The New England-St. Lawrence Valley Geographical Society (NESTVAL) was founded in 1922 to promote scholarly research and disseminate geographic information in the region. Originally founded as the New England Geographical Conference, the current name was adopted in 1956. NESTVAL, one of nine regional divisions of the Association of American Geographers, sponsors an annual conference every fall that is open to members and non-members. Membership, which includes a subscription to the Journal, may be arranged with NESTVAL's Secretary-Treasurer (www.nestvalonline.org)

The Northeastern Geographer is an annual publication that replaces the *Proceedings of the New England-St. Lawrence Valley Geographical Society*. The *Proceedings* were published from 1972 until 2006. *The Northeastern Geographer* publishes research articles, essays and book reviews on all geographical topics but the focus of the Journal is on the Northeast United States, the St. Lawrence Valley and the Canadian Maritime Provinces. All research articles submitted to the Journal undergo peer-review.

The Northeastern Geographer

Journal of The New England-St. Lawrence Valley Geographical Society

Special Issue: Environmental Change in Northeastern North America

VOLUME 4 (2), 2012

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Published by the New England-St. Lawrence Valley Geographical Society
(www.nestvalonline.org)

VOLUME 4 (2)

ISSN: 1948-5417

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ENVIRONMENTAL CHANGE IN
Northeastern North America

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During last year's annual conference of the New England – Saint Lawrence Valley Geographical Society (NESTVAL) in Montreal, Canada, we were approached by the senior editor of the *Northeastern Geographer* to consider co-editing a special issue of the journal that focused on environmental change. While we had not worked together in the past, we had separately conducted research projects, published papers and taught courses on various facets of the subject. Stephen Young, an American from Salem State University, is a physical geographer with expertise in the area of remote sensing and vegetation change, while Darren Bardati, a Canadian from Bishop's University, is a natural resource geographer with interests in resource and environmental management and climate change adaptation at the community level. We are as distinct in our conceptual approaches, methods and emphases, as two University professors studying environmental change in the Northeast can be. Yet, somehow, we found a complementarity to our research interests that is perhaps symbolic of other researchers in the region.

North America's northeastern region, which we define broadly as New York State, the six New England States (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire and Maine) as well as five Canadian Provinces (Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador) is highly diverse in its physical and human geography.

Recognizing that the study of environmental change includes the broad diversity of ways to understand change and disturbance in the environment by natural ecological processes, or those exacerbated by anthropomorphic activities including social, political and economic aspects, we felt that the *Northeastern Geographer* would be an excellent venue to highlights some of that diversity.

Following last year's NESTVAL Conference, a call for papers for this special issue went out to all geography departments at all the universities in the Northeastern region. Following initial abstracts, we received numerous papers by the April 30, 2012 deadline. Those who were selected to go through the peer-review process were then sent out for review over the summer months. Final reviews and corrections were submitted by October. In the following pages you will find five papers that represent the diversity of approaches on the topic that we were hoping to achieve.

The first article (*Land preservation and sustainability in America's northeastern northern forest*) by Daniel Moscovici (Richard Stockton College of New Jersey) takes a look at the Northern

Forest, which stretches from Lake Ontario in New York to Maine's Atlantic coast. These forests remain one of the last intact, mostly private forests in the United States and comprise the most productive forest region of the Northeast. With the demise of large forestry operations and forest-sector jobs in this region, new forms of economic development and land use are occurring and there is the need for coordinated, regional conservation planning. There is a concern about the fragmentation of the forest. The Northern Forest, in large intact parcels, can maintain a variety of positive ecosystem services for the region, such as maintaining water quality as many of the region's main waterways flow out of the Northern Forest. This paper uses GIS to examine the correlation between preservation of the forest and sustainability characteristics (such as elevation and forest cover) and then proposes ideas to help transition the region in sustainable development.

Staying on the forest theme, the next article (*The dendroclimatological potential of white birch (Betula papyrifera) in Labrador, Canada*) by Geoffrey Kershaw (Dalhousie University) and Colin Laroque (Mount Allison University) takes us to Labrador and the far northern reaches of the boreal forest in the Northeast. Trees that survive at the extreme of their climatological limits are well suited for building climate reconstructions and so the authors explore the usefulness of white birch at their climate extreme. They test the dendroclimatological potential of white birch by comparing a master chronology with temperature and precipitation data from the region. The study demonstrates a correlation between annual rings and summer temperature and as well as a minor relationship with moisture from the previous summer. This paper shows that high-quality dendrochronological data can be attained from white birch trees in the Labrador region. This is important information which will provide us with yet another tool to piece together past climates of the Northeast and further our understanding of environmental change in this region.

Our third article (*"Obsolete Archaism, Utopian Dreams and Manure": Biogas and Dairy Livelihoods in Vermont*) by Thomas Loder (University of Kentucky) explores the use of cow manure to produce electrical energy in Vermont as an interesting and potentially viable alternative energy source. The article provides a broad overview of the current biogas debate and then looks at the details of farm-base dairy biogas in Vermont. This article shows that at first there was great enthusiasm about biogas production in Vermont, but market realities dampened enthusiasm and the state had to step in to stabilize prices. The article looks deeply into dairy production and determines that while it might not make the best environmental sense, when considered with the added benefit to the economic lives of struggling dairy farmers, then it is a positive influence and should be supported. This article explores one of the potential alternative energy sources for the Northeast and demonstrates that the benefits are beyond environmental, social also.

The fourth article (*Analysis of Land Surface Temperature Change for Northeastern North America using MODIS Thermal data, 2001 to 2011*) is by Hengzhi Hu, Paul Curtis and Stephen Young (Salem State University). This article analyzes land surface temperature change from satellite data for the Northeast over the past decade. Based on a variety of data sources, it is becoming clear that the world is warming, and the Northeast appears to be no exception. The authors use global-scale satellite-based thermal data (MODIS) and analyze Land Surface Temperature (LST) of the Northeast. They analyzed LST for daytime (10:30 AM) and nighttime (10:30 PM) data from 2001 to 2011 on seasonal to interannual time scales. They found that over the time period the temperature in the region has been warming, both at night and during the day. They discovered a strong correlation between the North Atlantic Oscillation's (NAO) negative phase and a warming of Northeast North America with 2010 having the warmest land surface temperatures during a deep NAO negative phase. This research provides yet another way of understanding the changing environment of Northeastern North America.

Our fifth and last article (*The New Deal Versus Yankee Independence: The Failure of Comprehensive Development on the Connecticut River, and its Long-Term Consequences*) by Eve Vogel and Alexandra Lacy (University of Massachusetts, Amherst) and is our most in-depth look at an environmental issue in the region. One of the largest rivers flowing out of the Northern Forest is the Connecticut River. Vogel and Lacy look at the political tensions in the Northeast during the New Deal era and show how it influenced the lack of a coordinated Connecticut rivershed development and they show the modern-day consequences of it. During the 1930s and 40s, despite the fact that multiple people and agencies wanted comprehensive development of the Connecticut River basin, it was stalled by people arguing over it for twenty years. This resulted in the Connecticut River management being divided spatially, functionally and institutionally with no overarching management. In recent years, however, this management structure has allowed some flexibility in terms of providing natural flows for fish and ecosystems.

In addition to our five main articles we have included three book reviews. Norman Jones, Matthew Peros and Darren Bardati, all hailing from Bishop's University, each review a climate change textbook recently published and widely used in undergraduate classrooms. These include: *Climate Change: From Science to Sustainability* (by S. Peake and J. Smith, Oxford University Press, 2009); *Climate Change: Science, Impacts and Solutions 2nd edition* (by A. Barrie Pittock, Earthscan, 2009); and *Adaptation to Climate Change: From Resilience to Transformation* (by M. Pelling, Routledge, 2011). Each book provides the scientific basic foundation for students to form a solid understanding of climate change and its impacts, and each provides a discussion on the human responsibility and possible actions to be taken to help mitigate and adapt to these climatic changes.

We thank the anonymous reviewers for their helpful comments and the NESTVAL executive committee and geographical society for their support.

LAND PRESERVATION AND
Sustainability in America's Northeastern Northern Forest

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Richard Stockton College of New Jersey

ABSTRACT
The Northern Forest remains one of the last intact, mostly private forests in the United States. Rural areas of Maine, New Hampshire, Vermont, and New York struggle to prosper in an economy driven by timber, eco-tourism, and a propensity for rural residential sprawl. This paper examines the correlation between preservation of the forest and sustainability characteristics. Specifically, counties with higher percentages of preserved land will exhibit a stronger positive correlation with economic, environmental, and social sustainability characteristics. Findings indicate surprising connections between land preservation and sustainability. Recommendations include additional research and planning measures to stem high levels of fragmentation and parcelization. Based on the limited federal protection, varied state systems, and growing role of land trusts, a regional planning initiative is proposed to prioritize future preservation efforts. *Keywords: environmental planning; natural resource management; regional planning; land preservation.*

Introduction

The Northeastern Northern Forest is America's first great forest, stretching 645 kilometers from Lake Ontario to the Atlantic Ocean. The area covers more than 10 million hectares, extending from New York's Tug Hill Plateau through the Adirondack Mountains and across Vermont, New Hampshire, and Maine (Governors' Task Force on the Northern Forest, 1990; Reidel, 1990). The Northern Forest Lands Study, published in 1990, identified locales with high levels of industrial forest (i.e. forests with processing mills) and marked the region as a priority area for protection. Unlike the 1990 designation, the Northern Forest in this paper encompasses all of the counties in Maine, New Hampshire, Vermont, and the New York counties which fall fully or partially within the Adirondack Blue Line. The Blue line encompasses 2.4 million hectares of private and public (44%) land and acts a proclamation boundary for the jurisdiction of the Adirondack Park Agency (APA) (Edmonson 2004).

The region's economy relies heavily on forestry, tourism, and outdoor recreation. While popular recreation areas exist, the Northern Forest is also a working landscape (Lapping 1982).

Over 75% of the land is privately owned, and forestry is the economic mainstay (Northern Forest Alliance 2006). Approximately a dozen multinational timber companies and investors own a majority of the land in the Northern Forest, more than 6 million hectares. An additional 1.6 million hectares are private non-industrial forest and are owned by private forest owners or farmers who do not own or operate wood processing facilities (Vlosky 2000).

Numerous internal and external forces have recently been causing a decline in the region's forest products industry. The loss of timber mills and jobs threatens the economic and social wellbeing of the region. For example, in Maine from 1974 to 2006, five forest products mills closed at a cost of thousands of jobs. Since 2000, more than 4,500 jobs have been eliminated in Maine's forest products industry (Scott 2005). Population growth, demand for second homes, regional timber competition, and international timber competition are all factors. Additionally, pro-growth and home-rule traditions in this area, frequently do not allow Maine to effectively manage land use planning (Boyle 2007).

As the forest becomes parcelized and fragmented through subdivision of properties and development, the wood products industry loses viability. The industry requires large expanses of undeveloped and uniform ownership to be efficient. Furthermore, land values rise along with conflicts from non-forestry landowners. This shift towards development of the rural countryside is evident across the region. Maine, for example, converted 352,000 hectares of rural fields and woodlots into suburbs (an area the size of Rhode Island) from 1980 to 2000 (Brookings 2006). In addition, four of the top fifteen national watersheds, which are projected to experience the greatest increase in housing density on private forestland, are in New Hampshire and Maine (Stein 2010). The social challenge is that people from outside of the region are the ones who are moving to and drastically changing this forested landscape.

It is therefore essential that land preservation, more specifically the purchase of development rights (conservation easements), be utilized as a tool for protecting the forested landscape of this region. In the United States there are bundles of rights associated with the purchase of a property; air rights, timber rights, mineral rights, development rights, etc. By purchasing development rights (PDR), NGOs or government agencies can perpetually ensure that there will be no development other than what already exists, on the property. With this conservation easement the holder of the easement can also monitor, and ensure a sustainable harvest plan that can have positive environmental outcomes. When the development rights are purchased, the land owner maintains fee simple ownership of the property. This allows the individual(s) to still own the land and existing structures on the property. In addition, they receive financial compensation for the development rights, and those rights then become extirpated or are held in perpetuity by a land trust or government agency. While it is a pay-for-environment approach, often the result is a reinvestment into the business and a multiplier effect for local related industry, continuing a cycle of working landscapes and sustainable forestry (Lind 2001)

Development rights could be purchased for historic viewsheds, agricultural land, recreational corridors, waterfronts, islands and other natural areas, as well as other working landscapes like forestry, ranching, and mining (Gustanski and Squires 2000). By utilizing land preservation, which offers permanence, a strong regulatory zoning mechanism, and other techniques (like urban growth boundaries and special farming/forestry districts) the formation of an effective growth management plan is possible (Daniels and Lapping 2005; Daniels and Bowers 1997). In the Northern Forest, PDR has gained in popularity since 1990. It has proven to be the tool of choice for social acceptance, economic viability, and environmental planning (Levitt 2003). The conservation easement allows the timber industry to continue to operate according to a forest management plan, restores citizens' confidence in the local economy, generally provides for public access and outdoor recreation, and protects the land from residential or commercial development, in perpetuity.

