

Rapid Assessment Reference Condition Model

The Rapid Assessment is a component of the LANDFIRE project. Reference condition models for the Rapid Assessment were created through a series of expert workshops and a peer-review process in 2004 and 2005. For more information, please visit www.landfire.gov. Please direct questions to helpdesk@landfire.gov.

Potential Natural Vegetation Group (PNVG)

R7NHNE Northern Hardwoods Northeast

General Information

Contributors (additional contributors may be listed under "Model Evolution and Comments")

Modelers

Andrea Hille ahille@fs.fed.us
 Scott Reitz sreitz@fs.fed.us

Reviewers

Vegetation Type

Forested

General Model Sources

- Literature
- Local Data
- Expert Estimate

Rapid Assessment Model Zones

- | | |
|---|--|
| <input type="checkbox"/> California | <input type="checkbox"/> Pacific Northwest |
| <input type="checkbox"/> Great Basin | <input type="checkbox"/> South Central |
| <input type="checkbox"/> Great Lakes | <input type="checkbox"/> Southeast |
| <input checked="" type="checkbox"/> Northeast | <input type="checkbox"/> S. Appalachians |
| <input type="checkbox"/> Northern Plains | <input type="checkbox"/> Southwest |
| <input type="checkbox"/> N-Cent. Rockies | |

Dominant Species*

ACSA
 FAGR
 TIAM
 BEAL2

LANDFIRE Mapping Zones

63	62
64	
61	

Geographic Range

Northern tier of states in the east, including New England, NY, and the northern parts of PA and northeastern OH; also a southern extension in the Appalachian Mountains, including WV and portions of Maryland. May also be found at higher elevations sites in western and northern Virginia. South of West Virginia this type is represented in the Appalachian Cove Hardwood Forest found in fire refugia areas. This type can occur in physiographic provinces 212B, 212C, 212D, 212E, 221B, 212F, 212G, 221A, 221B, 221C, 221E, and 222I.

Biophysical Site Description

This type occurs in various dry-mesic to wet-mesic settings at low to moderate elevations (generally less than 2,000'). In the southern portion of its range, this type occurs on high-elevation, concave landforms and north-facing slopes in high mountain areas.

Vegetation Description

The prevailing smaller scale disturbance in this type favored shade-tolerant, slow growing, and very long-lived species. Opportunistic shade-intolerant species persist in low densities where larger gaps have occurred (Runkle, 1982). Beech-maple, hemlock-spruce old growth forests of the northeast have been characterized as requiring centuries to develop, with a high degree of vertical structure with large and long-lived (>250 years) trees, interspersed with patches of smaller trees, creating fine grained patch size (Spies, 2004).

Late successional communities composed of tall, shade-tolerant, long-lived broadleaf, mesophilic species with few evergreen trees. Dominated by sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), American basswood (*Tilia Americana*), and yellow birch (*Betula allegheniensis*); additional dominants characteristic of southern parts of the range are northern red oak (*Quercus rubra*) and tulip poplar (*Liriodendron tulipifera*). Common associates include black cherry (*Prunus serotina*), pin cherry (*Prunus pennsylvanica*), buckeye (*Aesculus flava*), striped maple (*Acer pennsylvanicum*), red maple (*Acer*

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit <http://plants.usda.gov>.

Rubrum), mountain maple (*Acer spicatum*), white ash (*Fraxinus americana*), hophornbeam (*Ostrya virginiana*), mountain-ash (*Sorbus americana*), serviceberry (*Amelanchier arborea*), dogwood (*Cornus alternifolia*), and American elm (*Ulmus americana*). Eastern hemlock (*Tsuga canadensis*) and eastern white pine (*Pinus strobus*) occur in lesser amounts. American chestnut (*Castanea dentata*) would have been an important associate in the southern portion of this type.

