RUTGERS
Office of the President
TASK FORCE ON CARBON NEUTRALITY
AND CLIMATE RESILIENCE

Climate Action Plan Supplemental Report

Report of Working Group on Land Use and Offsets

2021

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1. Rutgers' current baseline

1.1. Rutgers' greenhouse gas emissions due to land use

Information about baseline greenhouse gas emissions was compiled for several different components related to Rutgers University Land Use. Where possible we employed the SIMAP analysis to estimate the amount of carbon and equivalent CO2 emitted.

1.1.1. On campus grounds

Currently, University Grounds staff manage approximately:

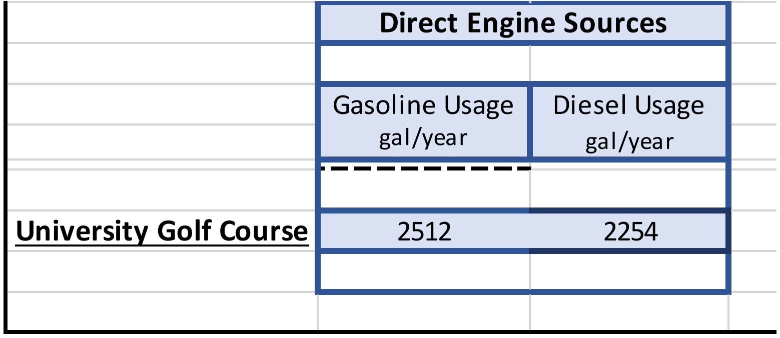
New Brunswick complex – 335 acres of turf
Camden Campus – 6 acres of turf
Newark Campus – 3 acres of turf

The Rutgers Golf Course maintains:

Fairways – 21 acres
Roughs – 25 acres
Tees/Greens - 5.9 acres

An Inventory of present on-campus ground maintenance practices was undertaken. Unfortunately, the fuel consumption for on-campus grounds maintenance is not specifically tracked. However, data was available for the University Golf Course (Table 1.1). Table 1.2 illustrates total fertilizer usage for University campuses. An inventory of Grounds maintenance equipment is provided in Table 1.3. University Grounds is in the process of establishing a pilot program to explore the utility of using battery powered line trimmers, edgers, hedge trimmers and leaf blowers.

Table 1.1. Fuel consumed on University Golf Course.



	Direct Engine Sources	
	Gasoline Usage gal/year	Diesel Usage gal/year
University Golf Course	2512	2254

Table 1.2. Fertilizer applied to University Grounds

Location	**Type**	**Nitrogen (lbs)**	**Potassium (lbs)**	**Note**
New Brunswick Complex	inorganic	30,642	2,898	liquid form, 14,490 gallons of concentrate liquid fertilizer applied per year, 3 applications, 20-0-2
RU Golf Course: *fairways, tees and roughs*	25% organic/75% synthetic	2,565	2,565	13,500 lbs or 19-0-19 applied at 1 lbs/1000 sq.ft. x2 per year, spring and fall on fairways, tees and roughs
RU Golf Course: *greens*	synthetic	138	69	84 gallons liquid concentrate of 16-0-7 applied at 1/10th lbs/1000 sq.ft. biweekly on greens.
Newark		Unknown	Unknown	data not available
Camden	synthetic	90	9	Liquid concentrate, 448 gallons, yearly, 20-0-2 20% Slow Release Nitrogen

Table 1.3 Inventory of Grounds Maintenance Equipment and Fuel Type Consumed

Equipment Type	**Gasoline**	**Diesel**	**Electric**	**2 Cycle Gasoline**
New Brunswick				
Backpack and hand held blowers			1	96
Line Trimmers				99
Lawn Edger	29			
Hedge Trimmers			7	34
Chain Saws			1	14
Riding mowers	73			
Push Mowers	30			
Snow Plow (dedicated - Bomadier type)	1			
Salt Spreaders			27	
Skid Steer		2		
Tractor/Loader		2		
Litter Vacuum (Tennant - small)		1		
Leaf Vac	7			
Power Washer	9			
Utility Vehicle		4		
Trucks p/u	6			
Camden				
Backpack and hand held blowers				10
Line Trimmers				6
Hedge Trimmers				2
Chain Saws				3
Riding mowers	3			
Walk behind Large mower	1			
Push Mowers	2			
De-Thatcher	1			
Aerator – walk behind	1			
Snow Blowers	4			
Skid Steer		1		

Tractor/Loader		1		
Street Sweeper	1			
Litter Vacuum (dedicated - Tennant type)				
Leaf Vacuum	1			
Kubota Utility Vehicle		5		
Trucks p/u	3			
Rack/Dump truck	1			
Electric Vehicles – Gem Carts			7	
Newark				
Backpack and hand held blowers	2			11
Line Trimmers				7
Lawn Edger				2
Hedge Trimmers				
Chain Saws				3
Walk behind Large mower	3			
Push Mowers	4			
Aerator – walk behind	1			
Snow Blowers	10			
Salt Spreaders	17		3	
Salt Spreaders (truck mounted)	2			
RU Golf Course				
Backpack and hand held blowers				4
Line Trimmers				5
Chain Saws				2
Riding mowers	6	10		
Push Mowers	1			
Utility Vehicle	10			
Electric Vehicles Carts			3	

1.1.2. NJ Agricultural Experiment Station Farms and Research Stations

An Inventory of present on-campus farm operations and maintenance practices was undertaken. Off-campus farms or research stations were not inventoried. The Inventory included:

- Annual energy consumption from utility bills (Table 1.4);
- Inventory of farm machinery and fuel type consumed (Table 1.5)
- Annual diesel/gasoline consumption in vehicles and equipment (i.e. gallons of fuel consumed) (Table 1.6);
- Number of head of livestock and manure production (Table 1.7).

Table 1.4 Table of energy use for on-campus NJAS farm facilities.

	Energy Usage	
	KWH/year	Therms/year
Hort Farms 1	213293	28396.19
Hazelnut + Dogwood Research Nursery		
Hort Farm 2	unreported	
Hort Farm 3	84790	17926.78
Cook Campus Farm	unreported	

Table 1.1. Inventory of NJAES farm machinery and fuel type consumed

Equipment & Vehicles			Gasoline	Diesel	Electric	2 Cycle Gasoline
Hort Farm 2	Tractors		1	2		
	Truck		1			
	Mowers		13	7		
	Field Prep Equip. Roto Tilers		3			1
	Utility Vehicles & Golf Carts		13	1		
	Sprayers		1	2		
	Unique Research Equip.		5			
	Backpack Blower + Turbine		1		1	4
	Chainsaw					1
	String & Hedge Trimmers		1			1
	Generator		1			
	Irrigation Pumps (Pumphouse) 460 V		1		3	
Iechanic Shop Equipme	Air Compressor 220V		1			
	Parts Cleaner 110V		1			
	Blade & Reel Grinders 110V		3			
	Golf Cart Lift 110V		1			
	Winch 110V		1			
	Metal Chop Saw 110V		1			
	Drill Press 110V		1			
	Bench Grinder 110V		1			
	Fan 110V		2			
	Oil Suction Pump 110V		1			
	Band Saw 220V		1			
	Water Heater 110V		1			
Cook Campus Farm	Heavy Duty Diesel Pickup Truck		1			
	Mid-sized Pickup Truck		1			
	Station Wagon		1			
	Van (for dairy farm use)		1			
	Vans (for student transport)		3			
	Gator'/Utility Vehicle		1			
	Electric Golf Cart		1			
	Skid Steer Loaders (sm, med, lg)		3			
	90 HP Tractors		2			
	70 HP Tractor		1			
	45 HP Tractor		1			
	18 HP Tractor		1			

Table 1.6. NJAES farms’ diesel/gasoline consumption from vehicles and equipment and fertilizer application

	Direct Engine Sources		Fertilizer Application				
	Gasoline Usage gal/year	Diesel Usage gal/year	N-P-K/Type	Synth/Org	lb/yr	% N	lb N
Hort Farms 1	unreported		unreported				
Hazelnut + Dogwood Research Nursery							
Hort Farm 2	2457.6	845.2	10-14-0	synth	58.0	10	5.8
			26-0-5	synth	1220.4	26	317.3
Turf Grass Research Plots			16-0-8	synth	1205.5	16	192.9
			12-24-8	synth	520	12	62.4
			21-22-04 (Scott's TurfBuilder w/ Mesotrione)	synth	12	21	2.52
			Scott's Standard Fertilizer 21	synth	21.5	10	2.15
			46-0-0 Urea	synth	148	46	68.08
Hort Farm 3	unreported		46-0-0 Urea	synth	500	46	230
Roughly 14 acres tree plots, 9 acres field plots			Chicken Magic	org	2000	5	100
			(for trees) 46-0-0	synth	1000	46	460
			(for trees) 20-0-0	synth	1400	20	280
			non-nitrogen additives:				
			pelletized lime		19200	(96000 lb applied every 5 years)	
			potassium		1333	(4000 lb applied every 3 years)	
			boron		200		
			sulfur		150		
Cook Campus Farm	700	300	Manure Produced by Livestock	org	1472620	0.68	10013.816

Table 1.7. Number of head of livestock and manure production.

Animal Headcount:		
Livestock	Adult	Juvenille
Beef Cattle	12	8
Swine	20	12
Goats	30	10
Sheep	24	10
Horses	25	
Poultry	25	

The total annual consumption for the NJAES On-Campus Farms (which were surveyed) and the University Golf Course (from section above) combined is approximately 541 eCO2 MT (Table 1.8) (conversion to equivalent CO2 based on https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#:~:text=To%20convert%20to%20carbon%20dioxide,in%20the%20year%20of%20co nversion.). Note that this does not include N Fertilizer application in the equivalent CO2 estimation.

Table 1.8 Total Energy consumed and CO2 equivalent for NJAES on-Campus farms and Golf Course.

	Direct Engine Sources		**Fertilizer Application**			**Energy Usage**	
	Gasoline Usage gal/year	Diesel Usage gal/year				KWH/year	Therms/year
Current Total	5669.6	3399.2	Total (Lb.)	14297.816		298083	46322.97
	eCO2 (MT)	eCO2(MT)				eCO2 (MT)	eCO2(MT)
CO2 Equivalent	50.4	34.6				211	245

1.2. Rutgers' climate vulnerabilities

Changing climate conditions has manifold implications for Rutgers University's campus grounds, research farms and forests. Hotter growing season temperatures, milder winters, extreme precipitation events and prolonged drought will affect plant health and productivity as well as stormwater runoff.

1.3. Ongoing activities to reduce emissions and vulnerabilities

Please describe ongoing activities to reduce the emissions and/or vulnerabilities described above.

- Present University policy requires that all capital projects incorporate perennial plantings capable of significant annual biomass development, and minimize extents of managed lawn, thereby reducing fertilizer input as well as mowing;
- A sustainability plan for NJ Agricultural Experiment Station (NJAES) research farms is under way.
- A deer management program has been initiated on University owned forests, to reduce deer population numbers and thereby promote a healthier, more diverse, and fully stocked forest that can fix and store more carbon.

1.4. Related ongoing educational, research, and service activities

There has been a concerted push to extend the formal boundaries of the classroom to encompass the campus grounds, the EcoPreserve and Rutgers Gardens and nearby features such as the Raritan River as a Living Laboratory.

2. Overview and Assessment of potential climate solutions

2.1. On campus and off campus facilities' grounds

The objective is to reduce greenhouse gas emissions of grounds maintenance and to increase carbon dioxide storage by increased carbon sequestration in soils and woody vegetation. We propose that a strategic plan be developed that includes "carbon defense" strategies designed to maintain the existing stores of carbon in the soils, above- & below-ground plant biomass, and "carbon offense" strategies designed to promote enhanced carbon capture potential (i.e., additional amounts above and beyond baseline conditions).

2.1.1. Grounds Maintenance

To meet the objective of understanding the present baseline of greenhouse gas emissions, we propose a more complete inventory of emissions relating to grounds maintenance. This then be followed by the development of an emissions reduction plan. The first step in this direction is to develop protocols for tracking fuel usage by individual piece of equipment.

Battery powered (EV) lawn equipment benefits extend beyond reductions in green house gas emissions. Cost savings can be realized through the use of EV equipment due to reduced maintenance requirement (no oil to change, fittings to be lubricated or belts to replace), gas and oil costs are zero. EV equipment is significantly quieter and produces no noxious fumes.

