

22 Soil Temperature and Anthropogenic Soils

Soil Temperature Study for New York City

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1. Introduction and objectives

Efforts to publish soil temperature data as part of a progressive soil survey within the Natural Resources Conservation Service for the United States Department of Agriculture have generally been unsuccessful in the past 100 years (NRCS Soil Climate Team, 1995). With the advent of automated data collection technology such as StowAway temperature loggers, the process of collecting and analyzing large amounts of data has been simplified.

Some of the parks in New York City have been soil surveyed and published without temperature data (Hernandez, 1997). Additional areas such as Central Park in Manhattan and the Gateway National Recreational Area in Brooklyn are currently being mapped with a concerted interest in capturing the temperature signature of anthropogenic soils. Consequently, the objectives for the New York City temperature study included –

- 1) Measuring the daily air and soil temperature at four sites in New York City to incorporate into future soil survey publications,
- 2) Testing hypotheses on the conjectured temperature signature at each site, and
- 3) Verifying the presence or absence of an exothermic effect of the Greatkills soil at a 60-acre landfill site in Latourette Park on Staten Island.

The soil temperature study in New York City is part of the NRCS Remote Soil Temperature Network (RSTN). The RSTN was established in 1996 as a part of the USDA-NRCS Global Change Initiative. Projects initiated during 1996 include studies in Tennessee, South Carolina, West Virginia, St. John Island in the Virgin Islands, Iowa, and Illinois. In 1997, temperature studies were designed for Idaho, Missouri, Nebraska, New Hampshire, western and central New York, New York City, North Carolina, Vieques Island off Puerto Rico, Wyoming, and Virginia. In 1998, additional units have been installed in Arizona, Arkansas, California, Colorado, the Big Island of Hawaii, Illinois, Nebraska, New Jersey, New York, North Carolina, Pennsylvania, Nevada, Florida, Tennessee, and Washington. Locations of about 150 sites are georeferenced for GIS presentation (Fig. 1).

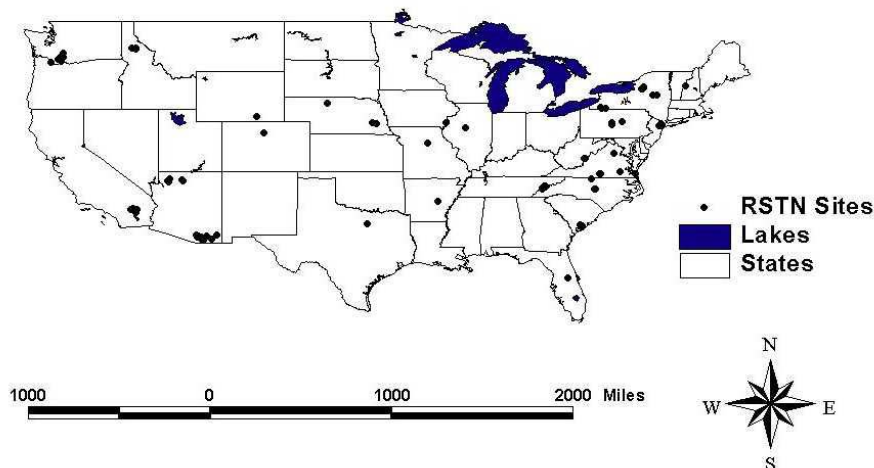


Figure 1. Location of sites in the Remote Soil Temperature Network.

2. Study area and annual weather

The study area is in New York City. New York City is the largest city in the United States of America and is home to eight million people. Its Manhattan skyline is one of the most recognized of any city in the world. Two soils in Manhattan’s Central Park and two soils in Staten Island’s Latourette Park were targeted for installation. Soil and ecosystem characteristics for each site are presented in table 1 (Hernandez, 1997). The location of the sites in New York City is displayed in ArcView layout form in figure 2. Site 5 in Brooklyn has not completed collecting data for one year; therefore, findings are not presented for that location.

Table 2. Soil and Ecosystem Characteristics of the Temperature Sites in New York City.

Attribute	NY City Site # 1	NY City Site # 2	NY City Site # 3	NY City Site # 4
Park Name	Central Park	Central Park	Latourette Park	Latourette Park
Ecosystem	Woods	Playground	Woods	60-yr old Landfill
Elevation	~40 ft	~25 ft	~20 ft	~20 ft
Slope	17%	1%	15%	2%
Aspect	340°	275°	280°	360°
GPS Latitude	N 40-47-41	N 40-47-22.1	N 40-34-23	N 40-34-13.65

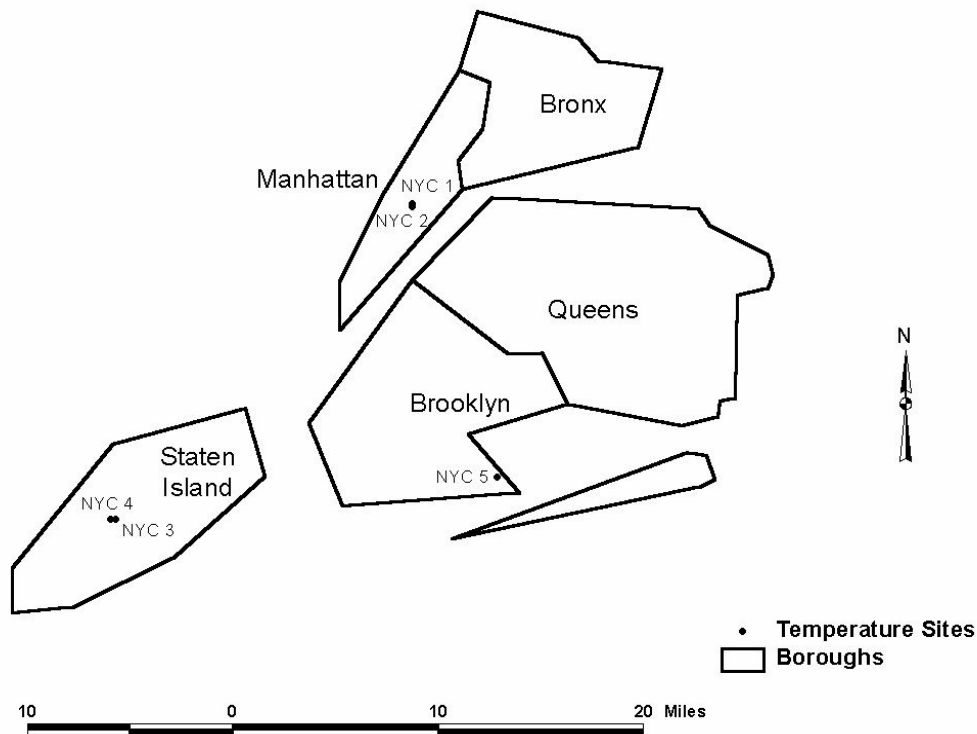


Figure 2. Location of temperature sites in New York City.