Late seral stages of this type usually had well-developed understory and midstory vegetation and an uneven-aged structure. Typical understory species include hobblebush (*Viburnum alnifolium*), viburnum species (*Viburnum* spp.), trilliums (*Trillium* spp.), blue cohosh (*Caulophyllum thalictroides*), trout lily (*Erythronium rostratum*), Canada mayflower (*Maianthemum canadense*), wood anemone (*Anemone* spp.), fern species, and various mosses.

Disturbance Description

Primary disturbance factors are wind, insects (particularly during droughts), and ice storms. These are more important than fire, although they predispose forests to fire during drought conditions. Canopy dynamics are primarily driven by single and multiple tree disturbances, encouraging gap-phase regeneration.

Catastrophic disturbances such as tornados, glaze storms, and thunderstorm downbursts affect the region periodically, creating widespread pit-mound topography, large gaps, and coarse woody debris. Other more common disturbances such as lightning and tree fall due to senescence affect the region nearly every decade (Ruffner unpublished, Ruffner, 1982).

Fire Regime Group V. Destructive fires occurred rarely within this forest type, usually occurring after catastrophic wind events, following periods of extreme drought. The principal cause of fuel formation leading to fire in northern hardwood ecosystems is broad-scale, storm-driven windthrow of catastrophic proportions, resulting in fire rotations of more than 1,000 years (Hough, 1936; Runkle 1982).

Replacement fires are severe fires that kill most trees and understory, removing most to all of the canopy and allowing pioneer species to emerge. Mixed fires pass through the understory kill most smaller trees, leaving behind some large, well-established trees while creating canopy openings. Fires tend to have a mosaic effect, due in part to the re-sprouting or suckering capabilities of several key species, including maple, beech, and oak.

Running the VDDT model resulted in 1% disturbance (fire and/or wind, weather, stress) annually, consistent with disturbance rates documented by Runkle (1981, 1985) and others. Wind, weather, stress alone resulted in 0.8% disturbance annually.

Adjacency or Identification Concerns

Northern Hardwoods Northeast is distinguished from Northern Hardwood conifer types (hemlock, spruce, white pine, etc.) by having a much smaller conifer representation, seldom exceeding 10%. This type falls between the Northern Hardwoods Hemlock and Spruce types to the north and at higher elevations and moister sites, and the more southern Appalachian Dry-Mesic Oak Forest and Mixed Mesophytic Forest types to the south and along major drainages. Using the International Ecological Classification Standard, this community corresponds most closely with the Laurentian -Acadian Northern Hardwoods Forest (CES201.564) and Appalachian (Hemlock)- Northern Hardwood Forest (CES202.593) (NatureServe, 2005).

Two major components of the type are currently threatened by serious forest health concerns. American beech is currently being impacted by the spread of the introduced beech bark disease complex, significantly increasing the land area in gaps. Within gaps created by dead beech trees, beech thickets formed by prolific root sprouting can pose significant competition to other seedlings (Hane, 2003; Krasny and DiGregorio 2000). American beech will continue to be a component of maturing forests, though the abundance of mature individuals will decrease over time. It's estimated approximately 1% may be resistant to the beech

bark scale disease complex, as described in Burns (1987) and Mielke (1986). Sugar maple decline is another current forest health concern that is attributed to a combination of factors including insect defoliations, drought, and site factors related to soil nutrient status (impacted by acid deposition) (Horsley, et al., 2002).

Many forests within this range are negatively impacted by overabundant deer populations. Deer have significantly altered understory vegetation structure and composition (Runkle, 1982; Marquis, 1975; Whitney, 1984). Wide spread unregulated harvesting in the late 1800s and early 1900s significantly changed species composition and structure of most of the Northern Hardwood forests. Second growth forests of today tend to contain a greater proportion of shade intolerant and shade intermediate species, such as black cherry and red maple, with a lesser portion of shade-tolerant species such as hemlock, sugar maple, and beech than original forests did (Bjorkbom and Larson 1977; Whitney, 1990; Whitney 1994). Second growth stands are characterized by an under representation of significant habitat elements such as large diameter trees, canopy gaps, gap saplings, "tip-up" mounds, coarse woody debris, and a limited range of seral stages (Litvaitis, 2003, Lorimer and Frelich 1994).

