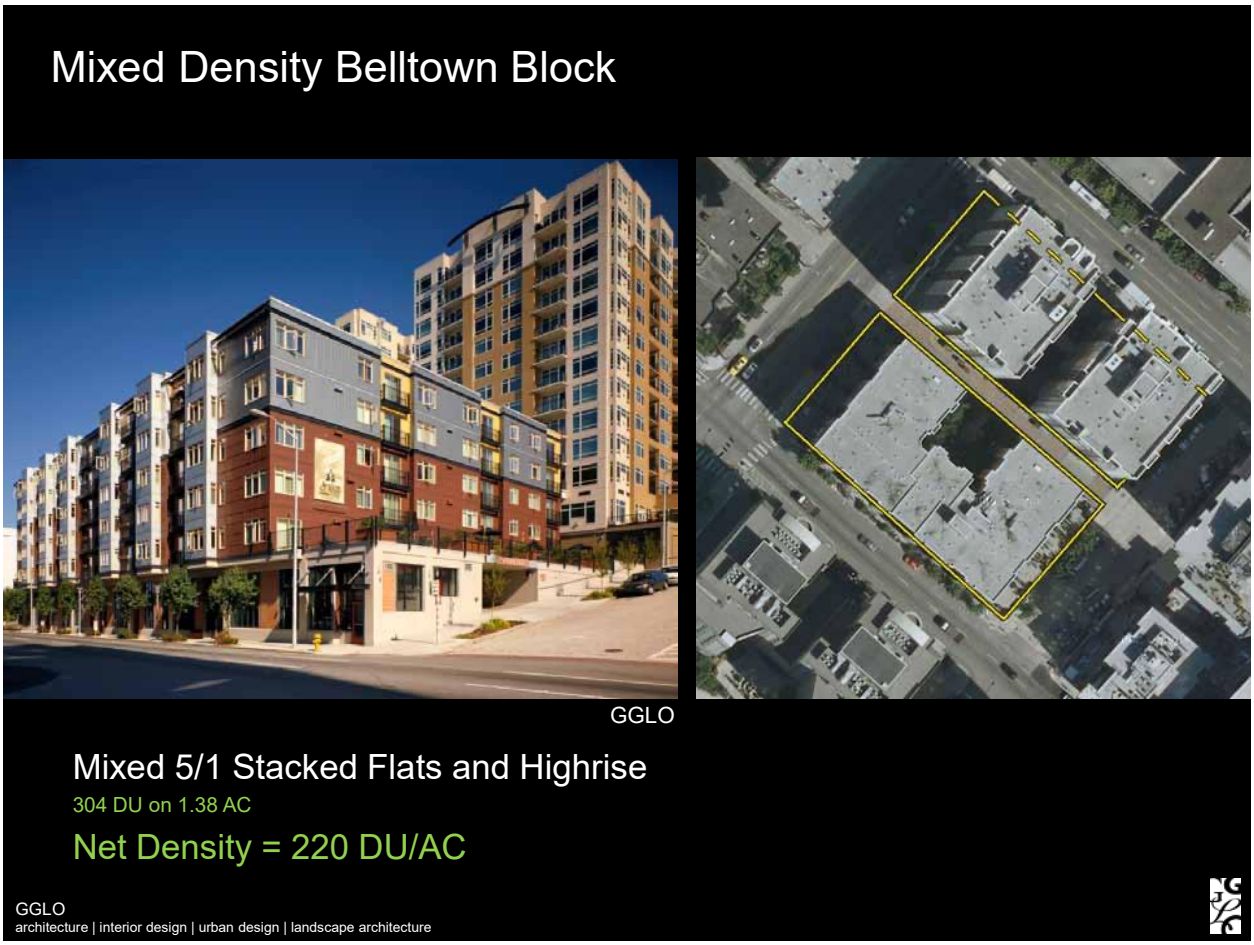
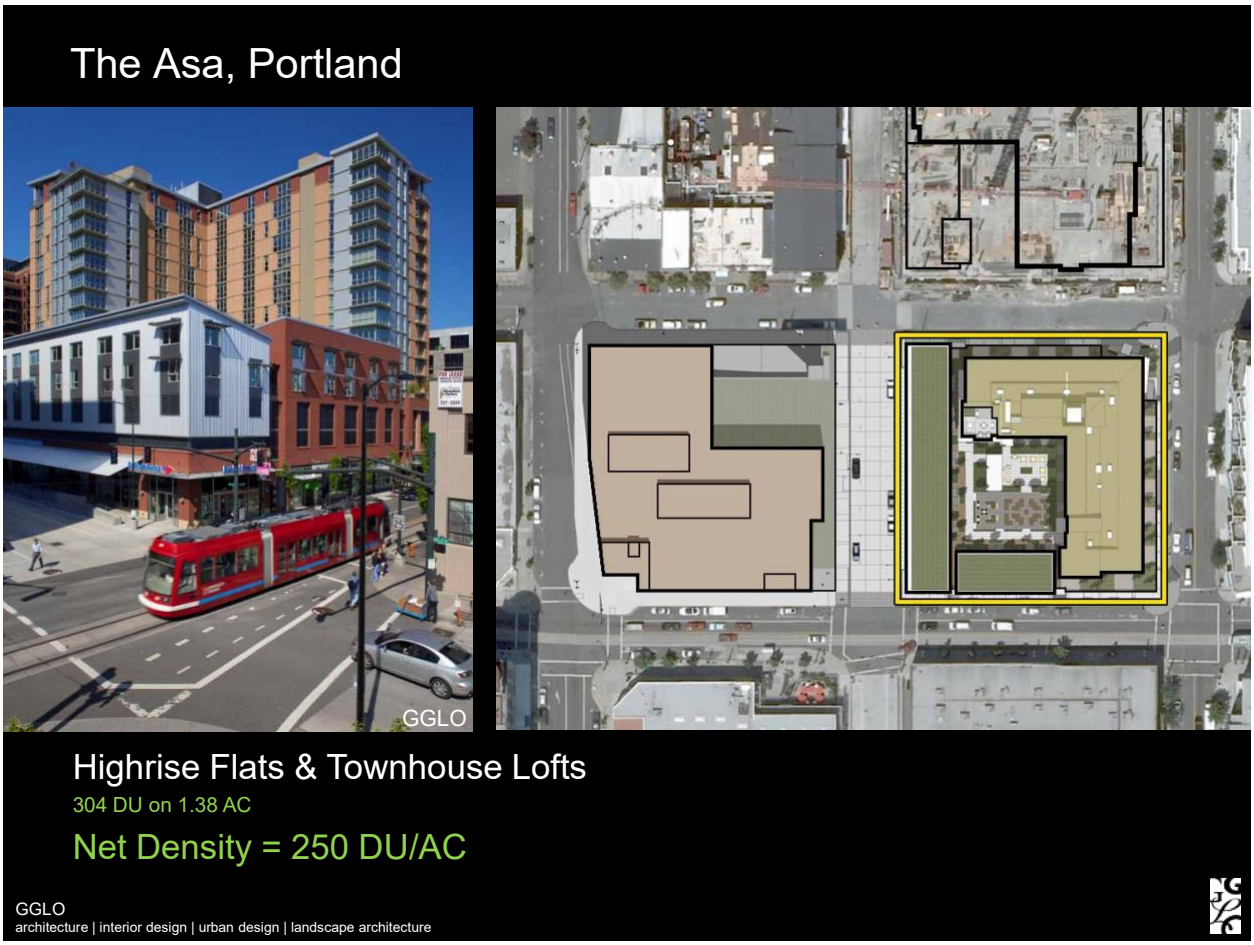
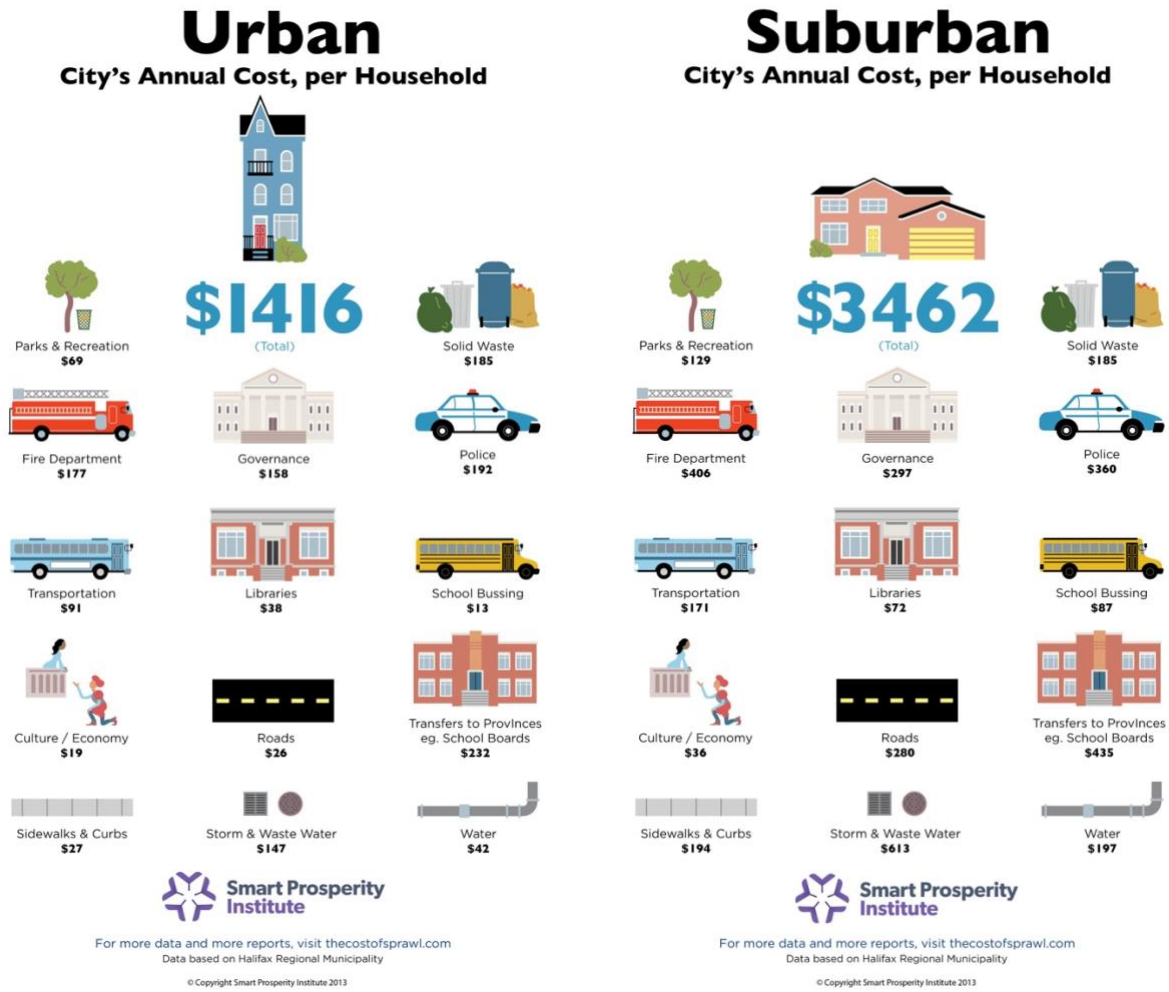

Mixed Density Belltown Block
GGLO
Mixed 5/1 Stacked Flats and Highrise
304 DU on 1.38 AC
Net Density = 220 DU/AC
GGLO
architecture | interior design | urban design | landscape architecture

Figure 9.13



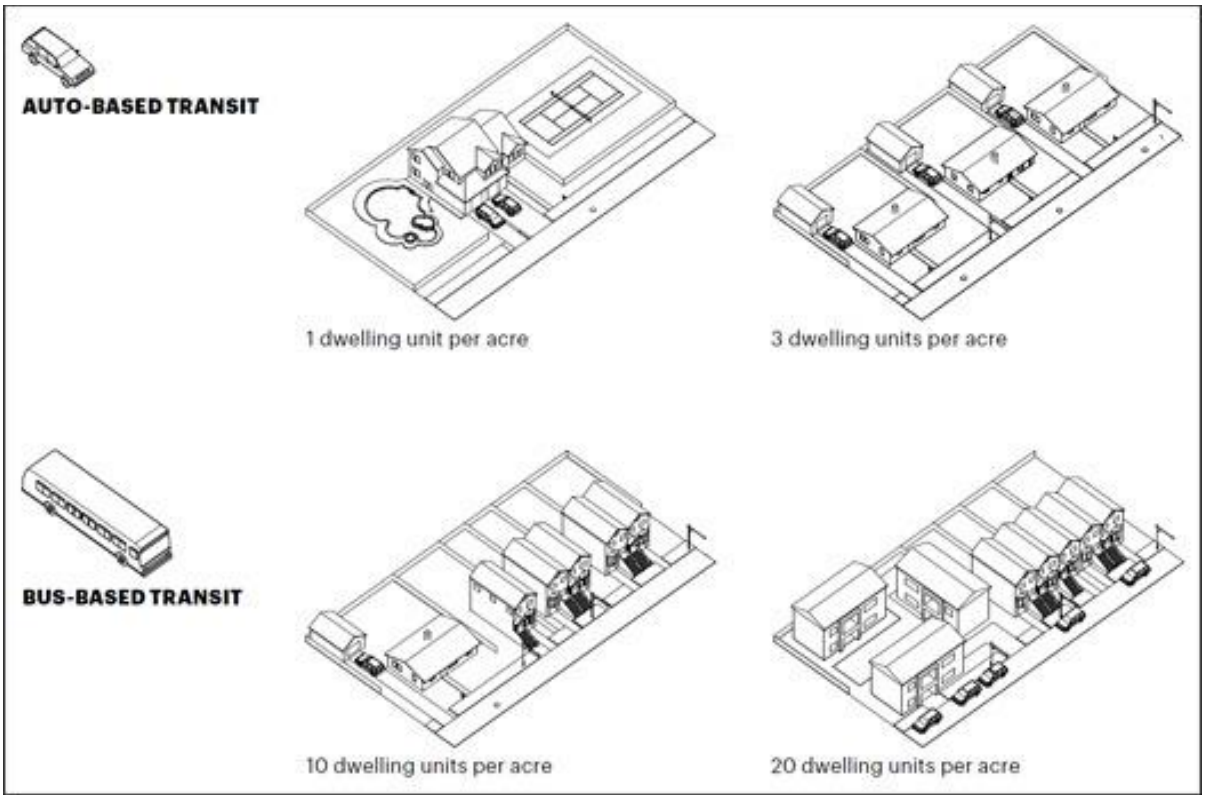
Source: Don Vehige, GGLO Design. Density Principles Presentation to Legislature for HB 1490.