This study has determined that in the Northern Forest, over four million hectares have been preserved to date. The majority of forestland preservation has taken place in the Adirondacks and in Maine – see figure 1. This land preservation fills the gap from a lack of protective low-density zoning, especially in Vermont and New Hampshire. The goal of forestland preservation is to support the local wood products and recreation industries, maintain ecosystem services, such as water recharge and wildlife habitat, and enable a degree of cultural independence in the Northern Forest. For instance, data from western states indicate that rural counties with greater than 10% of their land protected exhibit a 46% higher increase in jobs and a 27% increase in income than those without such protection (Daniels and Daniels 2003).

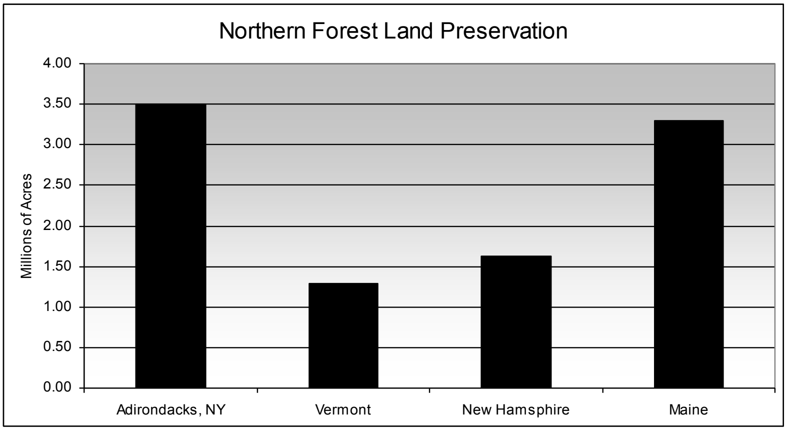


Figure 1. Northern Forest Land Preservation Comparative Graph, 2009.

Protecting the Northern Forest, in large intact parcels, can maintain and enhance a variety of positive ecosystem services. The most significant is the protection of major waterways. The headwaters of several major rivers originate in the region. These water bodies provide drinking water, recreation, aquifer recharge, and wildlife habitat. Significant river sources include the Hudson River in the Adirondacks; the Connecticut River in Northern New Hampshire; the Penobscot, Kennebec, and the St. John River in Maine. In addition, Lake Champlain, between Vermont and the New York, is an important water source for Canada's St. Lawrence River. Preserving large blocks of forestland can additionally protect the environment as trees filter pollutants out of the water, reduce temperatures, moderate flooding and erosion through absorption, and sequester carbon. Developing a large cohesive block of land preservation, or concentration area of preservation, as is possible in this region, can achieve the many environmental goals sought (Zonneveld 2007).

Testing for a Correlation between Forestland Preservation and Sustainability

Little research has been done linking land preservation and the triple bottom line of sustainability. This paper seeks to make a contribution by identify the correlation between all types of land preservation—working-forest, agricultural land, and passive recreation or wildlife habitat—with sustainability (triple bottom line factors for sustainability: environment, economy, and society). The hypothesis is that those counties with higher percentages of preserved land will exhibit a stronger correlation with economic, environmental, and social sustainability characteristics. If there is a strong correlation between land preservation and sustainability in the mostly private and rural landscape of the Northern Forest, policy recommendations can be developed to earmark efforts and funding for further preservation and long-term, nature-based growth across the entire region.

This study used geographic information system (GIS) techniques for data analysis of protected lands (Watkins 1997), and then a multiple linear regression with data from across 49 counties—an area of approximately 16.4 million hectares. This is considerably larger than the

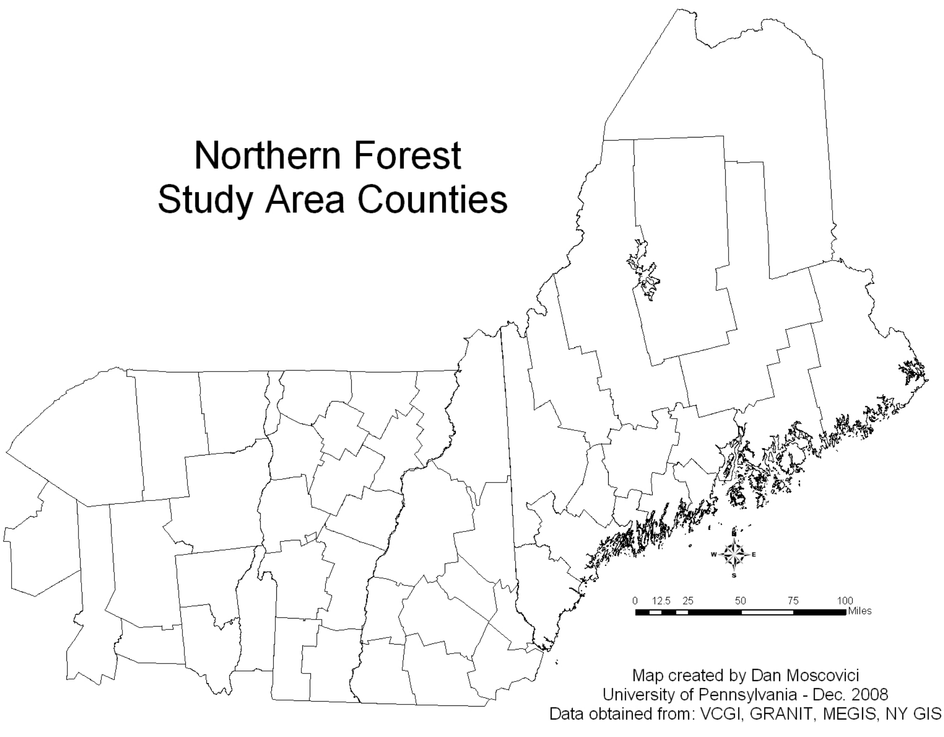


Figure 2. Northern Forest Study Area Counties Map

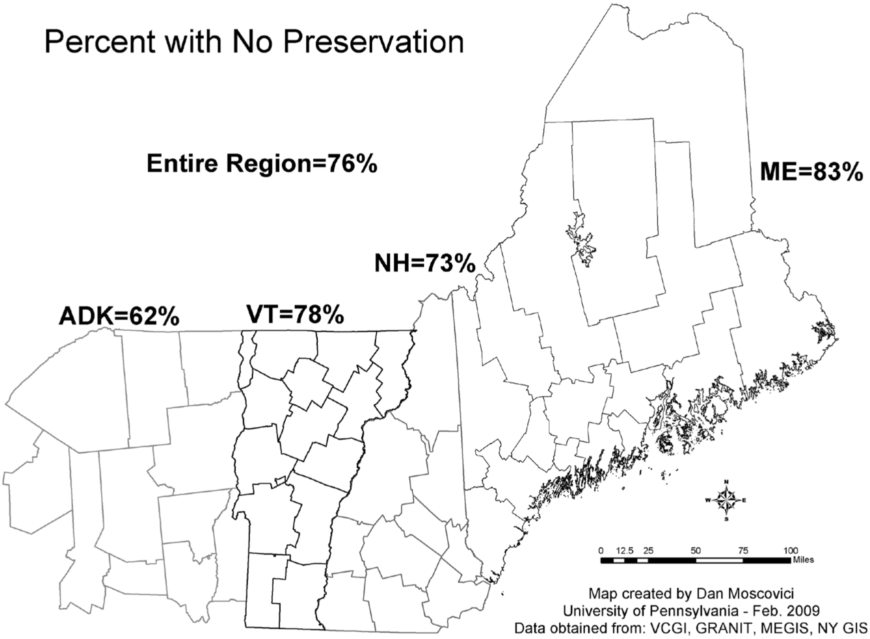


Figure 3. Percent of State or Region Lacking Preservation

original Northern Forest designation by the Governor's Task Force in 1990. While some counties are highly urbanized and others are mostly rural, all counties were selected to encourage a full regional view from all the states and stakeholders. These 49 include each county in Maine, New Hampshire, Vermont, and all of the counties that intersect with the Adirondack Park in New York. The Northern Forest in this study means these 49 counties in Figure 2.

Millions of acres have already been preserved through conservation easements, however 76% of this study area is still unprotected (see figure 3). While future funding is somewhat uncertain, particularly from the state and local governments, based on the historical involvement of the different governments, the motivation of the many non-profit organizations, and ongoing partnerships with the private sector, it is likely that forestland preservation will continue in all of these states.

Land Preservation & Northern Forest Status

Many agencies are involved in trying to conserve the Northern Forest, including the U.S. Forest Service, state agencies, and non-governmental organizations (NGOs), better known as land trusts. Large examples of this include the Pingree Forest Partnership (308,500 hectares) in

Maine, the Connecticut Lakes Headwaters Natural Area in New Hampshire (69,400), the Atlas and Champion lands in northeast Vermont (60,700) , and the Champion, International Paper, and Finch Pruyn lands in New York's Adirondacks (over 121,400 hectares). See table 2.

Federal Land

Total federal land ownership in the Northern Forest is small compared with much of the rest of the country. A mixture of national forests (Green Mountain National Forest and White Mountain National Forests), one major Department of the Interior national park (Acadia National Park), and a few fish and wildlife national wildlife refuges (Silvio O. Conte, Umbagog and Moosehorn National Wildlife Refuges) comprise the primary federal holdings (USFW 2008). In effect, the Northern Forest region is essentially a privately owned forest.

The White Mountains National Forest (310,737 hectares in New Hampshire & Maine) and The Green Mountain National Forest (131,526 hectares in Vermont) are managed by the U.S. Forest Service and operate under the principle of multiple-use sustained yield. They are managed for a range of uses, including outdoor recreation, range, timber, watershed, wildlife, and fishing (SPNF 2006; Public Law 86-517; Wilkinson 1987). Approximately half of these 450,000 hectares are managed as multiple use forests and approximately 16% are designation wilderness (Harper 1990). But this degree and definition of 'wild land' receives a great deal of debate and the value of the protection is often criticized (McMorran 2008).

Fee-simple purchases are no longer the sole choice for federal land preservation. As funds become scarce, pressure for development increases, and preservation measures become more and more urgent, the outright acquisition strategy has transitioned to purchasing conservation easements and developing partnerships. Funding is the new strategy. The Land and Water Conservation Fund (LWCF) exists to fund projects. The financing has ranged from $369 million in 1979, to four years of zero financing from 1996 to 1999. Funding from 2003 to 2008 was only $23 million (NPS 2008).

Another important funding opportunity, the Forest Legacy Program, has enabled the preservation of millions of hectares through the purchase of conservation easements. This program operates on a matching basis, so that a state must contribute at least 25 percent of the funding to receive federal funding. In 2010, almost one million hectares were preserved by the Forest Legacy Program (USDA 2010). From 2004 to 2008, funding ranged from $59 million to $62 million annually, and a majority of the funded projects were in the Northeast (U.S. Forest Service 2008).

State Land

Similarly, the states have taken a number of approaches to land preservation in the Northern Forest. These states balance the need for parkland and multiple-use management, while often bringing important revenue to the state. For example, total revenues coming to Maine through the state parks total $37 million for day use, $12 million for historic sites, and $8 million for campgrounds. Taking the multiplier effect into account, park visitors generate $95.7 million in economic revenue for the state. This includes 1,449 jobs providing $31.1 million in personal income (Morris 2006).

Maine has really focused on conservation easements in the past decade. In 1995 they held development rights for 2,025 hectares and in 2009 over 242,000 hectares. The state has been able to successfully protect land using bond initiatives approved by the citizens of the state. Known as the Land for Maine's Future Program, the state has leveraged over $110 million in bonds; $35 million in 1987, $50 million in 1999 and $27 million on two bonds from 2005 and 2007, and an additional $9.75 million in 2010 (Land for Maine's Future 2010).

State	Coordinating Agency	Protected Hectares
Vermont	Agency of Natural Resources (ANR)	186,564
New Hampshire	Department of Resources and Economic Development (DRED)	81.551
Maine	Parks & Land Bureau	233,508 + 80,000 (Baxter State Park)
New York	Adirondack Park Agency + Department of Conservation (DEC)	1,052,205

Sources: (VGGI 2008; New Hampshire Division of Forests and Lands 2008; Maine Department of Conservation 2008; APA 2001)

Table 1. State Land

Furthermore, Baxter State Park is a unique example of protection. The more than 80,000 hectares that make up Baxter are held in trust by the state for the people of Maine. Former Governor Percival Baxter personally purchased all of this land and donated it along with restrictions and an endowment for management expenses. Baxter is the largest wilderness area throughout the states of Maine, New Hampshire and Vermont (Irland 1999).

The Adirondacks stands as the strongest state-level preservation system in the region. The devastation of New York's forested landscape in the late 1800s led to the passage of a critical law in 1894, which stated that the goal of the Adirondack Park and Preserve was to keep the Adirondacks region "forever wild." This includes 2.4 million hectares within the Adirondack blue line, 44% which is owned by the state (Edmonson 2004). The State of New York thus owns more public land than any government agency in the Northern Forest. Timber-harvesting is, however, forbidden on state lands; the state employs a preservation-for-recreation system, meaning the land has been preserved for recreation, water quality protection, and future generations. (APA 1999). It is the largest park and preserve in the lower 48 states (Klinkenborg 2011).

Additional protection measures have been achieved as each state offers forestland owner's tax incentives to encouraging timber harvesting and discourage development. Vermont and New Hampshire both have a Current Use Program/Law, in Maine it is called the Maine Tree Growth Tax Law, New York's DEC manages the Forest Tax Law, and New Hampshire (Bureau of Taxation 1993; DEC 2005; Smith 2004; VT Division of Forestry 2005). While this keeps millions of acres from development, it is not in perpetuity and tax penalties might not outweigh the benefits from development.

