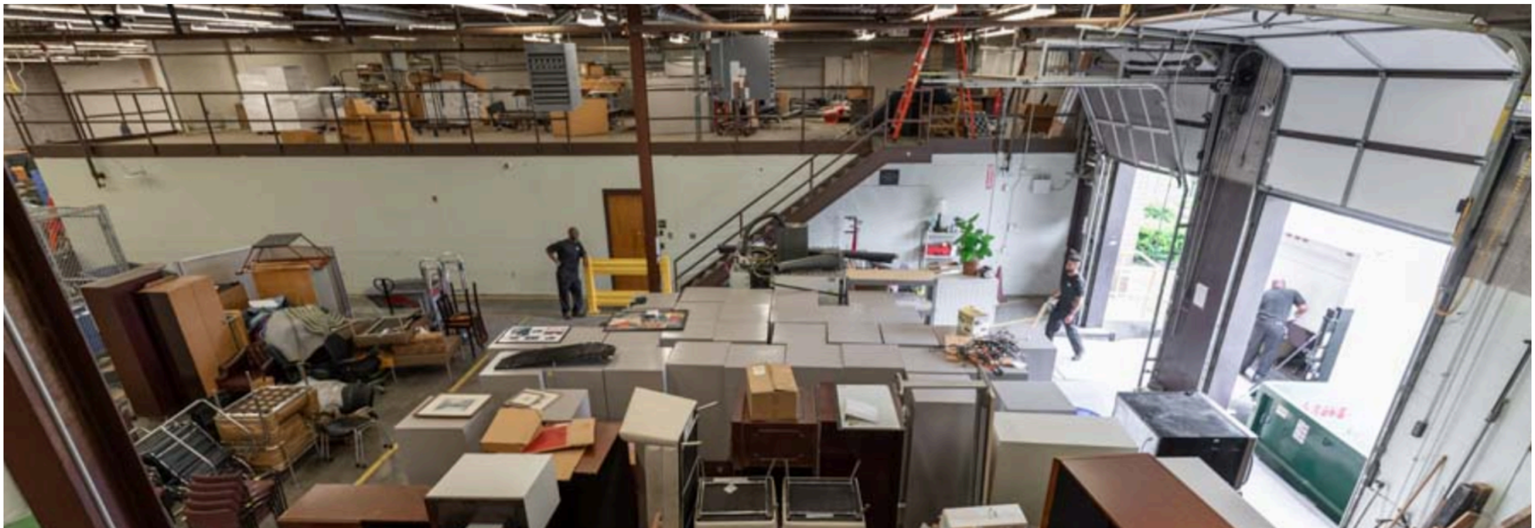
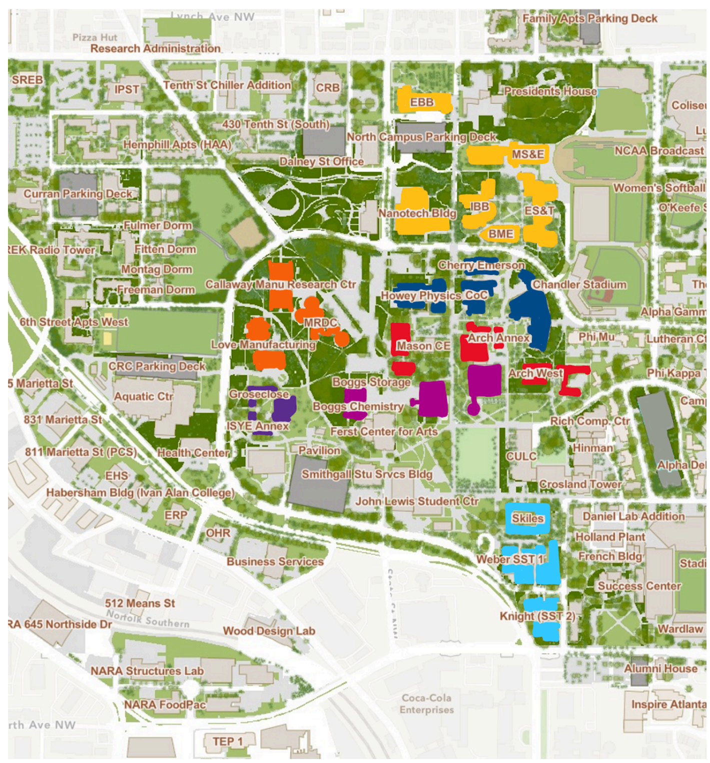


Georgia Tech

Swap to Sustain: Increasing campus circular economy

Increasing the efficiency of the surplus process to keep resources on campus and minimize waste through zone-based ‘Swap to Sustain’ events.



