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

Solutions Assessment: Land Use and Offsets

Report of Working Group 5

January 2021

Working Group Membership

Richard Lathrop, Co-Chair, *School of Environmental and Biological Sciences*, *Rutgers-New Brunswick*
Frank Wong, Co-Chair, Institutional Planning and Operations

Myla Aronson*, School of Environmental and Biological Sciences, Rutgers–New Brunswick*
Alvin Chin*, Bloustein School of Planning and Public Policy, Rutgers–New Brunswick*
Brian Clemson*, Institutional Planning and Operations*
Julia DeFeo*, College of Arts and Sciences, Rutgers -Camden*
Panos Georgopulos*, School of Public Health, Rutgers Biomedical and Health Sciences*
Paul Gottlieb*, School of Environmental and Biological Sciences, Rutgers–New Brunswick*
Pat Harrity*, Institutional Planning and Operations*
Marjorie Kaplan*, Rutgers Climate Institute*
Karina Schäfer*, School of Arts and Sciences, Rutgers–Newark*
Laura Schneider*, School of Arts and Sciences, Rutgers–New Brunswick*
Fiona Sergeant*, School of Environmental and Biological Sciences, Rutgers–New Brunswick*

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EXECUTIVE SUMMARY

As the State University and as a Land Grant Institution, Rutgers University has facilities spanning the state that include 91 discrete locations over 6,600 acres. While many of these locations are quite urban in character (i.e., many of the office buildings and health care facilities associated with Rutgers Biomedical and Health Sciences), Rutgers manages nearly 1,500 acres of farm land, 2,500 acres of forest land and over 600 acres of wetlands. Within the three main campuses of Camden, Newark and New Brunswick are lawns, treed areas and landscaped spaces covering over 500 acres. These 5,100 acres (or nearly 8 sq. miles) of "green space" land should be factored into any plan for the University to reach carbon neutrality by 2050. Accordingly, we propose possible avenues for the University to reduce greenhouse gas emissions associated with University land use and maintenance, increase carbon storage and reduce methane emission on University land, and reduce the University's energy demand through enhanced design of future land use development. More specifically, we propose a number of "carbon defense" strategies to maintain the existing stores of carbon in the soils, above- & below-ground plant biomass, and "carbon offense" strategies to promote enhanced carbon capture potential (i.e., additional amounts above and beyond baseline conditions). Our research suggests that there are existing off-site carbon offset policies and programs that could be adopted as an additional means of achieving carbon neutrality.

The inventory of present on-campus grounds and on-campus New Jersey Agricultural Experiment Station (NJAES) farm operations and maintenance practices was undertaken. Information about baseline greenhouse gas emissions were compiled and input to SIMAP to estimate the amount of carbon and equivalent CO2 emitted. The total annual CO2 equivalent emissions for the NJAES On-Campus Farms and the University Golf Course (the only component of campus ground maintenance where sufficient records were kept) is approximately 541 MT/year. These data are incomplete and enhanced record keeping is vital if we are to establish our baseline and chart our progress in reducing our emissions. To initiate this campus green space sustainability effort, approximately 25 acres of the New Brunswick-Piscataway campus lawns were converted to no/eco-mow zones. Replacement of a traditional lawn with what are termed eco- or low mow zones greatly reduced the frequency of mowing to one annually thereby reducing gasoline combustion emissions, as well as decreasing the amount of fertilizer, herbicide, and irrigation expended. Potential afforestation (tree planting) projects on campus and outlying properties were identified with a sum total CO2 equivalent storage of 14,680 MT.

Current prices for voluntary carbon offsets have been cited to range from <\$1 to >\$50 per credit for one metric ton of CO_2e. 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 occur. 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. As a member of the University Climate Change Coalition (UC3), 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.

5.1. Rutgers' current baseline

5.1.1. 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.

5.1.1.1. 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 5.1). Table 5.2 illustrates total fertilizer usage for University campuses. An inventory of Grounds maintenance equipment is provided in Table 5.3. 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 5.1. Fuel consumed on University Golf Course.

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

Table 5.2. 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 5.3 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	

5.1.1.2. 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 5.4);
- Inventory of farm machinery and fuel type consumed (Table 5.5)
- Annual diesel/gasoline consumption in vehicles and equipment (i.e. gallons of fuel consumed) (Table 5.6);
- Number of head of livestock and manure production (Table 5.7).

Table 5.4 Table of energy use for on-campus NJAS farm facilities.

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

Table 5.5. 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	
lechanic 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 5.6. 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
Turf Grass Research Plots			26-0-5	synth	1220.4	26	317.3
			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 5.7. 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 5.8) (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%20conversion.). Note that this does not include N Fertilizer application in the equivalent CO2 estimation.

Table 5.8 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

5.1.2. 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.

5.1.3. 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.

5.1.4. 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.

5.2. Overview of potential climate solutions

5.2.1. Potential solutions

As the State University and as a Land Grant Institution, Rutgers University has facilities spanning the state that include 91 discrete locations over 6,600 acres. While many of these locations are quite urban in character (i.e., many of the office buildings and health care facilities associated with Rutgers Biomedical and Health Sciences), Rutgers manages nearly 1,500 acres of farm land, 2,500 acres of forest land and over 600 acres of wetlands. Within the three main campuses of Camden, Newark and New Brunswick are lawns, treed areas and landscaped spaces covering over 500 acres. These 5,100 acres (or nearly 8 sq. miles) of "green space" land should be factored into any plan for the University to reach carbon neutrality by 2050. Accordingly, we propose that the University reduce greenhouse gas emissions associated with University land use and maintenance, increase carbon storage and reduce methane emission on University land, reduce the University's energy demand through enhanced design of future land use development, and develop mechanisms to offset University emissions.

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. More broadly, these plans will assess "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).

NJ Agricultural Experiment Station Farms and Research Stations

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.

Rutgers University Forested lands

The objective is to afforest "vacant" University-owned land as well increase carbon dioxide storage on existing forest lands by increased carbon sequestration in soils and woody vegetation by adoption of enhanced management practices. More proactive management of the University's forest lands is recommended to maintain the existing stores of carbon in the above- & below-ground plant biomass and soil (i.e., "carbon defense" strategies).