Figure 9.14



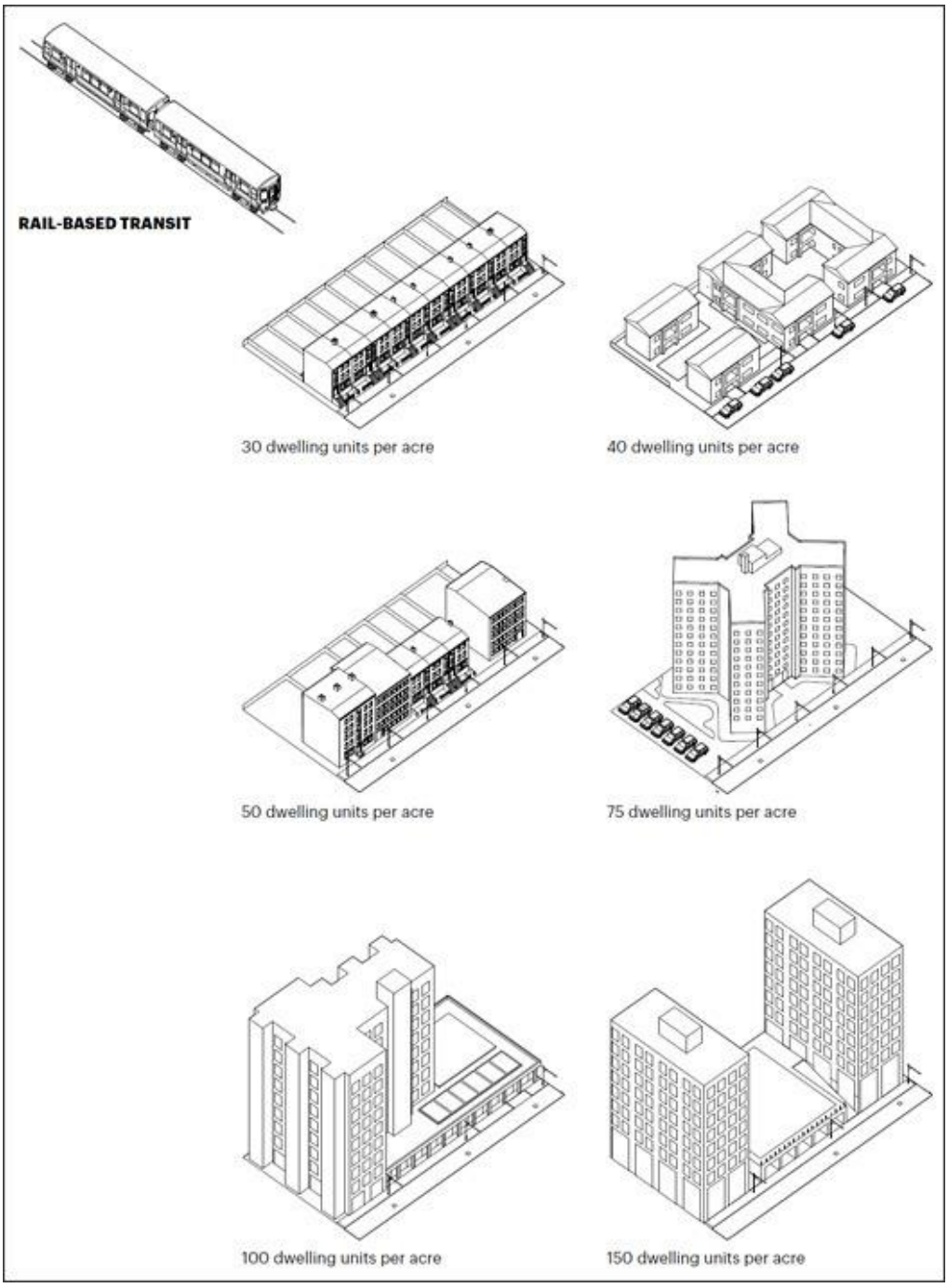
Source: "Infographics: The Cost of Sprawl." Smart Prosperity Institute, 2013. https://institute.smartprosperity.ca/library/publications/infographics-cost-sprawl.

Figure 9.15



Source: Pushkarev, B. S., Jeffrey M. Zupan, and Robert S. Cumella. 1982. *Urban rail in America: an exploration of criteria for fixed-guideway transit*. Bloomington: Indiana University Press. https://placesjournal.org/article/building-hyperdensity-and-civic-delight/#ref_10

Figure 9.16



Source: Pushkarev, B. S., Jeffrey M. Zupan, and Robert S. Cumella. 1982. *Urban rail in America: an exploration of criteria for fixed-guideway transit*. Bloomington: Indiana University Press. https://placesjournal.org/article/building-hyperdensity-and-civic-delight/#ref_10

Appendix D: Detailed Parking Analysis

1.0 Background

Notwithstanding conventional wisdom regarding campus parking the issue in most cases is not the lack of spots, but as Donald Shoup puts it, "parking problems… stem from mispricing, not scarcity."[108] For example, at U-M Ann Arbor, at times of peak occupancy there are multiple lots on campus with open spaces, ranging from 31 open spots to over 151.[109] (Figure 4.1 and 4.2) A switch from an annual parking pass to a daily payment parking system at all three campuses in conjunction with the removal of the university contribution to parking permits at the Ann Arbor campus, together with policies designed to yield consistent occupancy rates systemwide, will correct this mispricing. This is a form of active parking management and is a necessary key to reducing the drive-alone mode share.[110,111]

1.1 Case Study: MIT

The Massachusetts Institute of Technology (MIT) made the switch to a daily payment structure for parking in 2016 and have seen an encouraging decrease in two key parking metrics related to carbon emissions: 1) the overall number of people buying permits/registering a car in the system (Table 3.1) and 2) the overall frequency at which people drive to campus has decreased (Table 3.2)[112]. In addition, there has been a decrease in the average peak occupancy in the gated lots at MIT (Figure 4.3)[113]. This means there are more spots available on campus for those who do drive to campus, all without building more parking infrastructure. To fully understand how MIT has encouraged these changes, some background information on the parking context at MIT is required. MIT has two types of parking lots, gated and ungated, with a total of 4,000 spots. The gated lots are owned by MIT, while the ungated lots are a mix of lots owned by MIT or leased by MIT. Prior to 2016, the main type of parking permit was an annual pass, which cost $1,600 in 2016[114] and allowed the driver to park in their assigned lot all year. This cost, like with most annual parking passes, was paid once a year. This type of permit structure hides the true cost of parking each day, because drivers do not have to think about what it costs to park every single day.[115] [116]

Paying daily forces drivers to think about the true cost of parking again. Each day they drive they must make an active decision to pay to park, which means each day they could decide that cost is not worth it. With a daily parking permit, it is much easier for a person to decide they do not need to drive to campus on that specific day. Instead they can use another commute option (such as public transit, a bike, carpooling, or walking) or, if there are policies in place, work from home.

MIT has structured their parking system so that employees and students are not paying more than they would have before this system was implemented.[117] An annual cap has been placed on the amount any one person pays for parking in an academic year. If someone must drive to campus every day of the week, they will reach the annual cap (which is the same amount as an annual permit) around May, and parking will be free for the remainder of the academic year. The

reason the cap is the same as an annual permit, is that MIT was unable to switch to a 100% daily parking system. The ungated lots do not have the necessary infrastructure to charge drivers each day they park in the lot, and so some employees are given parking spaces that require an annual pass. In addition, there are some cases, such as students who store a car on campus, where daily parking is an unideal system. For a complete breakdown on the costs of parking permits, see Table 3.3.[118]

2.0 Equity Considerations

Further measures could be taken to ensure that employees who are lower on the salary scale are not burdened by an increase in the cost of parking (as would happen, especially with the removal of the university contribution). Following the example of Rutgers University and the Rochester Institute of Technology (RIT), the cost of a parking permit (or in this case the annual cap on parking) can be tied to a person's salary. There are two methods that could be used to determine how much a permit costs. The first is the method seen most frequently. This method splits salaries into ranges and each range pays a certain amount. RIT uses this method.[119] The final method also uses salary ranges, but takes an employee's specific salary and multiplies that by a rate common to the range. This method is used at Rutgers University[120]. Examples of the possible cost under the method used at Rutgers, as well as all possible costs at RIT are shown below in Figure 4.1.

Rochester Institute of Technology Model

Salary Range	Annual Cost
< $45,000	None
$45,000 - $94,999	$50
$95,000 - $141,999	$100
$142,000 or more	$150

Rutgers University Model

Salary Range	Rate	Fee Range
$0 - $24,000	0.0010	$0 - $25
$60,000 - $69,000	0.0022	$132 - $154
$110,000 - $119,000	0.0032	$352 - $384
$150,000 or more	0.0040	$600 ≤

Figure 4.1: Example of permit costs when cost is tied to salary Source: Rutgers Parking, RIT Parking

Parking infrastructure, especially parking garages, is costly. Recent University of Michigan structures cost roughly $45,000 per parking spot[121]. This does not take into account the many other costs of putting in a new parking garage, including land acquisition, and future upkeep costs. Delaying the need to build new parking infrastructure will save the university money in the long run. In addition, foregoing the construction of new parking lots and garages leaves land open to use for other purposes, such as more on campus housing and academic buildings.

The shifts proposed amount to a prioritization of management of existing spots over new construction as an approach to the parking problem. At the moment there are multiple parking lots on North Campus and the Ross Athletic Complex that have open spots during times of peak occupancy(Figure 4.1). These spots remain open because the cost of parking there is too high relative to centrally located parking, which is at or beyond capacity. A change in the pricing, through the removal of the university contribution, a switch to daily payment for parking, and a connection between the cost of parking and an employee's salary will help move parkers to these lots, reducing the need to build new parking infrastructure in the future and the emissions tied to driving a car to campus.

3.0 Tables

Table 3.1 Comparison of Number of Parking Permits Bought Before and After MIT Daily Pass Implementation

Table 4.5: Parking Permit Purchases (2015-18)

Permit Type	**2015-16** Pre-AccessMIT	**2016-17** Year 1	**2017-18*** Year 2
Regular commuter (annual)	2,147	678	598
All lots (annual)	43	18	15
All lots reserved (annual)	6	5	6
Carpool sticker (annual)	304	273	283
Economy commuter (annual)	274	0	0
Medical (annual)	4	11	6
Emeritus with compensation (annual)	11	12	13
Emeritus without compensation (annual)	85	86	78
Regular commuter with smartway discount (annual)	48	19	28
Economy/Occasional (daily)	297	463	416
Occasional/Evening (daily)	1,951	3,282	2,992
Occasional/Evening all lots (daily)	0	48	50
Total annual	2,618	829	744
Total daily	2,248	3,793	3,458
Total carpool	304	273	283
Grand Total	**5,170**	**4,895**	**4,485**
Change from 2015-16	-	*-5%*	*-13%*

*Through April 2018

Source: Rosenfield, Driving Change

Table 3.2 Average Parking Frequency Before and After MIT Daily Pass Implementation

Table 4.6: Average Parking Frequency

	2015-16	**2016-17**	**Change**
All staff at MIT	1.25 (N=11,002)	1.14 (N=11,283)	8.7% decrease
All benefits-eligible staff at MIT	1.35 (N=9,666)	1.23 (N=9,913)	8.8% decrease
Active parking permit holders (20+ transactions per year)	2.63 (N=3,218)	2.65 (N=3,007)	0.5% increase

Source: Rosenfield, Driving Change

Table 3.3 MIT Parking Schedule

PARKING ACCOUNT TYPE	COST	ANNUAL FEE	CAP
Employee Daily Rate (gated and ungated lots)	$10.50/day	$0	$1995/year
Employee Off-Campus (leased lots, limited)	$166/month	$0	No cap
Emeritus Faculty (paid and unpaid)	$10.50/day	$0	$336/year
Student Commuter	$10.50/day	$0	$1300/year
Campus Resident	$166/month	$0	No cap
Carpool (Groups of two or more employees or students)	$84/month divided by # people in carpool	$0	No cap
Affiliate* (Consultants, contractors, volunteers, DAPER members)	$10.50/day	$10/month ($120/year)	No cap
Department Vehicles	$2390/year	$0	No cap
Visitor passes and scratch cards**	$32/day	$0	No cap

Source: MIT Parking Website

4.0 Figures

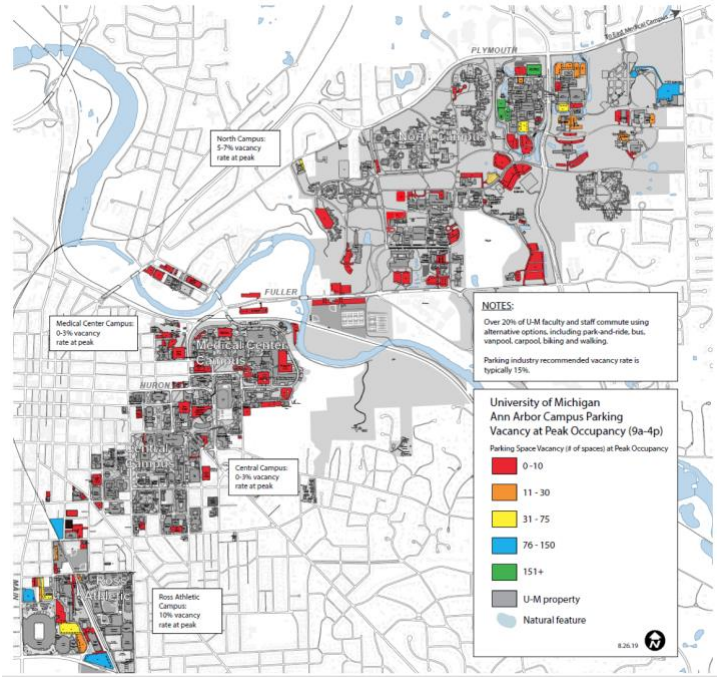


Figure 4.1 Peak-Period Parking Vacancy Map, Ann Arbor Campus (Source: Logistics, Transportation & Parking)

Location of Lot	Lot ID	Number of Spots Open at Peak Occupancy	Permit Type	Permit Cost (employee, student)
North	NC100	151+	Blue Gold	$766 $1,882
North	NC96	151+	Blue	$766
North	NC95	151+	Blue	$766
North	NC37	76 - 150	Park/Ride	Free
North	NC92	31 - 75	Blue Gold	$766 $1,882
North	NC85	31 - 75	Blue	$766
North	NC82	11 - 30	Yellow	$167, $237
North	NC83	11 - 30	Yellow	$167, $237
North	NC9	11 - 30	Yellow	$167, $237
North	NC103	11 - 30	Yellow	$167, $237
North	NC66	11 - 30	Unknown	Unknown
Ross	SC7	76 - 150	Orange	$84, $84
Ross	SC36	76 - 150	Orange	$84, $84
Ross	SC46	76 - 150	Yellow	$167, $237
Ross	SC5	31 - 75	Yellow	$167, $237
Ross	SC2	31 - 75	Blue	$766
Ross	SC6	11 - 30	Orange	$84, $84
Ross	SC35	11 - 30	Yellow	$167, $237
Ross	SC37	11 - 30	Blue	$766
Ross	SC12	11 - 30	Blue	$766

Figure 4.2 Explanation of Peak-Period Parking Vacancy (Source: Logistics, Transportation & Parking)