Establish goal of transitioning 50% of all 2-cycle and small (gasoline / oil fuel mixture) equipment to battery powered (EV) within 10 years. Costs associated with transitioning 50% of our small lawn ICE care equipment to EV could range from $100,000 to $150,000 over the next ten years ($10,000 to $15,000/year average). Currently Grounds works on a 5 year service life for lawn care equipment (purchase to replacement). As technology advances costs for EV equipment should moderate. The cost to fully convert our current inventory of our 2-cycle and small ICE equipment could range from $200,000 to $300,000. (Dollar estimates are based upon internet searches of EV equipment manufactures and based on the purchase of tools, batteries and chargers. Number of batteries purchased was assumed to be 1.5 batteries per tool and one dual charger per tool).

As technology advances investigate transitioning from large (Internal combustion engines (ICE) gasoline or diesel) maintenance equipment to battery / electric equipment (EV).

Currently electric commercial mowers are available from:
MeanGreen – www.meangreenproducts.com
Gravely – www.gravely.com
Greenworks Commercial – www.greenworkscommercial.com

Costs for EV commercial mowers range from 1.5 to 2.5 times conventional gas/diesel zero-turn large deck (48" to 72" cutting width) mowers. Documented continuous run times range from 6 to 8 hours (equivalent to 10 to 15 acres mowed area). Some of the current generation of EV mowers have removable batteries. Batteries recharge to full capacity in 8 to 10 hours. Some manufacturers offer PV panels that are mounted above the operator (providing shade) that actively recharge batteries during operation. Return on investment (as stated by manufacturers – considering initial purchase price, fuel cost, electricity cost, and maintenance cost) range from 10 months to 19 months. (www.meangreenproducts.com/blog/mean-green-mowers-simple-savings-calculator/ , www.gravely.com/en-us/roi-calculator). Electric mowers have significantly lower operating and maintenance costs than ICE (internal combustion engine mowers).

Develop program where campus trees that are removed due to disease, storm damage or displaced due to capital construction projects are harvested and used for lumber. Relationships can be developed with local sawmills or utilize university sawmill to mill lumber.   Campus trees should be viewed as a resource and not ground for mulch or used as firewood.

2.1.1.1. Who Will Implement the Solution?

Facilities management and staff would need to evaluate the utility of EV equipment based upon performance, initial cost, and cost savings. Management must put forward the case that high initial costs are significantly offset by very low annual operating and maintenance costs compared to ICE equipment. Benefits of incorporating EV equipment are not limited to reducing our carbon foot. EV equipment is significantly quieter than ICE equipment, do not produce noxious fumes, do not require disposal of waste engine oils, have significantly reduced maintenance requirements – no belts to be replace, oil to be changed, etc.

2.1.1.2. Impediments to utilizing EV equipment

- Initial cost of EV equipment
- Battery life (may not be significant issue with advances in battery technology)
- Cultural bias towards ICE equipment

2.1.1.3. Metrics to success

- Reduced carbon footprint
- Fuel cost savings (gasoline and diesel)
- Reduced maintenance (materials and time)
- Quieter campus

2.1.1.4. Dollars and resources needed

- Transitioning 50% of small/2-cycle lawn care equipment to EV over 10 year period - $100,000 - $150,000.

2.1.1.5. Sources for funds (baseline or additional)

- To be determined

2.1.1.6. Timetable

- 10 years to be 50% EV

2.1.2. On-campus Greenspace management

To initiate the proposed campus green space sustainability effort, approximately 25 acres of the New Brunswick-Piscataway campus lawns have been identified as candidates for conversion no/eco-mow zones. An additional 14.3 acres of lawn or disturbed areas have been identified to replant into trees. A more comprehensive implementation plan including costs should be developed.

Develop individual campus (RU-New Brunswick, RU-Newark and RU-Camden) “urban” forestry master plans. Within the master plan tree management strategies will be identified that will enhance the health and vigor of the existing forest, identify specific physical management practices that will advance the health of the forest and public / property safety, promote proper arboricultural practices, consider the forest a resource for potential urban harvested lumber, utilize the forest as a teaching and research resource, identify replanting/infill locations and strategies.

Establish requirements, in RU design standards, for:

- Minimum landscaping associated with capital projects.
- Require small percentage of capital project budgets to go towards campus landscape beautification/enhancement project.
- Require replacement of trees removed for capital projects based upon basal area calculation or biomass calculation.

Establish line item in University budget for yearly tree plantings (e.g. $125,000 would yield approximately 100 to 150 new campus trees per year @ 3”-3 ½" caliper).

Planting of new trees for the:

- Replacement for trees lost due to storm damage, disease, etc.
- Filling of voids within our campus tree canopy.
- Supplementing our teaching collection.
- Establishing the next generation of trees within our aging campus forest.

To implement the campus greening plan funds need to be made available to purchase, install and maintain plant materials. Funding is the single most significant impediment to implementing the plan. Funding at the institutional level would be the most secure and easiest to use to implement a university wide tree planting/campus greening strategy. Funding from specific capital projects would be the least secure.

2.1.2.1. Who Will Implement the Solution?

- Senior administration
    - Authorize expenditures.

- Authorize development of an adoption of revised design standards with mandates for minimum project landscaping and project contributions to campus greening.

2.1.2.2. Impediments

- Installation Costs
- Maintenance Costs – reduced staffing.
- Staffing

2.1.2.3. Metrics to success

- Number of trees and other woody vegetation planted on campus per year (goal 100 trees between NB, Camden and Newark campuses)
- Number of trees and other woody vegetation surviving at 1 yr, 2 yr, 5 yr, and 10 yr (through establishment)
- Diversity in species of trees and woody vegetation planted.
- Diversity in locations new trees and woody vegetation planted.
- Expansion or creation of eco/no mow areas by seeding or limited planting with perennial grasses and forbs.
- Planting beds created or converted to perennial plantings.
- Area converted to no/eco mow and duration maintained as no/eco mow during 10 yr period.
- Diversity of desirable plant species within no/eco mow areas (minimal or eliminate invasive/noxious species)
- Development and adoption of campus tree and landscape management plan
- Establishment of dedicated campus arboriculture crew
- Harvest 2500 board feet of lumber from campus trees per year (equivalent to approximately 310 2”x6”x8’ or 310 1”x12”x8’ finished boards)

2.1.2.4. Dollars and resources needed

- $xx,xxx for consultant (or $xx,xxx for faculty/student) to prepare campus tree management plan.
- $125,000 per year for university wide tree plantings
- $52,500 (25 acres @ $2,100 per acre) for conversion of managed turf to eco/no mow, perennial plantings and maintenance of new plantings (herbicide treatment, soil prep, seeding and temporary irrigation).
- $850,000 first year expenses to establish (equipment and first year labor costs) and $350,000 per year (labor and operating costs) for a dedicated campus arboriculture crew (shared between RU-Newark, RU-Camden and RU-New Brunswick campuses.

2.1.2.5. Sources for funds (baseline or additional)

- To be determined

2.1.2.6. Timetable

- 10 years

2.2. NJ Agricultural Experiment Station Farms and Research Stations

2.2.1. Background

Rutgers University owns and operates ten facilities statewide that together contain approximately 1,457 acres of agricultural land cover. Most of these acres are used for agricultural research (e.g., field trials), extension, and education.

As part of an inventory of land-related emissions conducted in Phase 2 of this project, our working group determined that annual energy consumption at the two surveyed NJAES on-campus farms and the University Golf Course generated approximately 541 MT of CO2e. This figure is incomplete—it ignores the impact of fertilizer, for example—but the methodology used to develop it will be improved and extended to the university's remaining 1,333 agricultural acres as part of a climate impact baseline analysis.

2.2.2. Goals and Metrics

The objective is to reduce greenhouse gas emissions of ongoing farming and livestock raising activities and to increase carbon dioxide storage by increased carbon sequestration in soils and vegetation by the adoption of enhanced management practices.

It is difficult to set a numeric target and date for this goal. We do not know the greenhouse gas (GHG) baseline for our agricultural acres today; when, where, or how management practices will change; or the tons of CO2e that will be eliminated following those changes. The reason for this uncertainty is that there is significant diversity in crops and production practices across NJAES research farms. Crop varieties and many management practices are fixed in the short run under the terms of research grants; they can be changed only as the existing grants are closed out.

Even if a portion of NJAES farmland was devoted to a sustainable agriculture program, the GHG impact at that particular site might not be positive. For example, if farmers were brought to an NJAES farm to see a demonstration of a sustainable management practice, it might be necessary to till an area of land repeatedly in order to accommodate successive agricultural extension classes. This could increase GHG at the demonstration site relative to baseline. If the sustainable tillage practice was adopted throughout New Jersey, however, then overall GHG reduction more than offset any additional GHG generated at the demonstration site.

The fact that NJAES research and extension activities can have beneficial impacts on GHG that are predominantly offsite suggests that NJAES metrics for measuring climate change success must be flexible: We do not want to "throw the baby out with the bathwater." The climate task force's willingness to consider the purchase of carbon credits acknowledges this same geographic reality. It is not about where, but rather about how much GHG reduction can be attributed to the university's climate change initiatives.

2.2.3. General Approach

In light of potential NJAES contributions to climate change mitigation in agriculture, not only onsite but in the larger community, we propose the following principals for the sustainable management of NJAES research farms going forward:

- Have a short and long-range plan for NJAES facilities that emphasizes the overriding importance of GHG reduction both on Rutgers property and on the land cultivated by our farmer and gardener stakeholders.

- Make sustainable practices a centerpiece of the NJAES facilities strategic plan. When infrastructure upgrades are required, make these investments with climate change mitigation and resiliency goals in mind.
- Incorporate a culture of sustainability in day-to-day management practices.
- Rigorously monitor baseline GHG and GHG outcomes over time, both on Rutgers property and at operations influenced by NJAES research and training. The goal will be to provide a "gold standard" for the real time monitoring of sustainability outcomes across the state. Educational and research opportunities tied to the very act of measurement should be maximized. Wherever possible, life cycle environmental footprints that take into account the manufacture and use of fertilizer and pesticide should be utilized.
- Provide incentives for sustainable management in connection with the internal and external grant programs that ultimately determine practices on NJAES research farms.
    - This can be the primary method of carbon defense on NJAES farms: internal grant applications for use of the farms could require a waiver or justification for any research protocol that increases GHG emissions over baseline at a particular site.
    - Mostly, however, NJAES will practice carbon offense. We expect that more field projects in sustainable agriculture will be applied for and funded over time. This, combined with climate-friendly improvements to NJAES facilities, equipment, and operations not governed by research protocols, will reduce GHG over time.

2.2.4. The Plan

NJAES has launched a three-year plan for all of its facilities called "Vision 2025." Many NJAES farms had fallen into disrepair, but repairs and maintenance were not always connected to a consensual vision. The Vision 2025 plan has remedied this, while also institutionalizing regular monitoring and planning on a three-year cycle. The Vision 2025 mission statement reads as follows:

> *NJAES programs, farms, stations, and centers will be national models of responsive, innovative and inclusive research, education and outreach that can address grand challenges of the state and broader society, and known for sustainable management of the land and natural resources they encompass.*

The plan's top-listed priority for FY 21-22 is "Climate Resilience and Adaptation":

> *…identify climate risk for agriculture, marine, and other resource industries, and demonstrate/evaluate climate management practices and resiliency preparedness responses.*

Specific actions under both Vision 2025 and the university-level climate change initiative are described below in two categories: (1) Sustainable agricultural practices and (2) Emissions reduction and efficiency of NJAES infrastructure and equipment.

2.2.4.1. Sustainable agricultural practices

- Initiatives to achieve reduction of greenhouse gas emissions will focus on improved soil and livestock management to reduce greenhouse gas emissions
- Network with other agricultural experiment stations across the U.S. Look to science-validated sources of best practices in sustainable agriculture, such as the program at UC-Davis.
- Review internal and external grant guidelines for future field experiments at NJAES farms
- Develop a Climate Smart Agriculture program with a strong extension component. Vision 2025 lists the following activities under this heading:
    - Establish programs to demonstrate climate smart agricultural practices on NJAES farms
    - Conduct economic analysis for climate adaptation practices
    - Survey current state of adoption and implementation of precision agricultural technology in New Jersey; develop training program to driver greater uptake1
    - Create a catalog of opportunities to help farmers navigate programs/pool funding
    - Create an ecosystems services database of production lands that can serve as a communications tool demonstrating social and environmental benefits generated by growers.