The 30-year normal precipitation and air temperature data for three stations in New York City are summarized in table 2. These values represent averages for the period of record from 1961 to 1990. The warmest month on average in New York City is July and the coldest month is January. The distribution of precipitation is nearly equal in all months of the year. On average, there will be 70 to 75 days a year with 0.1 inch or more of precipitation.

Table 2. Thirty-year Normal (1961-1990) Weather Data for New York City

Borough (Name)	Air Temperature (°F)	Precipitation (Inches)	Total Snowfall (Inches)	Growing Season (Days)
Central Park	54.7	47.1	23.5	224
Staten Island	53.7	47.8	29.0	205
Brooklyn	54.6	45.1	23.9	226

3. Materials and methods

StowAway temperature loggers store 1,800 data points from periods ranging from 15 minutes to 360 days. Their certified temperature threshold is $\pm 0.7^{\circ}\text{F}$ ($\pm 0.4^{\circ}\text{F}$). Prior to installation of the four sites in New York City, StowAway temperature loggers were programmed to collect data every 4 hours and 48 minutes for 360 days. This frequency is the same as five times each day.

At each site, a 9-in PVC pipe with a 4-in housed three StowAway temperature loggers and a desiccant pack to absorb excess moisture. Holes drilled in the PVC pipe allow 6-ft sensor leads to exit outside while the temperature loggers are protected from the weather elements. These PVC pipes were installed at four sites in the study area on June 26, 1996.

A hole was dug with a sharpshooter to a depth of 20 in (50 cm) at each site. Site data were then collected and the soils were briefly examined to gather a taxonomic classification. Except for the playground area in Central Park, one temperature sensor lead was tied to a tree sapling to capture air temperature and was generally placed from two to three feet above the soil surface. Two soil temperature sensor leads were installed at each site - one at the 4-in soil depth and one at the 20-in soil depth. Finally, the PVC pipe was buried at about 4 inches and covered with soil. The unvegetated playground in Central Park mandated a slightly different protocol. At that site, only soil temperature sensors could be installed and they were placed at 8 in (20 cm), 15 in (38 cm), and 20 in (50 cm) to collect data.

After retrieval of the temperature loggers, data were off-loaded on July 8, 1998 in New York City. Once off-loaded, the temperature signatures were examined for each site. Electronic failure of three temperature loggers resulted in loss of some data in the study area; however, the nine operative loggers collected more than 16,000 readings for this study. Temperature data were averaged by month for each of the sites and an annual mean was then determined and graphed using Microsoft Excel software. In addition to an annual mean, the Mean Summer Temperature (MST) and the Mean Winter Temperature (MWT) were calculated to access the extreme seasonal variation at each of the sites.

4. Results of temperature data

4.1. Central Park

Figures 3 and 4 show the temperature signatures and table 3 displays the monthly averages for the two sites in Central Park. The Mean Annual Soil Temperature (MAST) averaged 5.6°F (3.1°C) warmer at the playground area than the wooded area for the deeper depths. The differences between the Mean Summer Temperature (MST) and the Mean Winter Temperature (MWT) were greater at the playground area. These data suggest a greater difference between the MAST in adjacent ecosystems (vegetated versus unvegetated) than hypothesized.

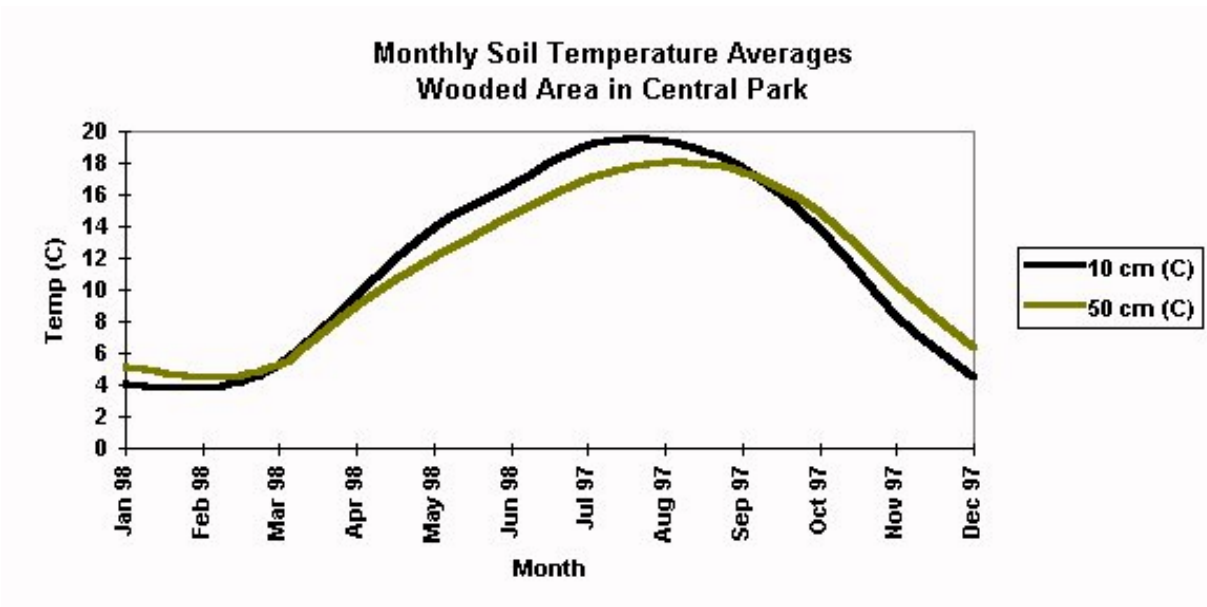


Figure 3. Monthly averages for soil temperature for a wooded area in Central Park. The annual soil temperature at 10 cm (4 in) was nearly the same as the annual soil temperature at 50 cm (20 in).