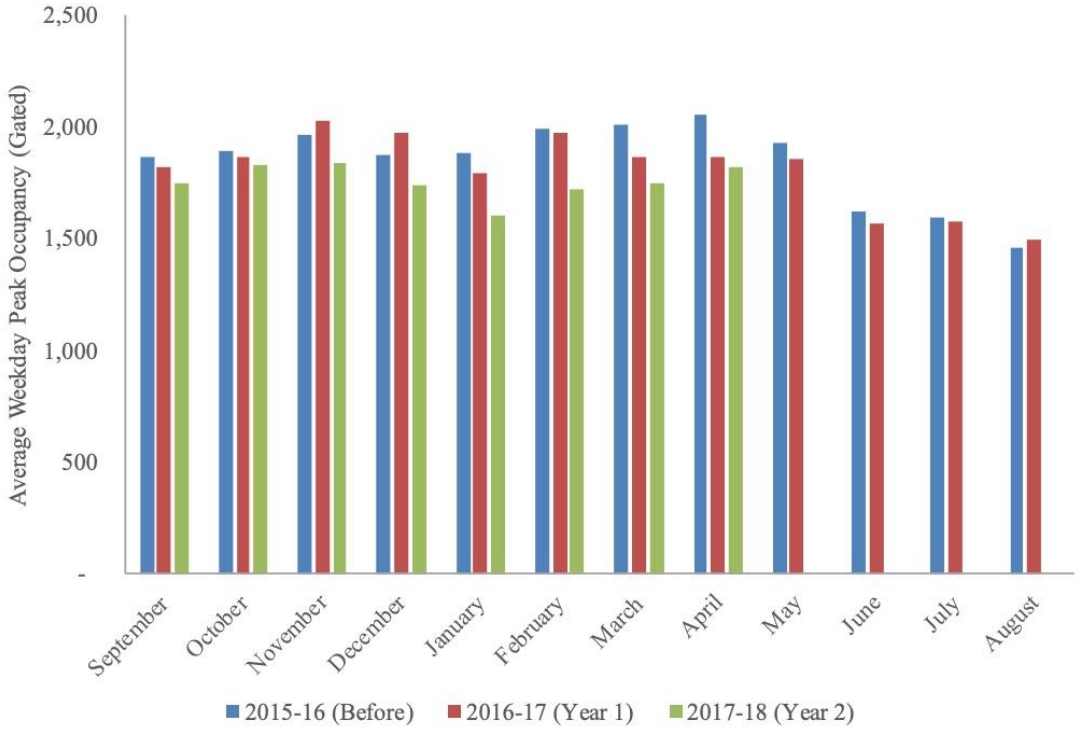


Figure 4.3 *MIT Average Weekday Peak Occupancy Among Gated Lots 2015-2018 (interim)*

Source: Rosenfield

Appendix E: Transit Improvements

1.0 Universal Access: This appendix provides detail pertinent to the recommendation for extension of universal transit access to the Dearborn and Flint Campuses.[122] [123] At other commuter campuses, implementation of universal transit access for all students, faculty, and staff has been shown to be effective in reducing carbon emissions. For example, Northern Kentucky University (NKU) is a campus of similar size and campus setting to UM-Dearborn and UM-Flint as well as a comparable percentage of student and faculty commuters. In 2007, Northern Kentucky entered a universal access contract with their regional transit authority, and within the first three years of their program reduced emissions by over 1500 metric tons of carbon equivalent by providing more than 650,000 fare-free rides to students, faculty, and staff.[124]

The main two financial considerations of universal transit access for UM-Dearborn and UM-Flint are how the agreements will cost and how the University will fund that cost. The cost of universal access on the Ann Arbor campus is $1.19 per passenger boarding an AAATA bus whio presents a valid MCard. The estimated total program cost is $2,694,160, or about $28 per university affiliate per year. The cost is partly defrayed by federal subsidies generated by the operations of the campus system that flow to the AAATA.[125]

At Northern Kentucky, the university pays their partner transit authority an annual fee for transportation services. This annual fee was about $151,000 in 2010-11 and is set to by 3% each subsequent year.[126] Before settling on a cost for universal access, the University should administer transportation preferences surveys to UM-Dearborn and UM-Flint to estimate existing transit use rates. Traditionally, institutions with successful universal access policies fund their programs with any combination of student fees, parking revenues, the universities' general funds, advertising, government subsidies, and employee payroll deductions. If the University were to rely on student fees and payroll deductions to fund universal access, it should be cognizant of the financial burden this puts on low-income students, faculty, and staff; for example, financial aid should be eligible to cover any additional student fees.

This policy can be scaled up over time by negotiating with the relevant transit agencies for additional University-oriented bus routes. The University could also pursue the development of park and ride services that specifically serve hubs where students, faculty, and staff live. As more regional options are potentially added to the UM-Flint and UM-Dearborn regions, there may be opportunity to develop more robust partnerships with regional transit systems. This is a policy that could be easily adopted by other universities to further reduce carbon emissions. UM-Flint's partnership with MTA Flint and UM-Dearborn's partnership with SMART could serve as models to other universities—such as Kettering University in the Flint area and Henry Ford College in the Dearborn area—for partnerships with MTA and SMART. There are numerous examples of single transit authorities providing universal access services to multiple universities.

Pursuing universal access programs for UM-Dearborn and UM-Flint should follow a three-phase progression. First, the University must begin discussions with SMART and MTA Flint, gauge community interest and current ridership through a student, faculty, and staff preference survey, and negotiate key terms of the agreement between the UM and the transit authorities. This includes the basis for pass pricing. Knowledge gained through the interest survey should include current travel behavior as well as willingness to pay so as to inform budgetary decisions. Phase two involves entering a formal agreement with SMART and MTA Flint and launching comprehensive marketing campaigns to maximize participation in universal access among

students, faculty, and staff. The final phase involves rolling out the new universal access program and providing UM-Dearborn and UM-Flint with fare-free bus service. In order to ensure maximum ridership, marketing campaigns should continue until the program is firmly cemented into campus culture. During this phase, the UM-Dearborn and UM-Flint should also develop periodical evaluation mechanisms for universal access in order to continue and improve the universal access agreements into the future. If phase one were to begin in fall of 2020, phase two could begin in summer 2021 in time for targeted marketing at incoming students at orientation. Following this trajectory, a universal access pilot program could be ready for implementation as early as fall 2021. In order to move forward, UM-Dearborn and UM-Flint must first reach out to SMART and MTA Flint, respectively, in order to assess the feasibility of universal access collaborations. The University should also reach out to student groups on both campuses who could act as advocates for universal access programs among the student body. A final immediate step that the University could take would be to develop a universal access interest survey to administer to students, faculty, and staff at Dearborn and Flint. This would help estimate the cost of such a policy as well as give the University data on what types of provisions it should negotiate for in a universal access agreement.

2.0 Ann Arbor Transit Improvements: The University of Michigan, in cooperation with numerous municipal, regional, and state bodies spearheaded a concept entitled "The Ann Arbor Connector," an effort that terminated in 2016 with an alternatives analysis report.[127] The project, if implemented, would have developed a rail corridor from US-23 and Plymouth Road in the northeast, through U-M campuses and Ann Arbor's downtown to the Briarwood area in the south. U-M ultimately decided that costs were too high, and plans were never brought to fruition.

A current concept, the U-M Connector, illustrated in Figure 2.1, is a scaled-back version of the Ann Arbor connector, extending from the North Campus Research Complex in the northeast to Central Campus Transportation Center in the south. It is currently conceived of as an exclusively University of Michigan project nearly exclusively on University-owned land. While the reduced cost and institutional complexity of an entirely University-based system hold understandable appeal, such a system would miss opportunities to improve transit access from the town and region to campus, focusing instead on intercampus movements. The recommendations in the main report are designed to increase the interconnectedness of the system with regional public transportation and to reserve well-located land (such as at the NCRC) for high-priority academic and residential purposes, rather than parking.

If the system is initiated by the University, the commuting team recommends that U-M take steps to ensure that it could feasibly be expanded in the future to be a shared campus-community resource. One of those recommendations, the use of Bus Rapid Transit (BRT) technology, is further explained here.

By providing exclusive infrastructure, BRT can provide service comparable to rail-based systems with two advantages: 1) Lower cost,[128] and 2) Superior integration with surrounding bus-based systems. The integration advantage stems from the capacity of BRT to reduce transfers (a known impediment to travelers' selecting the transit mode[129]) by through-routing of buses from other areas to the BRT. For example, consider the commuter from Ann Arbor's west side to North Campus. They currently must transfer at the Blake Transit Center for a bus that would let them off at Fuller Road, perhaps a 12-minute walk to their campus destination. Alternatively, they could fourteen minutes from Blake Transit Center to Central Campus Transit Center (CCTC) to catch a campus bus to north campus.

A rail-based Ann Arbor Connector that terminated at the CCTC would maintain the transfer, and possibly the walk from downtown Ann Arbor. By contrast, a Bus Rapid Transit facility could support routes heading from Ann Arbor's west side (and other areas) that get on the BRT for rapid service to and through Central, Medical, and North Campuses once they reach downtown. The benefit would extend beyond travelers to the University. For example, AAATA routes headed in a east or northeast direction from downtown could make use of the facility, thereby improving service to travelers headed to points beyond. A rail-based system would not offer similar community benefits, and AAATA headed in its direction would need to duplicate service by operating along city streets. By offering superior transit access, a BRT facility could make Central, Medical, and North Campuses much more central to the AAATA network than they are now, with attendant benefit to campus commuters.

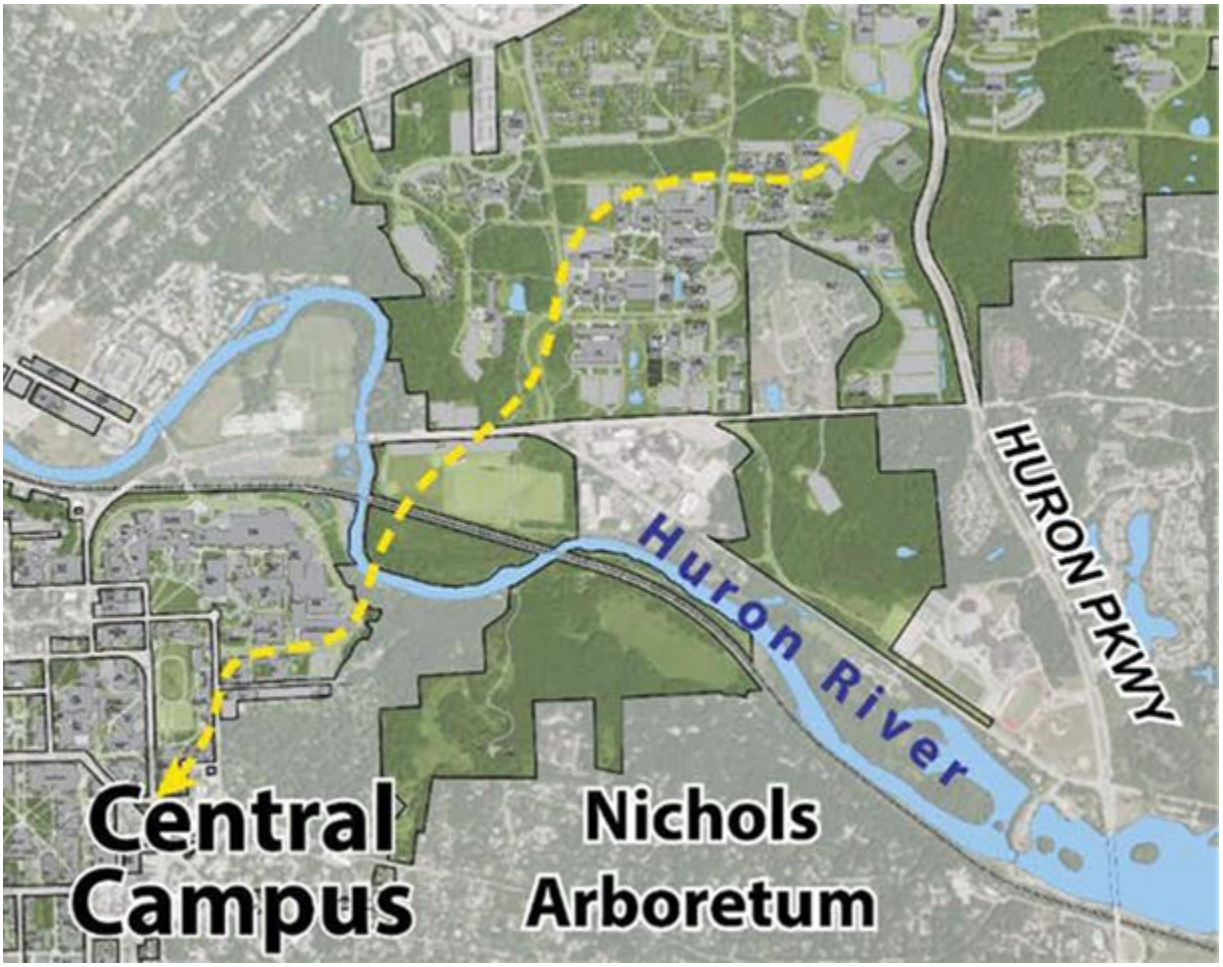


Figure 2.1: Current Concept for the University of Michigan Connector (Source: Logistics, Transportation & Parking, http://a2gov.legistar.com/LegislationDetail.aspx?ID=4222816&GUID=1035FA39-8E3C-4768-AD54-9EB7BE8F865A)

Appendix F: Rideshare Detailed Analysis

1.0 Details

The low mode share for ridesharing at U-M can be raised with enhanced institutional support, enhanced matchmaking, and incentives for commuters who choose to rideshare. Our peers at Indiana University have implemented a model program which has brought their rideshare mode share to 11% for faculty and staff. It comprises three planks:

- Permit perks: Indiana University offers significant permit perks including free or reduced price parking permits depending on number of passengers, and an included allotment of daily passes for all participants in the event that multiple members of a carpool must drive on a given day.
- Advertising and matchmaking: Advertising and matchmaking are integral to an effective rideshare program because a perception of institutional support creates the trust between participants necessary to start a carpool, and because it attracts enough users to make finding a partner likely.
- Fringe benefits: Indiana University offers significant fringe benefits to ride sharers, such as free ZipCar credit and raffles which create a sense of fun and enable participants to go car-free.

If the University does not choose to pursue a full parking redesign, it should instead expand incentives for carpooling through discounting and the implementation of a 'meal plan' of daily passes for all members of a registered carpool. Under this policy, ride sharers would have the option of tailoring their purchases of parking permits to their actual need. In the U-M system, by contrast, occasional parkers usually need to choose between a pricey annual pass and expensive and inconvenient daily parking payment.

2.0 Metrics and Tracking

The effectiveness of our rideshare program can be measured in two ways: 1) through an effective transportation study and 2) by tracking the increase in the number of vanpool participants and rideshare passes. While there may be some concern about undercounting informal/unreported ridesharing arrangements, this data may be cross referenced against the total number of parkers as the University moves to 100% gated lots. Alternatively, sufficient incentives will increase the likelihood that ridesharing arrangements will be reported.