2.2.4.1.1. Who at Rutgers needs to do what to implement?

NJAES Senior Associate Directors, NJAES farm directors, farm staff and faculty/staff with expertise in soil and water management.

2.2.4.1.2. Known institutional barriers to implementation

None

2.2.4.1.3. Metrics of success

All NJAES farms will have adopted and are demonstrating sustainable management practices that reduce emissions, provide carbon sequestration, provide for high quality soils, and reduce water usage.

2.2.4.1.4. Money & resources needed

Time commitment of faculty or staff leader; funding for students, research and implementation

Any available sources of additional funds to support – NJAES state funding, NRCS funding, USDA funding

2.2.4.1.5. Timetable

1 year to develop and 2-3 years to implement plans at the farms.

2.2.4.2. Emissions inventory and reduction plan

- Extend the Phase 2 energy usage inventory estimates to all off-campus facilities

- ·Explore altering guidelines on vehicle fleet to prioritize hybrid vehicles and better understand the hurdles for using electric equipment in a rural setting (e.g., high vehicle miles travelled and few commercial charging stations).

2.2.4.2.1. Who at Rutgers needs to do what to implement?

SEBS/NJAES faculty/staff with expertise in emissions inventories; NJAES Office of Research Analytics

2.2.4.2.2. Known institutional barriers to implementation

None

2.2.4.2.3. Metrics of success

Reliable data on emissions generated at NJAES farms and a plan for reducing them.

2.2.4.2.4. Money & resources needed

Time commitment of faculty or staff leader; funding for students, research and implementation

Any available sources of additional funds to support – NJAES state funding, NRCS funding, USDA funding

2.2.4.2.5. Timetable

1 year to develop emissions inventory and 2-3 years to implement plan

2.2.5. "EARLY WIN": The Revitalization of Hort Farm III

Hort Farm III, on Ryders Lane across Route 1 from the Cook campus, provides an early example of how to fix the general problem of deferred maintenance at NJAES research farms, but always with an emphasis on environmental conservation. This farm is currently used for hazelnut, vegetable, and small fruit trials. Over the last two years, Hort Farm III has been closed for renovation. Environmental and conservation objectives have been advanced at Hort Farm III in the following ways:

- Conservation planning is ongoing at this site. This planning is being done in collaboration with the New Jersey Office of the USDA Natural Resources Conservation Service. Carbon sequestration, water management, and erosion control are primary objectives of the plan.
- Abandoned fields were reclaimed for field trials, with activities that included soil testing, pH correction, and the planting of cover crops.
- Ten of twelve obsolete structures were demolished. In the short run, some permeable surface has therefore been added to the site.
- Several new pieces of farm machinery have been purchased, so the latest fuel efficiency standards and technologies are embedded in this capital equipment.

Hort Farm III will re-open in spring of 2021 and its research and extension programs related to hazelnuts, especially, will be expanded. Because hazelnuts are an orchard crop, cultivation can be less resource intensive than is the case for field crops.

2.3. Rutgers University Forested lands

Decadal goal: Sequester at least 4000 additional tonnes of carbon dioxide in campus lands and building materials

Though well known as the most densely populated state in the US, what is much less appreciated is that New Jersey still has over 2 million acres of forest lands. In addition, to its green space on campus, Rutgers University owns nearly 3,100 acres of upland and wetland forest scattered across eighteen different properties. To sum up the University's existing management policy for its forested lands, it is one of benign neglect. We propose that the University actively manage its campuses and these forest lands to protect their existing "bank" of carbon storage (what we refer to as "carbon defenses") as well increase their carbon dioxide storage by increased carbon sequestration in soils and woody vegetation through the adoption of enhanced management practices (what we refer to as "carbon offense"). An initial review of the forest type and status and assessment of appropriate management strategies classified University owned forest lands into the following 3 categories:

- **Focus on Tree & Forest Health Defense**: objective to maintain our existing trees and forest by protecting against forest pests/diseases/storms/invasive plants and deer overbrowsing; This includes **2325 acres** with >50% canopy cover for upland or wetland forest;
- **Focus on Reforesting**: objective to increase forest cover and carbon storage; This includes **706 acres** with sparse forest canopy sparse (10-50%);
- **Focus on Afforesting**: to increase/re-establish forest cover and carbon storage; **122 acres** of abandoned agricultural field or scrub/shrub for a first phase effort, and additional unquantified acres of existing cultivated lands that might be "retired" and afforested in future phases.

2.3.1. Positioning Rutgers to Lead by Example in Forest Stewardship

To help oversee a "carbon forward" management effort, we propose a multi-pronged approach:

- **develop a management plan for all of Rutgers University owned forest lands;**
- **hire agricultural extension position in forestry/natural areas land management;**
- **establish full time staff position to manage Rutgers-owned forest properties;**
- **establish arborist position to manage campus trees and greenspaces.**

The School of Environmental & Biological Sciences (SEBS) should **create an agricultural extension** position in forestry/natural areas land management. This position would not only work on RU natural areas, but also be a resource for private land-owners with forestry/natural area concerns. Until recently, SEBS had an extension specialist in forestry, but this position was not refilled upon retirement. The proposed position will also bolster the broader efforts to use the Rutgers Campus as a Living Laboratory as well as the push by the Departments of Ecology, Evolution & Natural Resources and Landscape Architecture to become accredited and known for a forward-thinking natural lands/open space management and forestry curriculum.

Rutgers as an institution has not adequately recognized its responsibility to proactively manage the forest resources under its care. To enhance the stewardship of forest lands and implement carbon offset projects to meet our stated decadal goal of sequester at least 4000 additional tonnes of carbon dioxide in campus lands, a **full time staff forester/natural lands manager position** is needed to coordinate and oversee these activities and programs. The proposed position would work closely with the extension specialist and campus arborist.

To complement the enhanced management of our natural lands, there needs to be enhanced "carbon-forward" management of our three main campuses as well as outlying properties. Many of the Big 10 Universities **employ full time arborist staff** to steward their campus trees and green spaces. Such a position(s) should be created in Facilities to work under/with the Campus Landscape Architect.

- **who** at Rutgers needs to do **what** to implement
  - Faculty/staff directors/stewards of Hutcheson Memorial Forest, EcoPreserve, Helyar Woods/Rutgers Gardens,
  - NJAES Farms/Stations
  - Campus Landscape Architect and Facilities
  - New Jersey Agricultural Experiment Station (NJAES

Known institutional barriers to implementation

- While several of Rutgers University's largest forest tracts are overseen by faculty directors, there is minimal to no proactive forest management at present. The existing operational budgets allocated to these properties is minimal with no dedicated monies for tree care or forest management. The University does not have an arborist, forester, or natural lands manager on staff responsible for managing the campus trees or forest stands. Tree service companies are brought on to remove downed or hazard trees on an as needed basis but not undertake proactive care (e.g., pruning).
    - There is presently no mandate, incentive or financial resources to proactively manage Rutgers campus properties to enhance carbon sequestration. In some cases, these properties are dedicated to various research activities that may preclude certain types or forest management and/or conversion from open field to forest. As managing forests or afforesting lands for carbon sequestration and storage is a long term proposition, careful planning that considers and balances competing land uses needs to be undertaken.
  - Metrics of success
    - Acres of land that is afforested or reforested.
    - Establishment of an extension specialist/staff position in forestry/natural lands management.
    - Hiring of a campus arborist.
  - Funding and resources needed
    - $25,000 to pay consulting forester to undertake a forest management plan.

            - + $15,000 to pay student interns to work with the consulting forester to undertake forest inventory of HMF, Helyar Woods, NJAES Farms/Stations.
        - $150,000 to fund an extension specialist
        - $150,000 to fund and outfit a campus arborist
    - any available sources of additional funds to support
        - Monies generated through campus offset fees could be used to support on-campus verified carbon offset projects.
        - Possible corporate, foundation, and alumni donations could be leveraged.
        - Investigate whether Rutgers University-owned properties are eligible for federal funding distributed by the Natural Resources Conservation Service and the US Fish & Wildlife Service to private landowners for natural lands management projects.

    - Timetable
        - Complete inventory and management plan in 5 years
        - Establish extension specialist and campus arborist positions in the next two years.

2.3.2. "Early win" afforestation implementation plan:

To help meet the Climate Task Forces identified Decadal goal of sequestering at least 4000 additional tonnes of carbon dioxide in campus lands and building materials, we are proposing that approximately 125 acres of University owned property be afforested/reforested over the next five years (Table 5.1). These projects will be undertaken as part of a broader *Campus as Living Laboratory* initiative with students engaged in all stages of the process: design, implementation, monitoring, and validation. To qualify as "official" carbon offsets, any afforestation projects must go through a rigorous verification process. We propose to follow, and instruct the students on protocols established by the Offset Network. A collaboration of higher educational institutions, has developed the Offset Network to provide educational and research opportunities that can result in novel offset protocols as well as cost reductions through implementation of a peer verification pathway. For the peer institution, this peer verification process presents the opportunity for students to gain valuable experience evaluating carbon offset projects. This project will serve as the first of its kind in New Jersey and we hope to bring in other New Jersey colleges and universities to serve as peer validators.

- **who** at Rutgers needs to do **what** to implement
    - Campus Landscape Architect, Brian Clemson
    - NJAES Extension Specialist in Urban Forestry, Dr. Jason Grabosky
    - Faculty/staff directors/stewards of HMF Dr Myla Aronson, EcoPreserve Dr. Rick Lathrop
- known institutional barriers to implementation
    - commitment and funding from University Administration to permit afforestation projects
- Metrics of success

    - Acres of land afforested/reforested at proper stocking rates
    - Amount of biomass and carbon stock
- Funding & resources needed
    - Campus landscape architect office staff time to oversee project
    - $11,000/acre x 126 acres = $1,386,000 for planting/site prep/monitoring/management

    Based on consultation with several groups that have experience with afforestation projects in New Jersey, we estimate the following costs:

        - $3000/acre for plant material ($10/individual potted sapling with a stocking density of 300 individuals/acre);
        - $2500/acre for site preparation, planting labor, and adequate protection against deer browsing (deer fence/tubing);
        - $5500/acre for follow-up monitoring and management. At least 5 years of monitoring after the plantings and additional plantings to address mortality are required to ensure project success. Watering and management of competing/invasive species are needed to ensure successful reforestation.

    We estimate the total cost to be approximately (126 acres x $11,000/acre = $1,386,000). While it would be ideal to afforest the entire 126 acres as one project, the project could be implemented in phases based on available funding.

- any available sources of additional funds to support
    - Possible corporate, foundation, and alumni donations could be leveraged.
- Timetable
    - Complete in 5 years

Table 1.9. Proposed Forest Afforestation/Reforestation Plans with Estimated Carbon Sequestration Amounts

Project	Area	C stock at 40 yr	CO2 equivalent
HMF Afforestation	80 acres	2,240 MT C	8,288 MT eCO2
HMF/RUEP Reforestation	32 acres	1,020 MT C	3,740 MT eCO2
Campus Afforestation	14 acres	1004 MT C	3,714 MT eCO2
Total	126 acres	4264 MT C	15,742 MT eCO2

2.4. Campus Master Planning

We propose that when planning for future land use development and/or redevelopment, that the University follow the planning principles and sustainability framework embodied in the

University Physical Master Plan - Rutgers 2030 to minimize energy demands and maximize carbon capture potential of campus green spaces.