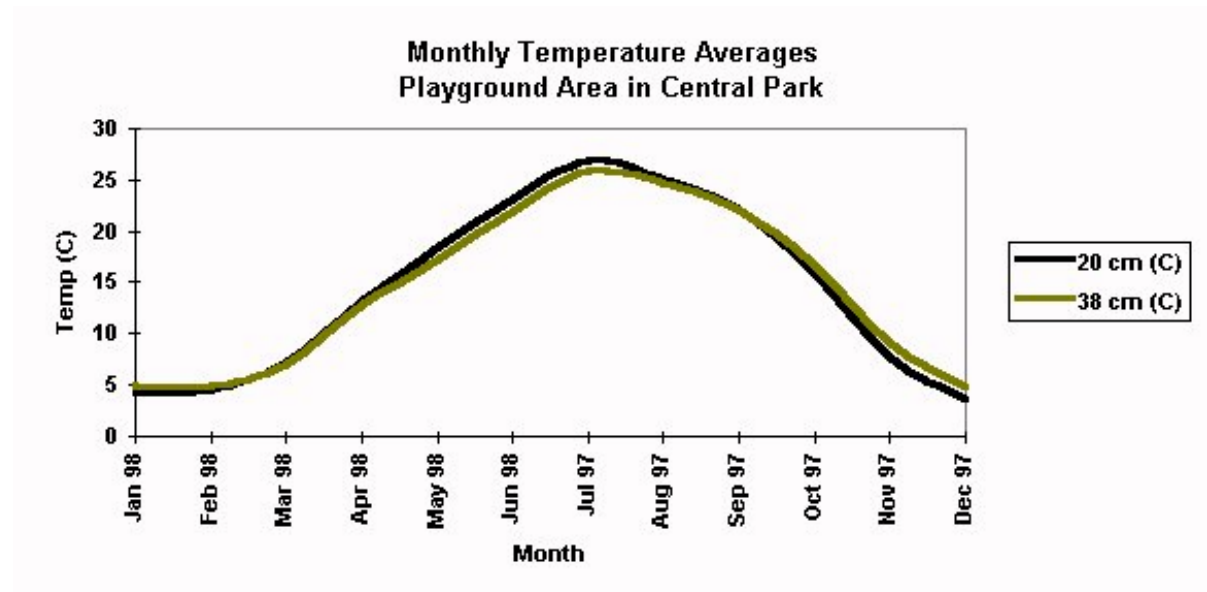


Figure 4. Monthly averages for soil temperature of a playground in Central Park. This site averaged 3.13°C (5.63°F) warmer than the adjacent wooded area in Central Park.

Table 3. Monthly Temperature Averages for Two Sites in Central Park.

Month	Woods		Playground	
	10 cm (°F)	50 cm (°F)	20 cm (°F)	38 cm (°F)
Jan 98	39.5	41.4	39.6	40.9
Feb 98	38.9	40.1	40.4	41.1
Mar 98	41.7	41.6	45.0	44.8
Apr 98	49.5	48.2	55.9	55.1
May 98	57.2	53.8	65.5	63.3
Jun 98	62.1	58.6	73.6	71.5
Jul 97	66.7	62.8	80.5	78.6
Aug 97	67.0	64.6	77.5	76.5
Sep 97	63.9	63.4	71.9	71.9
Oct 97	57.0	58.8	60.8	62.3
Nov 97	47.2	50.7	46.0	48.6
Dec 97	40.1	43.5	38.5	40.7
Annual Mean	52.5	52.3	57.9	57.9
MST - MWT	25.8	20.3	37.7	34.6

4.2. Latourette Park

Figure 5 shows the temperature signatures and table 4 displays the monthly averages for the two sites in Latourette Park. The MAST averaged 53.7°F (12.0°C) for the 4-in (10-cm) depth in the woods versus 73.9°F (23.3°C) for the 20-in (50-cm) depth at the landfill. The MAST at the landfill is 11.3°C (20.2°F) warmer than in the adjacent woods. The differences between the Mean Summer Temperature (MST) and the Mean Winter Temperature (MWT) for the 10-cm soil depths were also greater at the landfill area. The exothermic sources at the landfill site have dramatically increased the MAST for the 50-cm soil depth over the wooded area to the degree that the Greatkills soil has a hyperthermic soil temperature regime (Soil Survey Staff, 1996).

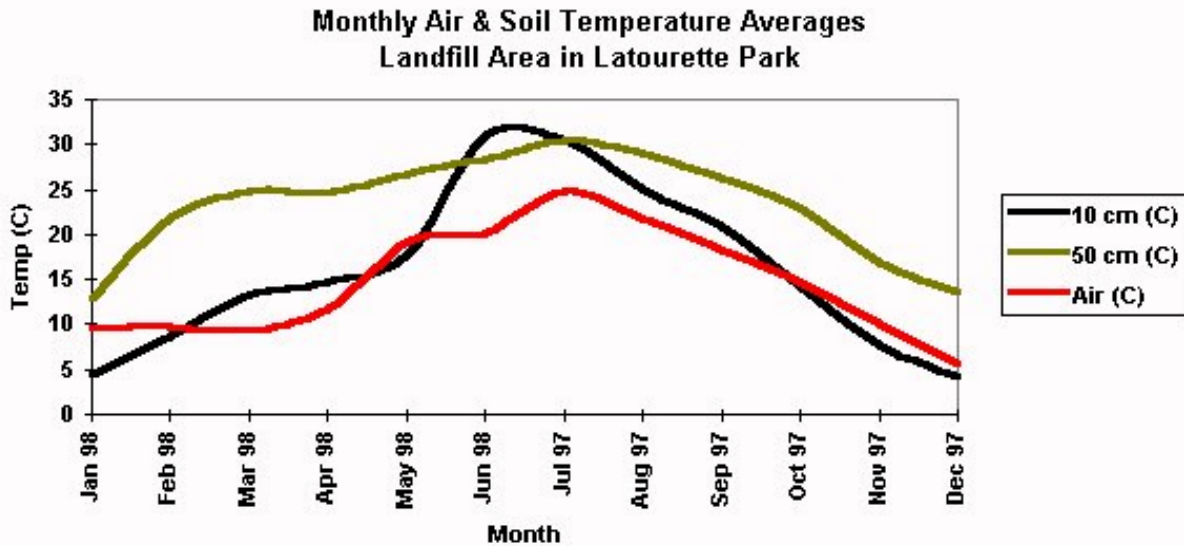


Figure 5. Temperature averages for the landfill in Latourette Park on Staten Island. Both the air and soil temperatures are warmer here due to exothermic activity.