3.0 Tables

Table 3.1 Forecast Change in Emissions Estimated with Ridesharing

Demographic	Value	Change in Yearly Emissions (Metric tons per year)
Staff & Faculty	%	-5.8%
	Absolute	-6,078
Students	%	-10.3%
	Absolute	-2,156

Table 3.2 Forecast Change in Emissions by Location per Capita - Faculty and Staff (kg/day)

Distance (mi)	**Cen-tral**	**North**	**East Medical**	**Med-ical**	**South**	**Total AA**	**Dear-born**	**Flint**
0-1	-0.18	-0.08	-0.06	-0.19	-0.06	-0.13	-0.14	-0.14
1-2	-0.10	-0.04	-0.06	-0.09	-0.07	-0.08	-0.09	-0.09
2-4	-0.07	-0.05	-0.06	-0.07	-0.06	-0.06	-0.07	-0.07
4-6	-0.07	-0.06	-0.07	-0.07	-0.06	-0.06	-0.06	-0.06
6-10	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
10-15	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.07	-0.07
15-20	-0.06	-0.06	-0.06	-0.05	-0.06	-0.05	-0.05	-0.05
20+	-0.06	-0.06	-0.06	-0.05	-0.06	-0.05	-0.06	-0.06
Total	-0.06	-0.05	-0.06	-0.05	-0.06	-0.05	-0.06	-0.06

Table 3.3 Forecast Change in Emissions by Location - Faculty and Staff (metric tons per year)

Distance (mi)	Central	North	East Medical	Medical	South	Total AA	Dearborn	Flint
0-1	-3	-1	0	0	0	-5	0	0
1-2	-20	-4	0	-8	-2	-34	0	0
2-4	-59	-23	-1	-49	-7	-139	-3	-1
4-6	-54	-26	-3	-61	-9	-154	-3	-2
6-10	-102	-40	-14	-125	-28	-308	-8	-15
10-15	-108	-58	-21	-190	-42	-419	-22	-11
15-20	-169	-70	-22	-220	-73	-553	-24	-12
20+	-735	-296	-80	-1,130	-243	-2,484	-71	-107
Total	-1,250	-518	-141	-1,783	-404	-4,096	-131	-149

Table 3.4 Forecast Change in Emissions by Location per Capita (kg/day) - Students

Distance (mi)	Ann Arbor	Dearborn	Flint
0-1	-0.01	-0.01	-0.01
1-2	-0.04	-0.04	-0.04
2-4	-0.10	-0.10	-0.10
4-6	-0.17	-0.17	-0.17
6-10	-0.13	-0.13	-0.13
10-15	-0.43	-0.43	-0.43
15-20	-0.61	-0.61	-0.61
20+	-0.49	-0.49	-0.49
Total	-0.14	-0.34	-0.36

Table 3.5 Forecast Change in Emissions by Location (metric tons per year) - Students

Distance (mi)	Ann Arbor	Dearborn	Flint
0-1	-46	0	-1
1-2	-30	-2	-1
2-4	-153	-23	-11
4-6	-38	-31	-19
6-10	-18	-23	-48
10-15	-38	-124	-75
15-20	-62	-142	-90
20+	-600	-165	-418
Total	-985	-508	-663

Appendix G: Cycling Detailed Analysis

1.0 Description

1.1 Developing an On-Campus Bike Store

An on-campus bike store is critical for developing a campus culture that promotes cycling, and also a necessary sense of safety for reluctant cyclists—knowing a flat will not prevent you from getting home is important piece of mind. While more effective advertising for the emergency ride home system also addresses this second point, an on-campus bike store provides the ability to repair a bike on the fly which creates a sense of dependability. This is vital as research has found dependability and safety to be key barriers to commuting by bike.[130]

Currently, a number of our peers already offer on campus bike stores which provide at-cost parts, tuneups, and—importantly—workshops on riding and bike maintenance. Below is the MSU Campus Bike Store which provides, rentals, service, at-cost parts, and training: necessary components of an on campus bike store.

Figure 1.1.1 'MSU Bikes' on Campus Service Center

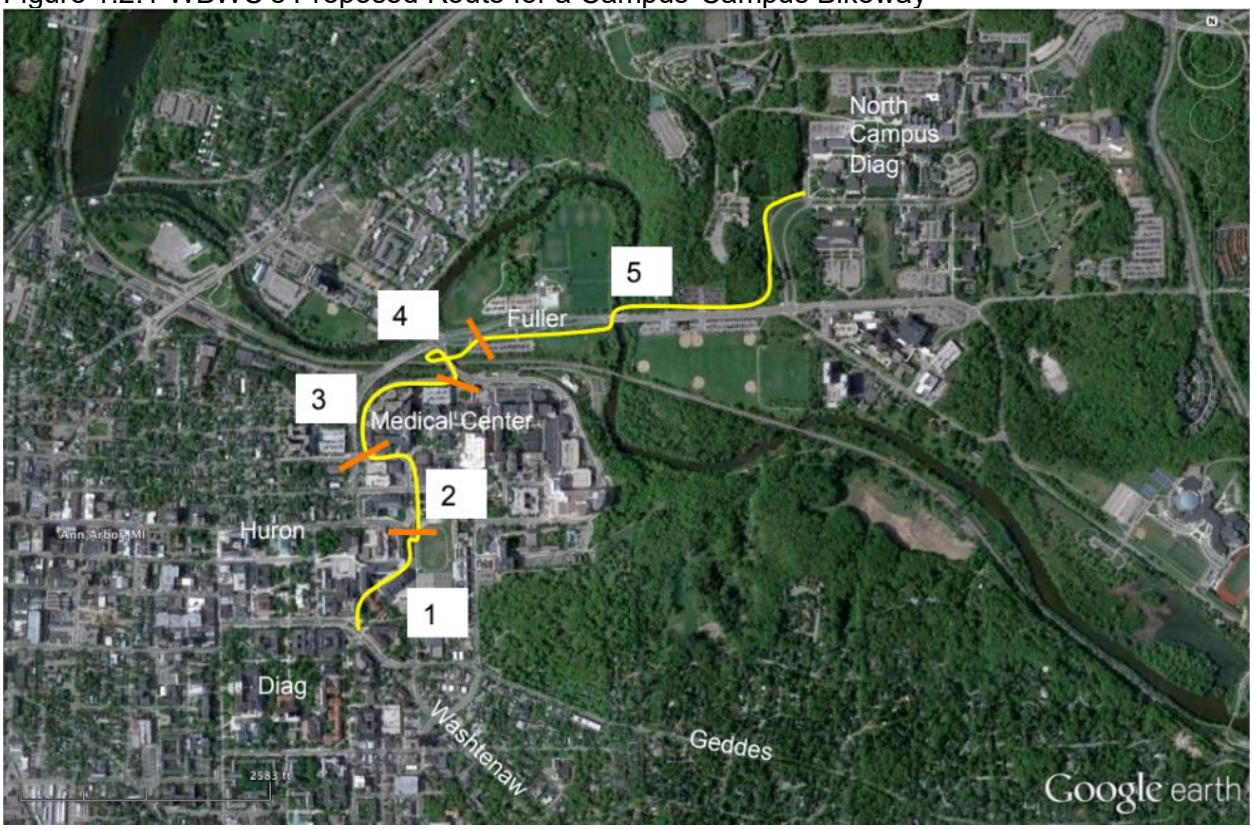
In combination with a complete network of bike routes, an on campus bike store is a necessary and cost-effective step to increase the cycling mode share at the University of Michigan.

1.2 Ann Arbor Network Improvements

Currently several key corridors in Ann Arbor do not have adequate cycling infrastructure.

- Cross-Campus Bikeway: It is difficult to cycle between the North and Central Campuses—a heavily trafficked corridor. Existing paths are often in poor repair, and the cyclist frequently needs to shift between path, roadway, and sidewalk in order to craft a safe route between campuses. Figure 1.2.1 details plans by the Washtenaw Biking and Walking Coalition for a bike route between North and Central Campus—a key corridor currently difficult to travel by bike.

Figure 1.2.1 WBWC's Proposed Route for a Campus-Campus Bikeway



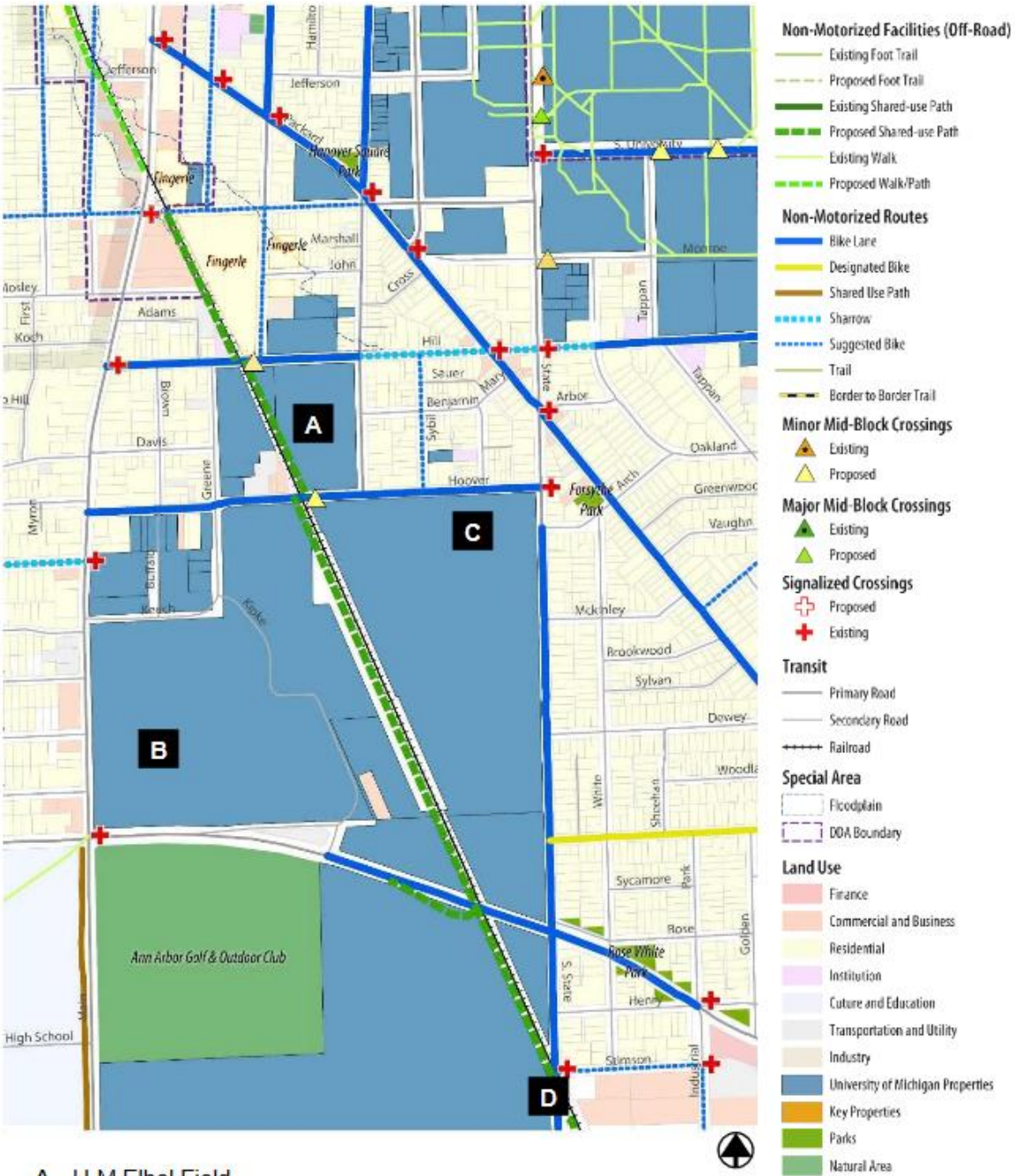
The proposed corridor includes:

1) A new protected bike lane on Zina Pitcher and Catherine
2) Restricting traffic on W. Medical Center Drive to busses, bikes, and local traffic
3) New ramps to utilize planned underpasses at the Fuller-Maiden Lane intersection

- Treeline Trail: The City of Ann Arbor is attempting to assemble the "Treeline Trail," a north-south pedestrian and cycle route through town, which would connect directly to the Diag viat the William Street protected bikeway. A key of the hoped-for route runs

through university property: from letter D in Figure 1.2.2 to the northwest side of the Fingerle property. The City has sought an easement from the University to allow the facility to reach the southern and of town, which the University has thus far been unwilling to grant. To aid in completion of the Treeline trail, we recommend that the University commit to granting an easement for pedestrian/cycle path through Elbel Field and along the road between the Intramural Sports Building and the Michigan Stadium (Figure 1.2.2)

Figure 1.2.2 **Proposed Route of Treeline Trail Easement (Source: City of Ann Arbor Treeline Trail Master Plan Project, https://www.a2gov.org/departments/systems-planning/programs/Pages/Allen-Creek-Greenway-Master-Plan-Project.aspx**



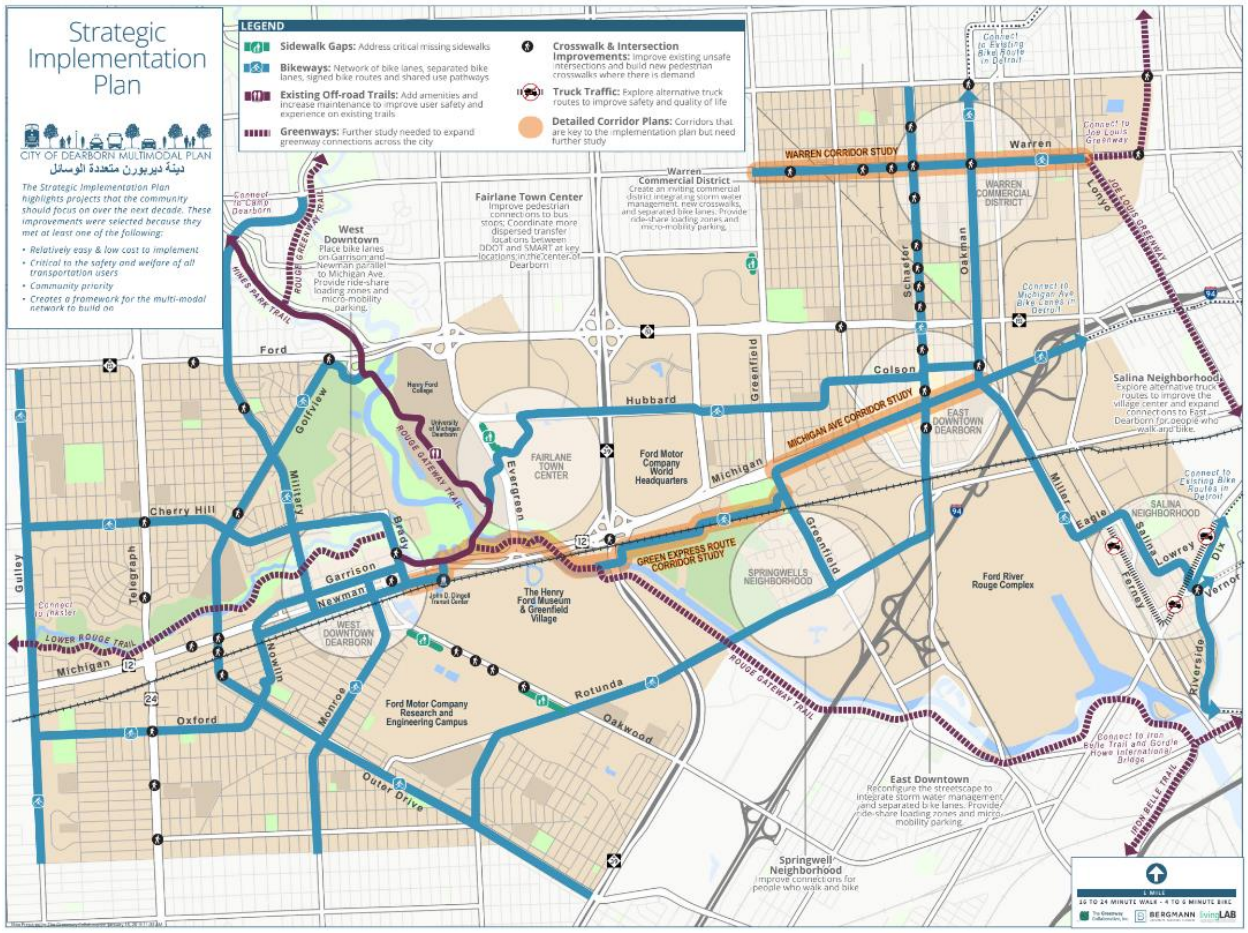
A. U-M Elbel Field
B. U-M Michigan Stadium
C. U-M Intermural Sports Building
D. State Street & Stimson Street (south boundary of master plan)

1.3 Support for the Dearborn Comprehensive Development Master Plan (CMDP)

In January 2018, the city of Dearborn began developing the CDMP to improve the state of cycling, walking, and transit infrastructure in the city. Importantly, a number of cycling

improvements are being recommended but are currently in limbo due to funding issues. Dearborn Sustainability Coordinator Dave Norwood identified University funding as central to these improvements, in particular the protected bike lane along Hubbard Avenue and completion of the Rouge Gateway Trail (Figure 1.3.1). Building these trails would increase bike connectivity to Detroit which does not currently have an adequate non-automobile link to campus—as explained in the transit section of the main report. This would lead to an increase in cycling rates and access to campus for Detroit residents.