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 (i.e., build up, not out, and return unused space to green space). Adoption of low carbon cement and concrete products in new campus construction projects would help to reduce their carbon footprint.

Offset University emissions

We define a *carbon offset* as an additional reduction to already existing mechanisms in emissions of *carbon* dioxide or other greenhouse gases made in order to compensate for emissions made as part of University-related activities. We have investigated the feasibility of existing off-site carbon offset programs as an additional means of achieving carbon neutrality. Simultaneously, we have examined policies and mechanisms for campus departments and organizations to purchase carbon offsets that are being applied elsewhere. We also assess the feasibility of the establishment of new off-site carbon offset programs here in the State of New Jersey in collaboration with other state and local partners.

5.2.2. Stakeholder input

We participated in the various Campus Roundtables and have incorporated the various comments and taken the concerns into consideration in the development of this report.

5.2.3. Opportunities for action in the current academic year

A review of campus grounds maintenance on the New Brunswick-Piscataway campus was undertaken and several areas were put under to ecomow practices.

5.3. Assessments of potential climate solutions

5.3.1 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.

5.3.1.1. Emissions reductions and resilience improvements

What are the associated emissions reduction and resilience improvements?

Broadly, a campus green space sustainability effort that includes adoption of the following best management practices:

- Reduce traditional lawn; Increasing low-maintenance turf care (reduced fertilizer/herbicide, irrigation and mowing) and/or switch to low maintenance turf varieties and/or expand eco/low mow zones;
- Replant existing eco/low mow zones with perennial meadow species
- Replacing gas engine with lower emitting electrical battery powered machinery, increasing electric vehicle charging stations;
- Establish management program for the campus urban forest to enhance forest health and vigor;
- Replace annual plantings with perennials/grasses/shrubs and trees;
- Install vertical gardens in area-limited locations;
- Increase on-site management of leaf litter/wood chips (shredding, compositing);
- Develop program to mill campus trees removed because of disease, storm damage or construction for usable lumber;
- Increase campus tree plantings - within parking lots (wherever feasible) to reduce urban heat island effect, within campus green spaces and with new projects;
- Increase the use of pervious paving materials with high sun reflectance index and "low carbon" concrete materials_into university projects;
- Establish a campus native tree/shrub nursery as part of the Campus as Living Laboratory teaching program.

Due to the lack of baseline data on present day emissions of campus grounds maintenance (except for the Rutgers Golf Course noted above), quantification of potential reductions in ongoing emissions is not feasible at this point in time. The first task is to begin recording the relevant fuel and fertilizer usage data.

To initiate this 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 (Table 1). Replacement of a traditional lawn with what are termed eco- or low mow zones greatly reduced the frequency of mowing to one annually thereby reducing gasoline combustion emissions, as well as decreasing the amount of fertilizer, herbicide, and irrigation expended. Additional 14.3 acres of lawn or disturbed areas have been identified to replant into trees (Tables 3.1, 3.2; Figures 3.1a, 3.1b). The breakdown is as follows:

Eco/Low-mow:	24.81 acres
Afforestation:	14.29 acres
Total acres:	39.1 acres.

At the beginning of the program, the recently transitioning eco/low mow areas will be predominantly cool season grasses (existing turf species). Over time the areas may be transitioned to a combination of cool season and warm season grasses and wildflowers and forbs to create a meadow ecosystem. Meadows are becoming increasingly recognized for their ability for carbon capture and soil restoration as well as their ecological virtues as habitat, especially for songbirds and pollinators, and as hydrologic buffers. They also provide aesthetic beauty that can help relieve stress in an ever-quickening world. Meadow ecosystems evolved to withstand, and thus can be invigorated by, disturbances, primarily in the forms of grazing and fire (USGCRP, 2018). As a result, much of their biomass exists underground as deep and extensive root systems. Infrequent mowing (i.e., once annually or biennially) can act as a partial replacement for naturally occurring grazing and limit the growth of woody plants. An ongoing challenge will be noxious weed/plant management and may require future herbicide treatments.

In order to have the most success in establishing these new meadows, the sites must be primed with a one-time treatment of herbicide, which, when applied properly, should not leave significant residue. This treatment is important to help the new seed establish so that it is not out competed by pre-existing and/or invasive species. Seeding should be done at least two weeks after the pre-treatment, and most native plants require a two month period of cold in order to germinate. In a meadow creation project a highly diverse seed mix typically includes 25% wild flowers, a dozen or more species and 75% warm season grasses (**Big Blue Stem, Little Blue Stem, Indian Grass, Virginia Wild Rye, Switch Grass,** etc.) (Tallgrass Ontario, 2020). The selection of plants that promote deep root establishment is critical to the capture of carbon in below ground biomass and as soil organic carbon. The potential amount of carbon that might be expected to be sequestered in below ground biomass and soil organic carbon for the proposed meadow creation projects was not quantified. The approximate cost to establish a meadow is on the order of $1,000 per acre depending on the amount of wildflower seed that is used (wildflower seed costs more per pound vs. grass seed; personal communication, Thomas Almendinger, Director of Conservation at Duke Farms, Hillsborough, NJ). Wildflowers add aesthetic appeal and serve as habitat for pollinators such as butterflies, bees and other insects.

For the proposed afforestation, the goal will be planting new trees at a density of approximately 200 2”-2 ½” caliper trees per acre. This density is derived from the New Jersey No-Net-Loss Compensatory Reforestation Program Guidelines. We are using the tree replacement factor for Established Forest (assumed prior 100% canopy coverage). Afforested and reforested areas will be a combination of large shade trees and understory trees. The large trees should range in mature height from 45’ to 100’. With a mature crown diameter that would range from 20’ to 80’. Small/understory trees will have a mature height range from 15’ to 35’ with a similar crown diameter. Additional trees will be planted along selected streets and pathways. The potential amount of carbon that might be expected to be sequestered in above and below ground carbon is estimated later in this document.

Table 5.9. 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 5.10. 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 5.1. Map showing location of proposed eco/low mow, afforestation, and reforestation zones on Busch/Livingston campus.