14,458,382.70 lbs CO2e

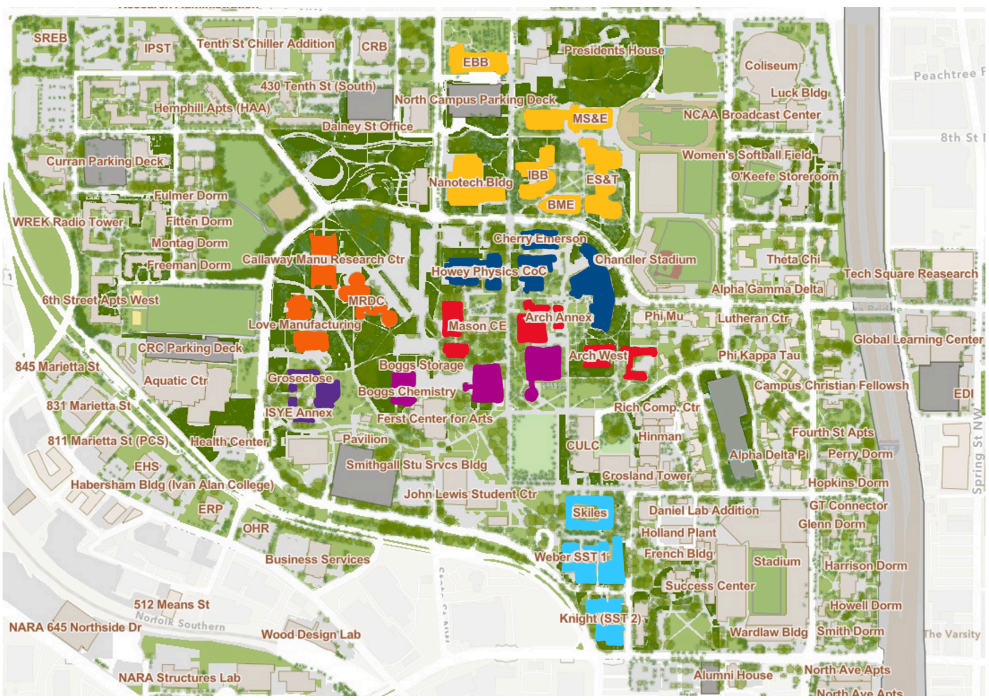
$6,757,764.75

Helping Georgia Tech to close the circle.

Nicole Allen, nallen49@gatech.edu
Apoorva Mahendranath, amahendranath6@gatech.edu

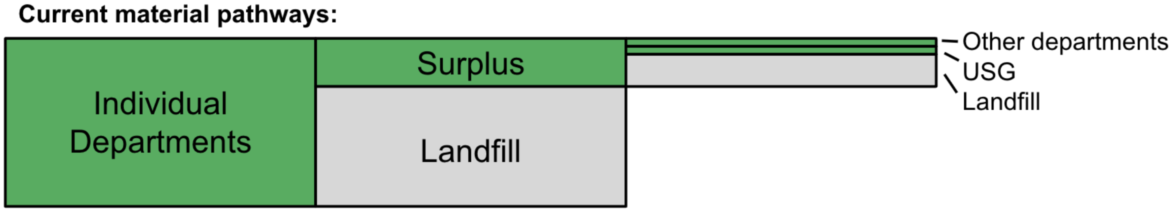
Project Scope

The concept of the 'Circular Economy' has gained recognition rapidly over the past decade, yet it continues to lack global implementation. Initiatives such as 'Freecycle' and local 'Waste Nothing' Facebook groups represent significant strides towards fostering circularity within communities, and these platforms exemplify grassroots efforts propelling us towards a more sustainable future. Demand for circularity within corporations and institutions is on the rise, as climate action shifts away from the individual and onto the organizational processes that are creating the most emissions. Looking at the 2023 Fiscal Year 2023 data provided by the Surplus team at Georgia Tech, 46,389 items were sent to surplus and only 17.67% of those were repurposed on campus or within the university system. Unused items sit in surplus, go to various recycling centers, or are sent to the landfill.. We propose a model for zone-based circular economies in order to increase the circularity of campus. These localized 'zone' systems will integrate into the broader campus-wide surplus department, forming a cohesive framework for reuse. The zones will host a yearly **'Swap to Sustain'** event, which will allow members of the similarly specialized departments to look through the goods given by surrounding faculty and labs near to their workspace, and encourage people to donate and reuse items as opposed to trashing them. Items left unclaimed will then be sent to surplus, or if broken or unusable, sent to the appropriate local recycling center.

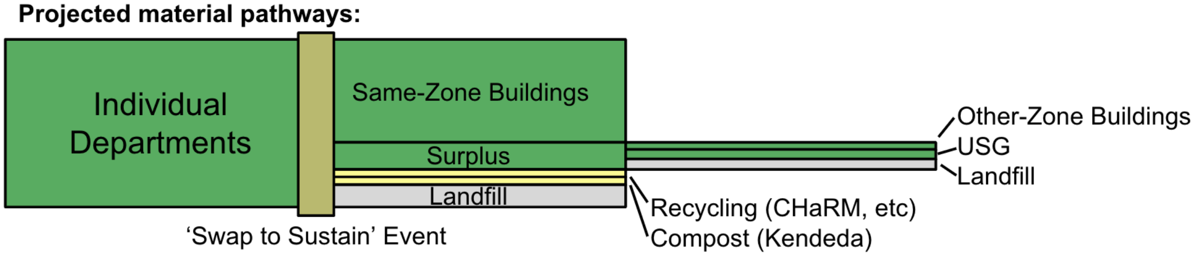


Zone 1	EBB
	MS & E
	ES & T
	IBB
	BME
	Nanotech Bldg
Zone 2	Cherry Emerson
	Howey Physics
	CoC
	Chandler Stadium
Zone 3	Mason CE
	Arch Annex
	Arch WEst
Zone 4	Callaway Manu Research Center
	MRDC
	Love Manufacturing
Zone 5	Groseclose
	ISYE Annex
Zone 6	Boggs Storage
	Boggs Chemistry
Zone 7	Skiles
	Weber SST 1
	Knight (SST 2)

Current material pathways:



Projected material pathways:



Applicable Sustainable Development Goals:

Carbon Reductions and Cost Savings

Key Datasets:

FY23 Surplus Data

2024 Bio Summer Swap

FY23 Reference Item PO

Individuals are more likely to engage in resource sharing and circular economies if practiced in smaller microcosms [2-6]. This finding can be proven to be applicable to Georgia Tech's campus, when comparing circularity through the entire campus surplus system [7] versus within the BioQuad [8].

Our "Swap to Sustain" initiative requires minimal financial investment to achieve our carbon reduction goals with its primary costs involving transportation and logistics for moving items between buildings and temporary storage before and after swap events. These expenses are expected to be low, as existing campus transport resources and communal areas to host swaps can be utilized. Other operating costs are minimal, including printing marketing materials such as posters and sending out digital communications. Some departments currently receive funding to update office and main areas with new furniture, and we propose that a portion of this be reallocated to cover costs associated with running the 'Swap to Sustain' event. Fewer articles of new furniture will need to be purchased as the currently owned furniture will be better distributed to those who need it, decreasing costs and carbon emissions.