Figure 1.3.1 Map of Proposed Bikeways in the Dearborn Comprehensive Development Master Plan



2.0 Bike Service Center Further Costs

Establishing an on-campus bike service center would require designation of about 1200 square feet of space in a university building, according to an interview conducted with the Common Cycle bicycle cooperative. The best way to implement the service center would be through collaboration with Common Cycle, who have indicated willingness to provide significant programming through volunteer labor. Moreover, staffing could be wholly or partly provided by a mix of students receiving work-study or completing classes with an experiential component. Operations would be largely self-supporting and staffing would likely range between $0-50,000 per year depending on span and scale of service, and retail volume.

3.0 Emissions Reductions Potential

Table 4.1 Forecast Change in Emissions

Demographic	Value	Change in Yearly Emissions (Metric Tons per Year)
Staff & Faculty	%	-0.5%
	Absolute	-0.60
Students	%	-0.7%
	Absolute	-0.85

Table 4.2 Forecast Change in Emissions by Location per Capita (kg/day) - Faculty and Staff

Distance (mi)	**Central**	**North**	**East Medical**	**Medical**	**South**	**Total AA**	**Dearborn**	**Flint**
0-1	-0.02	-0.02	0	-0.02	-0.02	-0.02	-0.007	0
1-2	-0.10	-0.09	0	-0.06	-0.10	-0.09	-0.031	0
2-4	-0.21	-0.16	0	-0.08	-0.12	-0.15	-0.042	0
4-6	-0.26	-0.10	0	-0.03	-0.07	-0.13	-0.035	0
6-10	-0.06	-0.11	0	-0.06	-0.06	-0.06	0	0
10-15	0	0	0	0	0	0	0	0
15-20	0	0	0	0	0	0	0	0
20+	0	0	0	0	0	0	0	0
Total	-0.09	-0.07	0	-0.02	-0.03	-0.05	-0.008	0

Table 4.3 Forecast Change in Emissions by Location (Metric Ton per Year)

Distance (mi)	Central	North	East Medical	Medical	South	Total AA	Dear-born	Flint
0-1	-4.41	-2.34	0	-0.28	-0.35	-7.4	-0.02	0
1-2	-54.8	-17.3	0	-11.7	-4.6	-88.4	-0.13	0
2-4	-162.7	-52.6	0	-49.5	-11.0	-275.8	-1.51	0
4-6	-102.7	-19.6	0	-15.5	-4.7	-142.5	-0.67	0
6-10	-25.8	-20.1	0	-31.5	-7.1	-84.5	0	0
10-15	0	0	0	0	0	0	0	0
15-20	0	0	0	0	0	0	0	0
20+	0	0	0	0	0	0	0	0
Total	-350.46	-111.94	0.00	-108.53	-27.62	-598.56	-2.33	0

Table 4.4 Forecast Change in Emissions by Location per Capita (kg/day) - Students

Distance (mi)	Ann Arbor	Dearborn	Flint
0-1	-0.02	-0.01	0
1-2	-0.16	-0.08	0
2-4	-0.31	-0.16	0
4-6	-0.35	-0.17	0
6-10	-0.28	-0.14	0
10-15	0	0	0
15-20	0	0	0
20+	0	0	0
Total	-0.11	-0.06	0

Table 4.5 Forecast Change in Emissions by Location (Metric Tonnes/year) - Students

Distance (mi)	Ann Arbor	Dearborn	Flint
0-1	-76	0	0
1-2	-107	-3	0
2-4	-459	-35	0
4-6	-76	-31	0
6-10	-37	-23	0
10-15	0	0	0
15-20	0	0	0
20+	0	0	0
Total	-754	-92	0

Appendix H: Maps

1.0 Commute Sheds

Figure 1.1 Ann Arbor Campus Faculty & Staff Commute Shed

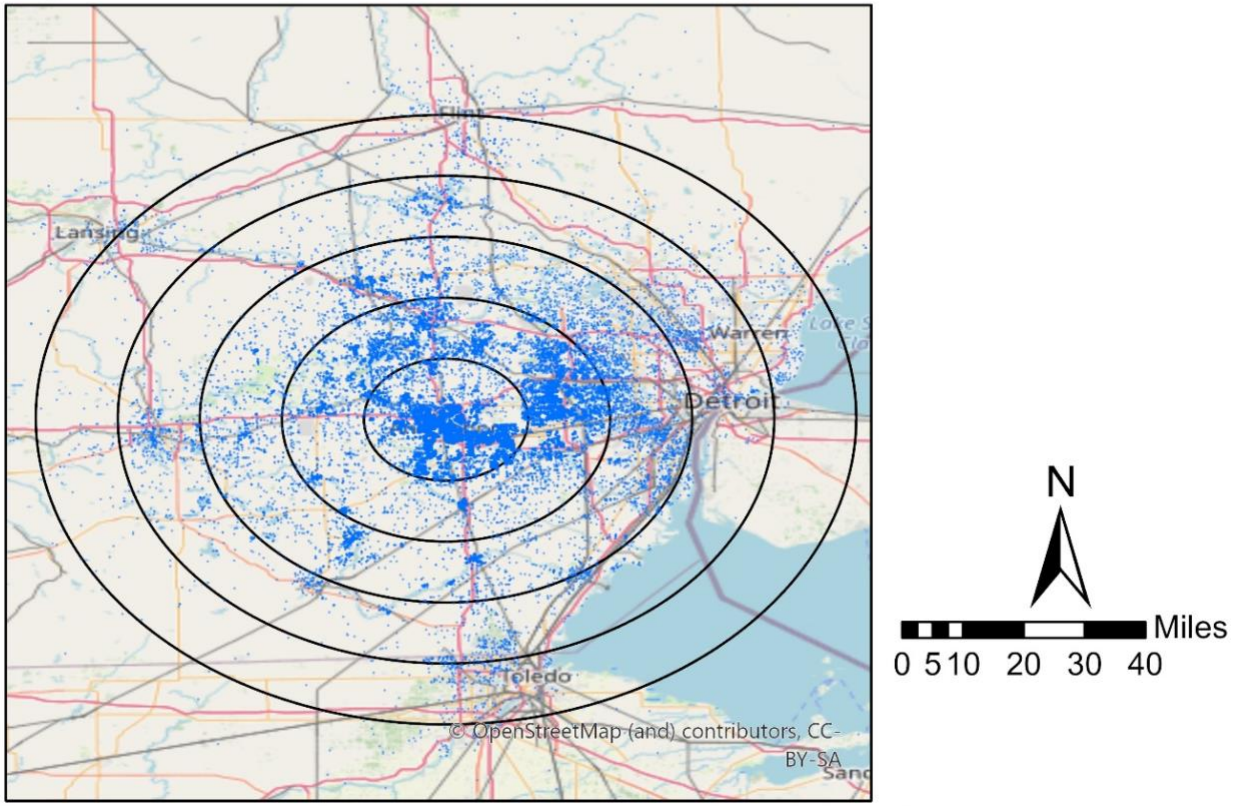
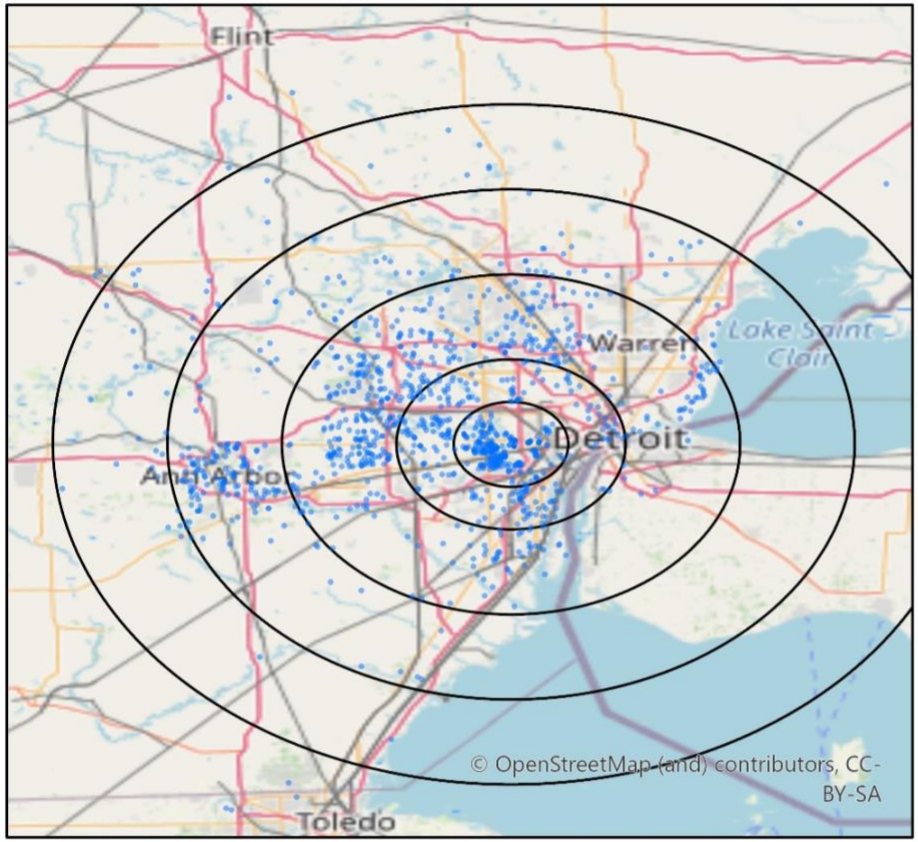
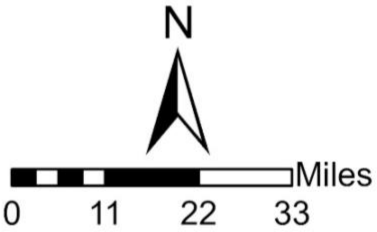