Vermont, Maine and New York are actively seeking both forest preservation and the continuation of a forest products industry. Purchasing conservation easements seems to be the new state government strategy. Partnering with non-profit organizations and timber companies can benefit the state economy and the local citizens. The NGO has therefore become an important stakeholder and funding source in the region.

Private Sector/NGOs

A growing non-profit community has facilitated the transition away from fee-simple acquisitions toward the purchase, bargain sale, and donation of conservation easements in hopes of eliminating the drawbacks associated with fee-simple. The non-profits have the ability to raise funds, create unique land deals, and transfer their titles to states for perpetual protection. The sheer growth in land trusts is indicative of a trend away from federal land ownership towards private partnerships. From 1980 to 2000, there was a 300% growth in the number of land trusts across the nation, from 431 to 1,263 (McQueen 2003). These conservation groups frequently maximize their dollars by purchasing development rights.

Non-governmental organizations have engineered some major deals in the Northern Forest (OSI 2008; TPL 2008; Northern Forest Alliance 2006; Fairfax 2005; SPNHF 2005; TNC 2005; Pataki 2004; Levitt 2003; OSI 2003; NH F&G 2003; VT Land Trust 1997). Some of the largest are highlighted in Table 2.

State	Project Name	Hectares	Finances	Players
Maine	Pingree Partnership	308,500	$30 million	TPL, TNC, US F&W, OSI, SPNHF, USDA Forest Legacy
Vermont	NE Kingdom – Champion Deal	69,400	$26.5 million	VLT, VT Housing & Conservation Board, Conservation Fund, Hancock Timber, US F& W, VT FPR, Freeman Foundation, Mellon Foundation
New Hampshire	CT lakes Headwaters	69,400	$32.7 million	TPL, SPNHF, Lyme Timber, State of NH, Forest Legacy, US F&W
Adirondacks	Sable Highlands	42,000	$24.9 million	Conservation Fund, TNC, NY State, Lyme Timber

Table 2. Largest Preservation Deals by State

The NGO community is frequently the intermediary. Their quick transactions, often transferred to the state, allow the NGOs to replenish their funds for the next big land sale or conservation easement opportunity. The only criticism is that these lands are being preserved in a reactive manner responding to urban growth, and do not address the planning for sensitive ecosystems that may need urgent protection (RPA 2011). There is however a few organizations which are proactively attempting to ensure a working landscape and rural character in the region (Vermont Working Landscape Council 2011). Overall, preserving almost one million hectares in just over ten years is a very significant accomplishment on the part of the land trusts and a major step towards conservation integration in the region.

Conservation integration is successfully working. However, is preservation having a positive effect? Or is the Northern Forest accepting all the funding it can (a majority coming from NGOs outside the region) for reactive purchases of the next big parcel or easement in hopes of combating sprawl and taking over the lands of failing timber companies? It could also be that the priority of land trusts is not in line with the government policies and plans already in place, creating further conflicting planning paradigms.

Research Model

This model is built on the assumption that a region is in an ideal balance when the environment, economy, and society are sustainable. This model also assumes that forestry and recreation-based economies practice sound ecological methods, bolster local economies through jobs and output, and also encourage vibrant and healthy communities. Forestland preservation may be the key in moving counties in the Northern Forest toward greater sustainability. It is hypothesized that those counties with higher percentages of preserved land will exhibit a stronger positive correlation with characteristics of economic, environmental, and social sustainability.

The model to test the hypothesis begins with percentage of land preserved in a county as the dependent variable and the three measures of sustainability as the independent variables. An analysis of related theory, a literature review, and available data helped to determine the 15 independent variables used in the model. The premise is that by using several sustainability factors, correlations can be established between certain independent sustainability variables and land preservation. The breakdown is as follows:

% of all Land in Preservation = f (Triple Bottom Line (Environment + Economy + Society))

Environment = mean elevation + predominant forest type + total timberland + non-forested areas + (Preservation or Conservation)
Economy = median household income + median home value + sawlog and pulpwood harvest output + number of building permits
Society = population change 1990-2010 + persons over 65 years + college education + state + public land + percent poverty
N=49

Category	Variable	Name	Mean	Min	Max	Source
Dependent	Percent of Land Preservation per county area - 2009	%PRES	20.8	1.5	83.6	4
Economy - Independent	Median county household income - 2009 ($)	HSHLD_INC	47,083	31,861	70,196	1
	Median county home value - 2009 ($)	HM_VL	170,777	76,800	313,400	1
	Sawlog and pulpwood harvest output per county area - 2005 (mbf/acres)	TMB_HVST	7.51%	1.18%	22.86%	2
	Building permits in county 1990 - 2007	BLD_PMT	5,470	413	24,243	1
Environment - Independent	Mean county elevation (ft)	ELEV	935	112	1,986	4
	Predominant Forest Type (categorical - 0=33% hardwood, 1=33% softwood, 2=33% soft & hardwood)	FST_TYPE	0*	0	2	3
	Total timberland per county area †	TMBLD	71.72%	14.03%	95.03%	3
	Total forestland per county area †	FSTLND	78.35%	14.03%	97.36%	3
	Non forested areas per county area †	NON_FST	20.98%	1.97%	93.79%	3
	Percent of recreational land preservation per county area - 2009	REC_LSP	8.61%	0.41%	68.99%	4
	Percent of working landscape preserved per county area - 2009	WRK_LSP	12.07%	0.12%	37.06%	4
Society - Independent	Population change 1990 - 2010 (persons)	POP_2010	14,539	(15,066)	203,138	1
	Persons over 65 years per county area - 2010	SNR_65	2.22%	0.10%	8.32%	1
	Persons with bachelor's degree per county area - 2009	COLL	1.96%	0.05%	10.60%	1
	Which state - Maine, New Hampshire, Vermont or New York (categorical - 0=VT,1=NH,2=NY,3=ME)	STATE	3*	0	3	4
	Public land per county area †	PUB_LND	8.04%	0.00%	33.43%	3
	Persons below poverty line per county area - 2009	PCT_PVTY	12.09%	4.59%	20.35%	1

1 - US Census Bureau
2 - State Forest Service Agencies
3 - USDA Forest Service Forest Inventory and Analysis Division (FIA)
4 - GIS Calculations - this study

† = Data compiled in different years from USDA FIA Mapmaker & FIA Forest Statistic Manuals

* = mode

Table 3. List of Variables and Ranges of Input Values for Each Model.

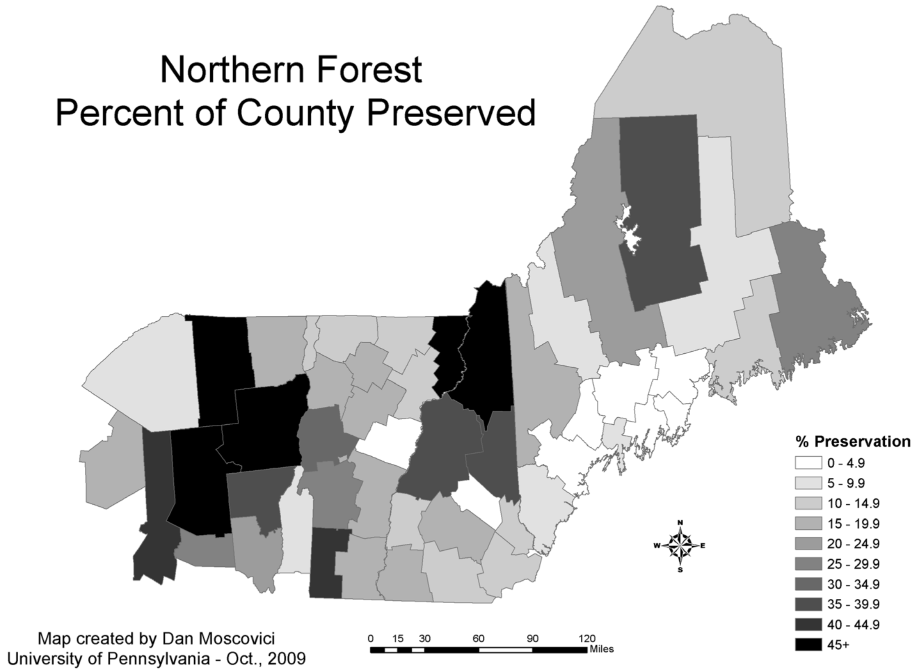


Figure 4. Northern Forest Percent of County Preserved.

Data

Dependent Variable

The model uses county-level data with a sample size of 49 counties spanning the states of Maine (14), New Hampshire (10), Vermont (14) and the Adirondack counties of New York (11) indicated in the map. Table 3 includes data sources and simple statistics for all the data used in the analysis.

The percent of land preservation (%PRES) by county has been selected as the dependent variable. This variable includes all land preservation in a county, including federal, state, local government and land trusts – both fee simple and conservation easements, compiled from a variety of state and NGO sources (Cheeseman 2008; Morrell 2008; APA 2001; Mcfaden 2006; Sundquist 2006; NH GRANIT 2008; VCGI 2008; Denis 2008; MEGIS 2008; Berry 2008; DeWolf 2008). However, to break out parcels by county, a GIS analysis was necessary which determined the land in each county preserved. The percentage was then calculated using land area statistics from the US Census Bureau. See figure 4.

Data for for Economic, Environmental & Social Variables

The first three variables for economic activity are median household income, median home value, and building permits. Each of these datasets was obtained from the US Census Bureau (US Census Bureau 2010; US Census Bureau 2010a). The fourth, amount of sawlog and pulpwood harvest output was acquired from individual state agencies (VT Division of Forestry 2008; Maine Forest Service 2008; Tansey 2006).

The environmental factors include county elevation (ELEV), which was calculated using a GIS zonal statistic calculation from the DEM layers (VCGI 2006; MEGIS 2006; NH GRANIT, 2006; APA 2001).

The second variable, primary forest type (FST_TYPE), in the entire county has been complied into categorical variables. Using the U.S. Forest Service FIA books by state, hardwood and softwood data were compiled to determine respective totals (McWilliams 2004; Frieswyk 2000; Frieswyk 2000a; Alerich 1995).

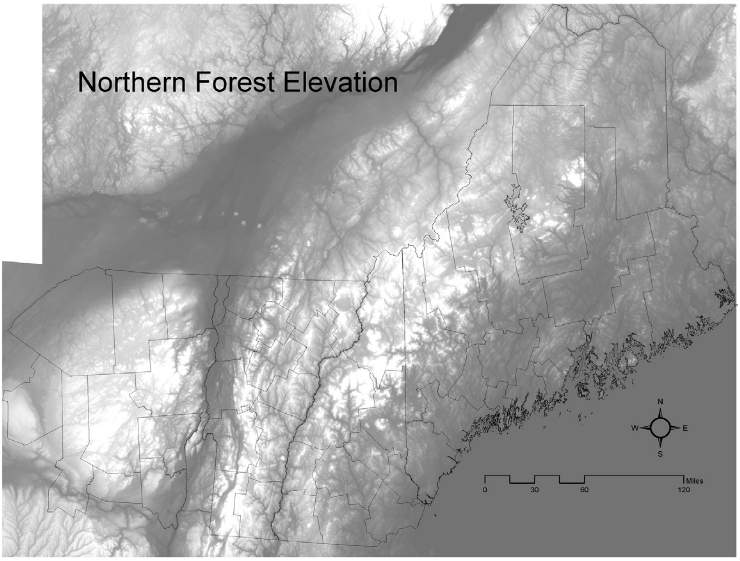
No existing research was available for a specific breakdown for this data; therefore a 33% threshold was used. Three categories represent with hardwood at greater than 33% of its timberland only, more than 33% of the county exhibited softwood timberland only, and counties that demonstrate greater than 33% for both hardwood and softwood—indicating a mixed hardwood/softwood forest.

Another environmental variable is total timberland (TMBLD), defined as "forestland producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre [.4 ha] per year) and not withdrawn from timber use" (Frieswyk 2000). The timberland data, as well as the variable for non-forested areas (NON_FST) was obtained from the US Forest Service's statistics books, the FIA Mapmaker or directly from department analysts (Frieswyk 2000; Frieswyk 2000a; FIA Mapmaker 2008; Alerich 1995; FIA Mapmaker 2008b; McWilliams 2004). The final environmental variable relates to the type of land preservation (WRK_LSP).