2.4.1. Low Carbon Construction Materials:

Rutgers should develop a policy that requires the consideration of alternative construction materials based upon their embodied carbon content. For example, structural wood timber construction as opposed to steel or concrete. Carbon is sequestered in timbers and wood construction can provide similar cost and overall functionality with the added benefit an overall lower carbon footprint. Similarly, there have been technological advances in the development of low carbon cement and concrete products that help to reduce the carbon footprint of new construction. The following are a series of more specific recommendations:

- Develop policy that requires the evaluation of alternative construction materials based upon their embodied carbon content.
- Revise/update design standards to incorporate existing technologies to reduce amount of cement used in redi-mix concrete (e.g. adopt NJDOT concrete specification – design strength based upon application)
- Follow advances in availability of low carbon concrete (LCC) at regional concrete redi-mix suppliers.
- Develop relationships with regional redi-mix suppliers to advise them of future planned projects and the potential volume of concrete that will be required (Clayton Concrete has incorporated CarbonCure technology into their production process at their Trenton plant based upon design requirements for a significant project at Princeton University). The Princeton project will be sourcing the redi-mix concrete from Clayton. Offerings at redi-mix plants can be influenced by customer project design requirements (customer driven). CarbonCure concrete is $6-$7 more per cubic yard than traditional concrete. Princeton project is projected to use 5500 cu yd of concrete ($38,500 extra cost)
- As technology advances and becomes regionally available incorporate LCC into university design guidelines, construction bids.
    - Performance based standards
    - Preferences for CO2 mineralization, or for low Embodied-carbon pozzolans (e.g. fly ash, ground glass, etc.)
- Develop and adopt design guidance for the use of LCC modular pavers (e.g. E.P. Henry Solidia pavers) for walkways and within parking areas. Pavers are re-usable and recyclable.
- Determine availability of pre-cast concrete structures such as manholes, catch basins, inlets, etc. Work with regional pre-cast companies to encourage the use of low carbon concrete.
- Promote recycling concrete debris from demolition. Recycle and re-use on campus or require accounting of how concrete is recycled and determine the carbon saved (use as RCA – recycled concrete aggregate, substitute for new quarried aggregate), RAP – recycled asphalt pavement, etc.
- Inclusion of a credit against construction costs: e.g. “The low embodied carbon discount rate [& the carbon capture, utilization, and storage discount rate] shall be established by the State Treasurer in consultation with the Commissioner of Environmental Protection

and shall be applied to bid prices on the basis of the global warming potential values for the concrete specified in the bids," https://www.njleg.state.nj.us/2020/Bills/A9999/5223_I1.HTM (proposed only, not passed). See also NY State's proposed LECCLAct .

2.4.1.1. Who will Implement?

- University Procurement Services for small projects:
  - "Large-scale renovations (under $2 million) are managed by University Facilities Project Services."
  - delegation of procurement authority to "Institutional Planning and Operations for new construction or renovation projects in excess of $2 million, engagement of architects and engineers, and real estate purchases."
- IPO > Fac & Cap Plan Dept > Univ Plan & Dev Office:
  - Responsible for the University Design Standards Manual > Part III, Tech Reqs Materials & Methods > Div 3, Concrete.

2.4.1.2. Known institutional barriers to implementation

- New LCC technologies are not readily available in this region. Locally, pre-cast products such as pavers are available. Redi-mix concrete for cast-in-place work (sidewalks, curbs, roadways, foundations, buildings, etc.) are not currently available for use on RU campuses.
- New technology may not be widely adopted yet while among approved architecture/design/construction firms or invited bidders.

2.4.1.3. Metrics of success

The cubic volume of the amount of low carbon construction materials used and the carbon differential vs. alternative materials.

2.4.1.4. Costs

See Appendix for more background on low carbon concrete/cement standards and costs.

APPENDIX A – Inventory of Existing Green Spaces and Potential Carbon Storage Enhancement

Inventory of Existing On-Campus Green Spaces

To initiate this campus green space effort, approximately 25 acres of the New Brunswick-Piscataway campus lawns have been identified as candidates for conversion no/eco-mow zones and an additional 14 acres have been identified for tree planting. More information as to candidate sites is provided below.

Table A.1 . Proposed Eco/Low Mow zones on the New Brunswick-Piscataway Campus.

No/EcoMow Zones				
Campus	**Name**	**Building Number**	**Building/Site/Road/Notes**	**no/eco-mow acres**
Cook/Douglass	Helyar House / Bioresource Engineering	6239/6061	wooded area between Bioresources engineering office and weather radar enclosure	1.6
Cook/Douglass	Makerspace	8863	edge of parking lot	0.16
Cook/Douglass	Env. & Natural Res. Sciences	6330	rear of building against tree line	0.4
Cook/Douglass	Community Garden/Lot 98b		area between Lot 98b, solar field and community garden	1.15
Cook/Douglass	Lot 99/Ryders Lane Buffer		Buffer between Lot 99 and Ryders Lane	0.61
Cook/Douglass	Bld #37 (Newell Apt)		lawn area between back of building and landscape buffer	0.3
Cook/Douglass	Starkey 573-596	6294	lawn area near west of building adjacent to wooded area	0.25
Cook/Douglass	Douglass Parking Deck	8433	lawn area between deck and Lipman Drive and behind deck towards Loree	0.69
Cook/Douglass	Gibbons/Univ Inn & Conf Center		lawn area between Gibbons Res Hall A and Univ. Inn and Conf Center expand meadow	2.3
Livingston	RD#3/Postal Rd		northeast corner	1.5
Livingston	Rd#3 Picnic Grove		expansion of existing eco-mow area, under and around trees, picnic activites to be	3.9
Livingston	Lot 112/Livingson Housing		lawn area northeast	0.6
Livingston	RD#3/Joyce Kilmer Ave		large lawn areas on east and west sides of RD#3	5.5
Livingston	Joyce Kilmer Ave/RD#2		adjacent to solar farm	1.43
Livingston	Lot 101/James Dickson Carr Library		lawn area between library and Tillett Hall	1.25
Busch	Nichols Apartment/Lot 58C/Kindercare Learning		lawn areas around parking and behind Learning center adjacent to woods	0.97
Douglass	George St./Hickman Hall		existing lawn areas both sides of Georges St and bridge	1.5
Busch	Busch Regional Stormwater Basin and block 9902/lot 12.03 Davidson Rd		existing basin/Davidson Hall, former residential lot	0.7
			total	24.81

Table A. 2. Proposed Afforestation projects on the New Brunswick-Piscataway Campus.

Re/Afforestation					
Campus	**Name**	**Building/Site/Road/Notes**	**total site sq. ft.**	**total site acres**	**afforestation acres**
Busch	Nichols Apartment/Lot 58C/Kindercare Learning	lawn areas around parking and behind Learning center adjacent to woods	23,675	0.54	0.54
Douglass	George St./Hickman Hall	existing lawn areas both sides of Georges St and bridge	17,250	0.40	0.40
Busch	Library of Science and Medicine/Lot 58	Quad landscape around library and planting island within Lot 58 - 275 large and small trees	170,000	4.00	4.00
Busch	Hoes Ln E (Rt 18)/Davidson Road	lawn areas between parking lot and Hoes Ln E and Davidson Road	74,000	1.70	1.70
Livingston	Soil Stockpile - behind track and field, corner of Metlars Ln and Ave E	soil stockpile	158,970	3.65	3.65
Busch	Busch Regional Stormwater Basin and block 9902/lot 12.03 Davidson Rd	existing basin/Davidson Hall, former residential lot	118,450	4.70	4.00
		total	**562,345**	**15.0**	14.29

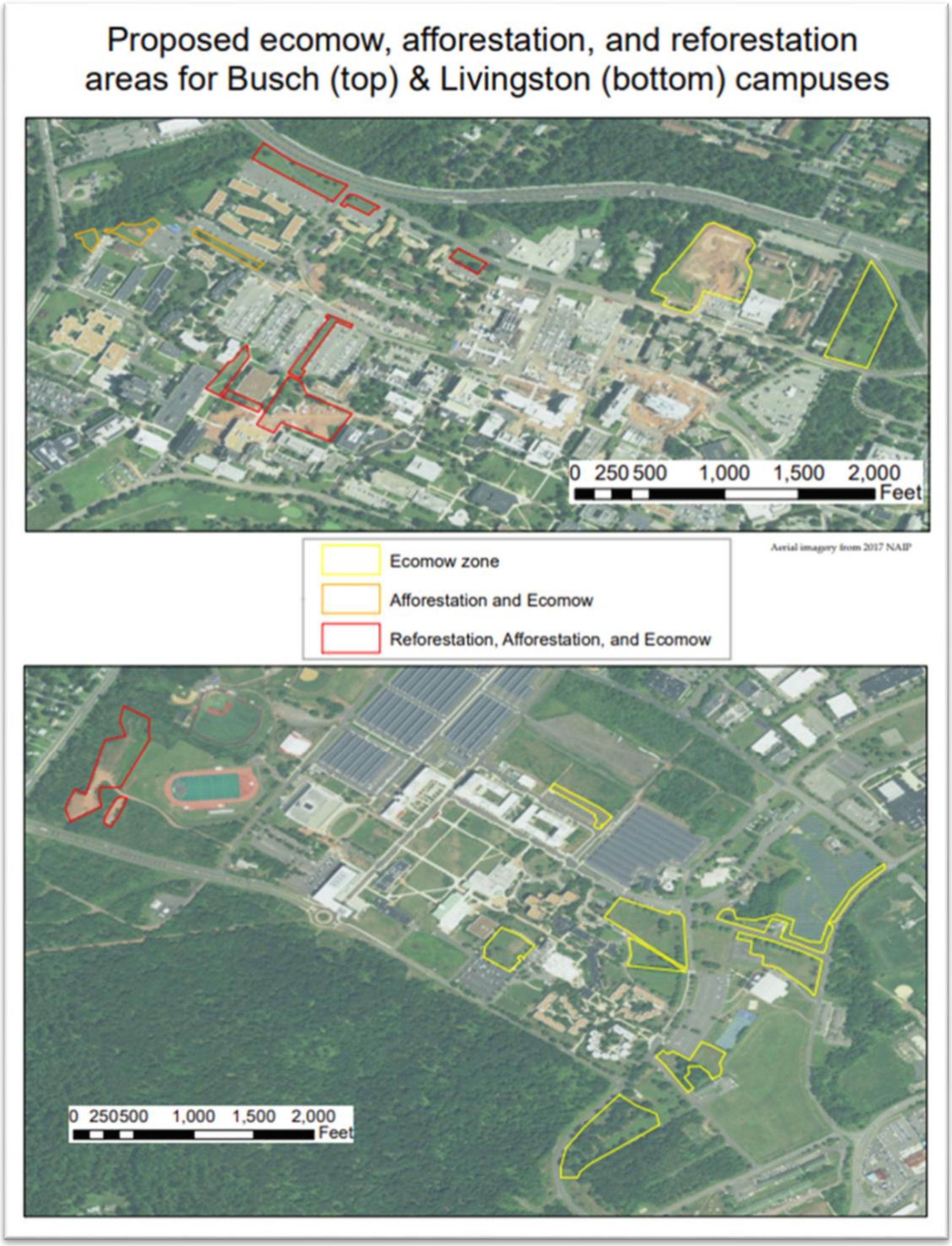


Figure A. 1. Map showing location of proposed eco/low mow, afforestation, and reforestation zones on Busch/Livingston campus.