Figure 1.2 Dearborn Campus Faculty & Staff Commute Shed

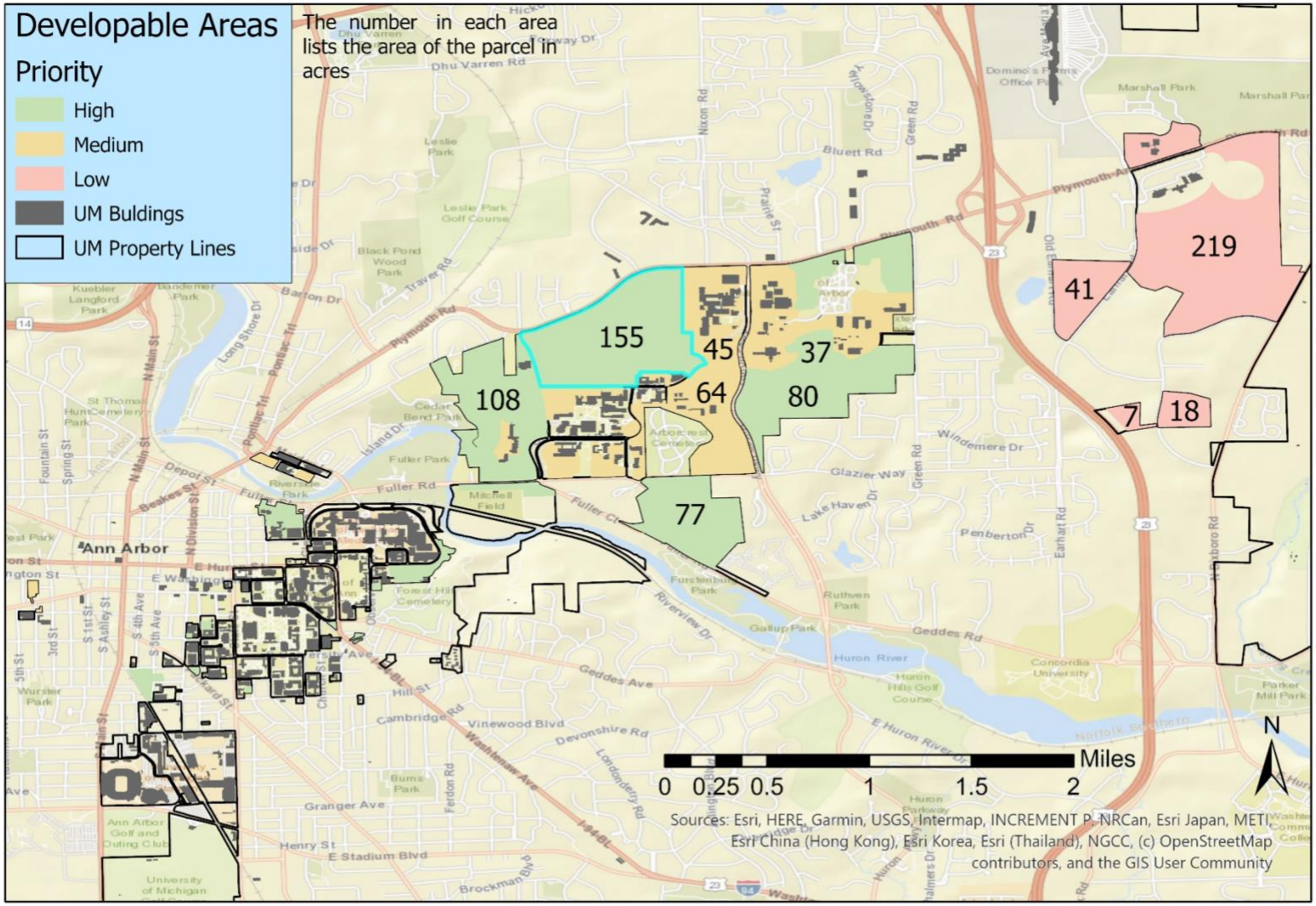




Cartographer: James Wooldridge
Data Source: University of Michigan

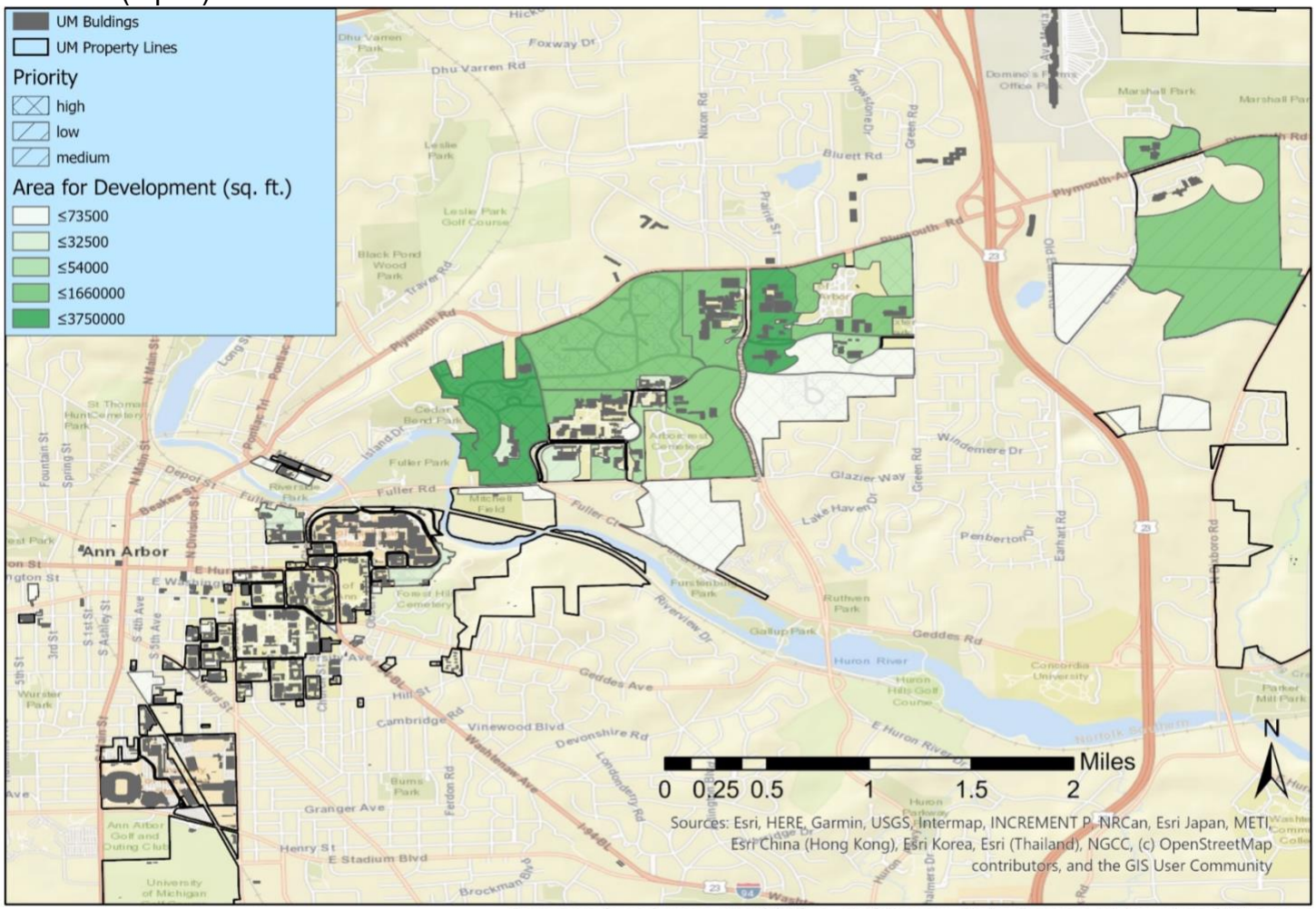
2.0 General Information on Land for Housing Analysis

Figure 2.1 Map of Priority Areas for Development



Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

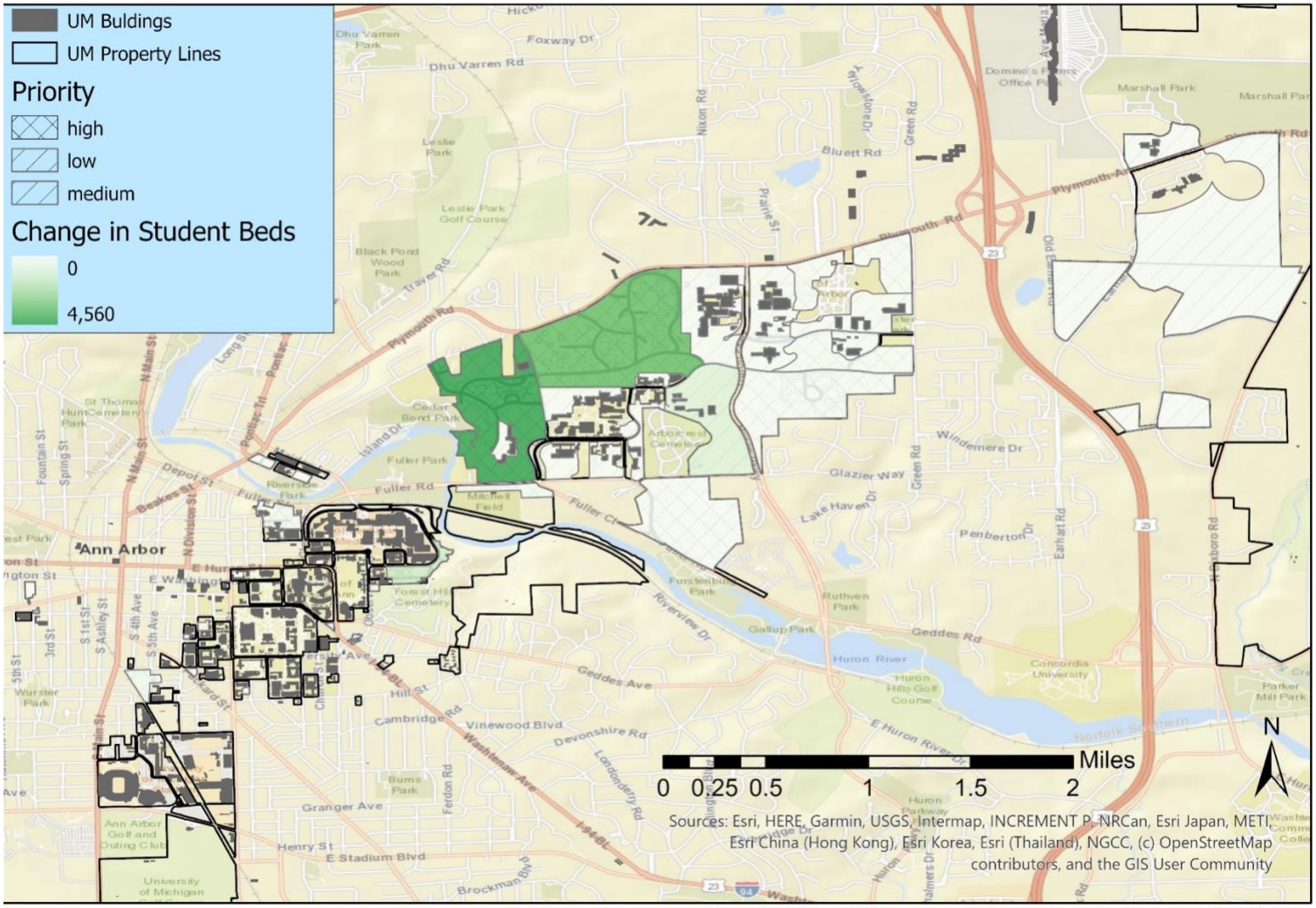
Figure 2.2 Available Development Capacity for Academic, Residential, and Commercial Facilities (sq. ft.)



Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

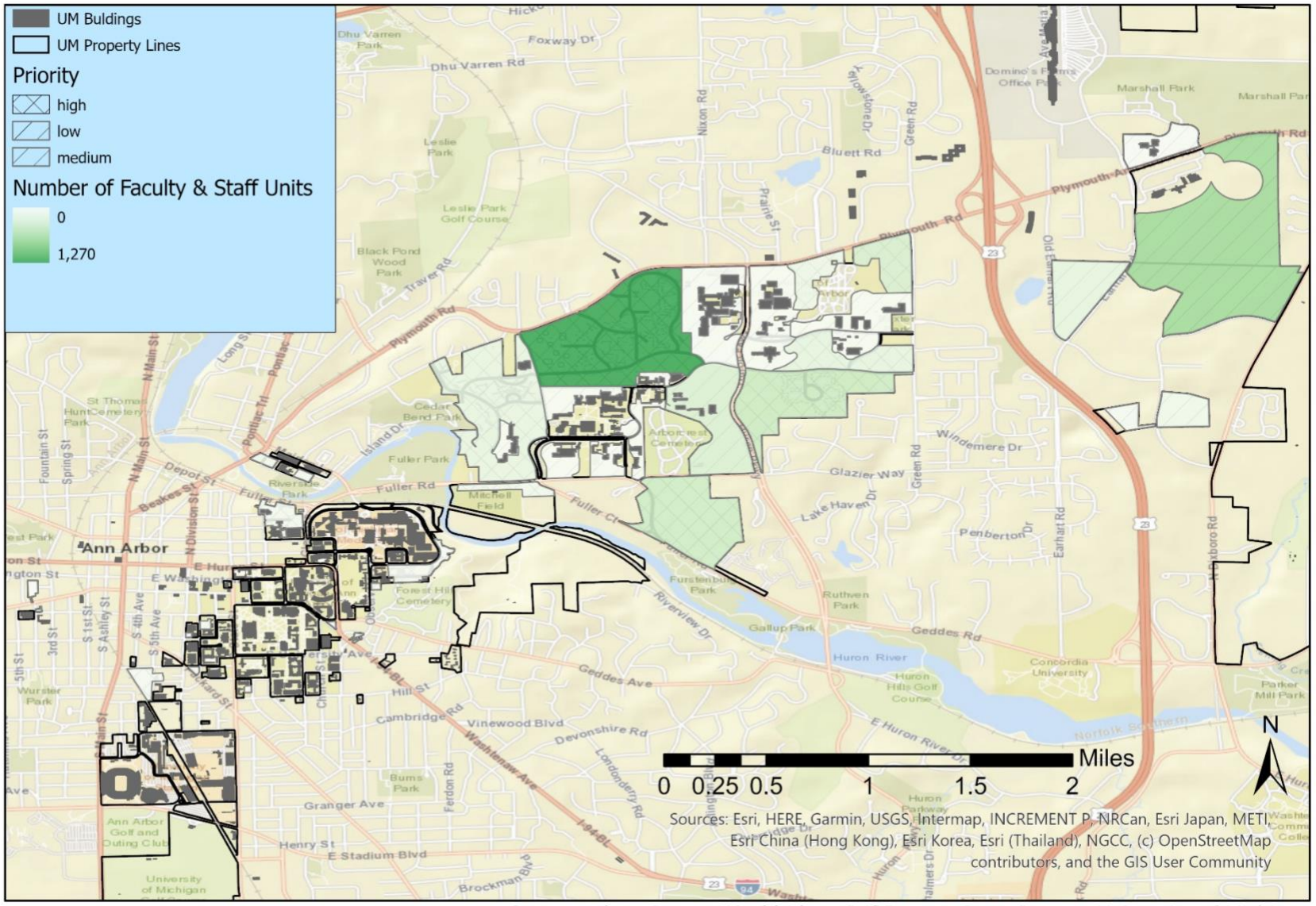
3.0 Parking, Student Housing, and Faculty & Staff Housing in Low, Medium, and High-Density Scenarios

Figure 3.1 Low Density Scenario Change in Student Beds



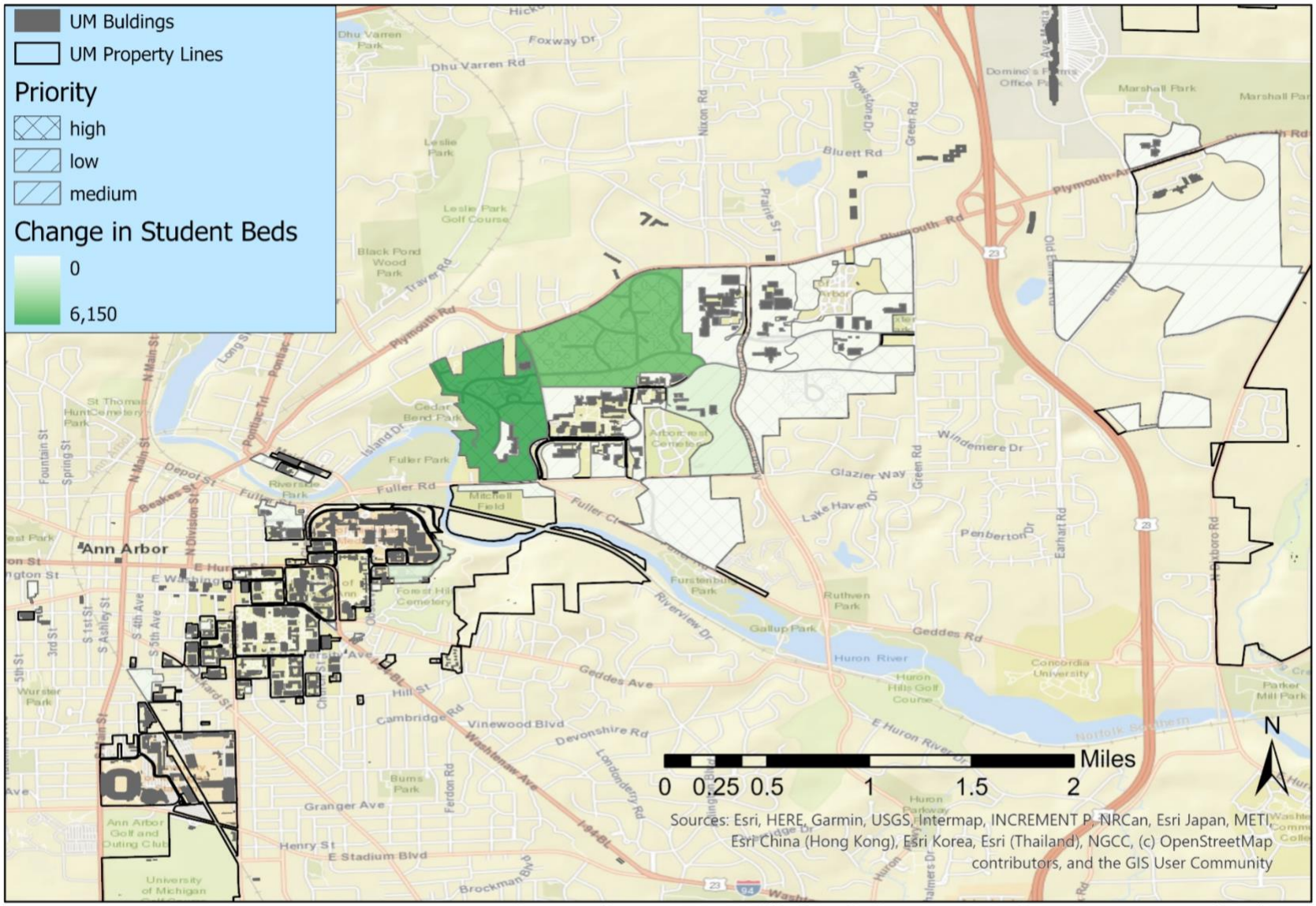
Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