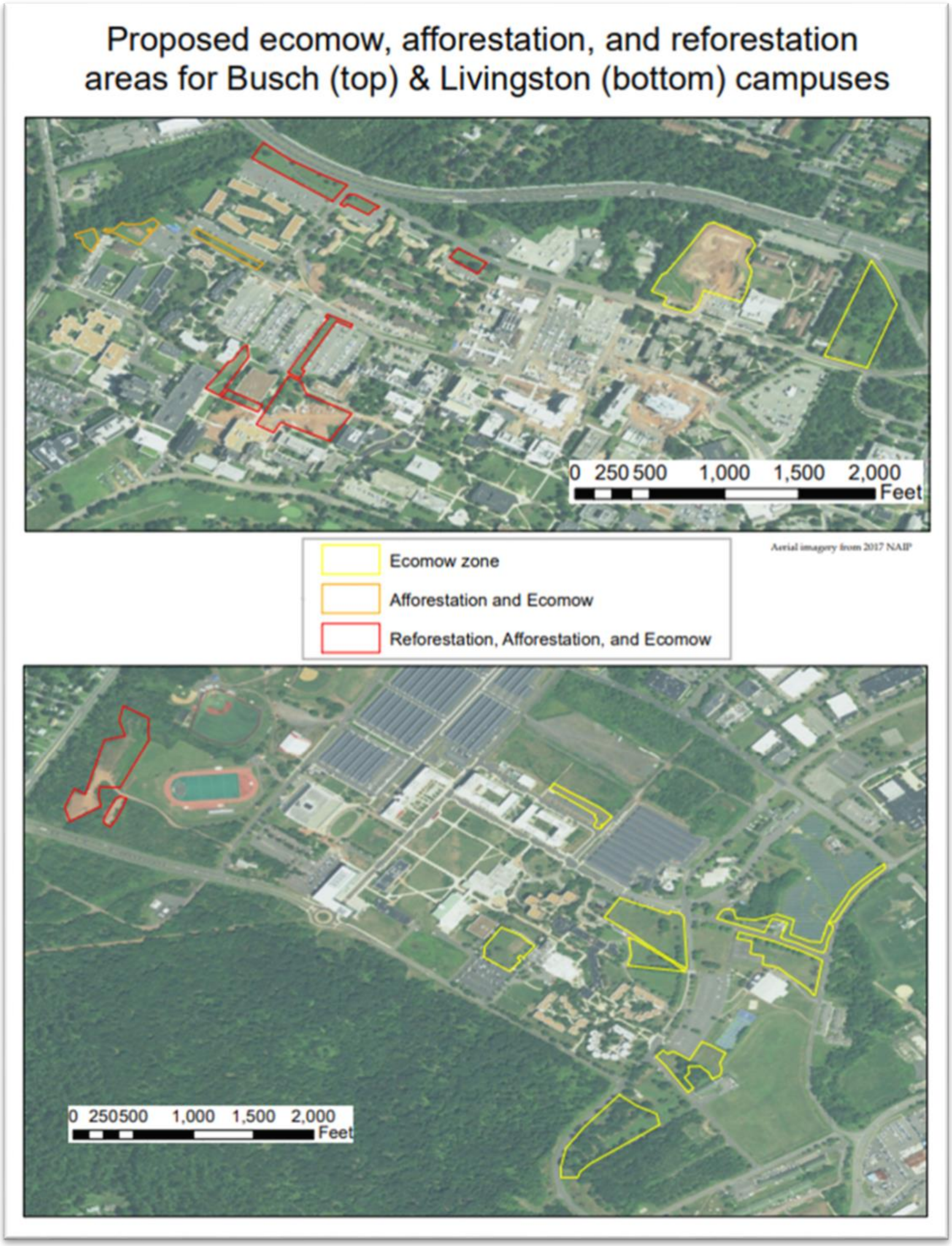
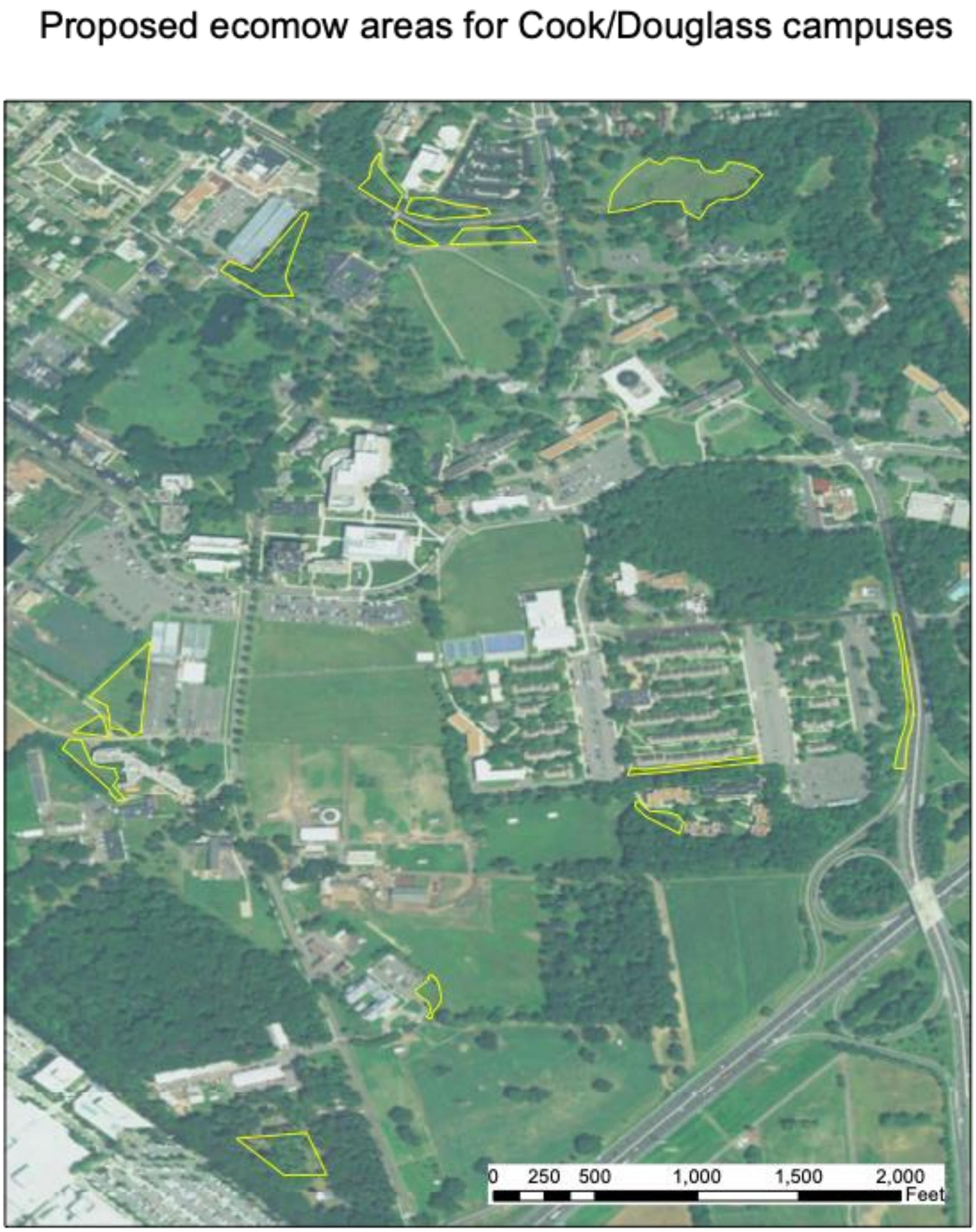