Other forest health concerns in the region include changing soil nutrient status due to acid deposition and concerns about potential increases in ozone from industrial byproducts.

The four "Northern Hardwood" models in the Rapid Assessment (R6NHMB, R7NHHE, R7NHNE, and R7NHSP) occur across both the Northeast and Great Lakes model zones and have several similarities, including: high moisture/nutrient gradients; historically included more conifer; often dominated by sugar maple; windthrow is the main disturbance agent with fires occurring every ~1,000-2,000 years. There are also several differences, including: beech has limited extent west of eastern Wisconsin and the central Upper Peninsula of Michigan; the amount of hemlock varies. Additional similar PNVGs include: R7BEMA, R7NHMC, R6MABA.

Scale Description

Sources of Scale Data Literature Local Data Expert Estimate

Both small and large-scale disturbances characterize the natural disturbance regime of this region, with wind, insects/diseases, and icestorms as primary disturbance agents. These forests are characterized by small scale disturbance, with a high degree of vertical structure and fine grained patch size (Spies, 2004). However, medium-scale intensity disturbances also characterize the region (Runkle, 1982; Ruffner, unpublished). A significant glazing or ice storm events can be expected every 50 years or so (Hough, 1963). Depending on the severity of ice loading, damage may range from minimal to severe crown damage.

SMALL GAP DYNAMICS:

Gap sizes range from 28 square meters to 2009 square meters, with a mean of 200 square meters. Canopy turnover rates of 0.5-2% per year with a return interval of 50-200 years characterize old growth beech and hemlock stands (Runkle, 1981, 1985). Repeat disturbances affecting the same location may be common. More recent estimates of the return interval based on actual tree ring analysis suggest that 10-20% of the canopy may be disturbed every decade depending on the topographic position of the stand (Ruffner, unpublished).

MESO AND LARGE CANOPY DISTURBANCES:

Large scale disturbances can affect areas ranging from 100 to 1,000 hectares (Ruffner, unpublished). Larger scale blowdowns affect upland and side slope sites more often (10 to 30 years) than more protected riparian sites (250 years) (Ruffner and Abrams, 2003). Ruffner and Abrams (2003) found medium intensity disturbances impact the upland and exposed side slopes of the Allegheny High Plateau every 210-630 years.

Issues/Problems

Model Evolution and Comments

Assumptions:

Replacement fire frequency >1,000 years

Mixed fire frequency 650 years, and would reduce canopy density 20% through individual tree mortality.

Stand replacement (catastrophic) wind frequency 1,000 years

Moderate scale wind frequency 140 years with 20% canopy reduction

Insects and disease are a disturbance factor that was included in the wind/weather/stress disturbance and not modeled separately.

Mid-seral open class took 25 years to return to closed condition due limited understory and midstory vegetation.

Late-seral open class took 15 years to return to closed condition more developed understory and midstory vegetation from understory reinitiation.

Canopy reductions due to disturbance refer to overstory, upper layer canopy.

Native American fire was considered but not determined to be a significant factor.

Uncertain on scale of infrequent fires (i.e.: range of acreages burned)

Suggested reviewers include Dr. Susan Stout (sstout@fs.fed.us), Dr. Pat Brose (pbrose@fs.fed.us), and Dr. Chris Nowak of Syracuse University (cnowak@esf.edu?).

Succession Classes**

Succession classes are the equivalent of "Vegetation Fuel Classes" as defined in the Interagency FRCC Guidebook (www.frcc.gov).

Class A 5%

Early1 All Struct

Description

Young even-aged (less than 25 years old), very dense stand characterized by yellow birch, black cherry, sweet birch, pin cherry, aspen, red maple, ash, and mountain-ash; herbaceous layer present in the very early stand reinitiation phase. Tree sizes generally range from seedling through sapling.