FY23 Surplus Data

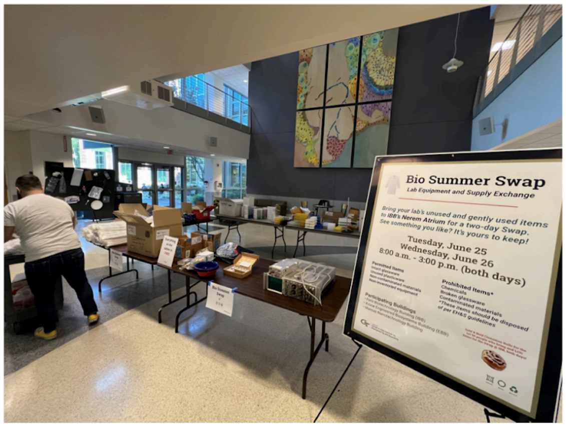
To analyze circularity in the campus-wide surplus system, we obtained access to data detailing items distributed from the surplus department, total quantity of items obtained, total quantity of items re-distributed, and costs of items if sold outside of Georgia Tech within Fiscal Year 23 (FY23). We unfortunately were not able to obtain data detailing all of the items given to surplus in FY23. We divide surplus materials into three main categories: Furniture, electronics, and general. Each category was then divided into multiple sub divisions (see above QR: FY23 Surplus Data). Embodied carbon is a term referring to the carbon that goes into the sourcing, production, and transportation of a product. Few companies publish the embodied carbon of their products, so to combat the lack of available data we grouped surplus materials into categories, and obtained the embodied carbon for one 'reference item' in the category. Reference items were chosen based on which items appeared most often in the category in FY23. Embodied carbon per unit for the reference furniture items were calculated using the MSR GWP Calculator for Furniture [9]. Embodied carbon per unit for general item categories were found using the Inventory of Carbon and Energy [10]. The values per weight for the general material were multiplied by average weight values of the reference item found on Amazon. Embodied carbon per unit for electronic items was found using charts provided by a series of item-specific research studies and production reports [10-14]. Cost per unit for reference items was evaluated using average prices when the reference item sold in FY23 [9], but some costs were not available so Amazon, University Loft Company, and procurement data was used to fill in the gaps. The following table shows a categorized summary of the FY23 surplus items that were re-distributed:

Key	Item Type	Quantity	Ref Item	Embodied carbon per Unit (lbs CO2e)	Total Embodied Carbon (lbs CO2e)	Cost per Unit ($)	Total Cost ($)
	Desk Chairs	1236	Rolling chair	159.762	197,465.83	14.91	18428.76
	Large Tables	496	Standing desk	462.971	229,633.62	16.99	8427.04
	Small Tables	36	Coffee table	379.195	13,651.02	247.50	8910.00
	Stools	63	Stool	85.738	5,401.49	6.50*	409.50
	Sofas	255	Sofa	559.974	142,793.37	199.99*	50997.45
	Plush chairs	503	Lounge chair	324.814	163,381.442	159.99*	80474.97
	Shelving	611	Wardrobe	239.753	146,489.083	149.99*	91643.89
	Small general electronics	1657	Phone	111.333	184,478.781	11.78	19519.46
	Large general electronics	101	Monitors	867.739	87,641.639	79.99*	8078.99
	Workout equipment	33	Treadmill	504.858	16,660.314	403.10	13302.3
	Appliances	91	Refrigerator	771.618	70,217.238	635.99*	57875.09
	Laboratory devices	53	Spectrometer	173.261	9,182.833	313.20	16599.60
	Landscaping tools	43	Mower	2,646.704	113,808.272	2125.00	91373.00
	Vehicles	36	Ford	37,478.585	1,349,229.06	6,800	244800
	Other (ceramic)	610	Plates	1.521	927.81	2.33	1421.3
	Other (fabric)	900	Scrub pants	7.608	6,847.22	19.99*	17991.00
	Other (paper)	1	A4 paper	3.730	3.730	7.92*	7.92
	Other (wooden)	600	Bed Ends	67.927	40,756.20	379.00*	227,400.00
	Other (metal)	860	Bed Springs	2.240	1,926.615	65.00*	55900.00
	Other (plastic)	4	Petri Dishes	35.452	141.808	6.99*	27.96
	Other (glass)	0	2L Flask	0.095	0.00	20.99*	0
	Totals				2,780,637.38		1,013,590.23

Note: The asterisk (*) denotes that the unit cost was estimated from procurement data or comped from Amazon or University Loft company.

2024 Bio Summer Swap Data

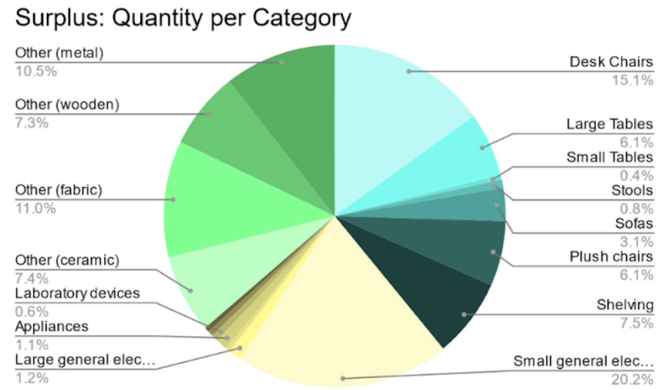
The same methodology was applied to a dataset of items exchanged at the ‘Bio Summer Swap’, which occured on June 25th & 26th, 2024 [8]. The ‘Bio Summer Swap’ is an annual event where-in the BioQuad buildings participate in a free yard-sale style event, with marketing done through the IBB that encourages labs to participate and clean-out their spaces of extra materials (see images below). The BioQuad has been conducting these swaps for the seven years, according to our interview with Colly Mitchell, the Director of Activities and Engagement at the IBB. She notes that over time, the amount of materials has decreased and landfill avoidance rate has increased. Prior to this year, data was not recorded from the swap.