Proposed ecomow, afforestation, and reforestation areas for Busch (top) & Livingston (bottom) campuses
0 250 500 1,000 1,500 2,000
Feet
Aerial imagery from 2017 NAIP
Ecomow zone
Afforestation and Ecomow
Reforestation, Afforestation, and Ecomow
0 250500 1,000 1,500 2,000
Feet

Figure 5.2. Map showing location of proposed eco/low mow zones on Cook/Douglass campus.



5.3.1.2. NJ Agricultural Experiment Station Farms and Research Stations
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.

- Complete a sustainability plan for NJAES research farms. See full description in interim report of Working Group 7;
- Proposed initiatives to achieve reduction of greenhouse gas emissions will focus on improved soil and livestock management to reduce greenhouse gas emissions;
- 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).
- NJAES cannot commit to any change in plantings, including trees, shrubs, or permaculture, that are inconsistent with its ongoing research projects or with the stewardship plan described in the WG7 interim report.

5.3.1.3. Rutgers University Forested lands
Rutgers manages nearly 3,100 acres of upland and wetland forest across the state of New Jersey. We propose that the University maintain these forest lands to protect their existing “bank” of carbon storage as well increase their carbon dioxide storage by increased carbon sequestration in soils and woody vegetation through the adoption of enhanced management practices.

A forest sustainability planning effort has been undertaken to provide an initial estimate of existing carbon stocks (i.e., carbon stored in plant biomass and soils), assess the potential for enhanced carbon sequestration (I.e., additional carbon stored above and beyond the baseline) carbon sequestration goal, and propose a suite of best management practices. Geospatial data on the type and general canopy cover of forests was used to map Rutgers University owned lands into the following 4 categories:

- >50% canopy cover for upland or wetland forest --> **Focus on Forest Health Defense -** maintaining forest as is and protecting against forest pests/diseases/ invasive plants and deer overbrowsing;
- the forest canopy is sparse (10-50%) --> **Focus on Reforesting** to increase forest cover;
- Abandoned AG field or scrub/shrub --> **Focus on Afforesting** to increase/re-establish forest cover;
- Existing Agricultural land that is "Vacant" and a possible candidate as a future forestland--> **Focus on Afforesting.**

Carbon sequestration benefits from tree planting activities (i.e. afforestation or reforestation) occur when the net CO2e (CO2e stored minus CO2e emitted) associated with planted trees exceeds baseline tree planting CO2. In other words, the tree planting should be *additional*, i.e., above and beyond “business as usual” practices. In some greenhouse gas inventories carbon sequestration from existing forested lands is considered a *sink* and subtracted from the total emissions. However in our assessment, carbon sequestration rates of existing forested lands were deemed as non-additional (and thereby were not calculated separately), even if proactive management is undertaken to maintain existing carbon stocks and sustain future carbon sequestration (i.e., Carbon Health Defense strategies outlined above). The net amount of carbon sequestered annually could be estimated using a combination of *in situ* forest measurements complemented with forest ecosystem process modeling (similar to the approach described below).

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 5.11). 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 5.12). 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 5.12).

Table 5.11. 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 5.12. 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 Offset 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.

