CSIRO PUBLISHING
International Journal of Wildland Fire, 2007, **16**, 266–270 www.publish.csiro.au/journals/ijwf

Fire scars reveal source of New England's 1780 Dark Day

Erin R. McMurry[A,C] *Michael C. Stambaugh*[A], *Richard P. Guyette*[A] *and Daniel C. Dey*[B]

[A]Department of Forestry, School of Natural Resources, University of Missouri, Columbia, Missouri 65211, USA.
[B]US Forest Service, Columbia, Missouri 65211, USA.
[C]Corresponding author. Email: ermfcd@mizzou.edu

Abstract. Historical evidence suggests that great wildfires burning in the Lake States and Canada can affect atmospheric conditions several hundred miles away (Smith 1950; Wexler 1950). Several 'dark' or 'yellow' days, as such events are commonly called, have been recorded, often with anecdotal or direct evidence pointing to wildfires as the source (Plummer 1912; Ludlum 1972). One such 'dark day' occurred across New England in 1780, a year in which people were technologically unable to confirm the source of such a phenomenon. Here we combine written accounts and fire scar evidence to document wildfire as the likely source of the infamous Dark Day of 1780.

'A horror of great darkness': a brief account of the event

As the morning dawned in Massachusetts on 19 May 1780, the sky was cloudy with a slight reddish hue, thunder rumbled in the distance, and a south-west wind prevailed (Ludlum 1972). By 1000 hours, dark clouds began to move in from the south-west, and shortly thereafter the sky became nearly as dark as midnight (Devens 1876; Ludlum 1972). The darkness continued to increase, and by noon people were forced to conduct business and serve meals by candlelight. Even the behaviour of plants and animals was affected, as flowers folded up their petals, chickens roosted, and night birds came out to sing (Devens 1876; Ludlum 1972).

The unearthly appearance of the dark sky at noon caused many people to react with terror, panic, or melancholy (Devens 1876; Ludlum 1972). Citizens flocked to meetinghouses and taverns, and even the Connecticut legislature moved to adjourn (Devens 1876; Ludlum 1972). Whereas other 'dark days' had occurred in the past, the darkness of this day was more intense and far-reaching than people had ever experienced, leading to much hysteria and overreaction (Ludlum 1972). Years later, the American Poet Laureate John Greenleaf Whittier would elevate the need for smoke management to an emotional level:

'Twas on a May-day of the far old year
Seventeen hundred eighty, that there fell
Over the bloom and sweet life of the spring,
Over the fresh earth, and the heaven of noon,
A horror of great darkness...
Men prayed, and women wept; all ears grew sharp
To hear the doom-blast of the trumpet shatter
The black sky...'

Some of the most valuable eyewitness observations of the darkness were reported by two men, a Harvard professor, Samuel Williams, and Dr Tenney of New Hampshire (Devens 1876). Reconstructions of the event based on their observations and surveys show that the darkness reached from Portland, Maine, all along the southern coast of New England, with the greatest intensity occurring in north-eastern Massachusetts, southern New Hampshire, and south-western Maine (Fig. 1) (Ludlum 1972). Ludlum (1972) calculated that the darkness spread 290 km in $\sim$7.5 h, or at a rate of $\sim$40 km h^{-1}.

Limited ability for long-distance communication prevented colonists from knowing for sure what caused the darkness, though several theories were proposed and debated in the weeks following the event (Ludlum 1972). Ideas ranged from the atmosphere being highly charged with reflecting and refracting layers of vapours, to sunlight being obstructed by a great mountain, to the belief that the event was a fulfilment of biblical prophecy (Devens 1876). Still others speculated that the darkness was a result of distant wildfires, based on precipitation characteristics and the smoky smell and appearance of clouds that day (Table 1), though this notion was disregarded by many as 'simple and absurd' (Ludlum 1972).