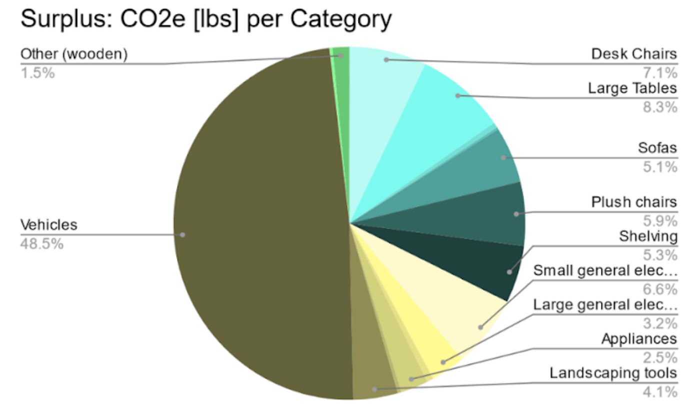


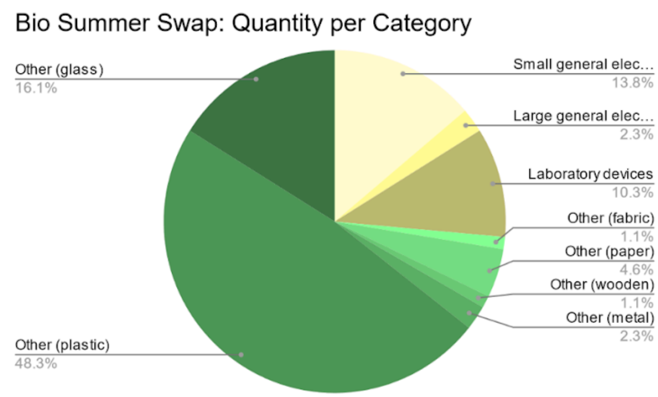
The following table shows items taken in and re-distributed in the ‘Bio Summer Swap’, which had an 100% landfill avoidance rate this year, meaning that everything was re-distributed or appropriately recycled. This suggests that these zoned swaps can reach peak efficiency within 7 years, as participants become used to the process, advertising increases, and donation amounts stabilize (for full dataset, see above QR: 2024 Bio Summer Swap).

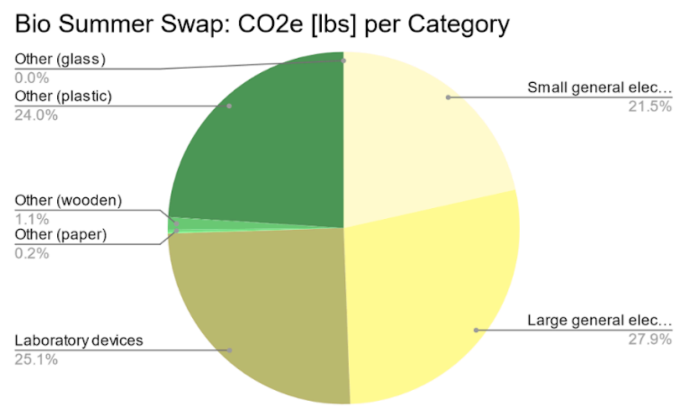
Key	Item Type	Quantity	Ref Item	Embodied carbon per Unit (lbs CO2e)	Total Embodied Carbon (lbs CO2e)	Cost per Unit ($)	Total Cost ($)
	Small general electronics	12	Phone	111.333	1,335.996	11.78	141.36
	Large general electronics	2	Monitors	867.739	1,735.478	79.99*	159.98
	Laboratory devices	9	Spectrometer	173.261	1,559.349	313.20	2,818.80
	Other (fabric)	1	Scrub pants	7.608	7.608	19.99*	19.99
	Other (paper)	4	A4 paper	3.730	14.92	7.92*	31.68
	Other (wooden)	1	Bed Ends	67.927	67.927	379.00*	379.00
	Other (metal)	2	Bed Springs	2.240	4.480	65.00*	130.00
	Other (plastic)	42	Petri Dishes	35.452	1,488.984	6.99*	293.58
	Other (glass)	14	2L Flask	0.095	1.33	20.99*	293.86
	Totals				6,216.07		4,268.25

Comparative Analysis

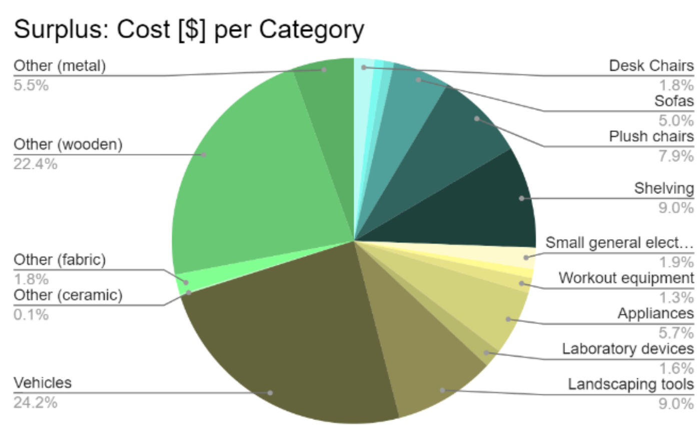


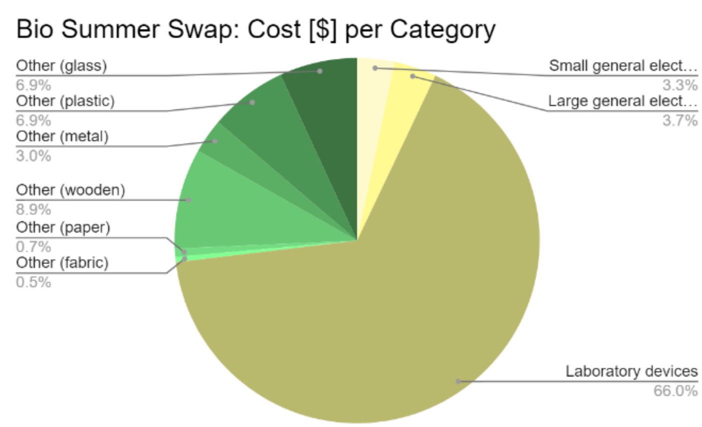






While there is a fairly even split in the quantity of items in each category in FY23 surplus, the embodied carbon is largely driven by electronics and secondly by furniture. Vehicles make up an obvious category to hold the most embodied carbon. In surplus, these include large passenger cars as well as golf-carts. The second largest category is large tables, which includes items like desks and conference tables. The comparison between FY23 surplus data and 2024 Bio Summer Swap showcases how different materials used in one specialized subsection of campus can be, another key benefit of the zone-based system.