The mean annual air temperature was greater at the landfill site than in the adjacent woods. It is conjectured that excess exothermic heat rising from the landfill has mixed with the ambient air temperature to increase the monthly averages, particularly during the winter season (table 4). This difference is not typical for adjacent vegetated versus unvegetated ecosystems. Data from a recent study in western Illinois suggests the air temperature difference between adjacent ecosystems do not differ by more than 0.4°F (0.2°C) in natural environments (Mount, 1998. Unpublished data).

Air and soil temperature data from this study have been posted on the NRCS Global Change HomePage. The internet address to access monthly averages at all of the sites is <http://www.statlab.iastate.edu:80/soils/nssc/>.

Table 4. Monthly Temperature Averages for Two Sites in Latourette Park.

Month	Woods 4 Inches (°F)	Woods Air (°F)	Landfill 4 Inches (°F)	Landfill 20 Inches (°F)	Landfill Air (°F)	
Jan 98		42.0	40.0	40.2	55.4	49.2
Feb 98		41.3	40.1	47.6	71.3	49.6
Mar 98		44.0	44.8	56.2	76.7	48.9
Apr 98		51.3	53.0	58.8	76.3	53.3
May 98		57.6	61.4	64.2	80.0	66.7
Jun 98		62.3	66.1	87.7	83.2	68.5
Jul 97		67.2	73.2	87.2	87.1	76.9
Aug 97		67.0	70.0	77.3	84.3	71.3
Sep 97		64.2	64.6	69.5	79.5	65.0
Oct 97		56.9	54.9	57.8	73.4	58.7
Nov 97		48.3	43.7	45.8	62.4	50.4
Dec 97		41.9	37.8	39.4	56.7	42.2
Annual Mean		53.7	54.1	61.0	73.9	58.4
MST-MWT		23.8	30.5	41.6	23.7	25.2

5. Conclusions

Anthropogenic activity in New York City has increased the MAST. The unvegetated playground in Central Park is 5.63°F (3.13°C) warmer than an adjacent wooded area. The MAST of the Greatkills soil in the 60-year old landfill area on Latourette Park is impacted by exothermic activity. The MAST for the Greatkills soil is 20.20°F (11.22°C) warmer than in the adjacent woods and its soil temperature regime is hyperthermic (Soil Survey Staff, 1996). This, along with the increase of the air temperature, results in a microclimate at the landfill area of Staten Island that contributes inputs to global warming.

Acknowledgments

The authors wish to acknowledge Rob Tunstead, NRCS Soil Scientist for the New York City Soil Survey, for his able assistance in the installation and data retrieval process of this Global Change Study. We also acknowledge John Kimble, Research Soil Scientist and Global Change Coordinator for the NRCS at the National Soil Survey Center in Lincoln, Nebraska for supporting this study with Global Change funds. Richard Kruzanski, Director of Soil and Water Conservation, Central Park is acknowledged for his assistance in retrieving the data loggers at the playground area on July 7, 1998. Without his diligence, there would have been much less data to present.

References

- Hernandez, L.A. 1997. *Soil Survey of South Latourette Park, Staten Island, New York City, NY*. USDA-NRCS. Syracuse, NY.
- NRCS Soil Climate Team. 1995. *Distribution of Soil Climate Stations for the United States*. USDA, NRCS.

Soil Survey Staff. 1996. *Keys to Soil Taxonomy, Seventh Edition*. USDA-NRCS. Washington, D.C. ISBN 0-16-048848-6.

Appendix I – OSED and Laboratory Data for the Greatkills Soil

LOCATION GREATKILLS NY

Tentative Series

JMG-LAH-STS 04/1999

GREATKILLS SERIES

The Greatkills series consists of very deep, well drained soils. These soils formed in a mixture of household garbage, construction debris and other discarded materials layered with anthrotransported natural soil materials. The soil has a mantle of anthrotransported natural soil materials 10 to 30 inches thick and occurs in landfills on artificial landscapes in and near major urbanized areas of the Northeast. Permeability is moderate or moderately slow. Slope ranges from 0 to 15 percent. Mean annual temperature is about 79 degrees F. and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Loamy-skeletal, mixed, active, nonacid, hyperthermic Typic Udorthents

TYPICAL PEDON: Greatkills coarse sandy loam in a broad, slightly dome-shaped revegetated landfill on a 5 percent slope. (Colors are for moist soil unless noted differently.)

A -- 0 to 2 inches; dark brown (7.5YR 3/2) coarse sandy loam; weak medium granular structure; very friable; many very fine and fine plus common medium and coarse roots; common coarse 3/4 inch thick, hollow Phragmites rhizomes; 10 percent gravel rock fragments; neutral; abrupt smooth boundary. (1 to 7 inches thick)

Bw -- 2 to 7 inches; dark reddish brown (5YR 3/4) gravelly coarse sandy loam; weak medium subangular blocky and platy structure; friable; common fine roots; common coarse rhizomes; 20 percent gravel rock fragments; neutral; clear wavy boundary. (3 to 8 inches thick)

BC -- 7 to 12 inches; dark reddish brown (5YR 3/4) gravelly coarse sandy loam; weak medium platy structure; firm; few very fine roots; common coarse rhizomes; 20 percent gravel rock fragments; 5 percent pieces of broken glass bottles; neutral; clear wavy boundary. (3 to 8 inches thick)

2C -- 12 to 80 inches; dark brown (7.5YR 4/4) extremely cobbly loam; massive; friable; few medium and coarse roots; few coarse rhizomes to a depth of 60 inches; 5 percent cobble rock fragments; 15 percent decomposable cobble-sized coarse fragments such as wood, iron, cardboard, and paper; 40 percent non-decomposable cobble-sized coarse fragments such as bricks, concrete, rugs, plastic bags, glass bottles, plastic toys and objects, and rubber pipes; few stone-sized coarse fragments of concrete and tires; neutral; clear smooth boundary.

TYPE LOCATION: Richmond County, New York: From the intersection of Richmond Avenue and Forest Hill Avenue, 600 feet northeast on Forest Hill Avenue, 266 feet southeast on an unnamed road in the Brookfield landfill, 200 feet northeast, then 10 feet west; USGS Arthur Kill topographic quadrangle; latitude 40 degrees 34 minutes 14.85 seconds North and Longitude 74 degrees 10 minutes 02.28 seconds West (Rockwell GPS Receiver); NAD 1983.

RANGE OF CHARACTERISTICS: The thickness of the landfill materials is generally more than 5 feet thick. The transported material may be any geologic deposit ranging from glacial till, glacial outwash, alluvium, coastal plains sediments, or residuum. The transported natural soil cap over the upper garbage layer ranges from 7 to 24 inches. The solum is 7 to 23 inches. Rock fragments range from 1 to 30 percent, and the textures are sandy loam, loam or silt loam or their gravelly analogs. Most pedons have lithochromic mottles in the fill cap. Reaction ranges from strongly acid to neutral in unlimed areas and from slightly acid to slightly alkaline in areas that have been limed.