Where there's smoke, there's fire

Recent dendrochronological evidence (i.e. fire scars) strongly point to far-away forest fires being the cause of the darkness. Low-to-moderate intensity surface fires often kill a portion of a tree's cambium, resulting in a scar on the growth-ring for that year. Fire scars are dated to an exact calendar year by comparing the tree's ring-width pattern to known tree ring patterns (Grissino-Mayer 2001). Based on fire history reconstructions using these methods, the year 1780 is one of the greatest fire years before 1850 known in eastern North America (Guyette *et al.* 2002). Fire dates based on tree rings and fire scars indicate that fires occurred in 1780 at several locations, including the Algonquin Highlands of southern Ontario, western Maryland, western

 10.1071/WF05095 1049-8001/07/030266

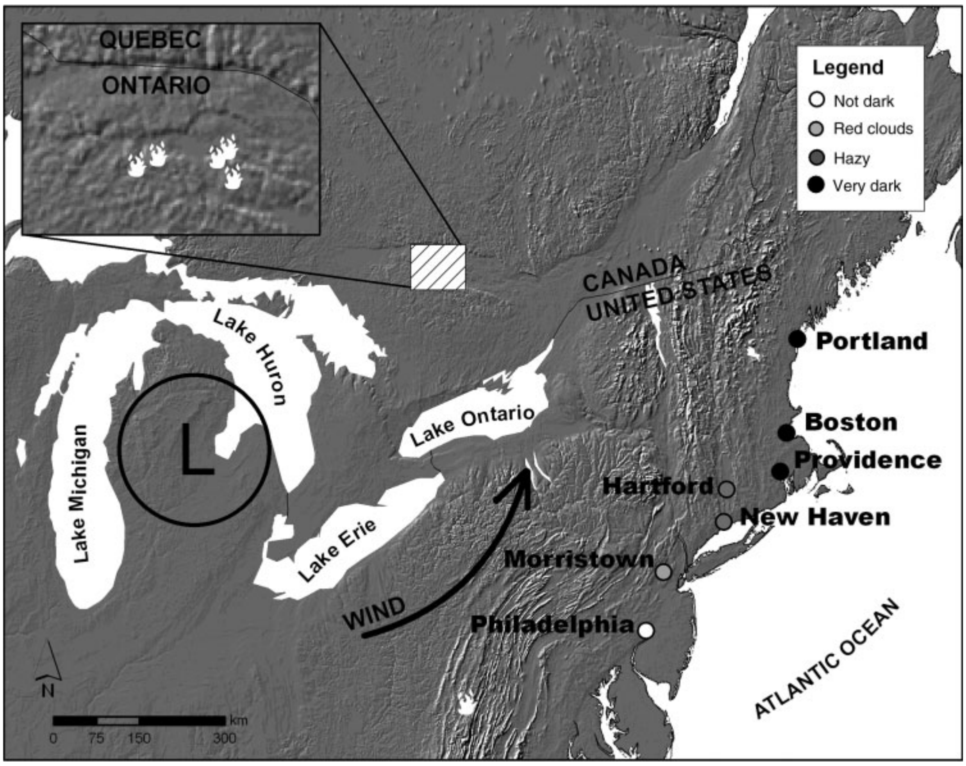

Fig. 1. Map of portions of north-eastern United States and south-eastern Canada. Cities listed are those with information describing conditions during the 19 May 1780 Dark Day (Ludlum 1972). City symbols are coded by degree of darkness (see legend). Inset shows closer view of Algonquin Park fire history study sites.

Table 1. Summary of reported meteorological conditions and observations related to the Dark Day of 1780

Barometric Pressure (mbar) readings in Massachusetts[A]		Atmospheric Conditions and Unusual Colour Effects	Precipitation	Wind	Other
0600 h	1009.8	Sun dim and red[B,C], air 'highly charged with vapors'[B], smoky[B]	Moderate rainfall and thunder reported in morning and afternoon hours in Massachusetts and Connecticut[A,C]	South-west wind in the morning at Salem, MA[A]	Large quantities of black substance seen floating in Merrimack River, up to 5 inches (12.7 cm) deposited on banks for several miles[A,E]
1000 h	1005.1	Cloudy conditions, clouds fast-moving[B,C]	Precipitation reported to be thick, dark, and sooty, with greasy qualities[A,E]	'Serene' easterly circulation reported in Salem, MA[D]	
1045 h	1004.7	Clouds red, yellow, brown[B,C]			
1215 h	1004.1	White objects appeared yellow, green objects appeared blue[B,C]			
1500 h	1004.1				
2008 h	1003.7				

[A]Observations of Professor Samuel Williams at Bradford, MA and Cambridge, MA, as recounted by Ludlum 1972; Devens 1876
[B]Observations of Professor Samuel Williams and Dr Tenney, as recounted in Devens 1876
[C]Observations of Nathan Read at Cambridge, MA, reprinted in Ludlum 1972
[D]Observations of unknown or anonymous persons, as recounted by Ludlum 1972
[E]Observations of unknown or anonymous persons, as recounted by Devens 1876

Virginia, the Missouri Ozark highlands, the Boston Mountains of Arkansas, and the Boundary Waters Canoe Area of northern Minnesota (Table 2).