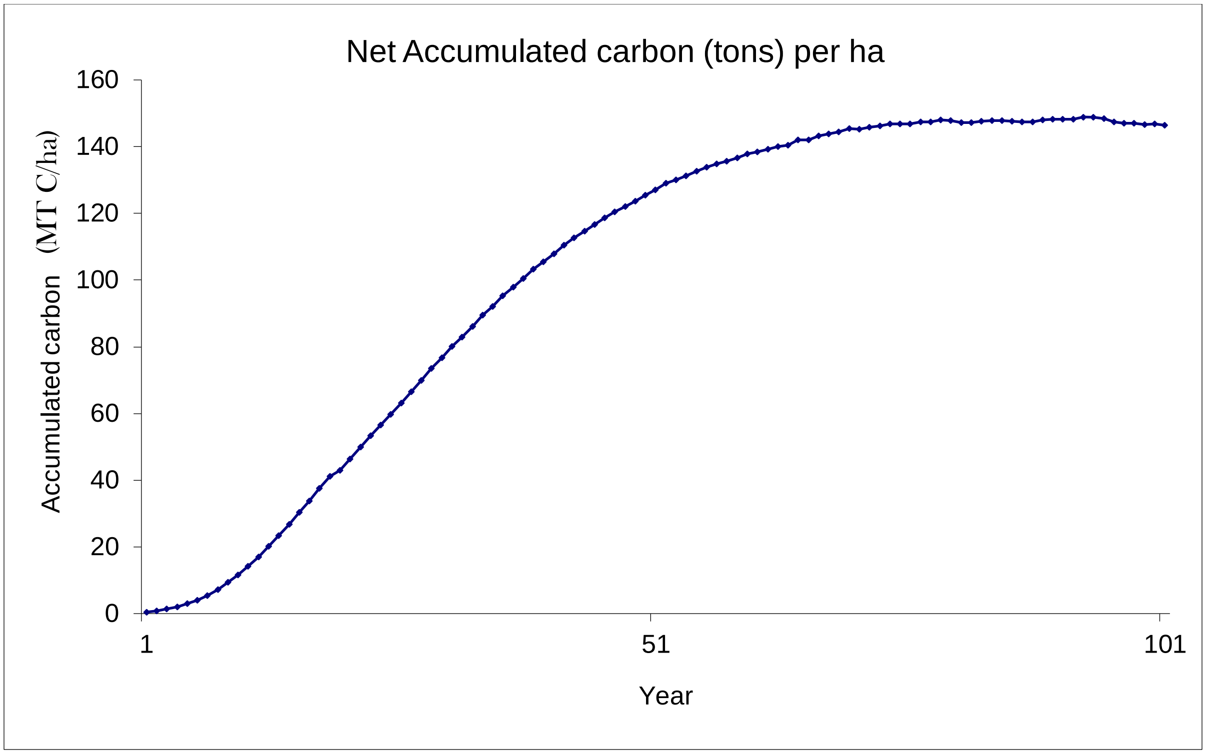
Duke University has established an Afforestation protocol that serves as a useful guide for calculating carbon offset credits. Under this protocol, the crediting period for an Afforestation Project is 40 years. Projects may be renewed but must calculate an updated baseline before offset generation is 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 (SSURGO, 1995). 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 5.3). After their peak growth stages, forest stands tend to mature and thin in tree density thereby declining in overall carbon stock. Examination of Figure 1 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 5.3. 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 5.13). 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 5.13. 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 14,680 MT eCO2 or 3,977 MT C or 3,977 carbon credits (Table 3.1.3.4).
The proposed afforestation of the 80 acres (32ha) of farmland would provide 8,288 MT eCO2 (2,240 MT C) at age 40. This equates to 924,196 gallons of gasoline consumed (from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator).
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. This equates to 420,839 gallons of gasoline consumed (from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). The proposed afforestation on 10 acres of campus would provide 2,653 MT eCO2 (717 MT C) at age 40. This equates to 295,825 gallons of gasoline consumed (from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator).

Table 5.14. Proposed Forest Afforestation/Reforestation Plans with Estimated Carbon Sequestration Amounts

Project	Area	C stock at 40 yr	CO2 equivalent	Gas consumed
HMF Afforestation	80 acres	2,240 MT C	8,288 MT eCO2	924,196gal
HMF/RUEP Reforestation	32 acres	1,020 MT C	3,740 MT eCO2	420,839 gal
Campus Afforestation	10 acres	717 MT C	2,653 MT eCO2	295,825 gal
	122 acres	3,977 MT C	14,680 MT eCO2	1,640,860 gal

5.3.1.4. Campus Master Planning

The planning principles and sustainability framework already embodied in the *University Physical Master Plan – Rutgers 2030* for future land use development/redevelopment intended to minimize energy demands and maximize carbon sequestration (i.e., curtail low-rise sprawl development, in favor of developing higher density, mixed-use buildings around transit hubs & return unused space to green space). For the *University Physical Master Plan – Rutgers 2030* to be successful in these regards, the following will be critical:

- Ensure that Significant Capital Projects are designed with appropriate landscape plantings, tree plantings, and site improvements, as well as energy saving building features.

- Monitor the implementation of Significant Capital Projects to ensure that these elements are not downsized or eliminated from the project scope as part of a "Value Engineering" process.
    - All capital projects are required to be reviewed by University Landscape Architect (ULA);
    - All capital projects are to provide landscaping, including perennials, shrubs and tree plantings that provide aesthetic and ecological function;
    - All capital projects are required to incorporate perennial plantings capable of significant annual biomass development, and minimize extents of managed lawn, thereby reducing fertilizer input as well as mowing;
    - Plant material is to be selected based upon being non-invasive, hardy for the climatic and USDA hardiness zone, perennial and resistance to deer browse;
    - Replace trees removed by Grounds because of disease or damage at a 1:3 ratio.

While not included in *University Physical Master Plan – Rutgers 2030*, the adoption of *low-carbon* cement and concrete for new construction projects represents an additional option for reducing the carbon footprint of campus development/redevelopment. Traditional concrete/cement manufacturing and curing processes emit tremendous amounts of carbon into the atmosphere. At an estimated 6% of total global carbon emissions, concrete ranks as the second largest contributor to carbon emission. However, an alternative known as Solidia Cement™ emits significantly lower amounts of carbon and is sometimes referred to as *low-carbon* cement or concrete https://www.solidiatech.com/solutions.html). The cement is manufactured at lower temperatures, thus lower energy costs and reduces associated carbon emissions by 30 to 40%. Even more importantly, rather than emitting carbon during the curing process, Solidia Cement consumes carbon from the atmosphere and sequesters that carbon in the concrete matrix. A co-benefit is that Solidia Cement consumes 80% less water.

Dr Richard Riman, Distinguished Professor of Materials Science and Engineering, co-invented the technology that makes Solidia Cement possible with Vahit Atakan, chief scientist at Solidia Technologies® and former Rutgers doctoral student (Rutgers Today February 13, 2017). Riman founded Solidia Technologies®_ in Piscataway, New Jersey, in 2008. In 2019, Solidia teamed up with EP Henry, a leading manufacturer of unit concrete products in North America, to manufacture paving stones and blocks. EP Henry's facility in Wrightstown New Jersey is the first US Commercial Venture. As of 2020, EP Henry-Solidia concrete paving blocks are being installed across the Mid-Atlantic and Northeast US region. Rutgers University should consider adopting the use of Solidia low carbon cement and concrete paving stones/blocks in future construction projects as a means of reducing the associated carbon emissions.