The costs spent overall on FY23 surplus are mostly on vehicles and other wooden items (a category that mostly consists of pieces of beds for on-campus housing). These costs are disproportionate to the quantity of the material found, and suggest that these areas could be key to focus on keeping within Georgia Tech in order to decrease expenditures. The cost breakdown between the FY23 surplus and the Bio Summer Swap are very different, showcasing again how specialized different campus zones may be.

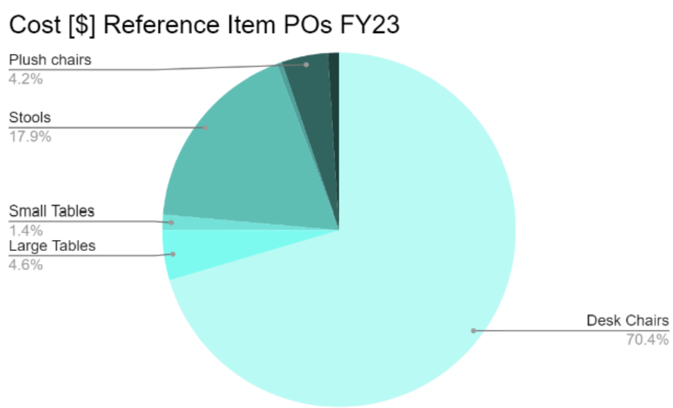
In the last year 46,389 items were sent to surplus. 8197 items were retrieved from surplus for use by other departments or the larger USG community totaling to 2,780,637.38 lbs of embodied CO2 and $1,013,590.23 of equipment, but only representing 17.67% of FY23 surplus. We do not know what happened to the other items.

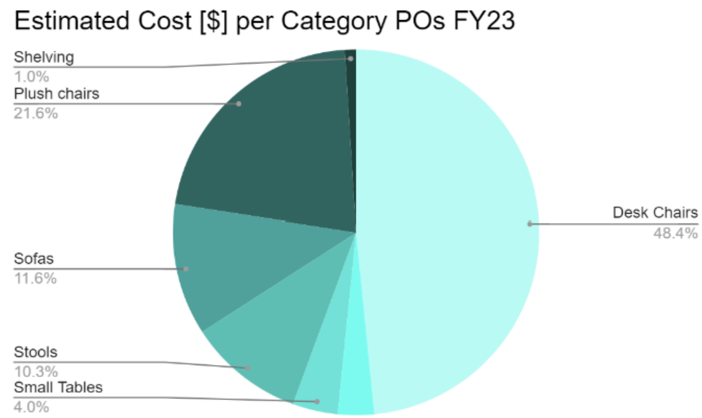
Assuming the reused items are representative of the average category distribution of items given to surplus, there were 15,736,487.7 lbs CO2 of embodied carbon and $5,736,220.88 of equipment sent to surplus in FY23. The 17.67% reuse rate is very different from the 100% of items that were reused or recycled appropriately in the 2024 ‘Bio Summer Swap’, highlighting that the zone-based approach will improve circularity drastically. If the amount that was reused within one department was reflected by the whole surplus, 12,955,850.3 lbs CO2 will be saved from entering the landfill and $4,722,630.65 of cost savings.

FY23 Purchase Order Data

These savings do not yet account for item reuse that would replace the purchasing of new materials. The following table summarizes procurement reports pulled for the ‘Reference Items’ for each category, meant to give an underestimate of the number of new items ordered fitting descriptions similar to frequent items in surplus this year (see above QR: FY23 Reference Item PO). Procurement reports were manually cleaned up to display only relevant line items.

Key	Ref Item POs Pulled	Quantity	Embodied carbon per Unit (lbs CO2e)	Total Embodied Carbon (lbs CO2e)	Total Cost of POs ($)	% Reference Items of Total Category	Est. Total Category Embodied Carbon (lbs CO2e)	Est. Total Category Cost ($)
	Rolling chair	1192	159.762	190,436.304	169,531.55	69.09	275,635.119	245,377.84
	Standing desk	36	462.971	16,666.956	11,043.19	68.15	24,456.282	16,204.24
	Coffee Table	28	379.195	10,617.46	3,376.83	16.67	63,692.022	20,256.93
	Stool	178	85.738	15,261.364	42,976.34	82.54	18,489.66	52,067.29
	Sofa	2	559.974	1,119.948	1,148.99	1.96	57,142.551	58,621.94
	Lounge chair	13	324.814	4,222.582	10,213.37	9.34	45,209.657	109,350.86
	Wardrobe	2	239.753	479.506	2,413.94	48.28	993.177	4,999.88
	Totals						485,618.47	506,878.98