TABLE 4 - Significant Statistical Results

Variable	Category	Unstandardized Beta	Standardized Beta	Significance P-value	95% Confidence Interval Lower Bound	Upper Bound
Non Forest Areas	Env	-0.699	-0.606	<0.001	-0.987	-0.412
Mean Elevation	Env	9.281	0..283	0.011	0.000	0.000
Total Timberland per county	Env	-0.731	-0.721	<0.001	-0.947	-0.515
Bachelor's Degrees/ha - 2009	Soc	4.641	0.690	0.013	1.013	8.269
Persons over 65/ha – 2010	Soc	-6.971	-0.847	0.005	-11.673	-2.269

Table 4. Significant Statistical Results



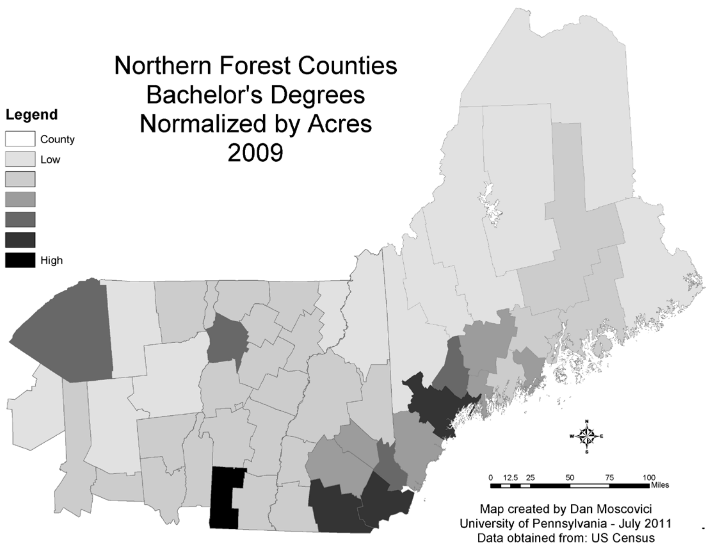
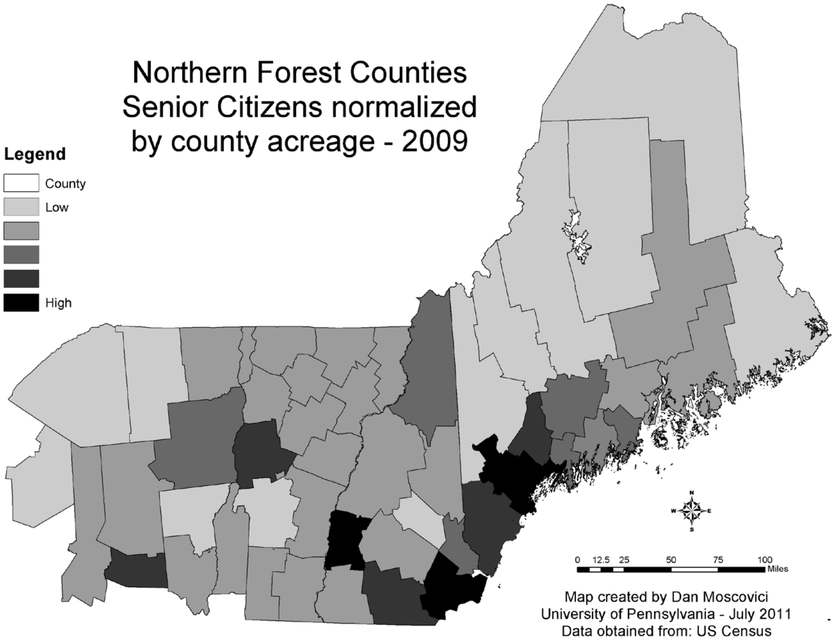
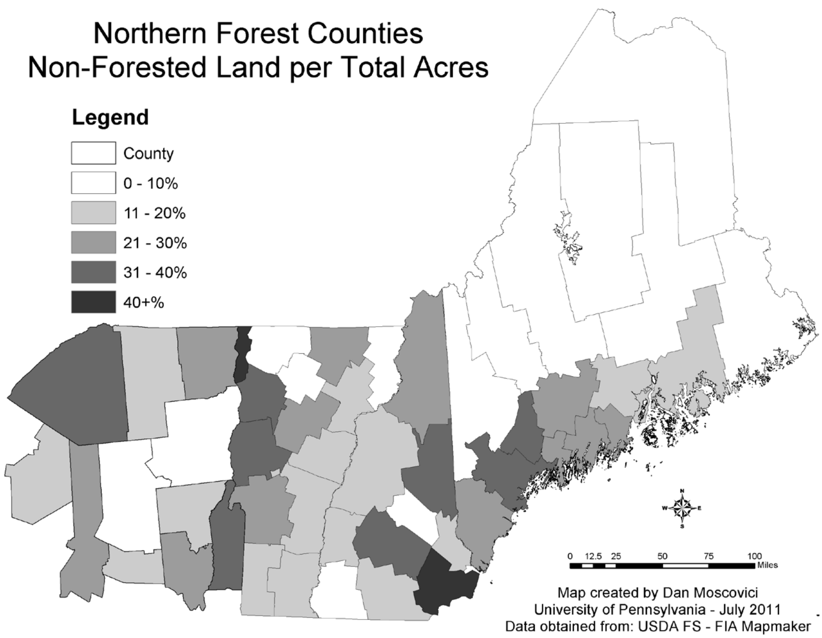


Figure 5. Geographic Representation of the Variables with Positive Correlation.


Northern Forest Counties
Senior Citizens normalized
by county acreage - 2009
Legend
County
Low
High
0 12.5 25 50 75 100
Miles
Map created by Dan Moscovici
University of Pennsylvania - July 2011
Data obtained from: US Census


Northern Forest Counties
Non-Forested Land per Total Acres
Legend
County
0 - 10%
11 - 20%
21 - 30%
31 - 40%
40+%
0 12.5 25 50 75 100
Miles
Map created by Dan Moscovici
University of Pennsylvania - July 2011
Data obtained from: USDA FS - FIA Mapmaker

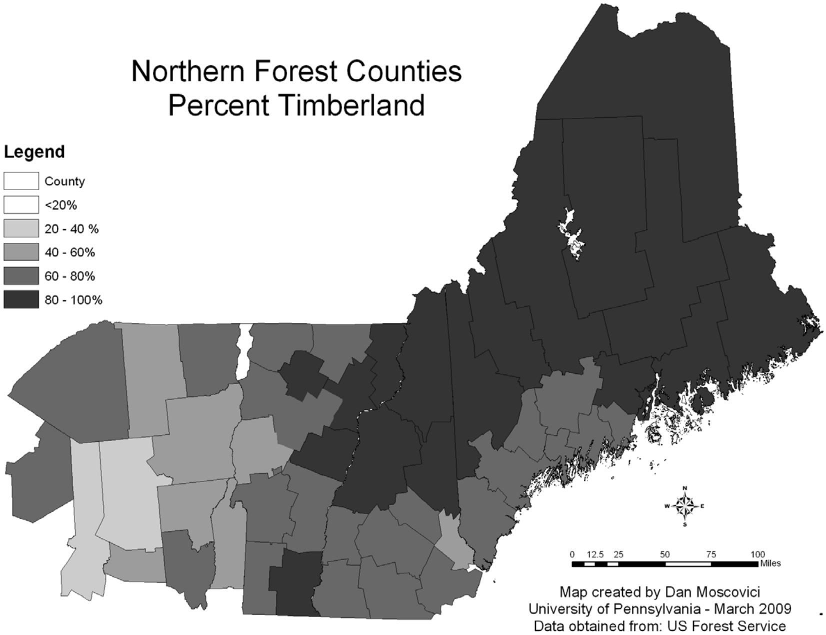


Figure 6. Geographic Representation of the Variables with Negative Correlation

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Among the different land preservation types are those set aside for recreational purposes or for wildlife protection. For example, the wilderness areas of the Adirondacks, Baxter State Park, and national wildlife refuges. These areas do not allow and will not permit timber harvesting of any kind, unless it occurs from a permitted salvage situation. The other type of land preservation protects parcels from subdivision and development, involves monitoring for and performing sustainable harvests with limited environmental impacts, and often includes recreational opportunities or additional riparian protection.

All of the preserved parcels, 24,709 GIS line items, were re-coded, intersected using a GIS analysis, recalculated geometry, and summarized. This figure was then divided by land area for consistency.

Societal well-being represents the final triple-bottom line sustainability goal. Land preservation is not merely an environmental or economic endeavor; it seeks to conserve forests for the benefit of the community. The five variables that were considered for the social portion of the analysis are as follows: county population; population over 65; population over 25 with college degree; the state geography; and the percentage of public land.

Population data (POP_2010) is the absolute population change from 1990 to 2010 (US Census 2010d). To test for the effect of age, education, and poverty, (SNR_65) (measured by persons over 65 years normalized by county land area), (COLL) education-level trends (measured by persons with a bachelor's degree normalized by land area), and poverty (PCT_PVTY) (measured by the percent of poverty) (US Census 2010b; US Census 2010c).

The effects of public land on land preservation (PUB_LND), was also included. The data sources include the UDSA Forest Service's FIA Forest Statistic Manuals and the FIA Mapmaker tools. In addition, the dataset is normalized by county hectares for comparable purposes (FIA Mapmaker 2008; FIA Mapmaker 2008a, FIA Mapmaker 2008b; McWilliams 2003; Frieswyk 2000; Frieswyk 2000a; Alerich 1995).

Finally, there are a variety of differences among the states across the region. Factoring state's forestry laws and growth management practices, and other initiatives inform the need for this state category (STATE). Therefore, a categorical variable helps distinguish between New York, Vermont, New Hampshire, and Maine.

Variations of data analysis

Understanding the correlations of individual and combined sustainability factors with land preservation (%PRES) may be useful for future preservation strategies. It is important to note that there are some overlapping effects of particular variables, which could result in some levels of multicollinearity, such as housing units and population. To deal with this problem, certain variables were removed from the final model based on their overall lack of statistical significance compared to their related variable, in order to develop the most accurate model.

Results

Many of the variables in the model exhibited insignificant outcomes. Table 3 indicates that five variables are correlated with the percent of land preservation in each county. These variables had a combined R-square of .754, indicating that mean elevation, total timberland, non-forested areas, college graduates, and populations 65 or older explain 75% of the variation in land preservation per county. All other variables were either removed due to multi-collinearity or their results exhibited no statistical significance.

Positive Correlation

Two variables exhibited a positive correlation with the percent of land preservation per county: college degrees and mean county elevation. The level of residents with a bachelor's degree in 2009 per hectare increases as population levels increase. Overall, this result was predicted. This finding could indicate two things, even though the findings do not indicate causation. First, educated people have a willingness to move towards areas with high levels of protection. Or, second, in areas with good levels of education there is a push to protecting the county.

The other variable to exhibit a significant positive correlation is mean county elevation. The positive correlation results again match the original supposition. There could be three reasons for this relationship. The first is that growth management techniques are encouraging land preservation and that, in combination, the laws and easements are having positive effects. Vermont's Act 250, the Adirondack Planning Agency's regulatory framework, and zoning in the LURC area are restricting development at high altitudes. Secondly, in Maine and New Hampshire, much of the development is along the coastline, with most of the preservation located at greater heights above sea level. These areas of high elevation—the White & Green Mountain National Forests, the Adirondack peaks, and Baxter State Park—are often the first to be preserved for recreation. Finally, high elevations are often not suitable for development, as steep slopes and rocky outcrops inhibit infrastructure requirements.

Negative Correlation

Eleven Three significant, yet negative, correlations also resulted from the model: population over 65; non-forested areas; and total timberland.

Contrary to the hypothesis, the percent of the population over 65 has a negative correlation with percent of county preserved. This suggests that, as the percent of seniors 65 or older decreases, there will be higher percentage levels of preservation. A quick spatial representation shows that the majority of seniors per county land area are congregated in the more urban areas and less in the rural regions.

Therefore, it seems incorrect to assert that the older populations are necessarily interested in maintaining forests in their natural state, for generations to come, while younger folks are interested in subdivision. In fact, seniors might have little, if any, preservation goals at all. Often time the elderly do not want to pay for land preservation within their communities because they are on a fixed income and increased taxes could jeopardize their monthly payments. However, for seniors owning land, they could be encouraged to sell and subdivide their land for retirement or their heirs (Stein 2010). In addition, it is possible that the preservation easement is still too new of an idea for the elderly population.

Another negatively correlated variable, non-forested areas, decreases statistically as land preservation increases, this matched the original hypothesis. Preservation in the region is typically in very rural areas and non forested territories could be considered a proxy for urbanization. Industrial forestland and recreational preserves tend to be far from urbanization. The third negatively correlated, significant relationship was between timberland and land preservation. The original hypothesis assumed that much of the preservation efforts in the region were geared towards the working landscape, and therefore more timberland would lead to higher levels of preservation. Interestingly, the average percentage of county land preserved for the working landscape (12.1%) is greater than county preservation for recreation or wildlife (8.6%) across the region. While this data seems to contradict the results of this analysis, the averages could be biased due to regional differences. Across the four states, there are six counties with greater than 25% of their land preserved for the working landscape.[1] However, only four counties have recreation or wildlife preservation over 25%, each of which is in New York.[2] In addition, Vermont could cause a disturbance in the overall analysis since the state actively protects farmland.

While fifteen variables were originally chosen to test correlation between the triple-bottom line and preservation in the Northern Forest, at the end of the analysis only five remained statistically significant. However, with an R-square of 75%, the overall model was successful in explaining the statistical variation in the dependent variable.

From among the significant correlations, almost half of the predictions were correct. Increasing education levels, decreased non-forested areas, and higher elevations are all associated with higher percentages of county preservation. On the other hand, the remaining half of the significant variables resulted in very surprising outcomes. Smaller elderly populations and lower levels of timberland indicated higher levels of county preservation. These overall results can enhance the conversations surrounding land preservation, growth management, and environmental planning, and lend themselves to a variety of theoretical and practical conclusions, and future research applications.

Conclusion

The purpose of this study has been to evaluate if there is a link between land preservation and a sustainable future, one which embraces environmental, economic, and social prosperity, and not determine causation. From the process, a variety of interesting observations and conclusions can be added to the fields of growth management, environmental, and regional planning. They help develop transferability and opportunities for future policy implementation and research.