Figure 3.2 Low Density Scenario Number of Faculty and Staff Units



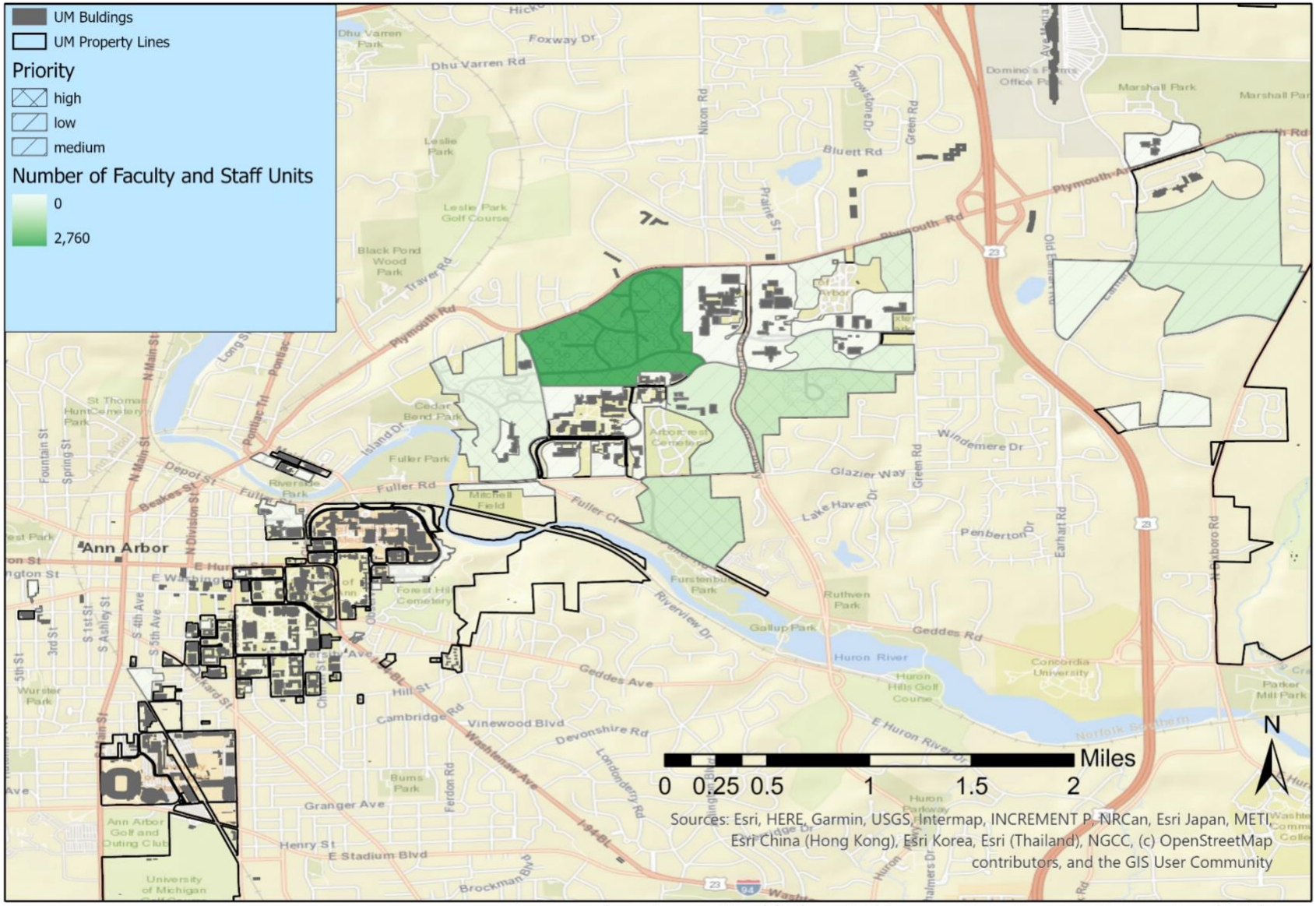
Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

Figure 3.3 Medium Density Scenario Change in Student Beds



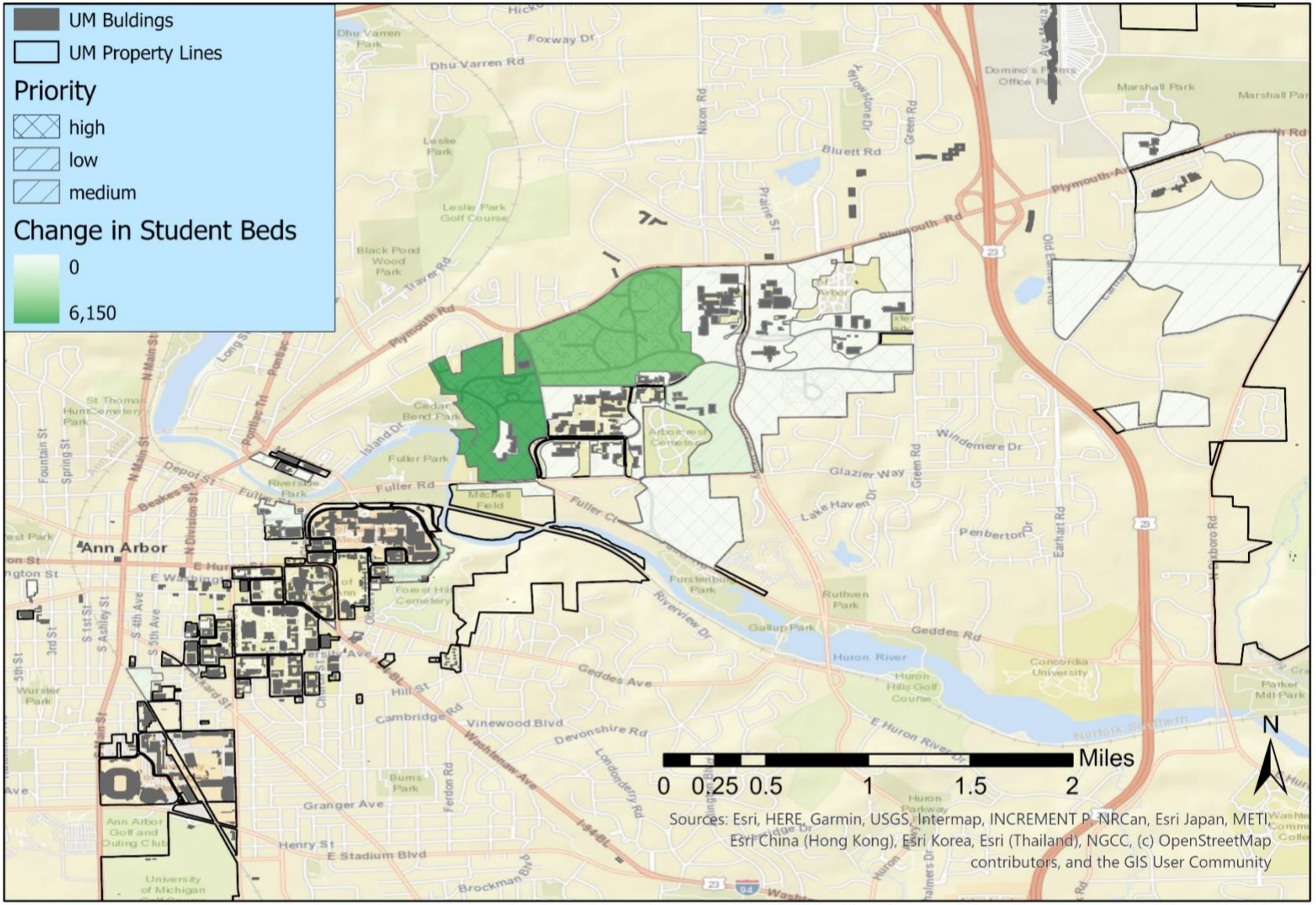
Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

Figure 3.4 Medium Density Scenario Number of Faculty and Staff Units



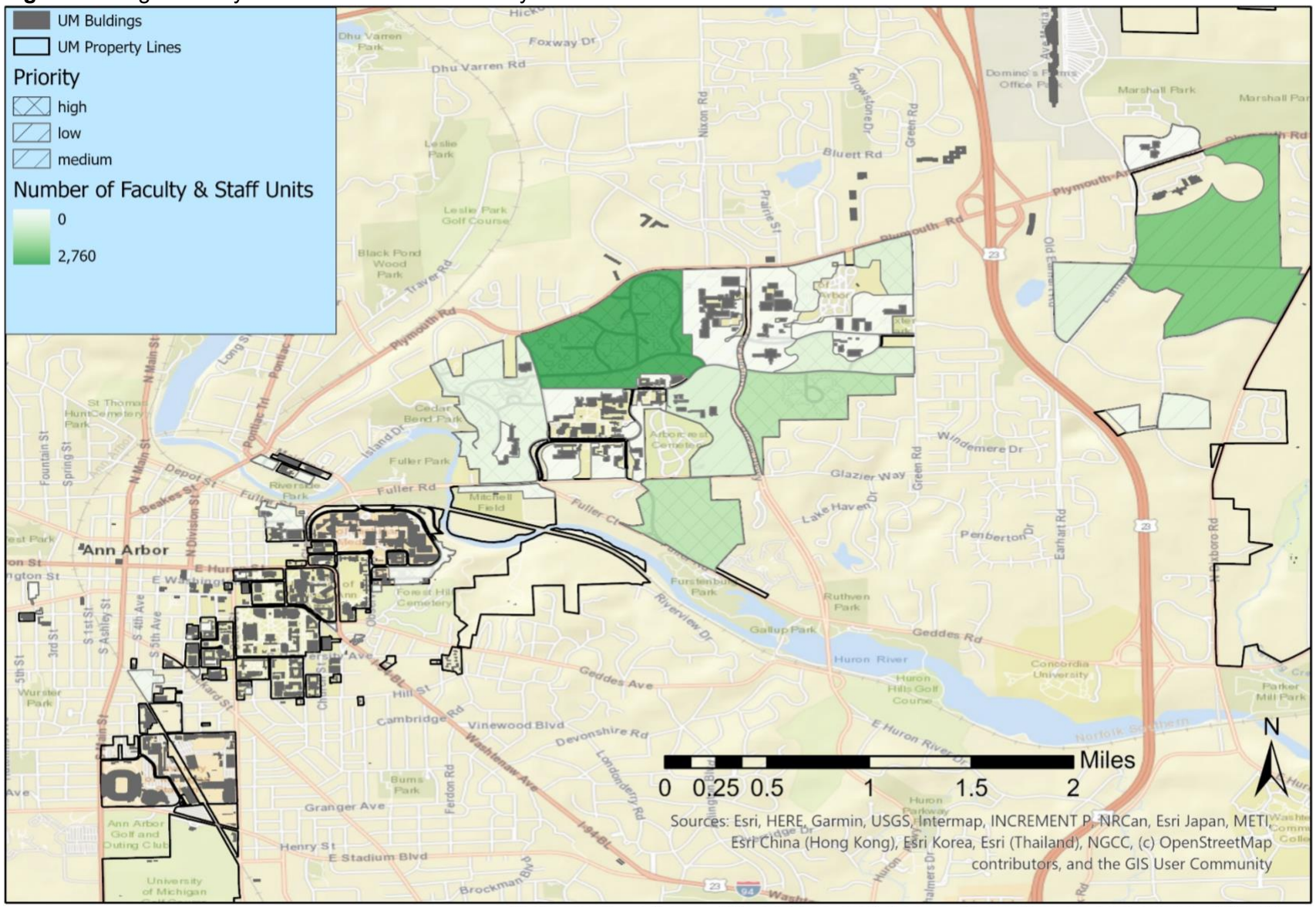
Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

Figure 3.5 High Density Scenario Change in Student Beds



Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

Figure 3.6 High Density Scenario Number of Faculty and Staff Units



Cartographer: James Wooldridge, Grif Barron Data Source: University of Michigan

Appendix I: Results from Town Halls

1.0 Background

The Commuting Team hosted a series of town halls in Dearborn and Ann Arbor during the month of January in order to engage with stakeholders from across the University community on the issues of commuting and carbon neutrality. The aim of the town halls was to assess how students, faculty, and staff felt that our proposed policies might fit into their daily lives and adapt campus-specific recommendations that were compatible and complementary to affected stakeholders. We also sought to broaden our understanding of issues and ideas that might have been overlooked in our intermediate work. A third town hall was planned for March at the Flint campus, but was unfortunately cancelled due to the COVID-19 outbreak.

2.0 Summaries

2.1 Ann Arbor Town Hall

On January 23, 2020 the PCCN Commuting Team had its second townhall at the Dana Building on the UM-Ann Arbor campus. At the event, researchers engaged eight community members in a dialogue on housing, transportation alternatives, and telecommuting. An additional 16 community members submitted feedback through an online survey for the Ann Arbor campus. Priorities for the attendees included making biking safer, increasing the reliability and frequency of both city and University buses, and providing clearer information on existing rideshare programs at UM and how they work. The idea of putting in place more robust telecommuting policies was popular, and attendees suggested mandating all lectures be recorded. The audience had varied levels of interest in the idea of University housing and there was support for a range of University-provided housing types. For example, one staff member expressed interest in University housing structured as co-housing with a community garden. Others preferred more conventional townhouses and apartments. The discussion highlighted the potential for the University to explore the demand for a range of housing approaches and experiment with housing development. Virtually all participants highlighted the importance of affordability of rents and sales prices in determining their potential acceptance of University housing.

2.2 Dearborn Town Hall

On January 22, 2020 the PCCN Commuting Team held its first town hall event at the University Center on the UM-Dearborn campus. At the event, Commuting Team members held a dialogue with 30 UM-Dearborn students, faculty, and staff on how the University could help them reduce the carbon impact of their commute. An additional 15 community members submitted feedback comments through an online survey for the Dearborn campus. The main concerns of attendees included the lack of adequate bus services to campus, difficulties traveling between campuses in Dearborn, and transportation between Dearborn and Ann Arbor. While it was noted that there is a culture of driving to campus, many community members, including the student government, have been advocating for a universal access program with SMART. There was widespread concern that it is inconvenient and even unsafe to walk or bike between campuses in Dearborn, leading to a culture of driving between the two campuses. The problem of commuting sustainably between the Dearborn and Ann Arbor campuses was repeatedly brought up. While many attendees attested that there is not a campus culture to support telecommuting, many were open to the idea. Students in attendance were unanimously in support of adding online recordings of classes to access from home.

Appendix J: Transportation Performance: Comparison with Other Campuses

1.0 Background

This appendix explores data showing the current mode share at three universities showcasing best practices we hope to emulate at UM through our policies (UC Irvine, UI Bloomington, and UW Madison). The data used has been pulled from the Census Transportation Planning Products (CTPP) based on questions in the American Community Survey. It has been compared across campuses and for UM Ann Arbor, has been compared to the Sustainability Cultural Indicators Program (SCIP) survey. The two metrics assessed are the means of transportation to work (mode share) and the travel time to work for workers over the age of 16.[131] Included are work trips; a student headed exclusively to class would not be counted. The comparison was made on the basis of the census blocks that made up each campus.[132]

2.0 Discussion

2.1 Mode Share Comparison

Figure 2.1 compares the percentage of people that commute to work by means of a carpool, a single-occupancy vehicle, a bus, a bike, or walking. UW Madison comes out ahead with fewer than half of commuters driving alone to work (single-occupancy vehicle, or SOV), and a similar share taking the bus, walking, or biking. UI Bloomington also has a relatively high percentage of people who bike or walk, nearly one-quarter of all commuters. This may be because over half of the faculty and over one-third of staff live within three miles of the university[133]. UC Irvine is tied, at 20%, with UI Bloomington for percent who walk. UC Irvine and U-M top the list for the share of solo drivers in the commute. All four schools have similar carpool percentages (8 – 9%).