The A or Ap horizon has hue of 10YR through 2.5YR, value of 3 or 4, and chroma of 2 through 4. Structure is granular or subangular blocky. Consistence is very friable to friable.

The Bw horizons have hue of 10YR through 2.5YR, value of 3 through 6, and chroma of 2 through 8. Structure is commonly subangular blocky or fine platy, and fine roots are common to many. Consistence is very friable to friable.

Some pedons contain BC horizons that are friable or firm with platy structure. They are mechanically compacted, but are not root-limiting. Roots grow between but not through the peds. The rest of the properties are similar to the Bw horizons.

The C horizons in the soil cap have hue of 10YR through 2.5YR, value of 3 through 6, and chroma of 2 through 8. Structure is platy or massive. Consistence is friable to firm. Some pedons have layers that are dense and root-limiting.

The 2C layers of garbage contain transported soil and rock material as well as household waste, paper, cardboard, plastic, glass, rubber, leather, carpet, clothing, shoes, organic waste, tires, unburned coal, and plastic bags. There is a smaller component of construction materials such as gypsum board, concrete, brick, lumber, steel, and asphalt, plus small amounts of coal ash. Household objects range from gravel to stone-sized, and construction materials range from gravel to boulder-size. There is a distinction between materials that will hold water and allow roots to penetrate, and will decompose versus those that will act like a rock fragment. Examples of rock-like fragments are glass, plastic, rubber, tires, and construction debris (except lumber). Generally, the earthy fill is similar to the soil cap over the uppermost garbage layer. Texture of the transported material ranges from loamy sand to silt loam. Rock fragments (natural and manufactured) range from 35 to 75 percent. Reaction ranges from strongly acid through moderately alkaline. Consistence is loose to firm. Some intermittent layers or materials such as plastic act as a barrier to root and water movement.

COMPETING SERIES: There are no competing series in the same family.

GEOGRAPHIC SETTING: Greatkills soils are on nearly level to gently sloping artificially created landforms in landfills. These soils formed in a mixture of household garbage and transported soil material, with a cap of transported soil material that is relatively clean of refuse. The transported soil material is dominantly from locally excavated upland materials such as alluvium, weathered till and outwash, Tertiary-aged marine sediments, or coastal plains sediments. Dominant rock fragments are human manufactured items with smaller amounts of sedimentary and metamorphic rocks, basalt, and quartzite pebbles. Slope ranges from 0 to 35 percent. Mean annual precipitation ranges from 40 to 50 inches. Mean annual temperature ranges from 61 to 85 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are Canarsie (proposed), Centralpark (proposed), Foresthills (proposed), and Greenbelt (proposed) soils. These soils do not have garbage in the control section.

DRAINAGE AND PERMEABILITY: Well drained. The potential for surface runoff is low to medium on vegetated slopes less than 8 percent, and high to very high on vegetated slopes 8 percent and greater. The potential for surface runoff is one class higher where the soil is unvegetated or the surface is poorly protected from erosion. Permeability is moderate in areas where the soil cap has not been compacted, but is moderately slow where it has been compacted and has platy structure.

USE AND VEGETATION: These soils are generally covered with common reed and mugwort. The reed density decreases and the mugwort increases in areas with compacted surface layers. The more compacted areas support sparse populations of various grasses, annuals, and perennials that invade disturbed areas. A few hardwoods such as black locust, tree of heaven, black cherry, and boxelder become established in areas that do not burn too frequently. Reclamation is unlikely in areas where the soil cap is less than two feet thick, where stones or garbage occur on the surface, or where common reed is unmanaged. Recreational use is also unlikely under those conditions.

DISTRIBUTION AND EXTENT: These soils occur on modified landscapes in and near major urbanized areas of the Northeastern United States. MLRA 144A and 149B. The soils of this series are small extent.

MLRA OFFICE RESPONSIBLE: Amherst, Massachusetts

SERIES PROPOSED: Richmond County, New York, 1995.

REMARKS: (1) Lithochromic mottles have inherited their colors from rocks.

(2) Complete characterization data collected for the soil cap as pedon S95NY085-006. Lab data is not available on the garbage subsoil because of possible hazardous material content.

(3) Manufactured objects that act like rock and coarse fragments make up more than 80 percent of the total rock fragments in the particle-size control section (10-40 inches). Transported soil makes up about one-third of the volume of the soil/garbage mixture.

(4) The transported soil materials are nearly always from Dystrochrepts; however, the nature of the garbage (concrete, gypsum) may weather into a soil that has properties of Typic or Dystric Eutrochrepts.

(5) Ground Penetrating Radar (GPR) and Electromagnetic Induction (EM38 and EM31) data is available.

(6) Many landfill areas were unregulated at the time of filling and may contain chemicals that are toxic to plant roots. In addition, some areas develop anaerobic conditions in the subsoil due to methane gas emissions. Field observations suggest that many pedons contain pockets of air where organic garbage has decomposed, and are subject to collapse under heavy equipment.

(7) One year soil temperature data is available for 4 inch and 20 inch depths.

(8) The internal soil temperature has been modified by high levels of biological activity and garbage undergoing rapid decomposition. The classification as hyperthermic is debatable. Lab data supports the hyperthermic soil temperature classification. The area would typically be mesic.

Diagnostic horizons and features recognized in this pedon are:

a. Ochric epipedon - the zone from 0 to 2 inches (A horizon).

National Cooperative Soil Survey
U.S.A.