Based on observations of wind direction and barometric readings on 19 May 1780 (Table 1), it seems most likely that a low pressure weather system carried dense smoke from the west or north to the New England region (Fig. 1) (Ludlum 1972). At several fire history sites in Algonquin Provincial Park, Ontario, and surrounding areas, there is fire scar evidence of a major fire occurring in 1780 (Fig. 2). At least half of Barron Township burned in 1780, with an area greater than 9300 ha affected (Cwynar 1977). At two other sites in Algonquin Provincial Park, 43 and 66% of trees were scarred by fire in 1780 (Guyette and Dey 1995*a*; Guyette and Dey 1995*b*). Trees likely survived at these sites owing to mitigating site characteristics and landscape position – the Opeongo Lookout site is a riparian bluff, and the Basin Lake site is an open sandy area with very little surface fuel (Guyette and Dey 1995*a*, 1995*b*).

Table 2. Eastern North American fire history studies reporting evidence of fire in 1780

Any evidence available in the cited publications is reported, and may include estimated area burned, number of fire scars, percentage of trees burned, or number of sites burned

Site	Evidence of 1780 fire	Citation
Barron Township, Algonquin Park, southern Ontario	At least half of the township burned (>9300 ha)	Cwynar 1977
Algonquin Park, southern Ontario	2 of 6 sites burned	Dey and Guyette 2000
Savage Mountain, western Maryland	1 ha burned	Shumway *et al.* 2001
Boundary Waters Canoe Area, Minnesota	1 scar found	Heinselman 1973
Houston Ranger District, Missouri Ozarks	1 scar found	Cutter and Guyette 1994
Current River watershed, Missouri Ozarks	10 of 23 sites burned, average of 28% trees scarred per site (>110 000 ha)	Guyette 1995
Caney Mountain, Missouri Ozarks	3 scars found	Guyette and Cutter 1991
Missouri Ozark Forest Ecosystem Project (MOFEP) sites	6 of 9 sites burned	Guyette and Larsen 2000; Guyette and Stambaugh 2004
Lower Boston Mountains, Arkansas	3 of 3 sites burned	Guyette and Spetich 2003
Central Appalachian Mountains, western Virginia	17 fire scars found at Mill Mountain site	Grissino-Mayer *et al.* 2005