Dominant Species* and Canopy Position

BEAL2 Upper
PRSE2 Upper
BELE Upper
PRPE2 Upper

Upper Layer Lifeform

- Herbaceous
 Shrub
 Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	80 %	100 %
Height	Herb Short <0.5m	Tree Short 5-9m
Tree Size Class	Sapling >4.5ft; <5"DBH	

- Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class B 5%

Mid1 Closed

Description

Intermediate or mixed stand generally 25 to 100 years old in the stem exclusion stage. Closed canopy characterized by red maple, black cherry, sweet birch, and white ash, with northern red oak in the south; understory contains young sugar maple, beech, and yellow birch. Herbaceous layer, though not well developed, may be

Dominant Species* and Canopy Position

BEAL2 Upper
PRSE2 Upper
FAGR Low-Mid
ACSA3 Lower

Upper Layer Lifeform

- Herbaceous
 Shrub
 Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	80 %	100 %
Height	Tree Medium 10-24m	Tree Tall 25-49m
Tree Size Class	Medium 9-21"DBH	

- Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit <http://plants.usda.gov>.

present where small canopy openings exist. Trees range from pole sized to medium sized.

Class C 5%

Mid1 Open
Description

Intermediate or mixed stand generally 25 to 100 years old in the stem exclusion stage. Open upper canopy characterized by red maple, black cherry, sweet birch, and white ash, with northern red oak in the south; understory contains young sugar maple, beech, and yellow birch. Canopy is less than 80% upper crown closure due to occasional moderate scale wind, glaze, insect/disease event or rare fire disturbance. More open canopy creates opportunities for more shade-intermediate or intolerant species such as red maple, black cherry, and cucumber tree to persist. Herbaceous layer may be present due to more open upper canopy conditions. Canopy closure generally occurs within 25 years. Trees range from pole sized to medium sized.

Fuel model 11 may occur in stands where windthrow has created large quantities of slash.

Dominant Species* and Canopy Position

BEAL2 Upper
PRSE2 Upper
FAGR Middle
ACSA3 Low-Mid

Upper Layer Lifeform

- Herbaceous
- Shrub
- Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	79 %
Height	Tree Medium 10-24m	Tree Tall 25-49m
Tree Size Class	Medium 9-21"DBH	

- Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D 10%

Late1 Open
Description

Mature (more than 100 years old), uneven-aged stand characterized by understory reinitiation and complex structure. Open upper canopy characterized by less than 80 percent upper canopy closure due to occasional moderate scale wind, glaze, insect/disease event or rare fire disturbance. More open canopy creates opportunities for

Dominant Species* and Canopy Position

ACSA3 All
FAGR All
BEAL2 All
TILIA All

Upper Layer Lifeform

- Herbaceous
- Shrub
- Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	40 %	79 %
Height	Tree Regen <5m	Tree Tall 25-49m
Tree Size Class	Large 21-33"DBH	

- Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit <http://plants.usda.gov>.

more shade-intermediate or intolerant species such as red maple, black cherry, and cucumber tree to persist. Dominated by sugar maple, beech, and yellow birch; understory characterized by young and mature trees of shade-tolerant species. Herbaceous layer, consisting of shade-tolerant and intermediate species is well developed. Canopy closure generally occurs within 15 years. Trees are generally large, though all age classes can be present.

Fuel model 11 may occur in stands where windthrow has created large quantities of slash.