S95NY-085-006 *** PRIMARY CHARACTERIZATION DATA ***
 (RICHMOND COUNTY, NEW YORK)

PRINT DATE 08/21/02

SAMPLED AS : GREATKILLS ;
 REVISED TO :

SSL - PROJECT 96P 32, (CP96NY084) NEW YORK CITY
 - PEDON 96P 167, SAMPLES 96P 1361- 1363
 - GENERAL METHODS 1B1A, 2A1, 2B

UNITED STATES DEPARTMENT OF AGRICULTURE
 NATURAL RESOURCES CONSERVATION SERVICE
 NATIONAL SOIL SURVEY CENTER
 SOIL SURVEY LABORATORY
 LINCOLN, NEBRASKA 68508-3866

-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20

SAMPLE NO.	DEPTH (CM)	HORIZON	(- - -TOTAL - - -)(- -CLAY- -)(- -SILT- -)(- - - - -SAND- - - - -)(-COARSE FRACTIONS(MM)-)(>2MM)										(- - - - -WEIGHT - - - - - WT							
			CLAY LT	SILT .002	SAND .05	FINE LT	CO3 LT	FINE .002	COARSE .02	VF .05	F .10	M .25	C .5	VC 1	2	5	20	.1- PCT OF		
96P1361S	0- 5	A	9.9	28.3	61.8				15.8	12.5	8.9	16.9	17.5	12.4	6.1	8	5	29	73	42
96P1362S	5- 18	Bw1	11.4	27.5	61.1				16.4	11.1	8.6	14.2	15.6	12.1	10.6	11	17	27	79	55
96P1363S	18- 30	BC	10.5	29.4	60.1		0.7	16.9	12.5	8.5	15.5	17.4	12.1	6.6	16	25	19	81	60	

DEPTH (CM)	ORGN C	TOTAL N	EXTR P	TOTAL S	(- - DITH-CIT - -)(RATIO/CLAY)(EXTRACTABLE)				(- BULK DENSITY -) COLE (- - -WATER CONTENT - -) WRD											
					FE	AL	MN	CEC	BAR	LL	PI	MOIST	BAR	DRY	SOIL	MOIST	BAR	BAR	BAR	SOIL
0- 5	6A1c	6B4a	6S3b	6R3c	6C2b	6G7a	6D2a	8D1	8D1	4F1	4F	4A5	4A1d	4A1h	4D1	4B4	4B1c	4B1c	4B2a	4C1
5- 18	1.36	0.117	1	1.6	0.1	0.1	0.88	0.56												6.4
18- 30	1.49	0.097	8	2.1	0.1	0.1	0.84	0.59												6.2

*** PRIMARY CHARACTERIZATION DATA ***

S95NY-085-006
 SAMPLED AS : GREATKILLS ;
 USDA-NRCS-NSSC-SOIL SURVEY LABORATORY ; PEDON 96P 167, SAMPLE 96P 1361- 1363

PRINT DATE 08/21/02

-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20

DEPTH (CM)	(- NH4OAC EXTRACTABLE BASES -)				ACID-EXTR	SUM	(- - - -CEC - - -)			AL	-BASE SAT-	SAT-	CO3 AS RES.	COND.(- - - -PH - - -)	MMHOS	CACL2	H2O
	CA	MG	NA	K			AL	SUM	NH4-								
0- 5	5B5a	5B5a	5B5a	5B5a	6H5a	6G9c	5A3a	5A8b	5A3b	5G1	5C3	5C1	6E1g	8E1	8I	8C1f	8C1f
5- 18	11.6	4.3	--	1.6	17.5	4.4	21.9	16.3		80	100	TR				6.2	6.5
18- 30	5.8	3.0	0.1	0.9	9.8	2.3	12.1	10.0		81	98					6.4	6.9

ANALYSES: S= ALL ON SIEVED <2mm BASIS

*** PRIMARY CHARACTERIZATION DATA ***

S95NY-085-006

(RICHMOND COUNTY, NEW YORK

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-1-- -2-- -3-- -4-- -5-- -6-- -7-- -8-- -9-- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20

SAMPLE NO.	HZ NO	ACID OXALATE EXTRACTION				PHOSPHOUS		KCL	TOTAL	(- -WATER CONTENT- -)				(- - - WATER DISPERSIBLE - - -)				MIN	AGGRT
		OPT DEN	FE	SI	AL	RET	ACID			CIT- MN	C	0.06	1-	2-	15	<- - PIPETTE - - >< - HYDROMETER - >	<- - - SML - - - >		
96P1361	1	0.06	0.36	0.03	0.05			4.84											
96P1362	2	0.08	0.37	0.04	0.05			1.51											
96P1363	3	0.06	0.72	0.06	0.07			2.13											

Effect of Whole Tree Harvesting and the Soil Temperature Regime Butte DEMO Unit 4 Research Area, Gifford Pinchot National Forest

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Abstract

This study was conducted to measure the effects of clearcutting on soil temperature in the Gifford Pinchot National Forest of Washington. A soil at a control site (site 4) has the coldest mean annual soil temperature at 9.1°C, followed by the soil at a wooded site (site 1 at 11.2°C), and then the soil at a clear-cut edge (site 2 at 12.3°C). Data infer that clear-cut site (site 3) is 2.5°C to 6.6°C warmer during July than the other three sites. In August, this difference is tempered and the difference ranges from 0.8°C to 5.7°C warmer than the other three sites. Site 2 at a clear-cut edge was the only location to freeze at 10 cm. One hundred percent of the possible data were captured for the 50-cm depth. The mean annual soil temperature at site 4 is 1.4°C colder than the clear-cut location at site 3, 1.4°C cooler than the edge location at site 2, and 0.8°C colder than the center of the aggregate retention cell at site 1. The soil temperature regime is frigid for sites 1 and 2 and cryic for site 3. Since the difference between the mean summer soil temperature and the mean winter soil temperature is only 5.9°C, site 4 is isofrigid. This soil at site 4 (1,160 meters) is also close to being cryic – one that has a mean summer soil temperature of less than 8°C. The impact of clear-cutting on soil temperature was similar between sites 2 and 3. Though the cutover area at site 3 has a warmer mean annual soil temperature than site 2 (7.0°C vs. 6.3°C), the MST is actually warmer at the clear-cut edge site than site 3 (12.6°C vs. 12.3°C). This indicates that the soil temperature increases at the edge of a clearcut and not some distance away. MWT is coldest at the border of the clearcut in this study. However, it is suggested that this edge warming in the DEMO Unit 4 Research Area is due, in part, to lower snowfall amounts than at the other sites.

1. Background

The temperature regimes for soils in eastern Washington are driven by elevation and aspect dependency. Currently, the division between the frigid and cryic temperature regime is about 1,066 meters. Areas with large snowfall amounts in Washington previously had little or no soil temperature information during winter months. With the advent of datalogging technology, a study was designed for Butte DEMO Unit 4 Research Area in the Gifford Pinchot National Forest. The effects of clearcutting on soil temperature have not been well understood. The study area assesses these impacts.

2. Butte DEMO Unit 4 Study Area Sites

Four sites were installed to measure air and soil temperature in the Butte DEMO Unit 4 Research Area of the Gifford Pinchot National Forest (GPNF) on June 18, 1998. These sites are in the northern part of the Gifford Pinchot National Forest and are located in Skamania County, Washington, which is located in the southwest part of the state. Table 7.31.1 present information for the sites.