Preservation could in theory continue until all the land is purchased fee simple or development rights are acquired – however at what cost? A great sum of money is required for these initiatives and the funding is no longer plentiful from the state or federal coffers. Rather, much of the new money is coming from outside the Northern Forest. The many non-profits funding these projects, (e.g. The Nature Conservancy and the Open Space Institute) are having significant impacts on the forest landscape. They create fast, flexible, and creative deals which are becoming the primary mechanisms for landscape scale preservation. There is however, a risk in overdependence on NGOs. Funding could stop if preservation priorities become more immediate in other parts of the nation or world. In addition, competing priorities exist as land trusts often undertake their work in a manner that is largely uncoordinated with public agencies, efforts and plans.

Conservation priorities should focus on the large contiguous land areas that remain undeveloped. These have the greatest ability to cleanse water for drinking and reduce downstream runoff and flooding. Wildlife thrives in larger areas in which confrontations with people are limited. Recreational opportunities are greatest when hikers and canoers cannot see cities and areas of development. A productive and sustainable forest products economy can only survive if it can operate on large parcels, where there are no conflicts with homeowners.

A new planning paradigm might be suggested to combat the parcelization, fragmentation and decrease in the forestry and recreation industries in the region. . Embracing a common history, mutual economic interests, and many of the same conflicts and pressures, New Hampshire, Maine, Vermont and the Adirondack counties of New York could use a new regional inter-state plan. While populations are increasing in southern New Hampshire and along Lake Champlain in Vermont, and decreasing in the Adirondack interior and northern Maine, a regional planning structure for the entire 16.4 million hectares could benefit and balance the entire Northern Forest. Even with high levels of forestland throughout the entire region, preservation levels have been haphazard on a per county basis. By developing a regional growth management plan, informed by data and overall preservation priorities, there will be less competition between states and counties for economic growth and conservation funding. A regional viewpoint could induce a balancing of recreation and timber resources, as well as promote a vibrant rural lifestyle.

Future Research

This study is part of a continuing dialogue regarding the benefits, relationships, and priorities for forestland preservation in the Northern Forest. A refinement of statistical detail, the integration of more specific data, and the transferability of these findings to other areas represent ideas for future research.

Analyzing preservation efforts within the Northern Forest from a large cartographic perspective has served as an important first step towards understanding the different players within the region. However, a next phase could dissect the data into two completely different research agendas. The first would look specifically at industrial forestland and conservation easements, in order to understand the impact this type of preservation has on businesses, the environment, and the social wellbeing of the region. The second would focus exclusively on recreation management and wildlife preservation. Moving beyond questions of regional planning, this type of research could answer important questions for both tourism and forestry academics and professionals.

Two additional questions arose from this study. The first asks, "What is the impact of preservation over time?" The date of when the land was preserved has been loosely or inaccurately compiled, if at all, over the years by the agencies which have protected the properties. The second additional question asks, "What is the effect of preservation on parcelization?" Currently, the preservation data is organized so that many of the larger parcels are broken into subgroups. Researching and combining each of these parcels would generate data related to the effect of average parcel size on the triple-bottom line indicators. Finding the associated prices paid would also add a very important dataset.

Finally, the Northern Forest was chosen based on its large percentage of private land, and its recent increases in population and land sales. However, land trusts and government agencies are working to protect forestland across the United States. The methodology for the study of land preservation, presented within this analysis, is highly transferable to other forested regions. While regional differences will exist, the evaluation of land preservation for sustainability in rural areas with timberland is of utmost importance across the entire country.

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Notes

1. Working Landscape Preservation over 25% of county: Franklin, NY (26%); Essex, VT (34%); Coos, NH (37%); Grafton, NH (30%); Washington, ME (25%); Piscataquis, ME (25%).

2. Recreation/Wildlife Preservation over 25% of county: Essex, NY (44%); Hamilton, NY (69%); Herkimer, NY (39%); Warren, NY (35%).

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THE DENDROCLIMATOLOGICAL
Potential of White Birch (*Betula papyrifera*) in Labrador, Canada

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ABSTRACT

Context: Sites where trees are at the extreme of their climatological limits are the best suited for building climate reconstructions. White birch (*Betula papyrifera*) are often found in Canada pressing the northern extent of the boreal forest. **Aims:** This study tests the dendroclimatological potential of white birch near its northern range limit by comparing a master chronology from Labrador City, Newfoundland, Canada (N52.58 W66.55) with temperature and precipitation data from the region. **Methods:** Twenty trees were sampled twice each and crossdated to create a standardized master chronology. Temperature and precipitation data spanning 1960 – 2008 were compared to a standardized version of the master chronology. **Results:** Core samples spanned 160 years (1851-2010) with a mean age of 135. Series exhibited high intercorrelation (0.425), mean sensitivity (0.374) and autocorrelation (0.808) values. The standardized chronology exhibited strong correlations with mid-summer temperature, as well as a minor relationship with moisture availability in the previous summer. **Conclusions:** The high mean sensitivity is indicative of other regional deciduous chronologies and represents heightened sensitivity to short-term climate variance. In comparison to previous dendroclimatological studies in the area, white birch appears to have a less muted climate signal, as evidenced by its strong annual growth correlations with June and July temperature. The weak association with precipitation is indicative of other species in Labrador. This study demonstrates that high-quality dendrochronological data can be attained from white birch trees in the Labrador region and consequently, this species should be recognized as potentially a key indicator of temperature trends in the region. *Keywords: dendrochronology, dendroclimatology, Betula papyrifera, Labrador, temperature trends.*

Introduction

Dendrochronology is the study of tree rings as proxy records of environmental inputs (Speer 2010). Within this discipline is the subdiscipline of dendroclimatology, which relates past and present climate conditions such as temperature and precipitation to changes in tree growth (Kaennel and Schweingruber 1995). The use of tree-ring records has been one of the key indicators used in climate change studies on local (Elliott 2011), regional (Linderholm, Moberg and Grudd 2002) and global scales (Mann, Bradley, and Hughes 1998).

In temperate climates, local site conditions often dominate the dendrochronological signal of trees (Schweingruber, Braker, and Schar 1979). More northern climates, where trees are often under extreme climatic regimes, tend to produce chronologies that primarily reflect climatological factors (Fritts 1976; Speer 2010). As it is these same northern climates that are undergoing the most severe shifts in climate today (Solomon et al. 2007), dendroclimatological studies looking to develop strong historical proxy records of climate change would benefit from focusing on circumpolar species (Lloyd and Fastie 2002). Labrador, being the most northern portion of eastern North America is an attractive region to explore for dendroclimatological studies, and has recently been attracting specific research attention to these ends (Dumeresq 2011; D'Arrigio et al. 2003; Nishimura and Laroque 2011; Trindade et al. 2011).

Using a single species for dendroclimatological study has historically been the most commonly used approach as it simplifies sampling and analysis (Forbes, Fauria and Zetterberg 2010; Helama et al. 2005; Oberhuber, Stumb, and Kofler 1998). More recently, a multispecies approach is often prescribed as it helps to develop ecosystem level responses and corroborate results by comparing different species responses (Dumeresq 2011; Laroque 2002; Nishimura 2009; Trindade et al. 2011). Recent dendrochronological research in southern Labrador has assessed the climate signals embedded in black spruce (*Picea mariana* (Mill.) Britton, Sterns, Poggenb.), white spruce (*Picea glauca* (Moench) Voss), balsam fir (*Abies balsamea* (L.) Mill.), eastern larch (*Larix laricina* (DuRoi) K. Koch), and trembling aspen (*Populus tremuloides* Michx.) chronologies (Dumeresq 2011; Kershaw and Laroque 2012; Nishimura and Laroque 2011).

White birch (*Betula papyrifera* Marsh.) sparsely populates southern Labrador, where it is pushed to the edge of its climatological northern range. The species has an extensive latitudinal range to the south and following the principle of ecological amplitude, its northern most populations will be of greatest dendrochronological value (Fritts 1976). Other dendroclimatology studies in Eurasia have applied the principle of ecological amplitude when selecting birch at the limit of their climatological range, generating important insight into the climatological conditions of the region (Yu et al. 2007). To date, no known chronologies have been developed for white birch in Atlantic Canada and the dendroclimatological utility of the species in the region has yet to be assessed. Being a deciduous species, birch is likely to be more sensitive to year-to-year climate variation than the evergreens in the area (Centre et al. 2010). Trembling aspen, another potential deciduous species for analysis in the area, was not present in great enough numbers or of great enough age to be sampled and assessed effectively.

The objective of this study is to develop a crossdated white birch tree ring chronology for the forest north of Labrador City and to assess its correlation with temperature and precipitation trends in the region. In doing so, it is intended that a viable deciduous hardwood species will be identified for dendroclimatological research in Labrador. This project will guide later research in the region looking for data sets to complement and corroborate findings from dominant evergreen species traditionally assessed in dendroclimatological research.

Materials and Methods

Site Description

The site was selected approximately 3 km north of Labrador City (N52 58.726 W66 55.277) (Figure 1), situated on a hill side with a mixed white birch/white spruce canopy and a dense alder understory (Figure 2). In this region, the summers are relatively short and cool with an approximately 100-120 day growing season and winters that are long and severe with deep snow cover (Bell 2002). The Wabush climate station, which is 6.7 km from the site (Figure 1), has a mean annual temperature of -3.2°C, a mean winter temperature of -20°C (DJF), and a mean summer temperature of 12°C (JJA). The mean annual precipitation is 1024 mm (Environment Canada 2010).

Twenty trees were sampled at breast height (DBH) with two cores taken at >90° separation using standard 5.1mm increment borers. For those trees on ground with a slope significant enough to affect growth, samples were taken 180° apart and perpendicular to the slope. Samples from the site were labelled and bundled and then transported to the Mount Allison Dendrochronology Laboratory for processing and analysis.

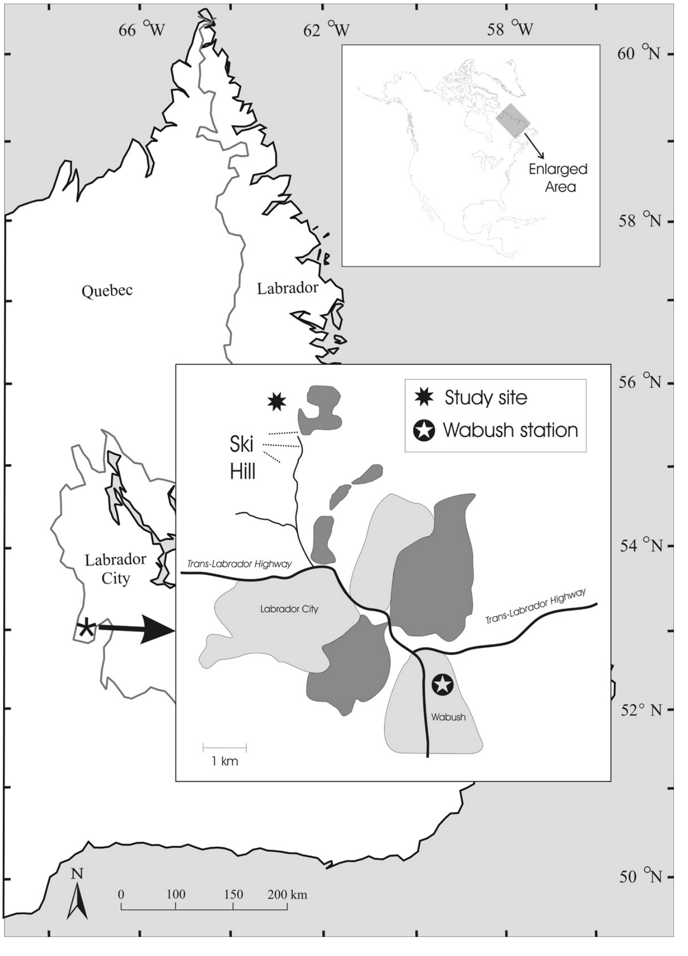

Figure 1. Map of the study site's location relative to Labrador City and the Wabush Environment Canada climate station.

Laboratory Analysis

Cores were mounted on wooden boards, and samples were

Figure 2. A view of the site with two of the measured trees visible.

sanded with progressively finer sandpaper from 80 up to 600 grit and then polished with a buffing wheel. Ring widths were visually crossdated and then measured with a Velmex stage system, a 63x microscope, and the program J2X. Each core's growth-increment pattern was checked for signal homogeneity using the program COFECHA version 6.06p (Grissino-Mayer 2001; Holmes 1983). Where crossdating inconsistencies arose that required correction, cores were rechecked with the guidance of COFECHA outputs and pointer years (exceptionally wide or narrow rings) recognizable across multiple cores. Pointer years consistently used to crossdate the series were 1881, 1945, 1965, 1971 and 2005.

After the master ring-width chronology was developed, cores were standardized using the program ARSTAN_41d (Cook 1985) with negative exponential regression (k>0), linear regression (slope>0), or a line through the mean. Standardization removed any chronology trends due to decreasing ring width with age (Helama et al. 2004). Standardized cores were then re-amalgamated into a standardized master chronology using ARSTAN's robust mean-averaging technique. None of the 40 series were removed from the data set in development of the final master chronology.