5.3.1.5. Offsetting University 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 measured in metric tons of (CO_2e) and purchase of 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)

Given that Rutgers is not under a regulatory requirement to reduce greenhouse gas emissions, this chapter focuses primarily on the voluntary offset market. Rutgers can purchase offsets on the voluntary market or Rutgers can offset its emissions by developing its own offset projects or in collaboration with other groups.

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.

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). Although the Offset Network currently recommends that only 30% of Scope 3 emissions be offset via the peer verification pathway, the Offset Network plans to reconvene a working group 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).

Offsets are measured in metric tons of carbon dioxide equivalent (CO_2e) and purchase of 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. As previously stated, the Offset Network currently recommends that only 30% of Scope 3 emissions be offset by peer-verified offset projects (Ruby Woodside, personal communication 2020). Such projects do not generate offsets until they are developed and verified. 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.

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).

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). American University purchased 30,723 offset credits in 2018-2019; 78.8% of these credits are voluntary market purchases. The remainder are a bundled offset project purchased through the broker Urban Offsets; 6,500 efficient transportation credits were purchased and paired with an urban forestry project in Washington, D.C. (Second Nature, 2019). 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.

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 anaerobic 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).

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). 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. 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).

5.3.2. Financial costs and savings

Campus Grounds

Currently Facilities does not track fuel usage at a level of detail to be able to determine fuel cost savings associate with the proposed reduction in managed turf. Fuel usage can be track at the macro level associated with individual "fob keys" used to access gas at the university fuel depots. The data associated with the "fob" usage does not provide enough detail so as to determine the amount of fuel used for mowing, line trimming, utility cart operation, etc.

Costs associated with the conversion of actively managed lawn to eco/low mow and the installation of canopy and understory trees have a potentially significant range depending upon the method of conversion from "mow" to "no/eco mow" and the size and who or how the trees are installed and maintained. With a reduction in actively managed turf, the university should realize a proportionate reduction in fuel, fertilizer and herbicide usage.

University Forest Lands

A preliminary analysis of planting and management costs has been undertaken to estimate costs for initial reforestation plantings and 1 year of management. Working with a student team, Dr. Aronson has estimated costs to range around $20,000/acre at a stocking density of approximately 400 stems per acre for #7 (large saplings) trees ($35/individual). Using seedlings (6"-12" height, $1.10/individual), Dr. Aronson's estimate is $7500/acre. These estimates include site prep, invasive species management, deer fence/tubing, planting labor, subsequent management over 3 years post planting, etc (all together estimated as $2285/acre)Data provided by Eric Olsen from the NJ Chapter of the Nature Conservancy estimates costs of around $5,000 per acre strictly for the initial planting costs at a stocking density of 220-320 stems per acre (i.e., does not include the labor costs for site prep, invasive species management, planting or subsequent deer management). The difference in the costs is largely due to the difference in the size of the container tree stocks to be planted. For the high estimate, Dr. Aronson used a #7 container while Mr. Olsen used #1-2 size containers. The #1-gallon is $5-$7, #2-gallon is $9-$12 while the #7-gallon is $35 per individual. The larger size stock has a higher chance of success but costs more to transport and plant. Cost estimates from the Natural Resources Conservation Service (NRCS) Best Management Practices manual (https://efotg.sc.egov.usda.gov/references/public/NJ/FY2019_Scenarios.pdf) are more in line with TNC's estimates. NRCS Practice 490 Tree/Shrub Site Preparation using heavy equipment site prep cost is $270/acre. Practice 612 Tree/Shrub Establishment (planting) estimates costs of $9.46 per plant for individual plantings, which equates to $3,953 per acre for a high-density hardwood planting (including tree tubes).

Combining these recommendations, we estimate $3000/acre for plant material ($10/individual with a stocking density of 300 individuals/acre) and $2300/acre for site prep, labor, and management. Site prep and management will ensure successful reforestation. Intense deer browse and overabundance of invasive species, both of which will cause high mortality to tree saplings and seedlings and failed reforestation if not intensely managed. B Total $5300/acre (this is a low-end estimate). This estimate only includes 1 year of management. There would need to be at least 5 years of monitoring after the plantings and additional plantings to address mortality.

Please note that the Carbon emitted as part of the site prep, planting and subsequent management activities will have to be estimated and subtracted from the previously quoted carbon sequestration credits.

We have undertaken a very simplified "back of the envelope" analysis of the expected costs vs. gains. Putting this together, we estimate approximately 14,680 carbon credits to be gained from the 80 acre off-campus afforestation project, the 10 acre on-campus afforestation project, and the 32 acre reforestation project. If the same amount of credits were purchased on the open market at somewhere between $1 to $10 per credit, we would expect to spend between approximately $15,000 and $150,000. We estimate that it would cost the University approximately $610,000 to undertake the projects (122 acres x $5,000/acre = $610,000). These per credit costs are 1 to 2 orders of magnitude higher than relying on the open market to purchase credit (even if carbon credits double as some expect in 2025 when the Paris Accord kicks in). Note that we have not incorporated the expected costs for the carbon credit validation or other program management/administrative costs. Further financial accounting needs to be undertaken to determine the annualized cost.

Solely on an economic basis, undertaking these projects for their carbon credit value alone may be difficult to justify. The real value in undertaking these projects, in addition to their other ecosystem service values, would be for their educational and public relations value. It may be possible to underwrite some of these per acre planting costs through grants from the NRCS or other government agencies.

Offsets

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.).

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).

Until scenario analyses are completed in terms of what the costs to the university would be to reduce all emissions on a per unit ton basis, it may not be possible to estimate the savings in comparing different approaches to offsetting university emissions.

5.3.3. Benefits to the University's educational and research mission and to campus culture

Campus Grounds and Forests

With the conversion of actively manage turf to Eco/Low mow, faculty and students will have easy and direct access to these areas for research and teaching. Establishing eco/low mow areas, completing afforestation and reforestation projects, and establishing and implementing a proactive urban forest management plan will provide physical, real-world examples of the application of best management practices that represent opportunities to influence cultural shifts in ground management.

The proposed "Forest Defense" and "Forest Offense" policies will provide a number of educational, research, and culture benefits. As part of a broader Campus as Living Laboratory initiative, the proposed afforestation/reforestation projects provide a number of educational opportunities. As described in the Offsets section below, students could be incorporated at all stages of the process: design, implementation, monitoring, validation.