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Table 7.05.1. Site Information for the Temperature Study in the Gifford Pinchot National Forest

Site (No.)	Latitude (North)	Longitude (West)	Elevation (m)	Slope (%)	Aspect (°)	Canopy Cover (%)
1	46°22'53"	121°34'37"	1,097	55	120	60
2	46°22'51"	121°34'37"	1,088	52	110	60
3	46°22'49"	121°34'43"	1,113	45	140	0
4	46°22'54"	121°34'43"	1,158	72	130	60

Site 1 is 3.5 meters at an azimuth of 250° from grid point B8. It is 56 m from the edge of a clear-cut timber area. Vegetation consists of western hemlock (*Tsuga spp. L.*) overstory with an understory and ground cover of Oregon grape (*Mahonia aquifolium L.*) and Solomon's seal. The soil is a medial-skeletal, amorphic, superactive, frigid Vitric Hapludand (Soil Survey Staff, 1999).

Site 2 is 4.5 meters at an azimuth of 37° from red flag labeled 5B8306 and about 10 to 15 meters from the edge of a clear-cut timber area. Vegetation consists of western hemlock overstory with an understory and ground cover of Oregon grape (*Mahonia aquifolium L.*) and Solomon's seal. The soil is a medial skeletal, amorphic, superactive, frigid Vitric Hapludand.

Site 3 is 2.77 m at an azimuth of 30° from tree tag #2 and is in the middle of a clear-cut timber area. Western hemlock trees on this site have been harvested. Bracken ferns, ranging from five to ten percent, cover the soil. The soil is a medial-skeletal, amorphic, superactive, frigid Vitric Hapludand.

Site 4 is near the Lewis County line and 160 m at an azimuth of 20° from grid point A9. It is 7.6 meters upslope from a vertical cliff that is difficult to navigate. Vegetation consists of Douglas-fir (*Pseudotsuga spp. L.*), pacific silver fir (*Abies spp. L.*), and western red cedar (*Juniperus spp. L.*) overstory with an understory and ground cover of vine maple and Solomon's seal. The soil at site 4 is a medial-skeletal, amorphic, superactive, frigid Vitric Haplocryand.

3. Results

Soil temperature at 10 cm. Table 7.31.1 reveals that control site 4 has the coldest MAST at 9.1°C, followed by the wooded site 1 (11.2°C), and then clear-cut edge site 2 (12.3°C). Though only two complete months of data (July and August 1998) are available, they infer that clear-cut site 3 is 2.5°C to 6.6°C warmer during July than the other three sites. In August, this difference is tempered and the difference ranges from 0.8°C to 5.7°C warmer than the other three sites. Site 2 was the only location to freeze at 10 cm.

Table 7.31.1. Monthly and Annual Analyses of Temperature Data (°C) for the 10-cm depth.

Analysis	Site 1	Site 2	Site 3	Site 4
Jan 99	0.5	0.3	--	0.7
Feb 99	0.6	0.3	--	0.8
Mar 99	0.5	0.0	--	0.5
Apr 99	0.5	1.1	--	0.4
May 99	2.3	4.9	--	0.8
Jun 98 & 99	8.0	8.4	--	6.0
Jul 98	14.7	15.5	18.8	12.2
Aug 98	15.2	16.9	18.1	12.4
Sep 98	13.9	15.3	--	11.6
Oct 98	7.3	8.3	--	6.1
Nov 98	3.1	2.8	--	2.4
Dec 98	0.7	-0.3	--	0.7
MAST	11.2	12.3	--	9.1
MST	27.2	27.2	35.6	20.4
MWT	1.3	0.2	--	1.5
Isotivity	26.0	27.0	--	18.9

Soil temperature at 50 cm. One hundred percent of the possible data were captured for the 50-cm depth. The MAST for the control location at site 4 is 1.4°C colder than the clear-cut location at site 3, 1.4°C cooler than the edge location at site 2, and 0.8°C colder than the center of the aggregate retention cell at site 1 (Table 7.31.2). The soil temperature regime is frigid for sites 1, 2, and 3. Since the isotivity value is only 5.9°C, site 4 is isofrigid (Soil Survey Staff, 1999). This site at 1,158 meters is also close to being cryic – one that has a MST of less than 8°C.

Table 7.31.2. Monthly and Annual Analyses of Temperature Data (°C) for the 50-cm depth.

Analysis	Site 1	Site 2	Site 3	Site 4
Jan 99	1.7	0.9	2.4	2.3
Feb 99	1.8	1.1	2.7	2.1
Mar 99	1.5	0.8	2.6	1.7
Apr 99	1.4	1.2	2.1	1.5
May 99	2.0	4.7	2.6	1.6
Jun 98 & 99	6.5	8.3	9.0	5.0
Jul 98	11.2	14.1	13.3	9.3
Aug 98	13.1	15.4	14.7	10.6
Sep 98	12.7	14.4	14.1	10.4
Oct 98	8.6	9.2	10.7	7.2
Nov 98	5.1	4.3	6.4	4.4
Dec 98	2.5	1.1	2.9	2.8
MAST	5.7	6.3	7.0	4.9
MST	10.3	12.6	12.3	8.3
MWT	2.0	1.0	2.7	2.4
Isotivity	8.3	11.6	9.6	5.9

The differences in seasonal and annual changes among the four sites are visually shown in Fig. 7.31.1.

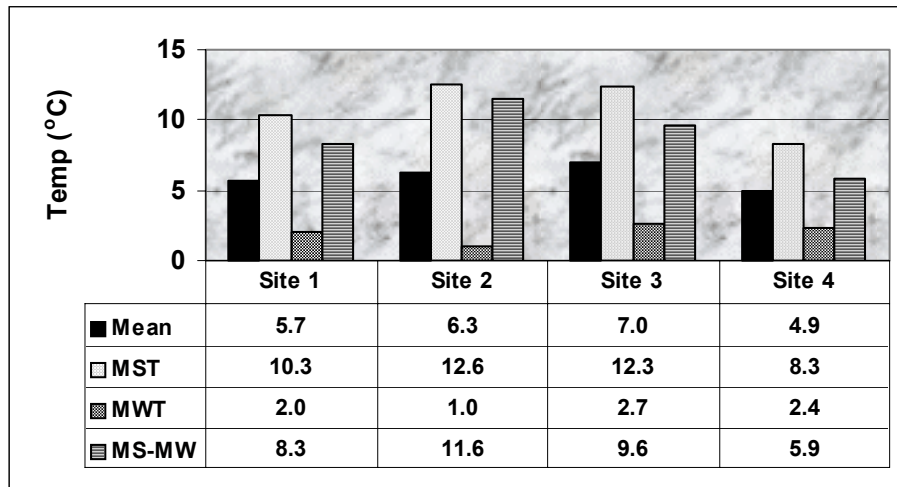


Figure 7.31.1. Seasonal and annual comparisons at 50 cm among the four sites in the Butte DEMO 4 area.

