Modeling the Historical Disturbance Regimes of NYC

Historical Disturbance Regimes

scale and frequency (Lorimer 1980, Foster et al. 1998, Pan et al. (2011), Lorimer and White 2003)

human influence (Day 1953, Russell 1997, 1997, Krech III 1999, Patterson and Sassaman (1988))

importance of lightning caused forest fires (Loope and Anderton 1998)

Fire

Custom Fuel Models

Hardwood forest types are based on model F9 (Anderson 1982, Scott and Burgan 2005). Where average loads for 1 hr 10 hr and 100 hr fuels were available for northeastern forest types the values were substituted (Reinhardt and Crookston 2015). The remaining fuel attributes remained the same as the base model. The USFS community types were cross-walked to the NY State Heritage community classification so fuels could be assigned for our landscape.

Fuel Moisture

Region specific initial fuel moistures (Reinhardt and Crookston 2015). All freshwater wetland communities (marshes, shrub-swamps and forested wetlands) were initialized with a wet fuel profile, all other communities with burnable fuel types were initialized with a moist fuel profile.

Size Class	Very Dry	Dry	Moist	Wet
1 hr	5	7	10	19
10 hr	8	9	13	29

Size Class	Very Dry	Dry	Moist	Wet
100 hr	12	14	17	22
Live woody	89	105	135	140
Liver herbaceous	60	82	116	120

Initial Conditions - Forest Age

Forest communities were initialized with ages drawn from the following normal distribution (Loewenstein et al. 2000, Pan et al. 2011). All no forest types were initialized with a forest age of 0

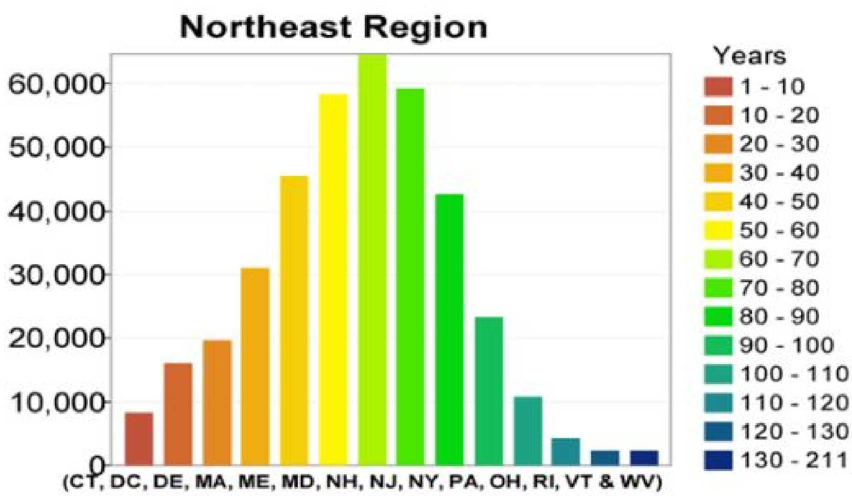

Figure 1: age class distribution

Initial Conditions - Canopy

For community types that can have a canopy, start values were randomized (using uniform distribution) within the following canopy classes:

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* grassland 0 < canopy < 20
* shrubland 20 < canopy < 60
* forest 60 < canopy
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Community types that do not have canopies were initialized with a value of 0.

fire size and frequency literature

effects of fires on temperate forests (Kozlowski 2012) power law(Reed and McKelvey 2002, Stephens 2005, Cui and Perera 2008)

Modeling Expected Frequencies

A Poisson distribution is used to model expected forest fire frequency (Johnson 2001, Yang et al. 2008). We created distributions for trail fires, garden fires and lightning fires.

Lightning Frequencies

The expected frequency (*lambda*) of lighting caused fires are based on areal frequencies from USFS wildfire records in region 9 (U.S. Northeast) between 1940 and 2000 (Stephens 2005). These values were converted from the given units (frequency/400000 ha)/yr to (frequency/km^2)/yr.

Region	Lightning		Human	
	Ha burned	No. fires	Ha burned	No. fires
9	11.840	2.170	327.990	39.950

	Lightning		Human	
	Area burned	No. Fires	Area burned	No. Fires
1 hectare	0.0000296	0.000005425	0.000819975	0.000099875
per km^2	0.00296	0.0005425	0.0819975	0.0099875

Human Fire Frequency Scenarios

The extent and effect of human caused fires on the landscape prior to European settlement is debated(Day 1953, Russell 1983, Patterson and Sassaman 1988). We have proposed two frequency scenarios, and through simulation have attempted to measure their relative effects.

source	no human fire	Russell (1983)	Day (1953)
trail	0	0.00222	0.01778
garden	0	0.00028	0.00222