Offsets

The previously mentioned Offset Network provides an educational and research opportunity particularly through its peer verification process. For the peer institution, this 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.

Academic institutions can also partner with third parties to provide educational and research opportunities that also benefit local community partnerships. For example, Urban Offsets is a commercial enterprise that partners with local communities and organizations including universities to implement the bundling of purchased third-party verified carbon offsets with tree plantings in local communities; these tree plantings are often in historically disadvantaged neighborhoods and engage university students and community members (Arizona State University, 2020; C. Hawkey, personal communication, 2020; Urban Offsets, 2018). The bundling concept integrates the long-term benefits of creating future offsets through urban tree planting with co-benefits of the environmental services provided by the trees along with the immediate greenhouse gas emissions reduction impact of purchasing verified third-party offsets (M. Arsenault & E. Fulop, personal communication, 2020; S. Gagné, personal communication, 2020). The local tree planting urban forestry projects are considered to be cost-effective because they involve peer verification, and they also provide local co-benefits addressing urban heat island, air quality benefits, beautifying the community, improving property values, improving stormwater management and providing a living laboratory for students (Arizona State University, 2020; S. Gagné, personal communication, 2020).

5.3.4. Other Co-Benefits

Campus Grounds and Forests

The reduction in actively managed turf will allow grounds staff to spend additional time on the maintenance and improvement of other campus landscape resources.

With the development, adoption and implementation of a campus wide “Urban Forest Management Plan” the health, vigor and resilience of the forest will be enhanced. In addition to enhanced carbon sequestration, increased tree cover will serve to cool campus buildings, reduce stormwater runoff, add wildlife habitat value and provide aesthetic benefits.

Eco/Low mow and increased forest resources will enhance the ecological diversity of the campus and support a more climate-resilient landscape.

Urban forestry offset projects can increase resilience by improving stormwater management and decreasing the urban heat island effect. In urban environments, trees can function as “green infrastructure;” root networks can reduce soil erosion and increase storm preparedness by absorbing excess rainwater (Berland et al., 2017). The urban heat island effect (UHI) refers to the observed phenomenon of increased heat in areas with high human population density; reduction in vegetation decreases shade on buildings and concrete, which absorb and slowly release large amounts of heat (Clements & Casani, 2016). Increasing trees in urban environments through an urban forestry offset project would serve to decrease the impact of the UHI. Urban trees and shrubs were found to reduce mean maximum daily soil temperature (Edmondson et al., 2016), while models have shown that a 50% increase in tree cover coupled with a 10% decrease in street width would reduce road-surface temperatures by 27.72 °F (Loughner et al., 2012).

Offsets

In addition to improved stormwater management and decreased urban air temperatures, other co-benefits of urban forestry offset projects include improved real estate values, increased urban wildlife habitat, and improvements in 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). Furthermore, 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 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).

5.3.5. Implementation Plan and Timescale

Campus Grounds and Forests

Following identification of grounds that are to be converted from mow to eco/low mow in the early summer of 2020, Grounds staff were directed to reduce mowing frequency or to stop mowing those areas entirely. This has allowed the existing cool season grasses and other (some non-desirable) herbaceous plant species to grow unchecked. A plan is being developed that identifies portions of the grounds that have been taken out of frequent mowing for conversion to wildflower/forb/warm season grass stands. Due to funding and staffing constraints the timing for the full implementation of the program should be within a 5- to 10-year time frame. The reforestation / afforestation of campus should also addressed as an on-going effort. Prioritization of grounds to be reforested / afforested should be determined based upon factors such as availability of funding, carbon sequestering potential, ecological and aesthetic benefits.

A forest inventory and stewardship plan for Rutgers owned forest lands (e.g., EcoPreserve, Helyar Woods, Hutcheson Memorial Forest) should be completed over the next five years. The initial portfolio of potential afforestation projects that have been identified should likewise be implemented over the next five to ten years. The carbon credit projects have an initial time span of 40 years. As we are dealing with long-lived trees, these projects will continue beyond that time frame to have a lifespan of a century or more.

Offsets

The university will have to complete its greenhouse gas emissions inventory and scenario analyses to determine how much emissions reduction can be achieved through practices other than through the purchase of offsets on the voluntary carbon market or to create its own offsets or enhance carbon sinks on its own lands. Further, the university should evaluate whether it wants to embrace the Offset Network approach for peer verification and be limited to the Network's current recommendation to limit peer-verified offsets to 30% of Scope 3 emissions. Note, however, the Offset Network plans to revisit this recommendation given that the Network's Peer Verification and Protocol Review processes have resulted in offset projects that are of high enough quality to remove the limitation (R. Woodside, personal communication, 2020).

Purchasing offsets on the open market is fairly straightforward and can be completed by working through brokers who specialize in working with universities and can purchase in bulk on an annual basis. The university could consider the "bundling" approach, which has been utilized by Duke University and Arizona State University, among others, in partnership with the organization Urban Offsets, Inc. Projects the university undertakes itself will take more time; for example, generation of credits from the Duke Urban Forestry Protocol will not be realized for five years (Duke Carbon Offsets Initiative, 2018).

5.3.6. Needed research and planning

Campus Grounds and Forests
More detailed forest inventory, stewardship planning, an enhanced silvicultural strategies are needed for each Rutgers University owned property with significant forest acreage. Further economic analysis is needed to determine financial costs and benefits of on-campus afforestation projects as a strategy to generating carbon credits as a means to offset campus emissions.

Offsets
It will be important to know the budget available for purchasing of offsets in the marketplace or developing offset projects and to cost out various types of projects over various timelines. Furthermore, the university must determine the method and mode by which it plans to purchase offsets from the voluntary marketplace or develop offset projects. It should also determine if it plans to partner with the Offset Network to develop protocols or utilize the Peer Verification Pathway.

5.3.7. Evaluation plan

Campus Grounds and Forests
Regular vegetation monitoring in needed on a 5 to 10 year return interval to ascertain the status of the campus grounds, forest lands and whether plant cover and species composition targets are being met.