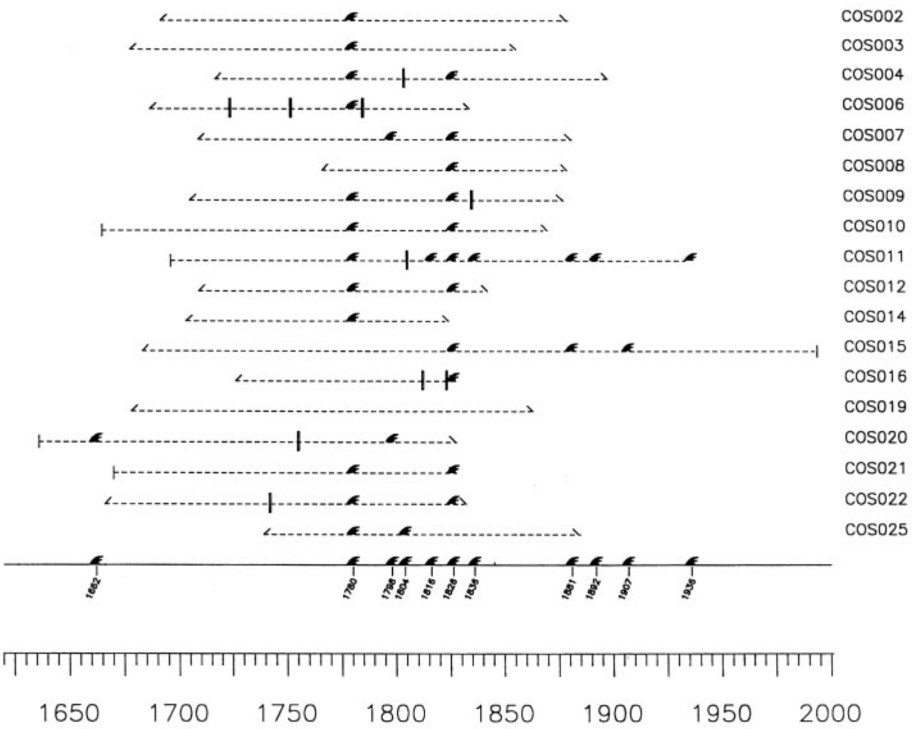

Fig. 2. Composite fire chronology from a fire history study site at Costello Creek in Algonquin Park, Ontario. Solid flames represent fire scars. Long vertical bars indicate injuries that may or may not be due to fires. Short, thin vertical bars indicate pith dates, and thin slanted bars indicate inner and outer rings of the sample. From Guyette and Dey, 1995*a*.

Owing to landscape and fuel heterogeneity, it is likely that not every portion of Algonquin Provincial Park burned in 1780, and also that areas outside of the park burned but do not have surviving fire-scarred trees recording the event. Nevertheless, the fire history sites in the Algonquin Highlands showing evidence of a 1780 fire are separated by as much as 58 km, and encompass a combined area of ~2000 km^2 (Dey and Guyette 2000; Guyette *et al.* 2002), potentially creating a scenario where large smoke columns were generated and carried into the upper atmosphere.

Some trees surviving the 1780 fire in Algonquin Provincial Park showed an increase in ring-width following the event, suggesting a sudden release from competition (Fig. 3). Close examination of red pine samples collected at one of these sites, Opeongo Lookout, revealed that some earlywood vessels formed before the fire killed the living cambium wood (Fig. 3), indicating

Fig. 3. Cross-sectional surface of a red pine (*Pinus resinosa* Soland.) from Opeongo Lookout, Ontario, Canada, showing the 1780 fire scar and subsequent growth increase. The presence of some earlywood vessels in 1780 (inset) indicates that the tree was fire scarred during the early part of the growing season (e.g. May), which is consistent with the timing of the 1780 Dark Day.

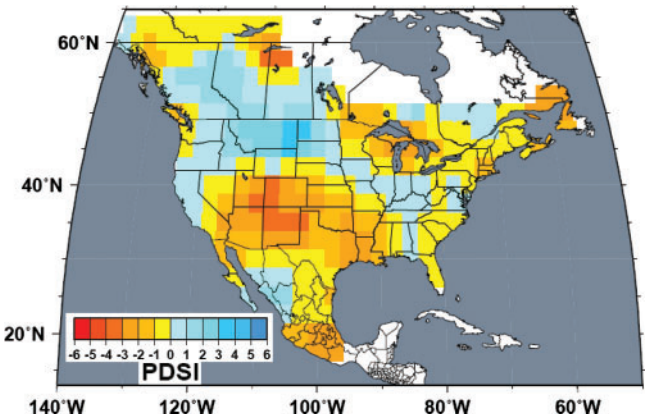

Fig. 4. Map of Palmer Drought Severity Index for the year 1780, from North American Drought Atlas (Cook *et al*. 1999).

that the 1780 fire occurred early in the growing season and could plausibly coincide with the Dark Day of 19 May.

Whereas the widespread fires in the Algonquin Highlands are the most likely cause of the darkness over New England, fires burning throughout the eastern United States in 1780 could also have contributed to the smoky atmosphere (Table 2). For example, 43% of sampled fire history sites ($n = 23$) in the Missouri Ozarks Current River watershed (>110 000 ha) had a high percentage of trees with 1780 fire scars (Guyette and Cutter 1997). In the Boston Mountains of Arkansas, three fire history study sites separated by over 15 km had trees scarred by fire in 1780 (Guyette and Spetich 2003).

Why so much fire in 1780?

Lines of evidence suggest the widespread fires of 1780 were likely the result of a combination of anthropogenic and lightning ignitions in conjunction with drought. Climate reconstructions based on tree ring-widths indicate that much of the area extending from the south-western United States to south-eastern Canada was affected to some degree by drought in 1780 (Cook *et al*. 1999) (Fig. 4). Major fire years are often associated with drought events (Agee 1993; Whelan 1995), but in 1780, settlement activities and conflicts likely exaggerated the effects of drought (Guyette *et al*. 2002). Across the United States and Canada, 1780 was a year beset with social and cultural upheaval. In addition to the ongoing American Revolutionary War, Euro-American settlement of northern New England was progressing rapidly (Perley 1899), and conflicts between Native Americans and Euro-American settlers were abundant (White 1991).