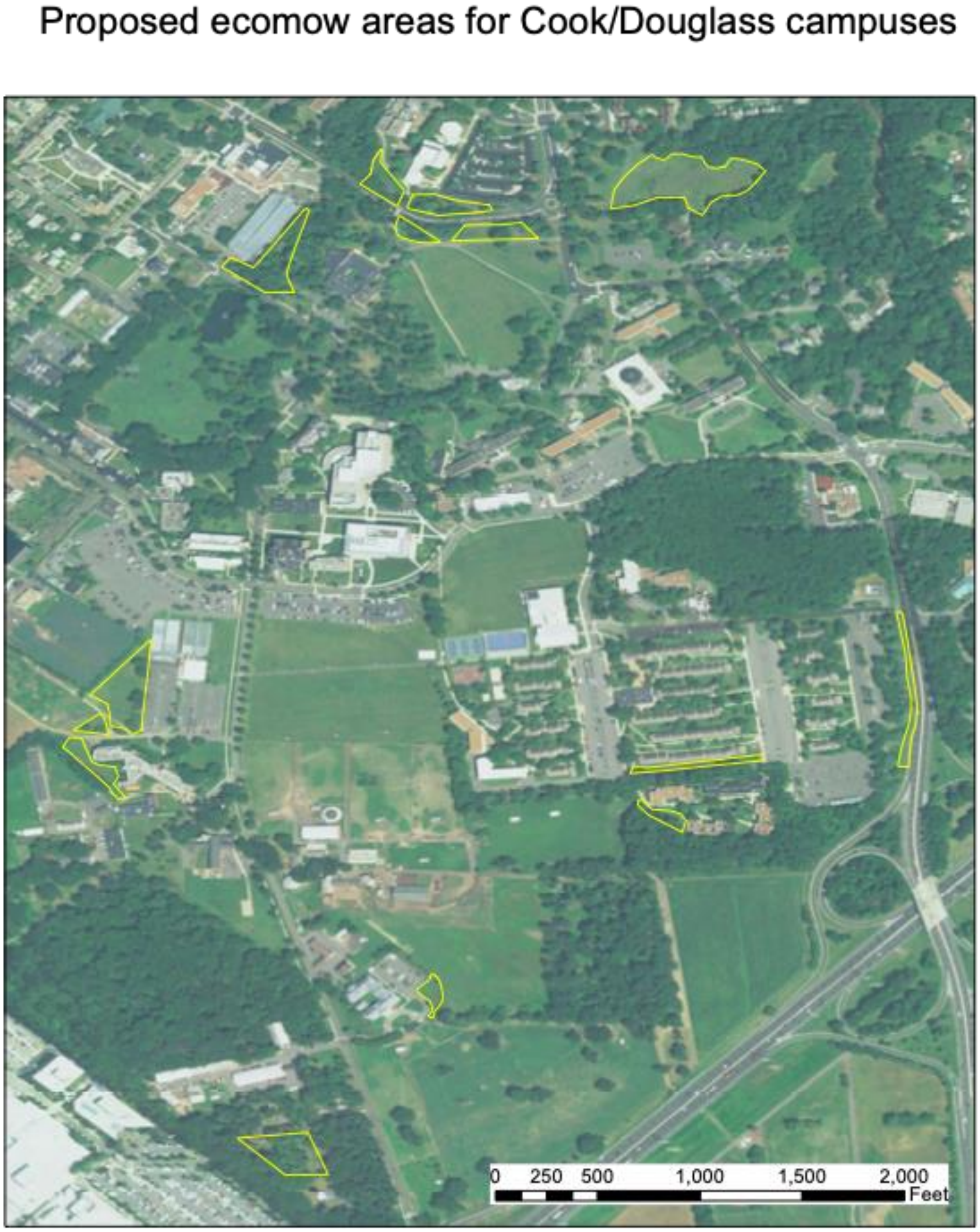


Figure A.2. Map showing location of proposed eco/low mow zones on Cook/Douglass campus.

Rutgers University Forested lands: Baseline Carbon Stock and Future Sequestration Estimation

Digital maps of Rutgers University owned properties were cross-tabulated with other mapped data sets using geographic information system (GIS) software to calculate the area of University owned forests and characterize the forest type and status (Table A.3). Key data sets were the 2015 New Jersey Land Use/Land Cover (LU/LC) dataset released by the New Jersey Department of Environmental Protection (NJDEP) in 2019 (NJDEP, 2019) and the US Forest Service Cover Class and Forest Type maps. 80% of Rutgers' forest lands (2325 acres) are in closed canopy forests where the priority should be in maintaining the existing, and hopefully accreting carbon stocks (i.e., focusing on Health Defense) (Table A.4). Another 20% of the forest lands (706 acres) are under-stocked and could be proactively managed (i.e., reforested) to enhance their growth and carbon sequestration potential (Table A.4).

Baseline Inventory of Rutgers University Forested Lands and Estimation of Carbon Stock

Table A.3. Area (in Acres) of Rutgers University owned properties with significant amounts of forest (i.e. > 0.5 acres.)

Campus	Upland Forest >50% Cover	Upland Sparse Canopy	Upland Scrub/ Shrub	Wetland Forest >50% Cover	Wetland Scrub/ Shrub	Total Forest (acres)
Rutgers University - Busch Campus	55.99	21.51	52.97	61.77	3.99	196.23
Rutgers University - Cook Campus	119.79	22.70	25.07	90.36	8.99	266.92
Rutgers University - Livingston Campus	262.84	54.16	184.79	41.19	8.13	551.11
Cream Ridge Fruit Research and Extension Cent	20.52	0.00	1.84	6.94	0.00	29.29
Atlantic Cape Community College	152.20	0.00	0.00	87.44	1.46	241.10
Buell Pinelands Research Station	191.48	3.04	0.00	0.00	0.00	194.53
New Jersey Aquaculture Innovation Center	3.39	0.00	62.06	9.46	43.60	118.51
Rutgers Division of Continuing Studies at MCCC	22.09	1.70	0.00	12.40	0.47	36.67
L.G. Cook 4-H Camp	505.50	0.00	0.00	9.47	0.00	514.97
Saint Barnabas Medical Center	19.99	1.56	0.00	0.69	0.00	22.24
Camden County College	48.52	0.60	0.00	12.64	0.00	61.76
Hutcheson Memorial Forest	110.15	7.15	197.74	74.59	3.94	393.57
Agricultural Research and Extension Facility	20.13	4.12	0.08	0.00	0.00	24.32
Snyder Research and Extension Farm	23.70	3.45	0.00	4.22	0.04	31.41
Marucci Blueberry-Cranberry Research and Exte	199.93	13.20	9.51	92.62	20.14	335.40
John H. Cronin Dental Center	12.05	0.00	0.00	0.00	0.00	12.05
New Jersey Child Support Institute - Cherry Hill	0.60	1.18	6.26	7.58	1.74	17.36
Jacques Cousteau NERR	2.12	2.74	0.00	42.11	0.00	46.97
Total						3094.42

Table A.4. Area of Forest by potential management strategies. Note: includes areas that are not presently forested but could potentially be afforested.

Campus	Health Defense (Acres)	Reforestation (Acres)	Afforestation (Acres)
Rutgers University - Busch Campus	117.76	78.47	10.24
Rutgers University - Cook Campus	210.15	56.76	0.00
Rutgers University - Livingston Campus	304.02	247.08	13.00
Cream Ridge Fruit Research and Extension Center	27.46	NA	NA
Atlantic Cape Community College	239.63	NA	NA
Buell Pinelands Research Station	191.48	NA	NA
New Jersey Aquaculture Innovation Center	12.85	105.66	NA
Rutgers Division of Continuing Studies at MCCC	34.50	NA	NA
L.G. Cook 4-H Camp	514.96	NA	NA
Saint Barnabas Medical Center	20.68	NA	NA
Camden County College	61.16	NA	NA
Hutcheson Memorial Forest	184.73	208.83	98.82
Agricultural Research and Extension Facility	20.13	NA	NA
Snyder Research and Extension Farm	27.93	NA	NA
Marucci Blueberry-Cranberry Research and Extension	292.55	NA	NA
John H. Cronin Dental Center	12.05	NA	NA
New Jersey Child Support Institute - Cherry Hill	8.17	9.18	NA
Jacques Cousteau NERR	44.23	NA	NA
Total	2324.45	705.99	122.06

Estimating Carbon Sequestration Potential of Identified Afforestation/Reforestation Projects

A combination of methods was employed to estimate the amount of carbon that could potentially be stored for several identified projects on the New Brunswick-Piscataway campuses, the Rutgers Ecological Preserve and the Hutcheson Memorial Forest HMF) and outlying properties in Franklin Township, New Jersey. At HMF 80 acres (32 ha) of farmland and 19 acres (8 ha) of gaps in the old growth in HMF were identified for potential afforestation projects. Another 13 acres (5.3 ha) of gaps in the RU EcoPreserve were identified and another 10.24 acres (4.1 ha) on campus are suitable for afforestation projects. Afforestation of existing farmland falls under Approach 4 and reforesting forest gaps falls under Approach 2 outlined in the text above. A review of the Duke University Urban Tree Protocol's Additionality Checklist suggests that the aforementioned projects satisfy the additionality criteria.

Duke University has established an Afforestation protocol that serves as a useful guide for calculating carbon offset credits. Under this protocol, the crediting period for an Afforestation Project is 40 years. Projects may be renewed but must calculate an updated baseline before offset generation is continued. Afforestation/Reforestation projects must yield surplus GHG emission reductions and removals that are *additional* to what would have occurred in the absence of intervention. The protocol designates forest carbon sinks as either required or optional in line with UN Clean Development Mechanism (CDM) guidance. For the purposes of this protocol, sinks of carbon for estimation include above ground biomass and below ground biomass. Optional sinks include soil carbon, deadwood, and litter (CDM). We adopted a more conservative approach and excluded the optional sinks from our calculations. The final determination of carbon offset credits is determined by the direct estimation of change by re-measurement of sample plots at baseline and a future date (i.e., 40 years) and the plot-level change in biomass is obtained by subtracting the plot biomass on the first occasion from the plot biomass on the second occasion. However, to estimate the potential carbon credits for the afforestation/reforestation projects under consideration, we have adopted a computer simulation modeling approach.

Forest carbon stocks were simulated using a forest ecosystem carbon process model, IntCarb (Song and Woodcock, 2003). IntCarb combines components from a forest population dynamics model (ZELIG) (Urban, 1990) and a terrestrial ecosystem biogeochemical process model (CENTURY) (Parton et al., 1993) to simulate forest development and heterotrophic respiration, respectively. The IntCarb model, by focusing on forest ecosystem processes, has overcome the common weakness of other terrestrial ecosystem models that use a limited number of biomes to represent vast areas and ignore potentially significant variation within biomes in terms of productivity. IntCarb simulates ecosystem carbon cycling by connecting forest stand level population dynamics and ecosystem biogeochemical process. In a simulation, first forest stand dynamics are simulated at a one-year time step. Relevant population dynamic processes such as individual tree establishment, regeneration, and mortality, and environmental stress such as drought and nutrient limitation are simulated. Then the growth is distributed to each tree component (leaves, branches, stems, fine and coarse roots) as driven by ecophysiological characteristics of each tree component and environments. The annual growth then enters the decomposition process.

IntCarb was parameterized for the five New Jersey physiographic regions to account for broad scale variations in climatic conditions, soil water capacity, soil fertility, and forest species composition (Lathrop et al., 2011). A spatially explicit "wall-to-wall" simulation was not undertaken but rather average conditions for each of the five physiographic regions were used. Parameterizing IntCarb for the other geographic zones under consideration (e.g., urban vs. rural or public vs. private) was not feasible, thus the carbon flux for these other geographic jurisdictions were not estimated. A 30-year record of monthly precipitation and temperature (from 1979 to 2008) downloaded from http://climate.rutgers.edu/stateclim_v1/data/index.html was used to derive monthly mean and standard deviation of precipitation and temperature. Based on soil features in each ecoregion, soil field capacity, wilting point and soil fertility were ranked from high to low as Ridge and Valley > Piedmont > Highlands > Inner Coastal Plain > Outer Coastal Plain. A list of dominant species for each physiographic region was developed based on personal familiarity with the forest species composition. For each simulated forest species, parameter variables incorporated include maximum age, maximum diameter, maximum height, annual growth rate, minimum degree day limit, maximum degree day limit, shade tolerance, soil moisture tolerance, nutrient stress tolerance and seeding ability. The maximum age, maximum diameter, maximum height and annual growth rate are variables driving tree growth. The minimum degree day limit, maximum degree day limit, shade tolerance, soil moisture tolerance, nutrient stress tolerance and seeding ability are variables controlling potential seedling establishment. The values for each parameter variable were taken from literature data (Pastor and Post, 1985). The IntCarb model simulates the growth of a forest on land that has been cleared and allowed to regenerate back to forest. The model 'grows' the forest from Time 0 through maturity (Time 300) and tracks the carbon accumulation over the 300-year modeling period. Piedmont forests are estimated to reach their maximum carbon density of 149 MT C/ha reached at age 80 (Figure A.3). After their peak growth stages, forest stands tend to mature and thin in tree density thereby declining in overall carbon stock. Examination of Figure A.3 shows that the maximum carbon stock value is predicted to be 149 MTC/ha reached at Year 80. Based on the Duke University Afforestation protocols, we have selected 40 years as the time frame of interest. Year 40 is 103 MT C/ha or approximately 70%.