Offsets

Progress can be evaluated annually to measure the emissions reductions that Rutgers seeks to achieve in relation to purchased offsets. Rutgers can also measure and monitor the progress of any type of legitimate offset project it would develop and could use the peer-verification program established by the Offset Network to independently audit and verify its findings.

5.3.8. Management roles

Campus Grounds and Forests

Some of the major University-owned forest properties, such as Hutcheson Memorial Forest and the EcoPreserve, are overseen by Faculty directors. Additional oversight of other properties that have a significant area of forest is needed.

Offsets

It will be important to understand where an offset program would be housed and managed and what other resources will be available. For example, Duke University has two full time staff in its Office of Sustainability, who only work on the Duke Carbon Offset Initiative (M. Arsenault & E. Fulop, personal communication, 2020). Given that Rutgers University does not currently have an Office of Sustainability or equivalent, it must be determined if such an office would need to be developed, and, if so, where it would be housed within the University hierarchy. If an Office of Sustainability (or equivalent) were developed, it would then need to be determined if the University requires at least one employee dedicated to the development and management of an offset program.

5.3.9. Institutional, Organizational and Cultural Challenges to Implementation

Campus Grounds and Forests

The single most significant challenge facing the conversion of maintained lawn to eco/low mow are cultural concerns associated with pest, disease vector insects, and the unkempt negative perception.

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 University can address this concern through the purchase of legitimate, third-party verified offsets. The university can also consider pairing their offset purchases with peer verified urban forestry projects in the cities of New Brunswick, Newark, and Camden which would provide an additional offset. The university could also establish a review process to establish criteria for and to vet proposed offset purchases it would make on the voluntary market to ensure these not only met PAVER requirements, but also met other concerns of the university community. For example, University of California established a Carbon Abatement Technical Committee that spans all 9 of its campuses to advise the development of the offset procurement strategy at University of California (University of California, 2020b). This committee serves to evaluate the cost effectiveness, quality, and risk of public or environmental harm (University of California, 2020a). The university can also consider prioritizing emissions reductions through other methods, rather than utilizing offsets as a primary means of achieving carbon neutrality.

5.3.10. Participation and Accountability

Campus Grounds and Forests

Greater integration of our forest properties into the Campus as Living Laboratory will help to ensure the participation of the broader full university community.

Offsets

Rutgers could consider a partnership with local communities for urban forestry that would also engage students and faculty, particularly if we became a member of the Offset Network and chose to utilize the peer verification approach as previously described. This strategy would engage students, faculty, staff, and communities adjacent to our campus and nearby. For example, the Offset Network Peer Review committee recommends that projects remain local (i.e., within 100 miles) of the developing institution.

Another strategy could be a program to offset university related travel (students, faculty, staff, athletics) similar to those employed at other universities where a fund is established to support offset programs by collecting a flat fee for every round trip airline journey. For example, Arizona State University purchases sufficient offsets annually in order to offset air travel that is related to university business (faculty and staff travel, athletic travel, study abroad travel). The purchases are financed through ASU's carbon fund, which is supported by a $12 flat fee applied to any round-trip university airline travel (C. Hawkey, personal communication, 2020).

In another example, an academic institution, 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 with Duke combined resources 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.

Other strategies could include an idea for addressing campus emissions through natural carbon sinks has been proposed by the nonprofit organization, Zerofoodprint (Zero Foodprint & Myint, 2020). In this approach, a local carbon farming project would be conducted to enhance soil health on university land or a farm that is within the university's supply chain to offset emissions from campus dining. The annual costs for the project could be borne voluntarily by student diners and calculated by aligning the cost of each ton of carbon removal from the carbon farming project with the carbon footprint of a year's worth of dining per student per year or by imposing a flat surcharge. Students could opt in on their annual dining plan (A. Myint, personal communication, 2020).

5.3.11. Contribution to Climate-Positive, Equitable, Sustainable Economic Development

Campus Grounds and Forests

The involvement of the University in carbon sequestration-climate resilient vegetation management activities will serve to provide hands-on educate students in the process. Designing, implementing and validating carbon offset credit programs will serve to provide hands-on educate students in the process. With New Jersey's membership in the Regional Greenhouse Gas Initiative, there should be a growing job market in this arena.

Offsets

Any offsets purchased or developed by Rutgers University should be climate-positive if procured or developed in a transparent framework such as through appropriate peer reviewed protocols and standards and verified by a third party as noted above. In addition to PAVER requirements, where appropriate, the University can also include a project buffer pool in its project accounting. Buffer pools serve as an insurance mechanism, typically in forestry and land use project types, to protect against a shortfall in predicted offset credits (Duke Carbon Offsets Initiative & Offset Network, 2017; The Carbon Offset Research and Education Program, 2020) In the event of a forest fire or severe drought, which could reverse emissions, credits can be supplemented via a sufficiently-sized buffer pool (The Carbon Offset Research and Education Program, 2020). For instance, if a given project is expected to yield 100 credits (100 tons CO_2e) but yields only 80 credits due to a natural disturbance, a portion of the project buffer credits can be utilized to meet accounting goals.

Furthermore, if the cost of an offset program at Rutgers University would be distributed evenly across the university community, no single group of university community members would be expected to bear the cost of offsetting the university's emissions. Rutgers can also ensure equitability through co-benefits of urban forestry offset projects which can be developed as well as implemented through external stakeholder engagement. As previously stated, 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.

5.3.12. Equity Concerns

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).

Although social benefits are taken into account by the Duke Urban Forestry Protocol, the Offset Network has not explicitly tackled equity (R. Woodside, personal communication, 2020). As previously stated, some university-based urban forestry and bundling projects are typically run in historically underserved communities; however these are not the only types of offset projects that are developed or purchased by universities. Carbon offset projects could and should be undertaken in off-campus neighborhoods in nearby urban areas such as New Brunswick, Camden and Newark.

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).

Rutgers could explore establishment of criteria for offsets that address co-benefits including equity criteria for evaluation of offset or carbon sink protocols it develops or offsets that it purchases. For example, 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).

APPENDIX A – References

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

Actions	Cornell	Michigan	Ohio State	Illinois	Mary land	Washington	Oregon State	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					