Critical Rainfall

In the model, fire spread was stopped when it encountered one of the following conditions: (1) a non-flammable type of land cover; (2) boundaries of the region; and (3) when rainfall exceeded a certain critical amount. By assuming that a daily precipitation of 30 mm or more would stop a fire, the R Crit in Eq. (2) was estimated as 0.026 (the proportion of total number of days that has daily precipitation of 30 mm or more) from the historical precipitation data of the Edison weather station. (Li 2000)

Tree Allometry

Description	Equation	Reference
Tree Height	$TH = 44 * ln(Age) - 93$	(Bean and Sanderson 2008)
DBH	$DBH = (Age - 34.44)/1.18$	(Loewenstein et al. 2000)
Crown Ratio	$CR = 0.4$	(Bean and Sanderson 2008)
Bark Thickness	$BT = vsp * DBH$	(Reinhardt and Crookston 2015)

- Communities to Bark Thickness * bark thickness multipliers for each community, for communities with co-dominate species the average bark thickness was calculated (Reinhardt and Crookston 2015).

community	dominant tree species	vsp scaler
Floodplain forest	avg(sliver maple, sycamore, American elm)	0.032
Red Maple Hardwood Swamp	red maple	0.028
Coastal Plain Atlantic Cedar Swamp	Atlantic cedar	0.025
Pitch pine - scrub oak barrens	avg(pitch pine, oak spp)	0.045
Chestnut oak forest	avg(American chestnut, oak spp)	0.043
Coastal oak beech forest	avg(oak spp, beech)	0.035
Coastal oak hickory forest	avg(oak spp, hickory spp)	0.045
Oak tulip forest	avg(oak spp, yellow-poplar)	0.038
Appalachian oak pine forest	avg(oak spp, pine spp)	0.038
Hemlock northern hardwood forest	hemlock	0.045
Inland Atlantic Cedar Swamp	Atlantic white cedar	0.025
Red maple black gum swamp	avg(red maple, black gum)	0.034
Red maple sweetgum swamp	avg(red maple, sweetgum)	0.032
Maritime holly forest	holly	0.042
Post oak black jack oak barrens	post oak	0.044
Appalachian oak hickory forest	avg(oak spp, hickory spp)	0.045
Beech maple mesic forest	avg(beech, sugar maple)	0.029
Successional maritime hardwoods	other hardwoods	0.044
Successional hardwood forest	other hardwoods	0.044

Fire Mortality Equations

Scorch Height

[1]

$$SH = 3.1817(FL^{1.4503})$$

(Bean and Sanderson 2008)

Crown Kill

[2]

$$CK = 41.961(100(\ln(\frac{SH - CH)}{CL})) - 89.721$$

(Bean and Sanderson 2008)

Percent Mortality

[3]

$$P_m = \frac{1.0}{1.0 + e^{-1.941+6.316(1.0-e^{-BT})-0.000535CK^2}}$$

(Bean and Sanderson 2008)

Horticulture

Archaeological Evidence for Gardening

(Kraft 2001, Cantwell and Wall (2001), Benison (1997))

Ethnohistorical

(Ascher 1860, Danckaerts and Sluyter (1867))

crop	yield (kg/ha)	calories/100 g	calories/kg	calories/ha
corn	1720	365	3650	6278000
beans (Phaseolus vulgaris)	110	33	330	36300
squash (Indian squash)	80	16	160	12800

corn-bean-squash ploy-culture yields in Tabasco, Mexico (Gliessman et al. 1998) pg 224 table 15.3

Caloric density [USDA Basic Reports Agricultural Research Services]

Agricultural Dependency Scenarios

caloric requirements (Speth and Spielmann 1983)

Dependency	calories/person/yr	ha/person	m^2/person
15%	94060.50	0.01	14.87
30%	188121.00	0.03	29.73
60%	376242.00	0.06	59.47
100%	627070.00	0.10	99.11

Beaver

Succession

We used a 4 sere sequence for the freshwater wetland pathway (Allen 1983, Naiman et al. 1988, Johnston and Naiman 1990, *Ecology of Red Maple Swamps in the Glaciated Northeast* 1993, Hay 2010, Logofet et al. 2016). Conversion from non-wetland community to active pond can occur along any perennial streams where the stream gradient is less than 15 degrees. Due to the temporal scale of our study, forested wetlands are treated as a terminal community in this series (*Ecology of Red Maple Swamps in the Glaciated Northeast* 1993). This rule defines beaver caused disturbance as a unidirectional change in successional trajectory. A non-wetland communities can be converted into a wetland type but this conversion cannot be reversed.

active beaver pond → emergent marsh → shrub swamp → forested wetland

Model Parameters

Parameter	Value		Source
probability of abandonment	0.10		(Logofet et al. 2016)
colony density	0.4	colonies/km^2	(Naiman et al. 1988)
territory (minimum distance)	1000	m	Naiman et al. (1988); Allen (1983)]

Analysis

time since fire (Johnson 2001) fire size frequency hist (Malamud et al. 1998, Reed and McKelvey 2002, Cui and Perera 2008)

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