DENDROCLIM 2002 was used to assess which mean monthly temperature variables within an 18 month window (prior-year April to current-year October) correlated with the standardized ring-width chronology (Biondi and Waikul 2004). Results were assessed at two significance levels; correlation analysis, which derived correlation values (CV), and principle component analysis, which derived response values (RV). The use of two significant tests is due to the elevated threshold of significance for RV relative to CV, but the importance of still recognizing those CV that don't register as significant with RV analysis (Biondi and Waikul 2004). The standardized master chronology developed in ARSTAN and the homogenized mean monthly temperature and precipitation data acquired from Environment Canada's nearby Wabush climate station [Station # 8504175] (Environment Canada 2010) were used in analysis.

Results

The core samples spanned 160 years (1851-2010) with a mean-tree age of 135 (Figure 3). Growth increment chronologies exhibited significant intercorrelation (0.425) and high mean sensitivity values (0.374) (Grissino-Mayer 2001). The autocorrelation of the master, which measures the agreement between two consecutive year's growth, was (0.808) (Table 1).

Analysis of the master chronology's relationship to climate data spanned 48 years (1960-2008) and involved all 40 series (Figure 3). The radial-growth response to climate variables for white birch was strongly influenced by mid-summer temperatures (Figure 4) with a more minor relationship to moisture availability during June the previous summer (CV= 0.26) (Figure 5). Specific months of significance for temperature's effect on growth were June (CV=0.51) and July (CV=0.61,) (Figure 4).

The more statistically robust response values reported no significant relation between radial-growth and precipitation. Temperature's relationship to radial-growth exhibited strong positive

mean series length (years)	number of trees (cores)	mean series intercorrelation	average mean sensitivity	unfiltered autocorrelation
134.6	20 (40)	0.425	0.374	0.8-08

Table 1. Descriptive statistics for the white birch (*Betula papyrifera*) chronology. The 99% confidence level for series intercorrelation is 0.3281.

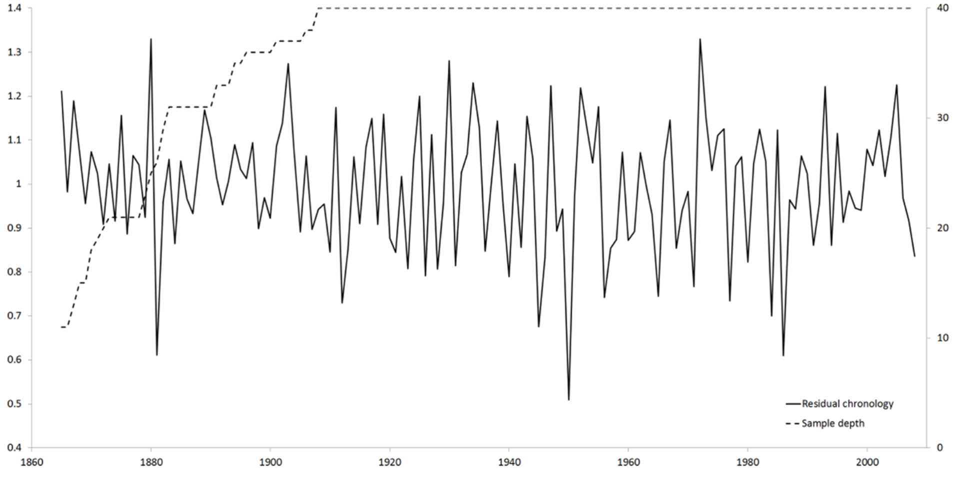

Figure 3. Master chronology's sample depth (0-40 cores) and residual values for each year's growth (deviation from chronology mean).

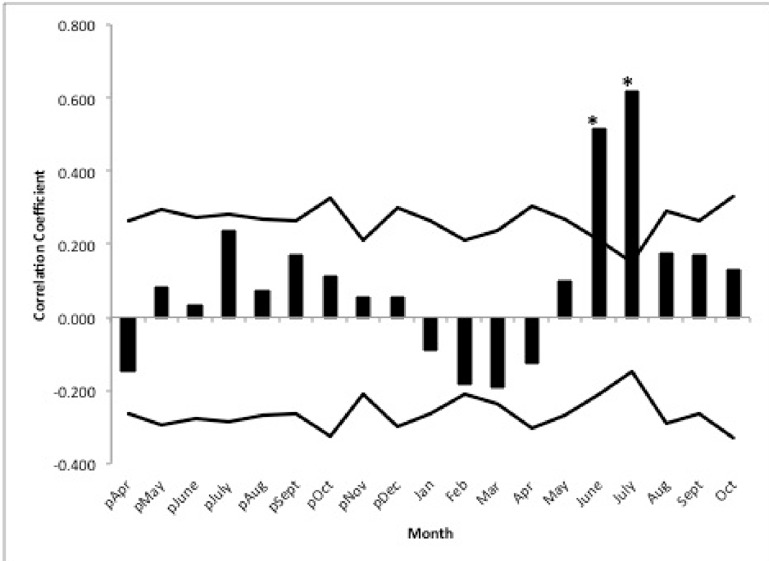

Figure 4. DENDROCLIM 2002 correlation value (CV) results for temperature's relation to growth increments organized by month (previous year April to current year October). Bootstrap correlation test requirements for 95% confidence denoted by the solid line. Starred months denote statistically significant correlations.

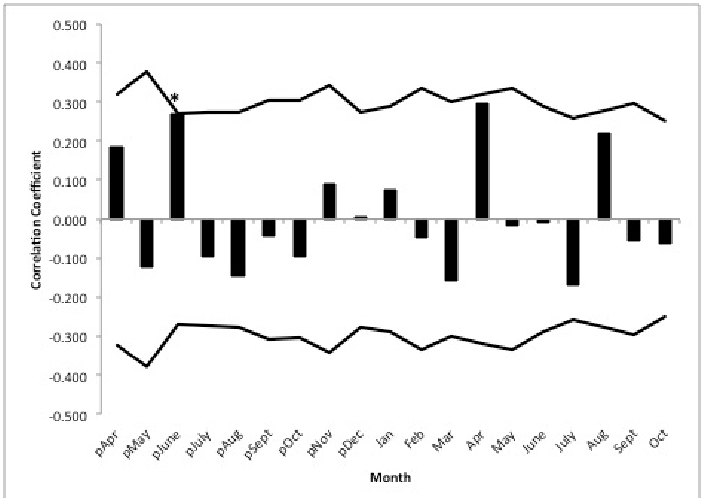

Figure 5. DENDROCLIM 2002 correlation value (CV) results for precipitation's relationship to growth increments organized by month (previous year April to current year October). Boostrap correlation test requirments for 95% confidence denoted by the solid line. Starred months denote statistically significant correlations.

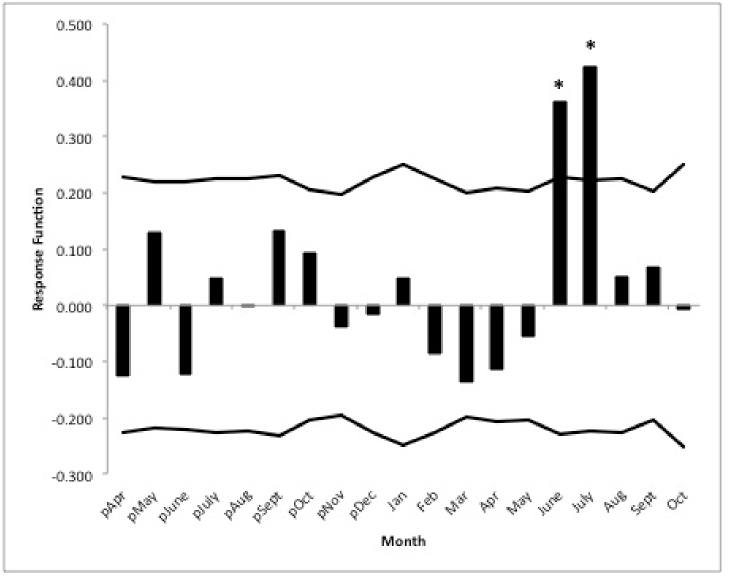

Figure 6. DENDROCLIM 2002 response value (RV) results for temperature's relationship to growth increment organized by month (previous year April to current year October). Bootstrap correlation test requirements for 95% confidence denoted by the solid line. Starred months denote statistically significant correlations.

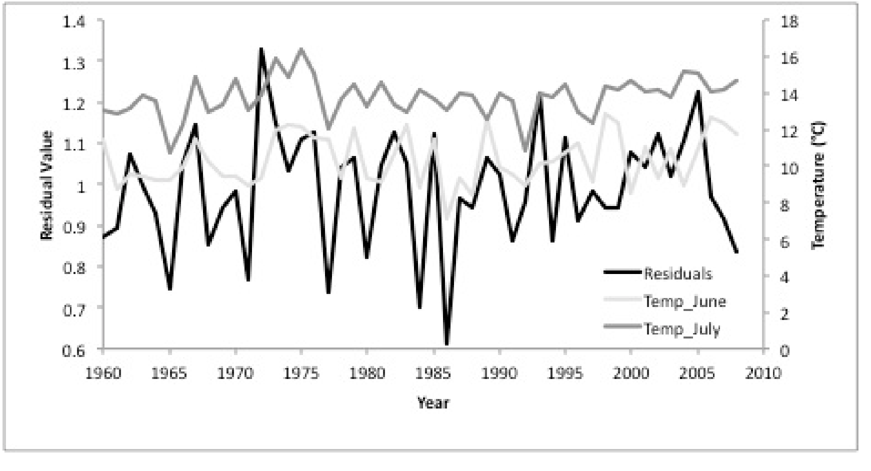

Figure 7. June and July monthly average temperatures from Environment Canada Wabush Station (8504175) (Canada 2010) plotted alongside the standardized master chronology residuals.

associations during June (RV=0.36) and July (RV=0.42) (Figure 6). Annual fluctuations in growth corresponded especially well to June and July temperatures in 1965, 1967, 1986, and 1993 (Figure 7).

Discussion

The autocorrelation values for this site are consistent with those measured for other species sampled in Labrador (Dumeresq 2011; Kennedy 2010; Kershaw and Laroque 2012; Nishimura and Laroque 2011). The intercorrelation value for this site is well in excess of the 0.3218 value needed to attain the 99% confidence interval threshold, meaning that the master chronology is a good representative of the series sampled. The relatively elevated mean sensitivity value for this birch site is consistent with deciduous aspen (Dumeresq 2011) and eastern larch (Dumeresq 2011; Nishimura and Laroque 2011) tree chronologies previously assessed from Labrador. This heightened mean sensitivity represents greater sensitivity to short-term climate variance (Oberhuber, Stumb, and Kofler 1998), and is likely associated with the higher susceptibility of deciduous trees to the extreme northern climate (Dunwiddie and Edwards 1985). Crown loss due to late spring snowstorms and early abscission caused by early fall frost events likely contribute to this heightened deciduous species sensitivity to climate relative to needle bearing species.

Birch's positive association with June and July temperature in this study is consistent with other research findings which have identified that temperature's most important months of influence on tree growth generally fall in the summer (May-August) in Labrador (Nishimura and Laroque 2011) and specifically June in inland Quebec (Lapointe-Garant et al. 2010). A recent study on birch in Iceland reported strong associations between both June and July temperatures with tree growth as well (Levanic and Eggertsson 2008). This reinforces the results of this study on a regional, as well as circumpolar scale.

While the dominant force limiting growth according to our results is temperature, there remains a weak association with the precipitation component of the climate signal encoded in annual growth (Figure 5). Other dendrochronology studies in Labrador illustrate that the dominant growth suppression factor on trees in the region is temperature, with precipitation, when discernible, being of minor secondary importance (Kennedy 2010; Lapointe-Garant et al. 2010; Nishimura 2009; Trindade 2009). Considering this research context, it is difficult to trust the precipitation results of this study as they barely manage to cross the threshold of statistical significance, and only do so for the weaker CV parameter and not the more robust RV significance test. This study does not support the use of birch in Labrador as a proxy of precipitation trends in the region.

If we limit our assessment of white birch's dendroclimatological research potential to the more stringent response value (RV) results, the efficacy of the species is quite apparent. Previous dendroclimatological studies conducted near Labrador City report statistical significance in temperature's relationship with growth in July for eastern larch (*Larix laricina*) (RV=0.28) and May for black spruce (*Picea mariana*) (RV=0.22. 0.31) (Nishimura and Laroque, 2011). In comparison, the birch chronology of this study is more strongly temperature limited as evidenced by the heightened RV values associated with June (RV=0.36) and July (RV=0.42) temperature (Figure 6). The birch chronology developed in this study has the second highest RV value for a growth relationship with monthly mean temperatures in all of Labrador on record (Dumeresq 2011; Kennedy 2010; Nishimura and Laroque 2011; Trindade et al. 2011). Therefore, birch should be considered one of the more sensitive indicator species for temperature fluctuations in Labrador and further research projects should accommodate it in their study design framework where possible.

Other hardwood species in the area are too sparse and too young for effective dendrochronological assessment, further emphasizing the importance of white birch in the area. A similar opportunity for birch chronologies filling deciduous hardwood gaps likely exists elsewhere in Labrador, particularly in the more inland and northern parts of the province, but due to the lack of attention white birch distributions receive (Payette 1993), the fulfillment of such potential is likely to be opportunistic in nature with sampling of birch stands done secondarily while focusing on the dominant conifer species in the region.

We recommend further study of birch in Labrador to assess its response to all the bioclimatic zones it is present in, as identified through dendrochronological modeling with other species (Dumeresq 2011; Kennedy 2010; Kershaw and Laroque 2012; Nishimura and Laroque 2011).