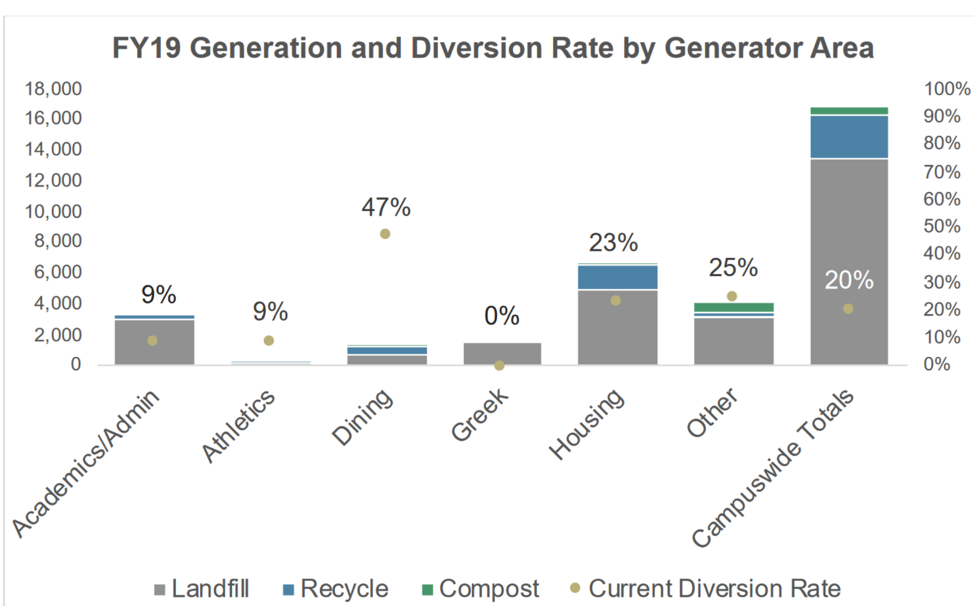




As the reference items represent a small quantity of all items per category, numbers were divided by the percentage of the quantity of total category items that reference items made up, to create more realistic estimates. The purchase of furniture is estimated to have cost $506,878.98 and used 485,618.47 lbs CO2e. From the FY23 surplus reports, furniture accounted for 25.58% of the cost and 32.32% of the embodied carbon. Using this to estimate the total cost and carbon saved from procurement, it appears that $1,981,544.10 and 1,502,532.4 lbs CO2e could be saved on items which could instead be pulled from surplus.

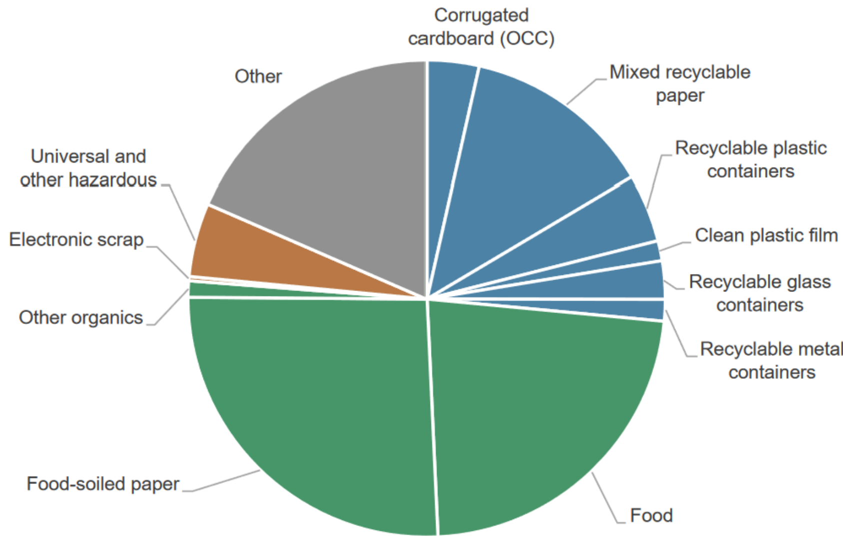
Vendor Waste Hauling Costs

From the Georgia Tech Materials Conservation Management Plan presented in December 2020, Georgia Tech generates 12,000 annual tons of landfill waste, and 2,500 annual tons of recycling [1]. $40,000 is obtained in annual recycling revenues, and $530,000 is spent in annual vendor hauling costs [1]. Academic/Administrative buildings generate 3,290 tons/year, which is ~19% of GT's material stream [1]. From this, we estimate that Academics/Administrative represent $100,700 in hauling costs, with a $760 return in recycling revenues. Implementing our proposal will decrease the total tonnage of waste entering the waste management system and increase the percentage that is recycling. It appears that 50% of the Academics/Administrative landfill stream are in similar categories to items we've documented in surplus. Some of this would also be non-procurement waste (i.e. recycled plastic drink bottles), but we will make the assumption that this does not represent a significant weight of materials. Hauling costs could be decreased by $50,350 from Academics/Administrative buildings, and recycling revenues would increase by an estimated $3,240. We are not currently able to calculate the associated carbon emission reduction due to less trips by hauling vehicles.



Recoverability of Landfill Stream

% recyclable material in landfill stream	32%
% compostable material in landfill stream	50%



(Figure from Georgia Tech Materials Conservation Management Plan December 2020)

From our interview with Anthony McCoy, Building & Delivery Manager for the College of Computing (CoC), we've found that a time of increased waste generation on campus occurs during moves, of which 60-100 occur per year in the CoC alone. The cost savings associated with moving a decreased volume of items for each lab or individual are difficult to quantify, but would add additional savings.

The initial investments required for the "Swap to Sustain" initiative are expected to be recouped within the first departmental move. By effectively utilizing existing resources and reducing the need for new purchases, we can leverage a fairly quick payback period. In the long term, as the program becomes more widely adopted, the savings will continue to provide a compelling return on investment, ensuring that the initiative remains financially sustainable and beneficial to Georgia Tech in the years to come. This change in expenditure and carbon emissions will not be achieved without our intervention.

Summary of Savings

Area of Improvement	Co2e Reduction [lbs Co2e]	Cost Savings [$USD]
Material reuse within zone	12,955,850.3	4,722,630.65
Reduction in purchase orders	1,502,532.4	1,981,544.10
Vendor hauling	No data	53,590.00
Totals:	14,458,382.70	6,757,764.75

A departmental swap program like this can lead to a yearly decrease in cost savings over time due to the nature of the swap. Initially, there would be significant savings as departments exchange furniture and equipment that might otherwise be purchased new. However, once the majority of usable equipment and furniture has been swapped and settled in their new locations, the frequency of swaps would naturally decrease. This means fewer opportunities for cost savings in subsequent years because the need for new equipment or furniture diminishes as items are already in place and in use for several years. Conversely, carbon savings would likely increase over time as the swap program reduces the need for manufacturing and transporting new equipment and furniture. As departments become accustomed to reusing existing items, the campus's overall consumption will lower, decreasing its carbon footprint. We predict a reduction in demand for new goods can lead to long-term environmental benefits.