<p>Class E 65 %</p> <p>Late1 Closed</p> <p>Description</p> <p>Mature (more than 100 years old), uneven-aged stand characterized by understory reinitiation and complex structure. Generally a closed upper canopy, with some scattered openings created by senescence of individual trees. Dominated by sugar maple, beech, and yellow birch; understory characterized by young and mature trees of shade-tolerant species. A well developed shrub and herbaceous layer exists. Trees are generally large, though all age classes can be present.</p>	<p>Dominant Species* and Canopy Position</p> <p>ACSA3 All FAGR All BEAL2 Mid-Upper TILIA Mid-Upper</p> <p>Upper Layer Lifeform</p> <p><input type="checkbox"/> Herbaceous <input type="checkbox"/> Shrub <input checked="" type="checkbox"/> Tree</p> <p>Fuel Model 8</p>	<p>Structure Data (for upper layer lifeform)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;"><i>Min</i></th> <th style="text-align: center;"><i>Max</i></th> </tr> </thead> <tbody> <tr> <td><i>Cover</i></td> <td style="text-align: center;">80 %</td> <td style="text-align: center;">100 %</td> </tr> <tr> <td><i>Height</i></td> <td style="text-align: center;">Tree Regen <5m</td> <td style="text-align: center;">Tree Tall 25-49m</td> </tr> <tr> <td><i>Tree Size Class</i></td> <td colspan="2" style="text-align: center;">Large 21-33"DBH</td> </tr> </tbody> </table> <p><input type="checkbox"/> Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:</p>		<i>Min</i>	<i>Max</i>	<i>Cover</i>	80 %	100 %	<i>Height</i>	Tree Regen <5m	Tree Tall 25-49m	<i>Tree Size Class</i>	Large 21-33"DBH	
	<i>Min</i>	<i>Max</i>												
<i>Cover</i>	80 %	100 %												
<i>Height</i>	Tree Regen <5m	Tree Tall 25-49m												
<i>Tree Size Class</i>	Large 21-33"DBH													

Disturbances

Disturbances Modeled

- Fire
- Insects/Disease
- Wind/Weather/Stress
- Native Grazing
- Competition
- Other:
- Other

Historical Fire Size (acres)

Avg: no data
 Min: no data
 Max: no data

Sources of Fire Regime Data

- Literature
- Local Data
- Expert Estimate

Fire Regime Group: 5

- I: 0-35 year frequency, low and mixed severity
- II: 0-35 year frequency, replacement severity
- III: 35-200 year frequency, low and mixed severity
- IV: 35-200 year frequency, replacement severity
- V: 200+ year frequency, replacement severity

Fire Intervals (FI)

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class. All values are estimates and not precise.

	<i>Avg FI</i>	<i>Min FI</i>	<i>Max FI</i>	<i>Probability</i>	<i>Percent of All Fires</i>
<i>Replacement</i>	1000			0.001	39
<i>Mixed</i>	650			0.00154	60
<i>Surface</i>					
<i>All Fires</i>	394			0.00255	

References

Bjorkbom, J.C. and R.G. Larson. 1977. The Tionesta Natural and Scenic Areas, USDA Forest Service General Technical Report NE-31.

Braun, Lucy. Deciduous Forests of Eastern North America. The Blackburn Press. Caldwell, New Jersey. 1951. pp. 337-440.

Brown, James K.; Smith, Jane Kapler, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Burns, B.S. and D.R. Houston. 1987. Managing beech bark disease: evaluating defects and reducing losses. Northern Journal of Applied Forestry 4:28-33.

Hane, E.N. 2003. Indirect effects of beech bark disease on sugar maple seedling survival. Canadian Journal of Forest Research 33: 807-813.

Hough, A.F. 1936. A climax forest community on East Tionesta Creek in Northwestern Pennsylvania. Ecology, Vol. 17, No. 1.

Hough, A. F. 1963. What a glaze storm brings. PA Forestry 53:4-5.

Horsley, S.P., R.P. Long, S.W. Bailey, R.A. Hallett, and P.M.Wargo. 2002. Health of eastern North American sugar maple forests and factors affecting decline. Northern Journal of Applied Forestry 19(2): 34-44.

Krasny, M.E. and L.M. Digregario. 2001. Gap dynamics in Allegheny northern hardwood forests in the presence of beech bark disease and gypsy moth disturbances. Forest Ecology and Management 144: 265-274.