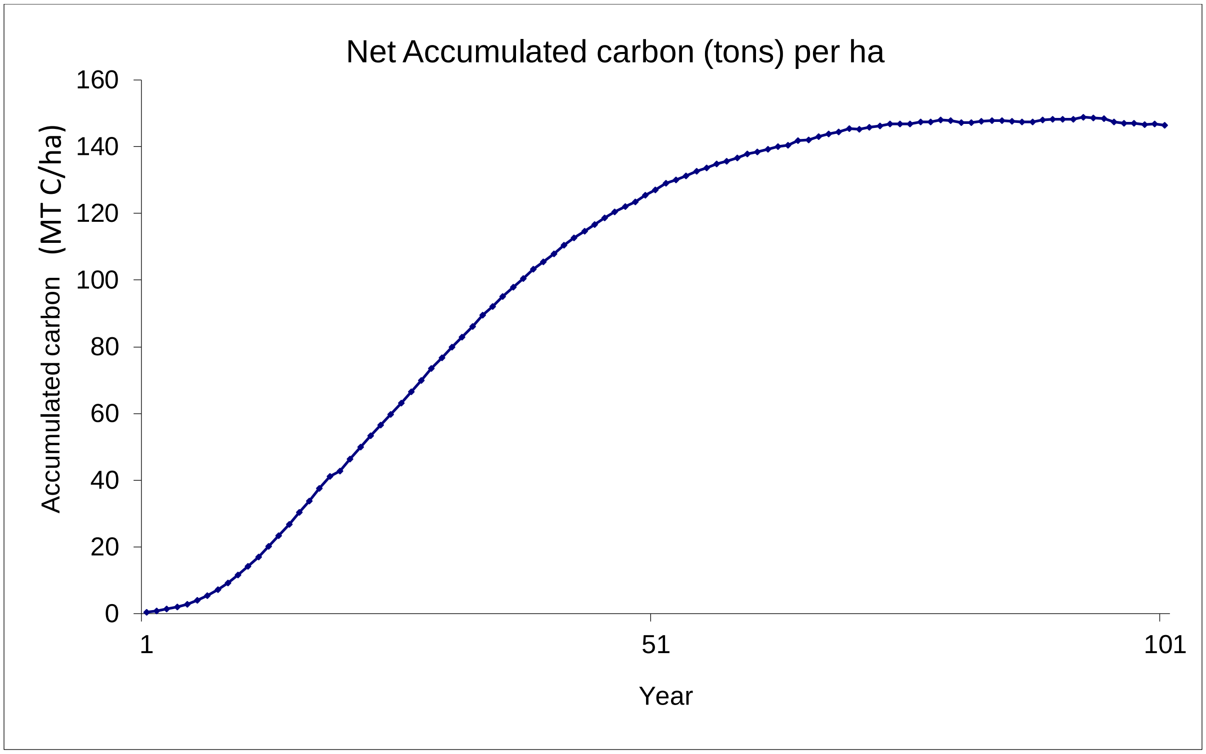


Figure A.3. Forest accumulated carbon density (including above-ground and below-ground including dead wood and litter) (Mg or MT C/ha) by stand age for New Jersey statewide.

The IntCarb model estimates were compared with other estimates developed by the US Forest Service (Table WG5 B5). Woodall et. al. (2013) provided estimates by general forest type for the broader Eastern US region (US Forest Service Region 9). Additionally, forest carbon data developed by the USDA Forest Service Forest Inventory & Analysis (FIA)

Program https://www.fia.fs.fed.us/ was used to estimate a more geographically specific estimate by querying a map form accessed through NJforestadapt.rutgers.edu. These mapped data were developed through application of a nearest-neighbor imputation approach, mapped estimates of forest carbon density were developed for the contiguous United States using the annual forest inventory conducted by the FIA, MODIS satellite imagery, and ancillary geospatial datasets (Wilson et al., 2013).

Table A.5. Comparison of carbon stocks (MT C/ha) between IntCarb model, Woodall et al. 2013, and USFS imputed values for typical New Jersey Piedmont forest.

Mg C/ha	IntCarb Model	Woodall 2013	USFS imputed
Aboveground Biomass	105	67-80	85
Belowground Biomass	13	12-15	15-20
Total AB+BG	118	79-95	100-105

Using the USFS imputed values for the central NJ region near to Hutcheson Memorial Forest of 100 MT C/ha, we estimate a carbon stock of 70 MT C/ha (70% of 100 MT C/ha). This amount equates to approximately 1.75 MT of carbon sequestration per year; the average US forest sequesters only 0.52 MT C/ha per year (or 2.1 MT eCO2/ha per year) https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#:~:text=To%20convert%20to%20carbon%20dioxide,in%20the%20year%20of%20conversion. The Clean Development Mechanism (CDM) AR-Tool 14 permits the use of differencing between two points in time as a means of calculating carbon credits. Assuming a baseline starting value of 0 (i.e., for farmland with no trees), then the carbon credit would be 70 MT C /ha or 259 MT eCO2 of (1kg of CO2 can be expressed as 0.27kg of carbon, as this is the amount of carbon in the CO2 or conversely 1 kg of carbon = 3.7 kg of CO2).
The sum total estimated carbon storage (at age 40) for the three identified projects is approximately 15,742 MT eCO2 or 4,264 MT C (Table WG5 B6). The proposed afforestation of the 80 acres (32ha) of farmland would provide 8,288 MT eCO2 (2,240 MT C) at age 40. Assuming that the forest gaps, are already starting at a higher level of carbon stock, set the baseline equivalent to 10 MT C/ha (roughly equivalent to the present estimate of below-ground carbon of mature forest). The difference in carbon stocks, or carbon credit, would then be 60 MT C/ha. The proposed reforestation of the 32 acres (17 ha) of forest gaps would provide 3,740 MT eCO2 (1020 MT C) at age 40. The proposed afforestation on 14 acres of campus would provide 3,714 MT MT eCO2 (1004 MT C) at age 40. Given that carbon sequestration is not linear with time (i.e., it starts off slowly then ramps up more quickly as tree start to reach maturity), we are proposing a conservative goal of sequestering approximately 2,000 MT of eCO2 during the first decade of the Climate Action Plan. We propose to implement the Duke University Afforestation protocol to monitor carbon sequestration gained through time (rather than predicted in this modeling exercise) and to measure/calculate carbon offset credits so earned.

Table A.6. Proposed Forest Afforestation/Reforestation Plans with Estimated Carbon Sequestration Amounts

Project	Area	C stock at 40 yr	CO2 equivalent
HMF Afforestation	80 acres	2,240 MT C	8,288 MT eCO2
HMF/RUEP Reforestation	32 acres	1,020 MT C	3,740 MT eCO2
Campus Afforestation	14 acres	1004 MT C	3,714 MT eCO2
Total	126 acres	4264 MT C	15,742 MT eCO2

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APPENDIX B – Third Party and Offsite Offsets

Introduction

Supporting Goal: Employ third-party offsets as a complementary strategy of last resort to address remaining emissions

Carbon offsets serve to reduce or remove carbon dioxide equivalent (CO_2e) greenhouse gas emissions made in a secondary location to compensate or “offset” emissions from other activities. Offsets are used widely in the United States by individuals, businesses, governments, nongovernmental organizations, and academic institutions to voluntarily meet their own goals for emissions reduction, as well as by regulated entities to comply with greenhouse gas emission reduction requirements as mandated by laws in several states in the country. Carbon offsets, however, are not a replacement for emissions reductions and the Task Force recommends that offsets be a complementary strategy of last resort.

Options the Task Force considered to offset emissions are purchases of third-party offsets in the voluntary marketplace (which can be used immediately), Rutgers developing on-site carbon removal/sequestration projects and Rutgers developing off-site carbon removal/sequestration offset projects (i.e., not on Rutgers property but in collaboration with local community or non-governmental organization partners). Rutgers-initiated on-site or offsite projects will take lead time to finance and implement. Another option the Task Force considers viable for exploring is purchasing emissions allowances from the compliance market, essentially removing them from the marketplace. Investments in all “offset” approaches such as purchases of carbon credits, emissions permits, or removal/sequestration projects (initiated by Rutgers on-site or offsite) should be overseen under the guidance of an advisory body, consisting of faculty, staff, and students from across the Rutgers system, the purpose of which is to adjudicate the legitimacy of all planned purchases and projects to ensure integrity of any program.

An offset credit yields the ownership of one metric ton of CO_2e, which is prevented from entering the atmosphere via an emissions-reduction project (Duke Carbon Offsets Initiative, 2020b). Carbon offsets may be voluntary or state-mandated. Voluntary offsets are traded via the voluntary carbon market, while mandated offsets are part of regulated carbon markets, otherwise known as the compliance carbon market (Hamrick, 2019).

Widely accepted criteria for the legitimacy of carbon offsets are “PAVER” requirements: Permanent, Additional, Verifiable, Enforceable, and Real (Duke Carbon Offsets Initiative, 2018; Duke Carbon Offsets Initiative & Offset Network, 2017). Atmospheric carbon reduction generated by an offset project must exist in perpetuity (**permanent**) and be beyond business as usual (**additional**). The reduction must be **verifiable** and confirmed to exist via independent third-party verification or peer-review verification. Each carbon credit generated by the program in question must be counted only once (**enforceable**); each credit must also be the result of robust accounting (**real**) (Duke Carbon Offsets Initiative, 2018).

As noted, offsets can be used by regulated entities to comply with a small portion of their greenhouse gas emissions reduction requirements. For example under the Regional Greenhouse Gas Initiative 3.3% of the regulatory requirement can be met by offsets (The Regional Greenhouse Gas Initiative, Inc., 2020), while under the California Cap and Trade program, compliance entities may use California Air Resources Board offset credits to meet up to 8% percent of their compliance obligation for emissions through 2020; 4% of their compliance obligation for emissions from 2021-2025; and 6% percent for emissions from 2026-2030) (California Air Resources Board & California Environmental Protection Agency, 2020).

Voluntary Market Purchases

In the voluntary market, an individual, company, government, or other entity (such as a university) can purchase carbon offsets to mitigate their own greenhouse gas emissions for example, from electricity use, travel, or other sources.

Typically, offset projects are developed according to standards and protocols outlined by independent registries also referred to as “standards” and verified by independent auditors. The four main registries recognized internationally include Verra (formerly known as the Verified Carbon Standard), Climate Action Reserve, American Carbon Registry and the Gold Standard. Registries establish standards, oversee independent verifiers, issue credits and track credits and transactions (American Carbon Registry, 2020b; Climate Action Reserve, 2020; Gold Standard, 2019; Verra, 2020d). Methodologies for each standard are project specific, and consider multiple variables including project goals and the starting condition of the project area, and include guidelines for project development, assessment, and reassessment (Verra, 2019).

Types of voluntary offset projects include agriculture (livestock methane, no-till/low-till agriculture, etc.), chemical processes and industrial manufacturing (ozone depleting substances, nitric acid, etc.), energy efficiency and fuel switching (waste heat recovery, coal mine methane, etc.), forestry and land use (REDD+, IFM, wetland restoration, etc.), household devices (clean cookstoves, water purification, etc.), renewable energy (wind, solar, hydro, etc.), transportation (carpooling, mass transit, vehicle electrification, etc.), and waste disposal (landfill methane, waste water methane) (Hamrick, 2019). Improved energy efficiency or development of public transportation infrastructure can also reduce greenhouse gas emissions and generate carbon offset credits (Hamrick, 2019). For example, Duke University’s Loyd Ray Farms project generates credits via the collection of hog waste in an anerobic digestor and the burning of resulting biogas; in addition to reducing methane emissions (a greenhouse gas 25 times stronger than CO_2), the project also reduces negative impacts on soil, air, and groundwater quality in the area. Collection and removal of hog waste reduces waste run-off in local waterways, reduces odor in the surrounding area and prevents leakage into soil and groundwater (Duke Carbon Offsets Initiative, 2020e). Waste handling and disposal offsets can be purchased on the voluntary market: in Lebanon County, Pennsylvania, collection and combustion of methane produced at the Greater Lebanon Refuse Authority Landfill generates offsets that are registered on the Verra registry (Verra, 2020b). Truck stop electrification projects reduce emissions from idling trucks at truck stops (in regions where idling is not regulated) by providing solar-generated electricity to power air conditioning and power outlets;

these credits are available through American Carbon Registry (American Carbon Registry, 2020a). The provision of low-smoke or clean-burning cookstoves to communities in underdeveloped communities can also offset carbon and produce carbon credits. The Myanmar Stoves Campaign provides fuel-efficient stoves to families in Myanmar, which reduces consumption of wood in order to decrease carbon emissions and deforestation; resulting credits are offered through the Gold Standard registry (Gold Standard, 2020b).