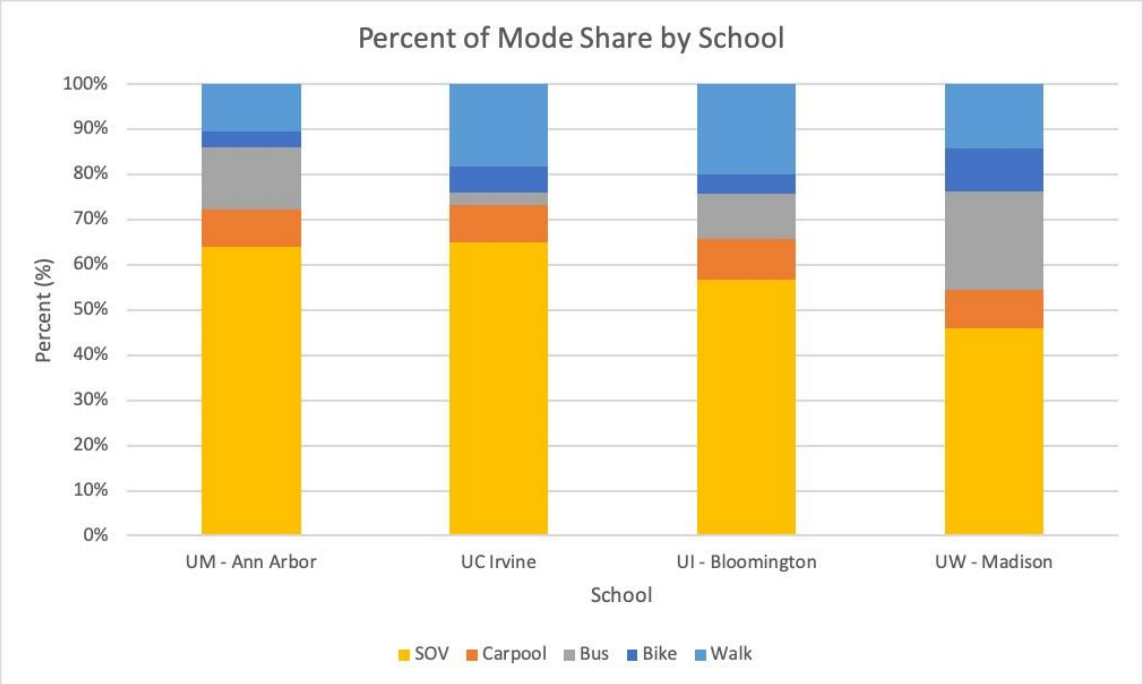


Figure 2.1: Percent of Mode Share by School
Source: Census Transportation Planning Package

2.2 Distance Band Comparison

Figure 2.2 compares the percent of people commuting from certain time bands. This is the best proxy for distance from the school found in the CTPP data. The key takeaways are that the two schools with the most people living under 15 minutes away from campus (UC Irvine and UI Bloomington) have the highest percentage of walkers (18% and 20% respectively). The high percentage of short-distance commuters in Irvine is at least in part a function of the large-scale development of faculty and staff housing on campus. Furthermore, though UW Madison and Ann Arbor have similar percentages of people coming from each time band, UW Madison has a higher percentage of people using sustainable commute methods (the bus, a bike, or walking). One way to improve is to follow the lead of UC Irvine and UI Bloomington and bring more people closer to campus, increasing the feasibility of more sustainable commute methods. The other is to improve transit infrastructure, specifically around buses and biking, to improve the mode share.

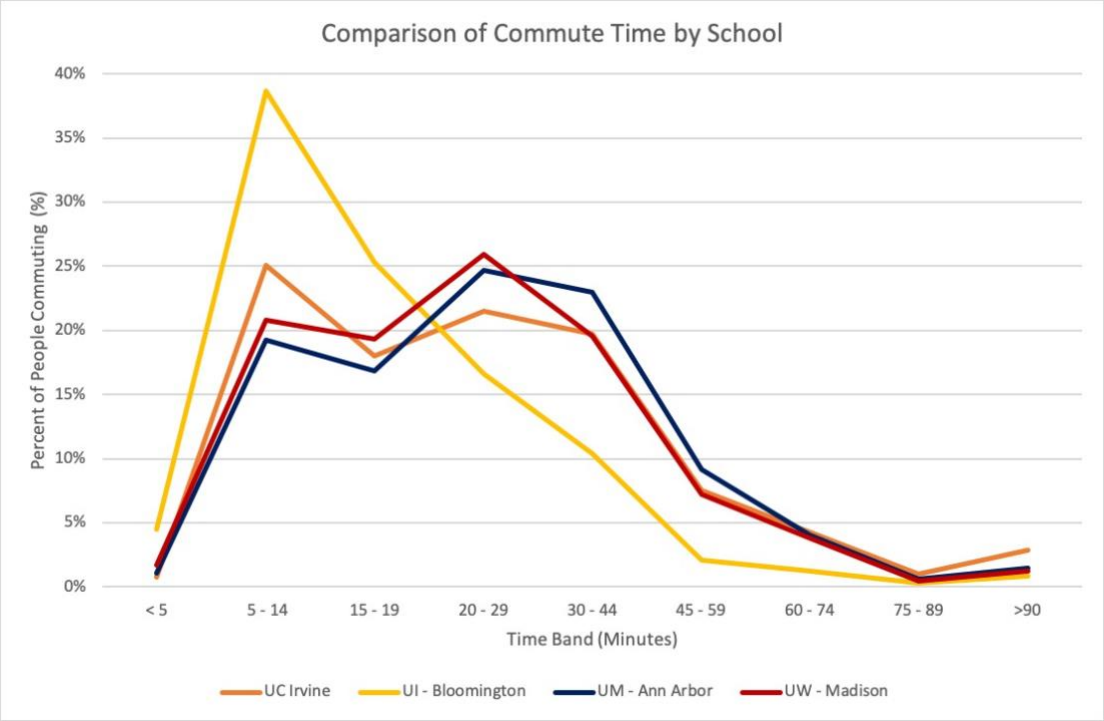


Figure 2.2: Comparison of Commute Time by School

Source: Census Transportation Planning Package

2.3 Comparison to SCIP

There are some major discrepancies between SCIP and CTPP. CTPP shows 8.35% of people coming to work via carpool (defined as 2, 3, 4, 5-6, or 7 or more people in a car, truck or van) while SCIP has 0.30%. One explanation may be how the surveys ask for the data. SCIP asks "How do you most often travel to and from home to your work place?" with "rideshare (i.e van, car pool, dropped off, etc.)" as the option for carpooling[134]. "Drive a car" is the first option, and those who drive a car for a carpool may pick this first, may not know they are technically in a carpool, or may not use that mode of transport "most often" in their minds. While there is a question asking "How often did you carpool" the options (never, rarely, sometimes, always/most of the time) do not provide much in terms of hard numbers of people[135]. The ACS on the other hand asks first for the method of transportation (car/truck/van, bus, bike, walk, etc) and then for how many other people are in the vehicle[136]. This method may capture a more accurate number because it does not depend on a university's definition of a carpool (as a UI Bloomington survey did) or people knowing they are technically in a carpool.

Appendix K: Data on Telecommuters, Ann Arbor Engineering and Dearborn

No. of employees surveyed	14
Total commute distance (one-way)	337 mi
Avg. commute distance (one-way)	24.1 mi
Median commute distance (one-way)	17 mi

Table 1: Commute Distance (one-way) of Telecommuters
Source: Information Technology Services at U-M Dearborn.

No. of employees surveyed	248
Total commute distance (one-way)	4176.7 mi
Avg. commute distance (one-way)	16.8 mi
Median commute distance (one-way)	14 mi

Table 2: Commute distance (one-way) of telecommuters from U-M's College of Engineering
Source: College of Engineering

Appendix L: Policy Comparisons

Policy Information				Considerations			
Category	Policy	Cost	s Reduction (metr	Revenue Generation	ts and Benefits Timefr	Equity	Priority
Housing and Land-Use Planning	Low Housing Scenario	High, but see revenue generation	14,600	Rental and sales revenues should cover costs. Faculty/Staff housing could potentially generate revenues in excess of costs based on value of currently unused or underused land. Student housing should remain cost neutral to keep education as affordable as possible	Costs begin to accrue when planning begins. Development of subsequent phases contingent on sales and leasing of earlier phases. Benefits accrue over years while housing is developed and occupied	Would have benefits in housing affordability, student performance, lower costs of higher education, as well as faculty/staff recruitment and retention. Affordibility benefits accrue directly to residents of on-campus housing, indirectly thorugh increasing Ann Arbor housing supply	1
	Medium Housing Scenario		29,150				
	High Housing Scenario		39,000				
	Dearborn Student Housing	Hight, revenue neutral but may help with student recruitment	200 metric tons per year for every 100 students	Student housing should remain cost neutral to keep education as affordable as possible	Costs begin to accrue when planning begins. Development and operational costs are offset over time	Would have benefits in housing affordability, student performance, lower costs of higher education therefore, making higher education more accessible	
	Flint Student Housing		125 metric tons per year for every 100 students				
	Financial Incentives Program	High, but see revenue generation	For every 100 employees at the Dearborn campus, there are 358 MT reduced per year. For every 100 employees at the Flint campus, there are 287 MT reduced per year	Mortgage payments should cover costs. Other subsidies will not be revenue generating	There is a large initial cost associated with creating the monetary fund and a small cost associated with administration. There will be a cost for the subsidies program and its administration	Would have benefits in housing affordability and faculty/staff recruitment and retention. At Flint, this will help with urban revitalizaiton efforts. This should not be applie to off campus housing in the Ann Arbor region, as it will increase the inafordability off campus housing. This only serves as an enticement and affordability tool for on campus housing at the Ann Arbor campus	

	Focus campus growth centrally	High	For every 1000 employees added to Central, Medical, or North Campus (as opposed to more remote locations): Estimated 900 metric tons per year. If policy constrains central parking availabilty, this number would grow. Insufficient data to assess student impact.	No, but benefits in face-to-face interaction among faculty, students, and staff	Long-term	Cost-saving for employees by makining non-automotive commutes feasible	
Parking	Elimination of Annual Pass	High infrastructure costs if ungated lots to be gated; low if daily parking in ungated lots handled with hang tag	6,300 for base-level policy. More extensive reform would build on this number.	Parking revenues can be maintained at same level, but some parkers would pay more. Alternatively, parking costs could be capped at current levels, but revenues would decline.	Immediate costs in infrastructure deployment, system reconfiguration. Benefits accrue starting in first year, grow as travelers become accustomed to varying their mode of travel.	This policy should be paired with a linking of parking charges to salary to improve the equity over the status quo. Puts parkers on more even footing based on their parking needs for the day.	2
	University Contribution Removal	Low		Will save the University $5 million/year	Cost savings and benefits would start upon implementation.	This policy should be paired with a linking of parking charges to salary to improve the equity over the status quo.	
	Link parking charges to employees' salaries	Low		Should be done in a revenue-neutral fashion	Impacts would be felt upon implementation	Important to assure equity of other elements of parking reform	

	Adjust rates in center and periphery to approach even utilization throughout parking system	Low, but would need to be accompanied by improved transit from remote lots.		Revenue neutral or revenue generating depending on rates charged in high-demand facilities.	Any cost impact immediate upon program initiation. Benefits accrue over years through avoidance of expansion of parking facilities in central areas.	Needs to be accompanied by improved transit from remote lots. The commutes of current parkers in remote lots would be improved.	
Motorized Transportation	Rideshare (Van/carpool)	Low	8,200	No, but will reduce need for additional parking	Cost begin upon program initiation. Benefits grow over several years with adoption by commuters	Will help save commuting costs, particularly for lower-salaried commuters from farther away.	3
	Universal Transit Access (Dearbom and Flint)	Medium	50	No, but will reduce need for additional parking	Each year of access and initial cost. Benefits begin with program initatiation and grow with commuter adoption.	Will give students and employees viable commute alternatives to driving alone	
	Integration of U-M Connector with surrounding public-transportation environment	High	need to est	No, but potential cost savings compared to a U-M-only system.	Five years plus	Will give students and employees viable commute alternatives to driving alone	
Cycling Improvements	Cycling Infrastructure	High	1500	No	Capital costs accrue in first couple of years. Benefits grow with commuter adoption.	Improves campus access and safety, lowers transportation costs, especially for low income students and employees.	4
	Bike Service Center	Low		Services could generate revenue	Startup costs in first couple of years. Benefits grow with commuter adoption.	Will offer students and employees easy access to maintenance and information.	
Telecommuting	Work From Home	Low	Indeterminate	No, but could reduce need for additional parking and may increase productivity and morale	Costs and benefits could grow over years with increasing commuter adoption.	Not an option for many low-salaried employees.	5

Endnotes

[1] Calculations for students, faculty, and staff on Ann Arbor campus only. Source for total carbon emissions: Office of Campus Sustainability. Source for commute carbon emissions: Carbon Accounting Methodology Appendix.
[2] Issues pertaining to the efficiency of the vehicle fleet used in the commute were the domain of the Mobility Electrification subgroup.
[3] For development of housing scenarios, see Appendix C, Section X. For emissions reduction potential modeling, see Appendix B, Section 3.1.
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[6] University of California Employee Housing, "Housing Access Policy," March 26, 2003, https://employeehousing.ucsc.edu/pdf/hap.pdf.
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[8] Adam Rosenfield, "Driving Change: How Workplace Benefits Can Nudge Solo Car Commuters Toward Sustainable Modes" (master's thesis, Massachusetts Institute of Technology, 2018).
[9] At the time of this writing, there were 29,125 faculty/staff parking permits held by employees of the Ann Arbor campus, representing an annual parking subsidy of $5,021,540.
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[13] Susan Sloan-Rossiter, Albert Ng, and Ryan White, "Transportation Demand Management Plan Indiana University Bloomington," Vanasse Hangen Brustlin Inc., 2012.
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[18] David Marcouiller, David Noyce, Patrick Kass, Rob Kennedy, and Casey Newman, "Long Range Transportation Plan," n.d., https://d1t7dpw65z19lw.cloudfront.net/wp-content/uploads/sites/20/2017/10/Appen-3-Long-Range-Transportation-Plan-2016-1019-low-res.pdf.
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[21] College of Engineering, Dearborn Campus, Flint Campus, and Michigan Medicine.
[22] Ford School of Public Policy; School for Environment and Sustainability; School of Information; School of Music, Theatre & Dance; and College of Literature, Science, and the Arts.
[23] Pengyu Zhu and Susan G. Mason, "The Impact of Telecommuting on Personal Vehicle Usage and Environmental Sustainability," *International Journal of Environmental Science and Technology* 11 (2014): 2185–2200, https://doi.org/10.1007/s13762-014-0556-5.
[24] Patricia L. Mokhtarian, "A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel," *Urban Studies* 35, no. 2 (1998): 215–241; and Seung-Nam Kim, "Is Telecommuting Sustainable? An Alternative Approach

to Estimating the Impact of Home-Based Telecommuting on Household Travel," *International Journal of Sustainable Transportation* 11, no. 2 (2011): 72–85, https://doi.org/10.1080/15568318.2016.1193779.

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[26] One potential cost pertains to equipment to facilitate telecommuting, whether at remote working locations or on-site (e.g., teleconferencing equipment). Telecommuters' remote working locations are often their own homes and are often already equipped with the equipment necessary to perform their duties (e.g., computer, Wi-Fi connection, cell phone).

[28] U-M Graham Sustainability Institute, *SCIP Methodology Report (2018)*, 29.

[29] U-M Ann Arbor Population Figures https://umich.edu/facts-figures/

[30] *Guidance for Quantifying and Using Emission Reductions from Best Workplaces for Commuter Programs in State Implementation Plans and Transportation Conformity Determinations*, 42.

[31] University of Washington-Seattle, *2018 Transportation Survey*, 12.

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