Based on these assumptions, we can predict a steady 20% - 25% decrease of cost savings annually and a 10%-15% increase of carbon embodiment savings, resulting in the following sensitivity chart.

Year	Co2e Reduction [lbs Co2e]		Cost Savings [$USD]	
	10% Increase	15% Increase	20% Decrease	25% Decrease
0	14,458,382.7	14,458,382.7	6,757,764.8	6,757,764.8
1	15,904,220.9	16,627,140.1	5,406,211.8	5,068,323.6
2	17,494,643.1	19,121,211.1	4,324,969.4	3,801,242.7
3	19,244,107.4	21,989,392.8	3,459,975.6	2,850,932.0
4	21,168,518.1	25,287,801.7	2,767,980.4	2,138,199.0
5	23,285,369.9	29,080,971.9	2,214,384.4	1,603,649.3

Assuming Georgia Tech has a tax rate of 30% and we are putting down an initial investment of $1000 to get started, we have calculated the WACC (Weighted Average Cost of Capital), NPV (Net Present Value), and IRR (Internal Rate of Return) as described below.

$$WACC \ = \left(\frac{E}{V} \times Re\right) + \left(\frac{D}{V} \times Rd \times (1 - Tc)\right)$$

Firm Equity Proportion E/V (Assumed)	0.6
Frim Debt Proportion D/V (Assumed	0.4
Cost of Equity Re $R_i = R_f + \beta_i * (R_m - R_f)$	0.9
Cost of Debt Rd	0.05
Corporate Tax Rate Tc	0.3
WACC	= 0.4 * 0.05* (1 - 0.3) + 0.6 * 0.1 = 0.74 = **7.4%**

Financial Calculations (WACC, IRR, NPV)

Initial Investment	$1,000
Life of Project (years)	10
Cost savings (pre-tax)	6757764.8
Growth	0.00%
Required return (WACC)	**7.40%**
Tax rate	30%

Year	0	1	2	3	4	5	6	7	8	9	10
Cost savings		6757764.8	6757764.8	6757764.8	6757764.8	6757764.8	6757764.8	6757764.8	6757764.8	6757764.8	6757764.8
(1) Cost savings x (1-T)		4730435.36	4730435.36	4730435.36	4730435.36	4730435.36	4730435.36	4730435.36	4730435.36	4730435.36	4730435.36
Depreciation expense		$100	$100	$100	$100	$100	$100	$100	$100	$100	$100
(2) Depreciation x T		$30	$30	$30	$30	$30	$30	$30	$30	$30	$30
(3) Initial Investment	-$1,000										
Total Cash Flows (1)+(2)+(3)	-$1,000	$4,730,465	$4,730,465	$4,730,465	$4,730,465	$4,730,465	$4,730,465	$4,730,465	$4,730,465	$4,730,465	$4,730,465

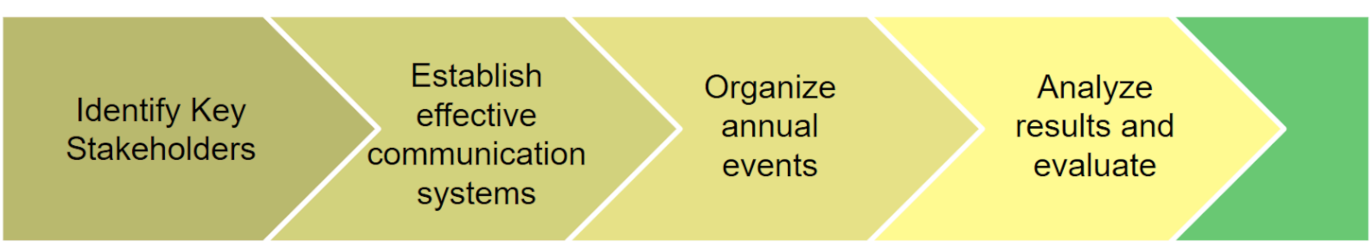
NPV	**$32,618,081.25**	Greater than 0, accept!
IRR	**473047%**	Greater than WACC, accept!

With a Weighted Average Cost of Capital **(WACC) of 7.4%**, the project comfortably surpasses the minimum required return. The Net Present Value **(NPV) of $32,618,081.25** demonstrates the substantial value this initiative will generate over its 10-year duration. Moreover, the Internal Rate of Return **(IRR) of 473,047%** is extraordinarily high, stems from the low initial investment required to implement the swap system combined with the substantial cost savings it yields.

Co-Benefits

1. ***Social Benefits:***
    a. Community building: By encouraging collaboration and resource sharing among different departments, we are fostering a stronger sense of community and networking on campus.
2. ***Environmental Benefits:***
    a. Waste reduction: Decreases the amount of waste sent to landfills, and thereby contributes to a more sustainable campus environment.
    b. Resource conservation: Promotes the reuse of materials, reducing the need for new resource procurement and manufacturing.
3. ***Health and Wellbeing:***
    a. Clutter reduction: Helps departments declutter and create more organized workspaces, hopefully leading to reduced stress and increased productivity.
    b. Physical activity: Volunteers in swap events engage in physical activity through the process of moving and transporting items.
4. ***Educational Benefits:***
    a. Sustainability awareness: Increases awareness about sustainability practices across departments and the importance of a circular economy.

Next Steps



Identify Key stakeholders

Based on the proven effectiveness of zone-based circular economies broadly and at Georgia Tech, we've divided the campus into the previously shown seven 'swap' areas, based on areas that would have similar resources used regularly within their communities and where would include at least one building with a suitable event space. Some areas (i.e. CRC) are not included currently, these would require follow up contact to determine if there is a large buildup (and waste) of materials. It's important that the swap areas are relatively small, so that it is not out of the way for faculty and students to move heavy or large quantities of materials to the drop off locations.