Renewable energy projects, which include hydroelectric, wind, photovoltaic solar energy, solar hot water, and biomass power, are voluntary offset project types included in the voluntary market if they meet PAVER requirements. Some universities account for renewable energy to meet their carbon neutrality goals, through another mechanism known as Renewable Energy Certificates (RECs); however, RECs should not be confused with offsets. A single REC represents one megawatt-hour (1MWh) of renewable energy (Green Mountain Energy, 2015); conversely, an offset represents a unit of CO_2e. While offsets are sourced from projects that reduce or remove atmospheric greenhouse gas emissions, RECs are generated from a renewable energy generator (EPA Green Power Partnership, 2018). Furthermore, while offsets are required to pass additionality tests (as part of PAVER requirements) to ensure the project is beyond “business as usual”, additionality is not a requirement for generation of a REC (EPA Green Power Partnership, 2018). Offsets are also applied as a net adjustment to an organization’s emissions (Scope 1, 2 or 3), while RECs are credited toward an organization’s Scope 2 emissions from electricity usage (R. Woodside, personal communication, 2020).

Universities can purchase offsets from the voluntary carbon market that can be used immediately. For example, Duke University expects to offset approximately 38% of total Duke emissions through carbon offsets by 2024 (M. Arsenault & E. Fulop, personal communication, 2020). These offsets are a combination of purchased credits and projects that Duke has developed or been involved in; more than half are credits purchased through the voluntary market (Duke Carbon Offsets Initiative, 2020a). Universities such as Arizona State University have purchased carbon offsets and renewable energy certificates to complement their on-campus emissions reduction actions to accelerate their timelines for achieving neutrality as an interim strategy (Hawkey, 2019). There is no recommended limit on the number of carbon credits that can be purchased from a voluntary carbon registry; however as previously noted, purchase of offsets is recommended as the last strategy for emission reductions.

Prices of voluntary offsets vary widely based on the type of project, its location, its co-benefits, and the year in which the carbon emissions reductions occurred (Second Nature, 2020a). Current prices ranges have been cited as <$1 to >$50 per credit (Second Nature, 2020a) while others cite that most of the offsets on the market are currently in the $1.50 to $12 per credit and that this range would be reasonable for short-term budgeting purposes (M. Arsenault & E. Fulop, personal communication, 2020; C. Hawkey, personal communication, 2020). As previously stated, one credit refers to ownership of one metric ton of CO_2e. Estimates for bulk purchases of offsets (>50,000 credits annually) are estimated in the range of $2 to $22 per credit by 2025. In addition to the factors previously noted, these prices also vary due to how the purchases are made (e.g., long-term contracts, contracts that specify a purchase up to a certain amount vs. a guaranteed number of credits purchased, etc.).

University-Initiated Offset Projects

Afforestation projects on university property is a gray area right now in terms of whether they are considered carbon offsets as opposed to carbon sinks (C. Hawkey, personal communication, 2020; R. Woodside, personal communication, 2020). A carbon sink is a compartment within the Earth system that acquires carbon from the atmosphere and stores it for a specified period of time. The distinction here is that for accounting purposes, the terminology "offsets" relates to third-party offsets to reduce or remove greenhouse gas emissions in a secondary location to compensate or "offset" Rutgers emissions. Most universities do not account for biogenic emissions from land use on their properties in their emissions inventories, including Rutgers (Hayes, 2014; M. Kornitas, personal communication, September 11, 2020; R. Woodside, personal communication, 2020). Second Nature and the Offset Network do not currently provide a strong methodology for campus land management accounting, which would include any land use change emissions or credit for baseline carbon sequestration. Conventional wisdom is to follow an offset protocol for any on-campus tree planting and ensure additionality and other PAVER criteria are met (R. Woodside, personal communication, 2020). Therefore, any new project that Rutgers would undertake to sequester additional carbon, whether it was on-site or offsite, would follow the same strict protocols and PAVER requirements and only be accounted for going forward beyond Rutgers initial carbon sequestration baseline.

A collaboration of higher educational institutions has developed the Offset Network to provide educational and research opportunities that can result in novel offset protocols as well as cost reductions through implementation of a peer verification pathway. This voluntary approach provides an alternative pathway for institutions of higher education to realize voluntary offsets for up to 30% of their Scope 3 emissions through peer-verified offset projects (Offset Network, 2020a). Such projects do not generate offsets until they are developed and verified. For example, new forestry projects generate future offsets which are typically not available until year 5 when the trees start to sequester carbon that is able to be monitored, measured, and quantified.

Under the Offset Network, peer verification is a process that can be applied to projects that use traditional protocols (from VERRA, CAR, ACR, etc.) or for project protocols that are developed and peer-reviewed through the Offset Network. Peer verification is the process of releasing the offsets to the school that developed the project. Peer verified projects are less expensive to verify because instead of outsourcing verification responsibility to a third-party accredited verification/validation body, a peer university undertakes tasks associated with project verification (Offset Network, 2020b).

Although the Offset Network currently recommends that only 30% of Scope 3 emissions be offset via the peer verification pathway, a working group is being reconvened to reassess this recommendation, as schools that have utilized the peer verification pathway have produced projects that demonstrate enough quality to remove the 30% limitation (R. Woodside, personal communication, 2020). The 30% recommended limit on peer-verified offset projects does not prohibit purchase of additional credits from the voluntary market. The Offset Network also generally recommends that carbon offsets be used as a university's final strategy to achieve carbon neutrality after reducing emissions in other ways to the greatest extent possible, especially Scope 1 and Scope 2 emissions (R. Woodside, personal communication, 2020).

Note that the Offset Network is facilitated by Second Nature, a nonprofit that works with colleges and universities to further sustainability initiatives (Second Nature, 2020b). Rutgers University is a member of the University Climate Change Coalition (UC3), which is also facilitated by Second Nature. As a UC3 school, Rutgers is under no obligation to follow Offset Network protocols or standards or to become a network member; however, Rutgers can benefit from engagement with the Offset Network. Offsets developed through the Offset Network cannot be sold on the voluntary market or traded; they must be retired by the university that produced them (M. Arsenault & E. Fulop, personal communication, 2020).

Development of Rutgers University on-site or offsite offset projects provides an educational and research opportunity. The peer verification process presents the opportunity for students to gain valuable experience evaluating carbon offset projects. Faculty can use the Offset Network to provide opportunities for developing protocols working with students outside of the traditional registries through its peer review process whereby experts review new protocols. Qualified faculty can also participate on the Offset Network Peer Review Committee if they are subject matter experts in carbon offsets and campus climate goals, or have experience implementing offset projects. The Offset Network's Project Development templates request that universities report on the co-benefits of their projects, particularly any co-benefits relating to student education (R. Woodside, personal communication, 2020).

Research into new approaches for offsetting carbon emissions can be undertaken independent of any specific program or standard; however, working through the Offset Network peer review and verification process can provide a useful path for offset project development.

Co-Benefits of Offset Projects

Offset projects can provide co-benefits besides offsetting greenhouse gas emissions. For example, urban forestry projects can improve stormwater management and decrease urban air temperatures, improve real estate values, increase urban wildlife habitat, and improve air quality. The 3.3 million live trees in Houston, Texas inventoried in 2015 sequester approximately 2.0 million tons of carbon and remove approximately 513,000 million tons of CO_2 from the atmosphere every year (Nowak, 2017) . Common air pollutants include carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide and particulate matter; trees improve air quality through direct removal of these chemicals (Nowak et al., 2018) Urban Houston trees remove 2,400 tons of air pollution annually in addition to increasing storm drainage capacity and reducing runoff by 173 million cubic feet (Nowak, 2017). Ecosystem services of urban trees can be quantified using i-Tree Eco modeling software; urban trees in the city of Houston were valued at $16.3 billion in 2015 and also reduced annual residential energy costs by $59.3 million each year (Nowak, 2017). An inventory of street trees in Lisbon, Portugal found that for every dollar spent in tree maintenance, residents received $4.48 in benefits from energy savings, CO_2 reduction, air pollutant deposition, stormwater runoff reduction, and increased real estate value (Soares et al., 2011). Urban forestry projects can also serve to engage the community in planting and management of green spaces throughout the project area.

Offset projects such as wetland restoration also serve as buffers to decrease the likelihood and severity of coastal flooding events. Coastal marshes and their vegetation have been found to protect coastal communities from storm surges and flood damage (Barbier et al., 2013). For example, the Pocosin Wetland Restoration Project at Duke University is intended to provide improved groundwater storage and flood control to the surrounding area (Duke Carbon Offsets Initiative, 2020d).

In addition to urban forestry, other offset project types can produce co-benefits in addition to carbon storage or removal. Wood-burning stoves not only produce greenhouse gas emissions, but also produce particulate matter which can be harmful to human health; replacing wood-burning stoves with more efficient cookstoves can improve human health through improvement in air quality (Boso et al., 2019; Gold Standard, 2020b). Household device offset projects can involve the distribution of cleaner-burning stoves to underdeveloped communities to reduce emissions from wood-burning stoves (Hamrick, 2019). American University provided efficient wood-burning cookstoves to homes in Kenya as part of an offset program that also improved the lives of Kenyan women; the more-efficient stoves improved air-quality in homes (American University, 2017).

Biofuel methane capture offsets, such as the Loyd Ray Farms project at Duke University also generate electricity in addition to removing methane from the atmosphere. Although carbon dioxide is generated, methane is still removed, with the added co-benefit of electricity generation and the reduction of agricultural waste (Offset Guide, 2020). As previously stated, manure can negatively impact water systems, soil, and air quality (Duke Carbon Offsets Initiative, 2020e). Similarly, landfill methane capture offsets, such as the methane capture project at the Greater Lebanon Refuse Authority Landfill, also generate electricity in addition to reducing methane emissions (Verra, 2020b).

Energy efficiency offset projects subsidize the procurement and installation of appliances and construction materials that are more energy-efficient than cheaper alternatives. Co-benefits include reduced energy costs and building improvements (Weiss & Vujic, 2014).

Financing Options

Offset programs costs need to consider staff to oversee projects and purchases. Consultation with offset program directors at peer universities, found that offset prices can vary widely from $2/MTCO2e to $22/MTCO2e (M. Arsenault, personal communication, February 16, 2021; C. Hawkey, personal communication, February 12, 2021; Hawkey, 2019; D. Phillips, personal communication, February 12, 2021).

A variety of funding options exist to provide the resources to finance an offset program. Some peer institutions fund their offset programs with alumni donations, discretionary funds from university leadership, or combinations of approaches. One strategy, which has been implemented at the University of California, is to build offset purchases into all budgets that generate emissions such that core academic functions are centrally funded and other functions (such as student housing, dining, recreation, and parking) fund offsets through their fees (D. Phillips, personal communication, February 12, 2021).

The University of Maryland, College Park offsets 100% of undergraduate commuter emissions with a $6 Student Sustainability Fee applied to all undergraduate term bills each semester ($12/academic year), raising approximately $330,000 annually. This fund was established by a vote of the Student Government Association (SGA) in 2007 and is administered by the Sustainability Office. In 2018, the student committee that oversees grant decisions with respect to this fund recommended that it be used to offset all undergraduate commuter emissions; in a non-COVID year this cost has been about $50,000 or approximately 15% of the fund (M. Stewart, personal communication, February 15, 2021).