The impact of clearcutting was similar between sites 2 and 3 (Figure 7.31.1). Though the cutover area at site 3 has a warmer MAST than site 2 (7.0°C vs. 6.3°C), the MST is actually warmer at the edge area at site 2 than site 3 (12.6°C vs. 12.3°C). This indicates that the soil temperature, especially during the summer months, increases at the edge of a clearcut and not some distance away. Winter soil temperatures are also coldest at the border of the clearcut in this study.

Air temperature. However, it is suspected that this edge warming in the DEMO Unit 4 Research Area is due, in part, to conjectured lower snowfall amounts than at the other sites. Air temperature at site 2 indicates marginal impact from snow cover and soil temperature sensors captured diurnal fluctuation throughout the winter months. The air temperature sensors were placed at 1 m above the ground at all the sites for this study. One hundred percent of the data were captured for sites 1, 2, and 4. The summaries for analyses of air temperature data are presented in Table 7.31.3.

Table 7.31.3. Monthly, Seasonal, and Annual Analyses of Air Temperature Data (°C).

Analysis	Site 1	Site 2	Site 3	Site 4
Jan 99	-0.4	0.2	--	-0.9
Feb 99	-0.9	-1.0	--	-1.1
Mar 99	-0.3	0.7	--	-0.2
Apr 99	1.6	3.2	--	0.0
May 99	4.4	5.7	--	2.9
Jun 98 & 99	8.9	9.5	--	7.8
Jul 98	16.6	17.5	18.8	15.6
Aug 98	16.2	17.4	18.6	15.7
Sep 98	14.5	16.1	16.3	13.5
Oct 98	6.5	8.0	7.4	5.8
Nov 98	1.6	2.0	1.7	0.8
Dec 98	-2.4	-1.8	-2.1	-3.0
MAAT	5.5	6.5	--	4.8
MST	13.9	14.8	17.0	13.0
MWT	-1.2	--	-0.8	-1.7
Isotivity	15.1	--	17.9	14.7

Data from site 2 are contrasted by the flat-lining of data capture that occurred at site 4 during the winter months (Figure 7.31.2).

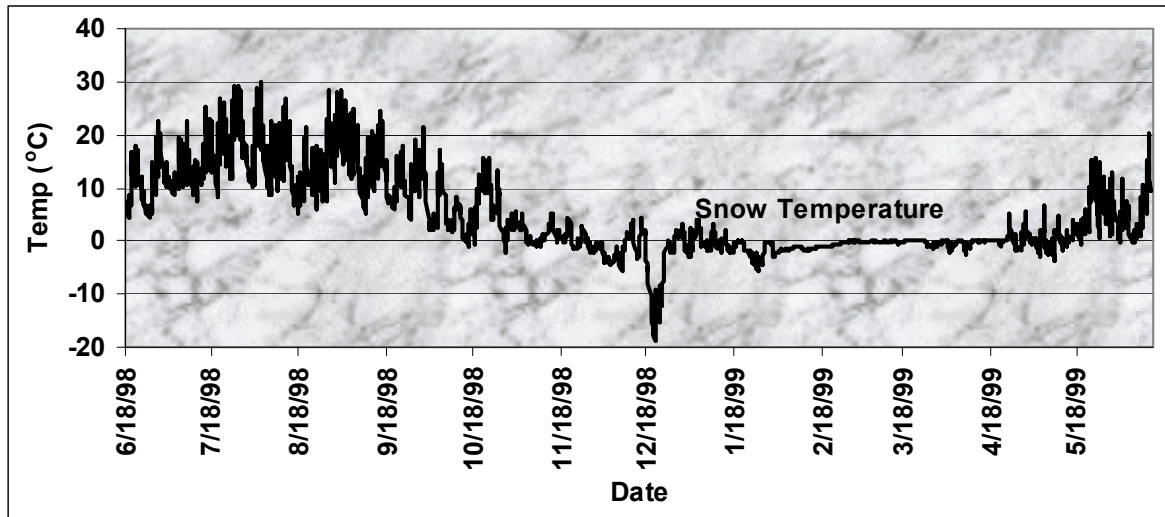


Figure 7.31.2. Impact of snowfall on air temperature at site 4.

Data for air temperature are mitigated by snow cover during the winter months. Consequently, the MWT and MAAT are expected to be somewhat colder than captured with the data loggers. Snowfall, covering the sensor at site 4, flat-lined to near 0°C during the winter. It was not until April 24, 1999,

when air temperature readings were recorded above freezing. Since the air temperature sensor at site 4 was still 1 meter above the forest floor when it was removed, it can be inferred that more than 1 meter of snowfall was covering the soil temperature sensor until April 24, 1999.

4. Discussion

The northern part of the Gifford Pinchot National Forest offers scientists unrestricted potential to assess soil temperature under controlled conditions. Since control site 4 was located with precise care and represents an ecosystem beyond the impacts of adjacent clearcutting, it can be inferred that there are measurable impacts of clearcutting on air and soil temperature. Soil temperature averages at 10 cm during July are 6.6°C warmer at clearcut site 3 than at control site 4. The 10-cm soil temperature for the clearcut location at site 3 reaches a maximum of 25.9°C on July 27 and 28, 1998. This is contrasted in the control location at site 4 where the 10-cm soil temperature peaks at 16.1°C also on July 27 and 28, 1998. Therefore, the 10-cm soil temperature at the cutover site is nearly 10°C warmer at its maximum than the 10-cm soil temperature at the control site.

Human activities changed the soil temperature regime from frigid to cryic at site 3. Though site 4 was borderline to cryic, sites 1 and 2 clearly have a frigid soil temperature regime. This study shows that human activities can change the soil temperature regime and it is correlated to vegetative cover.

This study also infers that a small (<2 ha) cell of uncut trees will also be impacted by a change in its air and soil temperature environment. The soil at site 1, in the middle of the aggregate retention cell, averages warmer temperatures than the soil at control site 4.

Acknowledgments

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