Conclusions

This study establishes that high-quality dendrochronological data can be attained using white birch trees near their range limit in southern Labrador. Birch at this site produced exceptionally strong correlations with temperature. The statistical relationship between growth and precipitation was weak and this corroborates earlier study results in the region. The absence of aspen in the area leaves birch as the only deciduous hardwood species in inland Labrador for supplementing the previously developed conifer chronologies. Given the strength of association with summer temperature, birch may be a better species to select where its range overlaps with other deciduous species such as aspen and larch. Given the confirmation between white birch and other species exhibiting a relationship with summer temperature and tree growth, and the heightened sensitivity of white birch's response, it can be concluded that this species could potentially be of vital importance in subsequent dendroclimatological studies in Labrador. Birch should be considered in all future dendrochronology studies in Labrador, and other northern boreal to sub-arctic transition zones where it is present.

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Acknowledgements

Thanks to CCI's director Dr. Marianne Douglas for co-supervising the author on his CCI grant application, and Graham Clark for help during statistical analysis. Also thanks to the Northern Scientific Training Program (NSTP) and the Canadian/Boreal Alberta Research program (C/BAR) for funding this research.

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"OBSELETE ARCHAISM, UTOPIAN DREAMS AND Manure": Biogas and Dairy Livelihoods in Vermont

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ABSTRACT

Biofuels have been a major growth area among "alternative" energy sources in recent years as a response to concerns about dwindling fossil fuels. While biofuels expansion has been controversial due to perceived negative environmental and social outcomes, social science and human geography literature has only recently begun to address these issues. This article will give a brief overview of issues surrounding biofuels and then provide a case study example focusing on biogas development on dairy farms in Vermont. While such development was initially viewed with extreme optimism, market realities surrounding both milk and energy prices have led to difficulties in guaranteeing producers a fair share of revenues, thus necessitating the introduction of government-backed priced stabilization. Focusing on the effects that biogas production has had on farmers directly involved in production, this article will argue that while this specific instance of biofuels use may not be a good long term solution for energy and climate problems, the benefits to the livelihoods of struggling farmers serve to make the program worthwhile. Adopting a similar attitude towards other instances of biofuels production could help to mitigate some of the worst environmental and social repercussions. *Keywords: Agriculture, Dairy, Energy, Sustainability, Vermont.*

Introduction

Anxieties surrounding potential threats posed by climate change and the rapid depletion of fossil fuel stores have led to an explosion of debate around sustainability and the promotion of "alternative" lifestyles and energy technologies to help mitigate environmental and social damage caused by poor resource use policies. Writing in 1990, I.G. Simmons (1990, 98) described this new preoccupation placing environmental crises at the forefront of media coverage and policy discourses as "the world … being viewed through tinted glass of a greenish hue." In the more than two decades since those words were written, green(ish) discourses and behaviors have grown tremendously as predictions regarding climate and energy insecurity have become increasingly dire and celebrity personalities such as former Vice President Al Gore and writers such as Michael Pollan, Eric Schlosser and Colin Beavan have helped to bring sustainability issues to a wider audience. Given that the root cause of environmental ills is often identified, whether rightly or wrongly, as the overreliance on fossil fuels, much focus has been placed on expanding alternative energy production as an effective way to counter the apocalyptic nightmares burned into the popular imagination by films such as *The Day After Tomorrow* and *An Inconvenient Truth*. While the success of alternatives promotion policies in solving existing crises is furiously debated, a whole host of new environmental and social issues related to expanded alternative energy production have arisen. Although warranting serious debate akin to that associated with other environmental issues, these new challenges rarely receive the attention they deserve.

Biofuels (energy sources derived from organic matter) in particular have come under criticism for exacerbating existing environmental and social inequalities as much recent production expansion has occurred in already impoverished areas of the developing world and could not be described as sustainable or environmentally friendly (see Farrell et al. 2006). In their influential report, *Bio-fuelling Poverty*, Oxfam (2007, 2) notes,

> Under the right conditions, biofuels offer important opportunities for poverty reduction by stimulating stagnant agricultural sectors, thus creating jobs for agricultural workers and markets for small farmers ... Unfortunately such conditions, including national and corporate policies with clear pro-poor, environmental, and social objectives, are not evident in the emerging agro-industrial model. Instead, a scramble to supply the European market is taking place in the South, and poor people are getting trampled

Similar charges have been leveled by Jacques Diouf (2007, 1), the former director-general of the United Nations Food and Agriculture Organization, who adds that, "We urgently need to draw up an international bio-energy strategy. In the absence of such a plan we run the risk of producing diametrically opposite effects: deeper poverty and greater environmental damage." Indeed, it is no accident that such criticisms focus on the damage that First World energy needs do to Third World livelihoods as much of the First World debate around biofuels focuses solely on economic viability and ignores environmental and social ramifications (see for example Gillon's (2010) discussion of the privileging of ethanol agribusiness needs over those of local corn farmers in Iowa). While the issues surrounding biofuels production (third world development, environmental degradation, climate change, resource use, etc.) would appear to make biofuels a topic ripe for academic research, social scientists have entered the conversation in a forceful way only recently and biofuels have received hardly any attention in human geography.

This article will provide a brief overview of biofuels literature in the social sciences and geography, paying particular attention to strengths and weaknesses of existing research. The literature review will be followed by a short history of biogas technology and a related case study focusing on the environmental and social effects of biogas development on dairy farms in Vermont. This article will then conclude with recommendations for future biofuels development that can serve the needs of both energy consumers and biofuels farmers.

Biofuels and Social Science

Issues of political economy and the environment have long held purchase in environmental social science and under the interdisciplinary umbrellas of human, cultural and political ecology. Perhaps the key factor that separates such methods of inquiry from apolitical ecologies is the notion that humans have had as much, if not more, impact upon the "natural" environment than nature has had on humans. Such ideas have been expressed as far back as 1914, when sociologist E.C. Hayes (1914) asserted that humans were not simply passive vessels molded by their physical environmental, a la Semple (1911), but active transformers of both the social and natural world through their use of technology. Geographers too have played an important role in the development of these three ecologies with Harlan Barrows (1923, 3) declaring in his Association of American Geographers presidential address, "Geography as Human Ecology," that it is important to avoid, "the danger of assigning to the environmental factors a determinate influence which they do not exert" and Blaikie, Cameron, and Seddon (1977, 17) noting, "space is what the political economy makes it, and it is constantly defined and redefined by the dominant mode of production." While these three ecologies have been influenced by theories as diverse as Systems Theory, Marxism, and Actor-Network-Theory, the core theme of human transformation of the environment has remained constant.

As issues such as development, inequality and environmental degradation are the bread and butter of the three ecologies, one would expect environmental social scientists to have expanded their existing research into biofuels at a rapid pace. However, social science, and human geography in particular, have been largely silent on biofuels until very recently, often mentioning them only in passing as part and parcel of other resource struggles. Although Third World food security has long been identified as one of the pitfalls of Green Revolution technologies (Cleaver 1972), it is only within the past five years that social scientists have begun focusing on the so-called "food vs. fuel" debate and the negative effects associated with replacing food crops with biofuel crops, which Vandana Shiva (2008) refers to as "soil not oil." In their introduction to *The Journal of Peasant Studies* special issue "Biofuels, Land and Agrarian Change", Borras, McMichael, and Scoones (2010) note that food vs. fuel concerns came to a head as a result of the 2007-2008 food price crisis and have been exacerbated by the post-2007 global financial crisis. In another article in this same special issue, McMichael (2010) argues that food vs. fuel is yet another in a long line of failed neoliberal agricultural policies. Indeed, such a focus on neoliberalism, which has dominated much critical scholarship on biofuels, has led to a focus on global "land grabbing" with few case studies of local manifestations of biofuels, despite calls from authors such as Novo, et al. (2010) to move towards research that takes into account the specificities of place.

Biofuels research in geography also tends to focus on the global rather than the local, although examples all together are quite sparse. As Bridge (2011, 824-825) notes, citing only 3 examples, that, "processes of enclosure, land conversion, social transformation and ecological exchange are at work around the development of biofuel resources, although to date there has been relatively little work by geographers on the complex geographies and political ecologies of biofuels." Much of the geographic scholarship that does exist such as Tenerelli and Carver's

(2011) agro-spatial modeling and Mabee and Merck's (2011) evaluation of forest resources in Ontario is often of the apolitical variety, favoring quantitative techniques and including little field-based qualitative data. Even political ecology influenced research such as Walker's (2011) article on biofuels in Amazonia focuses on global processes at the expense of the local. The one example that attempts to tie changes at the global level to the experiences of biofuels farmers is Cope, McLafferty, and Rhoads' (2011) article on switchgrass production in Illinois, which gathered data using both surveys and GIS-aided focus groups. As similar localized, qualitative studies are few and far between, the following review of biogas technology and the related case study will serve to fill in gaps that are often not addressed by focusing solely on food vs. fuel and neoliberal agriculture.

A Short History of Biogas Production

Biogas is a type of biofuel created by extracting gaseous components (usually methane) from decaying organic material (biomass), with animal manure, which will be the focus of this article's case study, being one of the more commonly used biomass. The extraction process is often sped up using a machine called an anaerobic digester, which maintains a warm, high carbon dioxide environment where bacteria that aid in decaying can flourish. While biogas has been used as an energy source since the late 18th century, it is only in the post-World War II era that industrial-scale digesters have become widespread. Cheap and plentiful fossil fuels available in the Western World during the 1950's and 1960's led to little research and development into alternative energy technologies, thus these large digesters were used mainly by farmers looking for ways to better manage their excess manure and the resulting biogas was usually flared off. However, in rural areas of Asia where peasants either could not afford or had little access to fossil fuels, manure biogas was used to provide heat and electricity to resource-strapped communities (Gautam, Baral, and Herat 2009; Chen et al. 2010). Concerns about methane emissions in the 1970's led to the creation of cheaper and more efficient digesters and Western farmers adopted them more frequently, yet they were still rarely used for electricity provision outside of the rural Third World (Abassi, Tauseef, and Abassi 2011).

Since the 1970's, biogas for energy has grown quite slowly in the West despite manure, both human and animal, commanding a growing share of energy production in places such as rural India (Jewitt 2011). As of March 2012, AgSTAR (a joint venture between the Environmental Protection Agency (EPA), United States Department of Agriculture (USDA) and the Department of Energy (DOE) which promotes and provides funding for anaerobic digesters) has 186 operating manure digesters (split between cow, pig and chicken manure, with dairy being responsible for 153 digesters) listed in its registry, approximately half of which are capable of producing electricity. However, having the capacity to produce electricity does not always guarantee off-farm use, as farms often have difficulty integrating with the existing methods of electricity provision that would allow their electricity to reach the market. Many farms are not connected to "smart grids" (advanced automated grids that provide electricity on an efficient, as needed basis) and other grid-connected (GC) systems that are necessary for electricity produced outside of power plants to be fed onto a larger electric grid. Traditional fossil fuel electrical utilities, which often have exclusive control over large swaths of the electrical grid due to deregulation in the 1990's, strongly oppose the construction of such efficient systems as they feel it would weaken their authority and profitability and lead to the eventual phasing out of fossil fuels (Warwick 2002; Bouffard and Kirschen 2008; United States Department of Energy 2010). Therefore, construction on these new types of grids has been slow (especially in rural areas where most digesters are located) and biogas farmers have had uneven opportunities to sell their electricity. Our case study, however, will show that a successful biogas program that is well integrated with new grid technologies can exist, while also providing manure management and income benefits for farmer producers.

Case Study: Vermont's Cow Power™ Biogas Program

In the early 2000's, customers of Central Vermont Public Service (CVPS), a publicly owned utility, began asking if it would be possible to receive their electricity from alternative sources. Being somewhat familiar with existing biogas generation systems in states such as New York, Pennsylvania, and Wisconsin, farm efficiency expert Dave Dunn began investigating the possibility of creating a way to use Vermont's large number of dairy farms to meet these demands. Many farmers whom Dunn approached were already interested in anaerobic digestion as a way to manage their manure and were excited by the prospect of being able to earn extra income in order to cushion themselves against swings in milk prices (Dave Dunn, Cow Power™ Coordinator, telephone interview 4 March 2011). Thus, this new, voluntary program, dubbed Cow Power™, in which customers would pay a nominal fee to help fund digester development, was born. While this program would likely have met with resistance from utilities were it proposed in other states, as Vermont's utilities are all publicly owned, have exclusive service territories and have their prices set by the Vermont Department of Public Service. Thus, there was little reason for utilities to oppose alternative energy development on the grounds that it would lead to a weakening of their authority or hurt their bottom line. Indeed, Vermont utilities have been cooperating since the 1930's and such has also been the case with Cow Power™ as it has extended beyond CVPS's service territory (Dunn 2011, telephone interview). Other strong factors allowing Cow Power™ to get off the ground were the strong support of state politicians, grants provided by AgSTAR and the USDA Rural Development and concerted efforts to modernize the state's electrical grid (D'Ambrosio 2011; Baird 2011). Thus, although it should not be assumed that it was easy for Cow Power™ to be operationalized (as will be demonstrated shortly), many of the stumbling blocks that have prevented adoption in other areas are not present in Vermont and the program was actively encouraged and supported by those who would traditionally be classified as opponents. Indeed, as this case study will show, despite being a program that has been considered by all involved a success, Cow Power™ has not been without its growing pains.