Another potential funding source is the implementation of an air travel carbon fund; examples include Arizona State University and University of California – Los Angeles. A flat fee is applied to university business air travel; however, UCLA's rate distinguishes between domestic and international travel. Funding sources vary, although in general the fees are charged to local departments at the point of reimbursement. UCLA exempts cases where federal or other grants would prohibit payment of the carbon mitigation fee but provides an option for payment into the fund by travelers who wish to offset their air travel. Arizona State University, which applies a $12 carbon fee to all round-trip business air travel, has achieved their goal of 100% carbon neutrality for Scope 1 and 2 emissions in part due to funding from such a program (C. Hawkey, personal communication, February 12, 2021). Carbon fees relating to air travel are often considered because air travel is relatively easy to track compared to other sources of Scope 3 emissions (D. Phillips, personal communication, February 12, 2021)
Duke University, partnered with the commercial airline, Delta, to offset Duke business travel (Lucas, 2018). Delta was interested in offsetting its own emissions and therefore combined forces with Duke to purchase offsets while also bundling that with support for urban forestry in the Raleigh-Durham area. Approximately half of the urban forest projects were in historically disadvantaged neighborhoods (S. Gagné, personal communication, 2020; Lucas, 2018). The International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) required airlines to begin rigorously monitoring emissions in January 2019 and will require airlines to cap emissions at 2020 levels beginning in 2021 (Gallant, 2018). With a nexus to a major international airport and seaport, Rutgers could consider offset partnerships with commercial airlines and potentially shipping companies.

Concerns Regarding Carbon Offsets

Critics of carbon offsets argue that marketplace purchases of carbon credits are not a replacement for emissions reductions: it is not acceptable to "lead a carbon-heavy lifestyle" so long as emissions are offset (Sauer & Climate Home News, 2019). Furthermore, offset projects must meet established guidelines, including the PAVER requirements outlined above. When offsets fail to meet PAVER requirements and are not paired with legitimate emissions reductions through changes in practices, they do not effectively mitigate climate change. Although legitimate offset projects, which are correctly verified, do serve to remove CO_2e from the atmosphere, the public is aware that not all projects are legitimate (Peach, 2019).

The cost of an offset program should be distributed evenly across the university community to ensure the costs of funding offset purchases and project development are not levied unfairly on specific groups within the university community. The University of Maryland student government chose to address this by offsetting undergraduate commuting emissions through a flat $6 "sustainability fee" applied to all undergraduate term bills each semester (M. Stewart, personal communication, February 15, 2021).

External stakeholder engagement in project development and implementation can contribute to equitable distribution of offset project benefits. Urban forestry projects can improve property values in the areas where street trees are planted (Nowak et al., 2006). Furthermore, urban tree planting projects that have previously taken place under the leadership of peer universities (Duke, Arizona State) have primarily taken place in historically disadvantaged communities (M. Arsenault & E. Fulop, personal communication, 2020; S. Gagné, personal communication, 2020). Forest planting projects that take place in the urban areas surrounding Rutgers University properties should be of financial benefit to those communities, in addition to their co-benefits on public health through the resulting decrease in air pollution, temperature reductions. Urban forestry or coastal wetland restoration projects would, if implemented, contribute to future sustainability of surrounding communities through increased resilience to storms.

The equity and social implications of carbon offsets on host communities is an important consideration. How offsets may result in new or additional constraints on emissions in developing or disadvantaged regions and communities that would concurrently bear increased responsibility for operating as carbon sinks for other regions and other unintended negative socio-economic consequences to citizens of these regions should be evaluated (Wittman & Caron, 2009).

Although climate benefits are the currency of voluntary offsets, societal co-benefits are increasingly being incorporated into offset standards including aligning co-benefits with the UN Sustainable Development Goals (Hamrick & Gallant, 2018). Verra's Sustainable Development Verified Impact Standard (SD Vista) outlines "rules and criteria for the design, implementation and assessment of projects that aim to deliver high-impact sustainable development benefits" ((Verra, 2020c). Similarly, Verra's Climate, Community and Biodiversity (CCB) Standards identify offset projects that support communities and biodiversity in addition to addressing climate change (Verra, 2020a). Offsets that have met the standards outlined by these programs are identified as such on the Verra Registry. Similarly, the Gold Standard considers sustainable development goals in the development of its protocols (Gold Standard, 2020a).

As part of its mission, Duke University's Carbon Offsets Initiative notes prioritization of local, state and regional offsets that provide significant environmental, economic, and societal co-benefits that are beyond the benefits of greenhouse gas reduction. Included within the societal co-benefits priorities are projects that assist local and regional communities with respect to increased social equity; i.e., the offset project helps increase the well-being of community members with low socio-economic status in order to decrease the inequality gap and the benefits and costs of the project are shared equally by all project participants regardless of age, religion, race, ethnicity, gender, socioeconomic level, and education background (Duke Carbon Offsets Initiative, 2020c).

The University of California has developed a set of Evaluation Criteria to apply to all voluntary market purchases as well as peer-verified offsets. Although these criteria also address cost and quality, the offset project must also have low risk of causing harm to people and ecosystems (University of California, 2020a).

Emerging Trends and Other Approaches

Currently, there is no recommended limit for the number of traditional voluntary market purchases of offsets by universities (T. Carter, personal communication, February 11, 2021). Based on a review of information provided by Second Nature for 17 colleges and universities (five of which are R1 schools) and information provided by colleagues from peer institutions, it is evident that the number of offset purchases from the voluntary market varies among institutions. In 2019, 0.3% to 120% of emissions were offset through purchases on the voluntary market across 17 colleges and universities (five of which are R1 schools); some universities purchased more offsets than needed to bank them into the future (A. DeMeo & Second Nature, personal communication, February 16, 2021). In 2019, the average number of offsets purchased by this cohort was 27% of all emissions, while the average number of offsets purchased by the five R1 universities in this cohort was 10% of all emissions (A. DeMeo & Second Nature, personal communication, February 16, 2021).

Peer institutions with near term carbon neutrality goals are looking toward developing more of their own than projects. In 2019, 26% of emissions were offset by Arizona State University through purchases on the voluntary market; however, ASU is developing its own offset projects as well (C. Hawkey, personal communication, February 12, 2021). The University of California intends to offset 30% of all emissions by 2024 through a combination of purchases on the voluntary market and creation of their own projects; the intent is that UC-initiated projects will become more dominant over time and that total offset use will decrease over time (D. Phillips, personal communication, April 13, 2021). Duke University plans to offset approximately 30% of all emissions through purchases on the voluntary market by 2024, while 14 to 19% of the offsets required to reach their 2024 neutrality goal will be peer-verified (M. Arsenault, personal communication, February 16, 2021; Duke Carbon Offsets Initiative, 2020a).

In addition to development of Rutgers own offset projects, the Task Force suggests exploring the option to purchase emissions allowances from the compliance market as an offset strategy. Precedent exists for non-regulated entities to purchase allowances from market-based carbon emissions programs (Adirondack Council, 2021). The Task Force recommends that such a strategy include a protocol that would restrict any future sale of such allowances, in effect retiring them from the marketplace, and ensure that such purchases take place only when allowance markets are sufficiently tight to provide a binding cap. Such an approach could be coupled to academic experiences for students to learn about and gain experience with regulatory compliance markets.

Oversight and Guiding Principles

To address concerns regarding Rutgers investments in offsets through approaches such as carbon credits, emissions allowances, or removal/sequestration projects, the Task Force recommends these projects be overseen under the guidance of an advisory body, consisting of faculty, staff, and students from across the Rutgers system, the purpose of which is to adjudicate the legitimacy of all planned purchases and projects to ensure the integrity of any program.

The advisory body should function under a set of guiding principles as set forth below that at a minimum should include: a hierarchy of priorities for the applicability, location, and type of offsets; high quality due diligence evaluation guidelines; align with Rutgers educational, research, and public service missions; and ensure equitable co-benefits.

Principles Guiding Carbon Sequestration and Offsets

1. Prioritize reducing Rutgers own emissions
2. Maintain transparency
3. Institutionalize periodic revisiting of offset strategies and criteria
4. Establish a geographic hierarchy of projects (etc., on-site, Rutgers nexus, New Jersey, region)
5. Evaluate projects using high quality due diligence principles
    a. PAVER requirements
        i. Permanent (lasts minimum 40 years)
        ii. Additional (beyond Business as Usual)
        iii. Verifiable (confirmed by a third party)
        iv. Enforceable (counted only once)
        v. Real (measured by robust accounting)
    b. Project Assessment
        i. Review project protocol, monitoring or verification reports
        ii. Conduct direct outreach to project developers, stakeholders, project funders, brokers, or relevant regulatory entities to vet project
        iii. Site visit (in person or remote tour)
6. Increase chances of acquiring high quality offsets by choosing projects that are:
    a. Reasonably priced
    b. Recent vintage
    c. Least environmental risk
    d. Least financial risk
7. Aligned with Rutgers University mission

    a. Research
    b. Education
    c. Public service
        i. Social justice and Equity
        ii. Health benefits
        iii. Advance scalable climate solutions
        iv. Align with university community and host community priorities
        v. Low risk of harm
8. Transition from market-purchased voluntary offsets to Rutgers-initiated local projects over time
9. Align with partners that will invest in research to address Rutgers and/or their emissions while concurrently purchasing offsets to address these emissions
10. Prioritize projects with equitably distributed co-benefits (improved health, improved environmental quality, biodiversity, employment, job training, etc.).
11. Equitable distribution of costs across the university community.

Contribution to Climate Positive Economic Development in New Jersey

There are avenues available to ensure that a carbon offset program contributes to climate-positive, sustainable economic development at Rutgers University and in its host communities that the Task Force recommends exploring. Although we are not aware of any voluntary market offset projects that generate credits available for purchase in New Jersey, were such projects developed in the area, they could provide climate positive economic development benefits (e.g., jobs, emissions reductions, air quality benefits, or resiliency benefits) depending upon the project type and location. Again, these projects should adhere to the guidance noted above, including equitable distribution of benefits and alignment with community priorities.

Several types of peer-verified offset projects have additional co-benefits beyond carbon sequestration. For example, an urban tree planting project in Rutgers campuses host communities have the potential to enhance land valuation and provide job training to community volunteers in urban forestry techniques, in addition to providing other non-economic health and environmental wellness co-benefits. Similarly, agricultural offset projects, such as the Loyd Ray Farms biofuel methane capture project coordinated by Duke University, would provide job training in agriculture (Duke Carbon Offsets Initiative, 2020c). Duke University has also participated in an energy efficiency retrofit programs for low-income mobile homeowners, which increased property values and monthly savings for homeowners in addition to reducing carbon emissions (Duke Carbon Offsets Initiative, 2021).

An idea for offsetting emissions from campus dining that would provide climate-positive, sustainable economic development, builds upon the nonprofit Zero Foodprint Initiative. Zero Foodprint proposes an optional fee on campus dining (e.g., fee on student dining plans) could be used to offset emissions associated with campus dining by implementing carbon sequestration practices on university-owned farm or farms or on a farm or farms within Rutgers' dining supply chain (A. Myint, personal communication, February 11, 2021). Rutgers could explore this option and development of a peer-verified protocol possibly through the

Offset Network. Such practices have healthy soil co-benefits for farms and are being implemented in California through ZFP as a complement to the State of California's Healthy Soils Program (Myint, 2021). ZFP has offered to assist Rutgers in developing such a program (A. Myint, personal communication, February 11, 2021).

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APPENDIX C – Land Use and Offset actions proposed as part of other Big10 and peer institutions plans

Actions	Cornell	Michigan	Ohio State	Illinois	Mary land	Washingto	Oregon	Prince ton	U Penn
Land Use actions									
Develop estimates of carbon-capture potential on University lands	X				X	X			
Afforestation - tree/shrub planting	X	X	X	X	X			X	
Active forest/tree management for enhanced carbon sequestration but promote storm resiliency	X								X
Enhanced soil organic carbon storage through application of biochar and compost				X				X	
Determine economic feasibility of management actions to increase carbon capture									
Actively seek public/private funding	X								
Monitor regulatory environment and carbon markets	X					X			
Reduce carbon emissions of landscape management practices									
Increase eco/low mow zones and low maintenance lawns and sustainable plantings	X			X				X	
Reduce lawn area					X			X	X
Increase sustainable plantings					X				X
Replace equipment with low emission models									
Reduce building energy use by strategic planting of trees and shrubs									
Reduce Agricultural land emissions									
Perform comprehensive assessment of GHG emissions and plan for reduction				X					
Convert some portion of cropland to Ag forestry				X			X		
Change cropland ag practices and animal husbandry practices							X		
Integrating Teaching									
Campus as Living Laboratory to promote teaching and research on sustainability	X							X	
Offsets									
Investigate mission-linked offsets and develop criteria for offset purchases	X	X	X	X		X			

Allow campus units to voluntarily purchase offsets				X					
Local or regional linked mission offsets	X			X					