Department Heads by Zone: In each zone, we've identified tentative department heads responsible for overseeing the swap events. The department head is someone who operates out of a building that has an event space and marketing resources. We would reach out to these building managers to inquire if they would be interested in taking on this initiative or if they know who in their department would be able to as a part of student services.

Zone Number	Department Head	Contact Information
Zone 1	Essy Behravesh	e.behravesh@bme.gatech.edu
Zone 2	Brent Minter	brent.minter@biosci.gatech.edu
Zone 3	Adjo A. Amekudzi-Kennedy	adjo.amekudzi@ce.gatech.edu
Zone 4	Kenneth Garrick	kenney.garrick@mse.gatech.edu
Zone 5	Michael Carson	michael.carson@isye.gatech.edu
Zone 6	Mike Riley	mike.riley@chemistry.gatech.edu
Zone 7	Nigel Auzla	nauzla3@gatech.edu

Surplus Management: Campus surplus is a valuable stakeholder as all un-swapped items will go next to the larger campus circular economy at the surplus warehouse. Luckily, the surplus department already has an easy to use SharePoint site [8]. Anthony McCoy, Building & Delivery Manager for the College of Computing (CoC), told us that the SharePoint was logically organized and easy-to-use, and he uses it sometimes before procuring new items.

On-campus Recycling Centers: Campus recycling centers will become important resources for our swap, to ascertain where different materials can go. Swap materials may go to the Center for Hard to Recycle Materials (CHaRM), Kendeda Compost, and other recycling units on the material reuse pathway flowchart, instead of the landfill.

Communication

Marketing and Interest initiative: Launch marketing campaigns to inform faculty and staff about the benefits and logistics of the swap events. Department heads could then fill out an interest form to be scheduled based on their and other departments' needs.

Monthly updates: Provide regular updates on available surplus items in the stock rooms and warehouse, and upcoming swap events via email newsletters.

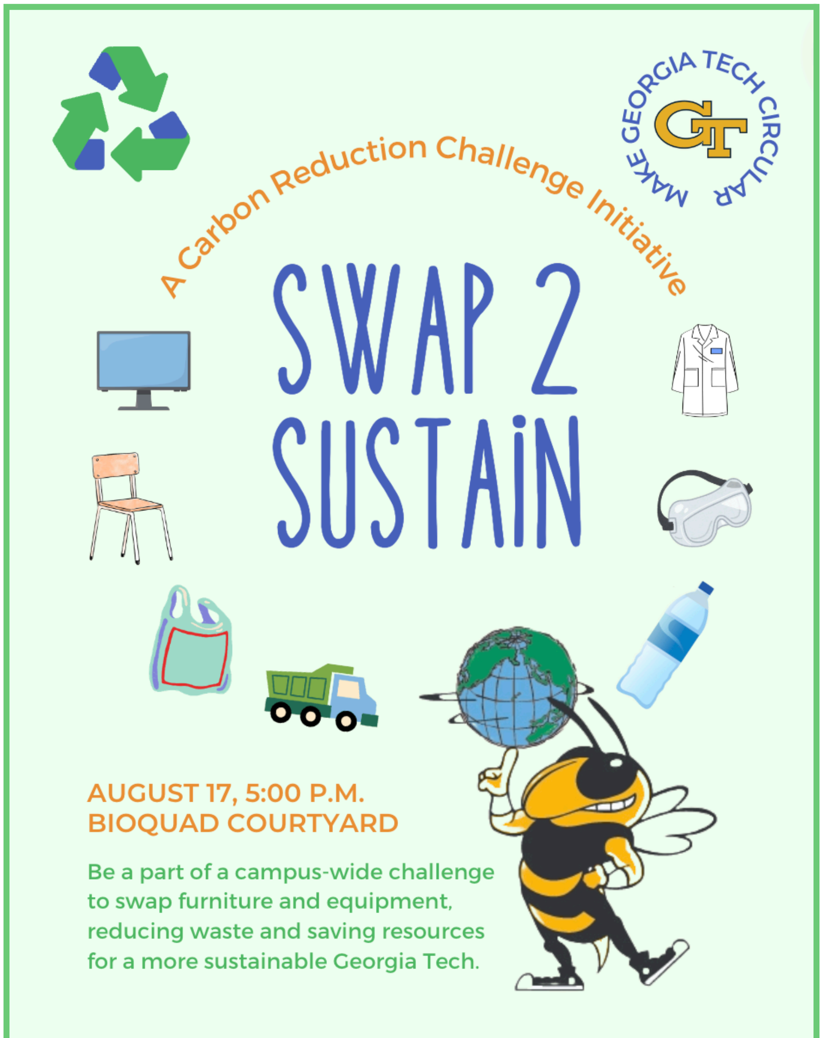
Batteries

- Accepted: Small and medium rechargeable and non-rechargeable batteries
- Locations: Drop-off Locations: Campus Bookstore, Expo Hall information desk, Clough Information Desk, ORGT at CRC, and the Library Information Desk. Many offices and departments have collection boxes. To request a box, email **batteries@gatech.edu**

Electronics (E-Waste)

- *State-owned property*: If you have a state-owned computer or electronics to be disposed of (whether inventoried or non-inventoried) contact the Property Coordinator for your department. They will fill out the proper paperwork to have your equipment picked up and taken to surplus for recycling.
- *Personal property*: Personally owned computers and electronics can be recycled year-round at The Kendeda Building Loading Dock.

On- campus Recycling Center Collaborators



Sample flyer to advertise our events

Organize Swap Events

Scheduling: Plan and schedule swap events, optimizing times and locations to facilitate the maximum number of items exchanged based on Interest form responses and follow ups.

Logistics: Arrange for transportation and storage of items before and after the events.

Data Tracking/ Documentation: Keep detailed records of items swapped, items left over, and their subsequent destinations (e.g., recycling, further surplus).

Analyze Results and Evaluate

Data Analysis: Using the data collected, estimate carbon savings and cost avoidance. Analyze the content category submission by building to ensure that zoning is allowing for the best possible crossover of specializations.

Feedback: Implement a feedback system through the Swap website to gather insights from participants and improve future events.

Interest form

Swap Data Tracking

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