Kuchler, A.W. 1964. Northern hardwoods (Acer-Betula-Fagus-Tsuga). #106 In: Manual to accompany the map Potential Natural Vegetation of the United States. New York, NY: The American Geographical Society. 156 p.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit <http://plants.usda.gov>.

Litvaitis, J.A. 2003. Are pre-Columbian conditions relevant baselines for managed forests in the northeastern United States? *Forest Ecology and Management* 185: 113-126.

Lorimer, C.G., and L.E. Frelich. 1994. Natural disturbance regimes in old-growth northern hardwoods. *Journal of Forestry* 92:33-38.

Marquis, D.A. 1975. The Allegheny hardwood forests of Pennsylvania: Their Bounty of Timber and Deer are the Results of Events that Occurred Many Years Ago. USDA Forest Service General Technical Report NE-15.

Mielke, E.M., D.R Houston, and A. T. Bullard. 1986. Beech Bark Disease Management Alternatives. Pages 272-279 in *Proceedings- Integrated Pest Management Symposium for Northern Forests*, University of Wisconsin, USA.

Natureserve Explorer. 2004. <http://natureserve.org/explorer/servlet/NatureServe>.

Ruffner, C.M., and M.D. Abrams. 2003. Disturbance history and stand dynamics along a topographic gradient in old-growth hemlock—northern hardwood forests of the Allegheny Plateau, USA. *Natural Areas Journal* 23: 98-113.

Ruffner, C.M. and M.D. Abrams. Unpublished. Historical ecology of Allegheny Plateau forests. Submitted to the ANF as a component of the Revised Forest Plan.

Runkle, J.R. 1981. Gap regeneration in some old-growth forests of the eastern United States. *Ecology* 62: 1041-1051.

Runkle, J.R. 1982. Patterns of disturbance in some old-growth mesic forests of eastern North America. *Ecology* 63: 1533-1546.

Runkle, J.R. 1985. Disturbance regimes in temperate forests. In *The ecology of natural disturbance and patch dynamics*. Pp. 17-33. Edited by S.T.A. Pickett and P.S. White. Academic Press, New York.

Runkle, J. R. 1996. Central Mesophytic Forests, pp. 161-177. In Davis, M.B. (ed.), *Eastern Old-Growth Forests, Prospects for Rediscovery and Recovery*. Island Press, Washington D.C.

Runkle, J.R. 2000. Canopy tree turnover in old-growth mesic forests of eastern North America. *Ecology* 81: 554-567.

Schmidt, Kirsten M, Menakis, James P., Hardy, Colin C., Hann, Wendel J., Bunnell, David L. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. Gen. Tech. Rep. RMRS-GTR-87. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 41 p. + CD.

Spies, T.A. 2004. Ecological concepts and diversity of old-growth forests. *Journal of Forestry* 102: 14-20.

Southern Appalachian Man and the Biosphere. 1996. *The Southern Appalachian Assessment Terrestrial Technical Report*. Report 5 of 5. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region.

US Department of Agriculture, Forest Service, Southern Region. 1997. *Montane and allied spruce and spruce-*

fir forest old-growth forest community. Pp. 100-102 in: Guidance for conserving and restoring old-growth forest communities in National Forests in the Southern Region: Report of the Region 8 Old-Growth Team. Forestry Report R8-FR 62. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 120 p.

U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, December). Fire Effects Information System, [Online 12 February 2004]. Available: <http://www.fs.fed.us/database/feis/>.

Whitney, G. G. 1984. Fifty years of change in the arboreal vegetation of Heart's Content, and old-growth hemlock-white pine-northern hardwoods stand. *Ecology* 65:403-408.

Whitney, G.G. 1990. The history and status of the hemlock – hardwood forests of the Allegheny Plateau. *Journal of Ecology* 78: 443-458.

Whitney, G.G. 1994. From coastal wilderness to fruited plain; a history of environmental change in temperate North America, 1500-present. Cambridge University Press, Cambridge, U.K.