The effects of settler activities during this era on fire regimes have been documented throughout the United States and Canada (e.g. Heinselman 1973; Pyne 1982). In southern Ontario, for example, fire frequency increased significantly for several decades beginning in 1780 as Europeans and aboriginal tribes settled, raided, and moved through the area (Guyette and Dey 1995*a*). Land-clearing practices in New England commonly involved the felling of large tracts of forest and the subsequent burning of extremely large slash piles (Perley 1899; Pyne 1982). Fires during this era were often ignited purposefully for hunting, revenge or defence, or spread accidentally from campfires, lanterns and candles (Pyne 1982).

Alternatively, the combination of drought and a low pressure weather system may have increased the potential for ignition by lightning. Drought has been shown to increase the occurrence of dry lightning and wildfires in the north-eastern USA (Pyne *et al*. 1996), and the Algonquin Highlands experience more frequent lightning ignitions than surrounding areas, with 6–10 lightning fires per 400 000 ha per year (Schroeder and Buck 1970).

Smoke movement

Given such widespread fires, could smoke from fires in Ontario or Missouri travel far enough to blanket the entire New England region? In 1780, the notion of smoke from distant wildfires causing the darkness perhaps seemed absurd to many. In fact, a general consensus on the cause of the 1780 Dark Day would remain elusive for more than a century, when another day of darkness occurred with a known wildfire source (Ludlum 1972). On 6 September 1881, smoke from massive forest fires in Michigan and Ontario blanketed the New England region, reducing sunlight by up to 90% and necessitating the use of candles to conduct daily business (Wexler 1950; Ludlum 1972). Other notable wildfire-caused dark days in eastern North America occurred in October 1918 and September 1950 (Lyman 1918; Wexler 1950).

Conclusion

The Dark Day of 1780 provides a unique opportunity to corroborate early historic accounts of wildfire effects with empirical fire scar and climate data. The historic texts relating to the Dark Day also validate the widespread fires of 1780 found in the fire scar record. The events of that infamous day serve as a reminder that large volumes of smoke and sun obscuration can accompany large wildfires even in eastern North America. Specifically, this event illustrates how wildfires in Ontario may have impacted distant populations. Fire–societal links such as this are often poorly understood, though human perceptions of wildfire are of perennial interest.

Acknowledgements

The authors would like to acknowledge the contributions to fire history research by the Ontario Ministry of Natural Resources, the USFS Northern Research Station, and the Joint Fire Sciences Program.

References

Agee JK (1993) 'Fire Ecology of Pacific Northwest Forests.' (Island Press: Washington, DC)

Cook ER, Meko DM, Stahle DW, Cleaveland MK (1999) Drought reconstructions for the continental United States. *Journal of Climate* **12**, 1145–1162. doi:10.1175/1520-0442(1999)012<1145:DRFTCU>2.0.CO;2

Cutter BE, Guyette RP (1994) Fire history of an oak-hickory ridge top in the Missouri Ozarks. *American Midland Naturalist* **132**, 393–398. doi:10.2307/2426595

Cwynar LC (1977) The recent fire history of Barron Township, Algonquin Park. *Canadian Journal of Botany* **55**, 1524–1528.

Devens RM (1876) 'Our First Century.' (CA Nichols and Co: Springfield, MA)

Dey DC, Guyette RP (2000) Anthropogenic fire history and red oak forests in south-central Ontario. *Forestry Chronicle* **76**, 339–347.

Grissino-Mayer HD (2001) FHX2 – Software for analyzing temporal and spatial patterns in fire regimes from tree rings. *Tree-Ring Research* **57**, 113–122.

Grissino-Mayer HD, Lafon CW, Deweese Wight G (2005) Fire regimes and successional dynamics of yellow pine (*Pinus*) stands in the central Appalachian Mountains. Poster presentation, Annual Meeting, Joint Fire Science Program, 1–3 November 2005, San Diego, CA.

Guyette RP (1995) A tree-ring history of wildland fire in the Current River watershed. A report prepared for the Missouri Department of Conservation, the Ozark National Scenic Riverways, and the National Park Service Climate Change Program. (Columbia, MO)

Guyette RP, Cutter BE (1991) Tree-ring analysis of fire history of a post oak savanna in the Missouri Ozarks. *Natural Areas Journal* **11**, 93–99.

Guyette RP, Cutter BE (1997) Fire history, population, and calcium cycling in the Current River Watershed. In 'Proceedings 11th Central Hardwood Conference'. (Eds SG Pallardy, RA Cecich, HE Garrett, PS Johnson) pp. 354–372. USDA Forest Service General Technical Report NC-188. (St. Paul, MN)

Guyette RP, Dey DC (1995*a*) A dendrochronological fire history of Opeongo Lookout in Algonquin Park, Ontario. Ontario Forest Research Institute, Forest Research Report No. 134. (Saulte Ste Marie, ON)

Guyette RP, Dey DC (1995*b*) A presettlement fire history of an oak–pine forest near Basin Lake, Algonquin Park, Ontario. Ontario Forest Research Institute, Forest Research Report No. 132. (Saulte Ste Marie, ON)

Guyette RP, Larsen D (2000) A history of anthropogenic and natural disturbances in the area of the Missouri Ozark Forest Ecosystem Project. In 'Missouri Ozark Forest Ecosystem Project: Site History, Soils, Landforms, Woody and Herbaceous Vegetation, Down wood, and Inventory Methods for the Landscape Experiment'. (Eds SR Shifley, BL Brookshire) pp. 19–40. USDA Forest Service General Technical Report NC-208. (St. Paul, MN)

Guyette RP, Spetich M (2003) Fire history of oak–pine forests in the Lower Boston Mountains, Arkansas, USA. *Forest Ecology and Management* **180**, 463–474. doi:10.1016/S0378-1127(02)00613-8

Guyette RP, Stambaugh MC (2004) Fire history of Panther Cave Hollow (MOFEP 9). In 'Proceedings of the Society of Range Management Savanna/Woodland Symposium'. (Eds G Hartman, S Holst, B Palmer) pp. 27–39. (Missouri Department of Conservation Press: Jefferson City, MO)

Guyette RP, Muzika RM, Dey DC (2002) Dynamics of an anthropogenic fire regime. *Ecosystems* **5**, 472–486.

Heinselman ML (1973) Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. *Quaternary Research* **3**, 329–382. doi:10.1016/0033-5894(73)90003-3

Ludlum DM (1972) New England's Dark Day: 19 May 1780. *Weatherwise* **25**, 112–119.

Lyman H (1918) Smoke from Minnesota forest fires. *Monthly Weather Review* **46**, 506–509. doi:10.1175/1520-0493(1918)46<506:SFMFF>2.0.CO;2

Perley S (Ed.) (1899) Dark Days. *The Essex Antiquarian* (April 1899). (Salem, MA)

Plummer FG (1912) Forest fires: their causes, extent and effects, with a summary of recorded destruction and loss. USDA Forest Service Bulletin No. 117. (Washington, DC)

Pyne SJ (1982) 'Fire in America: a Cultural History of Wildland and Rural Fire.' (Princeton University Press: Princeton, NJ)

Pyne SJ, Andrews PL, Laven RD (1996) 'Introduction to Wildland Fire.' (John Wiley and Sons: New York)

Schroeder MJ, Buck CC (1970) Fire weather. USDA Forest Service, Agricultural Handbook 360. (Washington, DC)

Shumway DL, Abrams MD, Ruffner CM (2001) A 400-year history of fire and oak recruitment in an old-growth forest in western Maryland, USA. *Canadian Journal of Forest Research* **31**, 1437–1443. doi:10.1139/CJFR-31-8-1437

Smith CD, Jr (1950) The widespread smoke layer from Canadian forest fires during late September 1950. *Monthly Weather Review* **78**, 180–184.

Wexler H (1950) The great smoke pall – September 24–30, 1950. *Weatherwise* **3**, 129–134.

Whelan RJ (1995) 'The Ecology of Fire.' (Cambridge University Press: Cambridge, UK)

White R (1991) 'The Middle Ground: Indians, Empires, and Republics in the Great Lakes Region.' (Cambridge University Press: Cambridge, UK)

Manuscript received 13 October 2005, accepted 13 November 2006