A major obstacle that many farmers have faced in setting up digesters and generators has been cost. With a total sticker price of approximately $1.5 million, securing financing, particularly in a tight credit market, can be difficult. While this may have discouraged many from attempting to set up Cow Power™ in the first place, due to the interest of AgSTAR, USDA Rural Development and state level agencies such as Vermont Clean Energy Development Fund and

Vermont Agency of Agriculture, most farmers were able to secure grants that covered a majority of their costs and loans that could be paid off without expending all biogas income. Farmers have noted that while they were pleased with these terms, they felt that the true cost of the project has been far more than expected. Although Vermont has made significant progress in upgrading their electrical grid, many individual farmers had yet to install the newer technologies that would allow them to connect up. This was a significant cost for several farmers, particularly those located further from power substations, with one farmer noting that he knew several farmers who wanted to join Cow Power™ but felt that the grid conversion necessary would be either too expensive or too cumbersome to make joining worthwhile. Each phase of the project, from approval to construction to going online, required many different feasibility studies and assessments by local and national regulatory agencies. These assessments proved to be not only a significant extra expense, but were also viewed by farmers as being redundant and often useless. Given that many of these assessments were required due to Vermont's strict environmental laws, one farmer described the process as, "being forced to buy a Cadillac when a Toyota would do the same job." Farmers felt that the lack of transparency and the often contradictory messages sent by different funding and regulating agencies made the process far more convoluted than they felt it should have been. One farmer, whose entire implementation process took more than 3 years, addressed his situation thusly:

> The number of agencies that we dealt with were about 12 and I can't say that any certain agency was actually "difficult" to deal with but you needed to jump through every hoop placed in front of you and so combined, it was an administrative nightmare. We are glad that we took the steps that we did and saw this through completion, but hope that we never have to build another one…the thought sends shudders down our spines.

Indeed, while all farmers have been satisfied with their systems once they began operating, they felt that getting to that stage was the most unpleasant part.

Another area that farmers have expressed displeasure with is income derived from biogas. As mentioned above, one of the major reasons that farmers were interested in joining Cow Power™ was to provide extra income in the event of rapid milk price swings, which occurred frequently during the years 1995-2011 (University of Wisconsin, Department of Agricultural and Applied Economics 2012). From January 2005 (when the first Cow Power™ farm came online) to April 2008, farmers received good returns on the sale of electricity as price per kilowatt-hour remained high. However, from mid-2008 to early-2009, wholesale electric prices and the share that farmers received dropped precipitously to a low of 8 cents per kilowatt-hour (previous prices had fluctuated between a high of 15 cents and a low of 9 cents). This price drop came at a very bad time for farmers as milk prices also dropped to the lowest since 2004. As a result, biogas farmers agitated for relief from the state government, which responded by making available through its Sustainably Priced Energy Development Program (SPEED) a 20-year contract that would guarantee farmers a fixed-rate of 18 cents per kilowatt hour through a mechanism known as a feed-in-tariff (FIT) (Wang et al. 2011). All farmers interviewed were asked if at any point they felt they had made a mistake by signing up with Cow Power™ and several felt that they experienced such feelings when they were not being paid what they felt was a fair price for their electricity. Many noted they would be in severe financial trouble if they did not have the FIT, particularly given the debts that they incurred as a result of the milk price crash. However, farmers have been extremely pleased with the FIT and are glad that it has allowed the program to continue.

While the biogas to electricity portion of Cow Power™ has gone less than smoothly, one area that all parties involved consistently rate as being excellent is manure management and the beneficial changes it has made to pollution and farm operations. Digester and generator operations in particular provide opportunities for farmers to both reduce cost and improve the health of their animals. Although farmers are not able to use the electricity they produce directly, when the biogas is converted via a generator, this generates a significant amount of heat. This heat can then be piped into various buildings around the farm including barns, machine shops and greenhouses. Many farmers noted the difficulty and expense of keeping cows and calves warm, especially during winters, thus they have been extremely pleased with this benefit. Indeed, one farmer whose digester had yet to be completed at the time of interview, expects she will save upwards of $4,000 per month during some of the colder months. Farmers are also able to save money by using leftover manure solids as bedding for cows, which is not only far more sustainable than sawdust or hay, but far cheaper; sawdust has become a popular biofuel in its own right, as it can be pelletized and used as clean burning fuel in wood stoves, thus its price has increased as much as five fold in some cases (Millman 2008). One farmer interviewed expected to save $100,000 per year on sawdust while another estimated he could save twice as much. This bedding also has significant effects for both cattle health and milking operations as these processed solids do not carry the risk of introducing pathogens that comes with bringing in outside bedding (Cheroski, Li, and Mancl 2011). Cows on several farms have shown dramatic decreases in somatic cell counts, which functions as both a measure of a cow's overall health and the quality of its milk. Thus, cows are sick less often and spend less time out of the milking regimen, costing farmers less in terms of medical care and allowing them to make greater profits in milk sales.

Digestion and combustion not only aid in milking, but also have significant environmental benefits. As Cow Power™ farms are technically factory farms, or Confined Animal Feed Operations (CAFOs), they are subjected to EPA regulation under the Clean Air and Clean Water Acts. CAFOs are specifically identified as "point sources" of pollution and thus subject to stricter standards than operations that pollute indirectly (Till 2010). One farmer felt that the EPA was one of his biggest problems as they have been "overzealous" in attempting to regulate farm emissions and end up hurting farmers more than they help the environment. Thus farmers have been pleased with the digestion process, which converts a large portion of methane into carbon dioxide, which although still of concern is far less detrimental in terms of atmospheric warming than methane (U.S. Department of Energy 2011). Manure effluent, which in the case of post-digested manure is usually the liquid pressed out of solids destined for bedding, is also made less toxic. Several farmers noted that this was extremely important as it not only helps to satisfy regulators, but also helps to reduce eutrophication, much of which has been blamed on agricultural runoff, in nearby Lake Champlain and Lake Memphremagog (Creaser 2009). Indeed, although farmers have had their quibbles with Cow Power™, many have felt that it is one of the few things keeping dairy farming alive in Vermont, particularly because it allows for the sustainable preservation of the working landscape, which is often listed by farmers as their most important task.

Conclusions

What does Cow Power™ mean for biofuels scholarship and the three ecologies?

As mentioned previously, the three ecologies have rarely focused on biofuels and has rarely addressed them using localized case studies. Therefore, Cow Power™ is important for both "political" ecologies and biofuels research as it provides a concrete example that helps to connect a specific instance of biofuels production to the larger global political economic concerns that form the bedrock of much environmental geography and social science. Indeed, Cow Power™ not only helps to add more biofuels research to political ecology (see Bridge 2011), but fits in well alongside existing research in areas such as rural development, agricultural geography and energy geographies that focus on more traditional ecologies such as coal and oil. Thus, while this article provides only one example of a localized biofuel, it can serve as a springboard to future research that contributes to both political ecology and environmental geography, but also biofuels scholarship and environmental social science more generally.

Is Cow Power™ a good long-term strategy and what can it teach us about other instances of biofuels production?

Perhaps the biggest question that this study has peaked is whether Cow Power™ is sustainable, both in terms of the cleanliness of the energy produced and the long-term viability of the economic model on which the program operates. Regarding the former, while trapping methane and producing biogas is certainly better than letting manure fester, as the origins of this manure are in environmentally unfriendly industrial agriculture, biogas can be seen as somewhat of a greenwashing of larger unsustainable practices. Eisentraut (2010) has argued that unless the entire supply chain from which biofuels emanate is green, the energy produced cannot be considered green. In terms of economics, Cow Power™'s position could be stronger. Now, for the first time, biogas production has outpaced customer demand, forcing CVPS to sell the programs renewable energy credits to out-of-state utilities, often at below market value (CVPS Cow Power™ 2012). Indeed, while farmers are currently protected by the FIT, if Cow Power™, which was never intended to make CVPS a profit, is seen as too much of a financial loser, it could put future developments in doubt.

Given the above evidence, Cow Power™ may not be able to deliver on the promise of sustainable and economically sound biofuels. However, the benefits that struggling farmers receive should be reason enough to support this and other similar programs. When so many biofuels developments serve to undermine agricultural communities, any instance that actually strengthens them should be commended. Indeed, when Cow Power™'s long-term livelihood benefits, rather than merely its short-term profitability, are taken into account, keeping Cow Power™ a viable enterprise is well worth any economic losses.

Thus, the lesson that Cow Power™ can provide for biofuels production as a whole is the importance of balancing the needs of those involved in the growing and processing of biomass stocks with those of energy consumers. Scholars such as Shiva (2008) and McMichael (2010) have argued, the interests of Western businesses and governments are often placed ahead of those of people living in areas where biomass is cultivated. This results in a situation reminiscent of colonialism in which wealth is transferred to wealthier nations while those supplying the resources are left to bear the burdens of extraction. As a counterpoint to exploitative production systems, Cow Power™, while perhaps not the most successful program in purely economic terms, teaches us that biofuels can be used to both solve energy and climate problems and strengthen rural communities. However, such a balance cannot be achieved without some sacrifice on the part of energy and profit-hungry energy users. Indeed, while climate change is an issue that must be dealt with, it must not be done in a fashion that creates a "climate of injustice" which protects wealthy First World residents at the expense of the poor (Roberts and Parks 2007).

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Acknowledgements

Special thanks to Tad Mutersbaugh, Sue Roberts and Andy Wood for their comments on an earlier version of this article.

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ANALYSIS OF LAND SURFACE
Temperature Change for Northeastern North America Using MODIS Thermal Data, 2001 to 2011

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ABSTRACT
Many types of empirical research indicate that the globe's climate has been changing over the past century, and in particular, the world is getting warmer. The earth is not warming uniformly, with some places cooling and other places warming. There is a strong heterogeneity to the world's warming, with particular warming occurring at high latitudes. New England and Eastern Canada are experiencing a changing climate which is consistent to global patterns. There are currently a number of methods used to measure our changing climate from in situ air temperature measurements, satellite-based snow cover and surface temperature measurements, to recording physical and biological phenomenon such as first ice-out days and first date of sap flow. In this study we measured the land surface temperature of northeastern North America using the Moderate Resolution Imaging Spectroradiometer (MODIS) thermal infrared bands on NASA's Terra satellite (MOD11C3). We analyzed changing surface temperature for daytime (10:30 AM) and nighttime (10:30 PM) from 2001 to 2011 on seasonal to interannual time scales. We found that at the annual time scale and each season (except summer), the study area warmed both at night and day. There was a strong correlation between the North Atlantic Oscillation's (NAO) negative phase and a warming of Northeast North America with 2010 having the warmest land surface temperatures. Throughout the time period most of the warming occurred at higher latitudes. *Keywords: climate change, remote sensing, northeastern North America, land surface temperature*

Introduction

From empirical evidence it is becoming clear that the world is warming (IPCC 2007). Not only have *in situ* and satellite-based air temperature measurements detected a warming world, but the oceans have undergone a warming (Domingues et al. 2008) and much of the cryosphere (areas of frozen water) is experiencing a melting of its ice and snow cover (Screen and Simmonds 2010). In response to this global warming, the climate is changing in many places, with hotter summers and winters to decreased snow cover. One of the results of the changing climate is that the flora and fauna on the earth, from the arctic to the tropics, are rapidly changing (Hughes 2000; McCarty 2001; Parmesan and Yohe 2003). Change is occurring to the phenology and physiology of organisms, the distribution and extinction of species, along with the structure and dynamics of ecosystems (Hughes 2000; Wuethrich 2000; McCarty 2001; Walther et al. 2002). The spatial distribution of climate change and global warming has been uneven, with some regions experiencing extensive change and others areas experiences few changes. Globally, surface air temperature has increased during the 20th century and continues to do so in the first decade of the 21st century, with disproportionate increases taking place in most northern temperate regions (Houghton et al. 2001; Hansen et al. 2006).

New England and eastern Canada have experienced a warming trend consistent with global patterns (Keim et al. 2003). Reflecting the warmer surface air temperatures are earlier dates of spring lake ice-out (Hodgkins, James, and Huntington 2002) and river ice-out (Dudley and Hodgkins 2002), as well as earlier snowmelt-driven spring runoff (Hodgkins, Dudley, and Huntington 2003) and fewer snow-covered days in winter (Burakowski et al. 2008). There has also been a decrease in the ratio of snow to total precipitation (Huntington et al. 2004) and decreases in river ice thickness (Huntington, Hodgkins, and Dudley 2003).

Northeastern North America has also experienced phenological changes. Early spring warming has caused earlier blooming of lilacs (Schwartz and Reiter 2000), as well as altering bird migration (Dunn and Winkler 1999), and anadromous fish migration (Huntington, Hodgkins, and Dudley 2003). The growing season in New England has increased over the past 200 years (Baron and Smith 1996; Cooter and Le Duc 1995).

This paper presents an application of the Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) thermal infrared bands for analyzing changes in surface temperature for Northeast North America from 2001 to 2011. Our study is the first, to our knowledge, to use the MODIS thermal data to document the surface temperature of northeastern North America on seasonal to interannual time scales. We chose to use MODIS data as these are the first satellite-derived data that provides high quality and calibrated temperature products (globally) which are extensively preprocessed and ready for use (Wan et al. 2004, 2002).

The MODIS thermal bands capture land surface skin temperatures (*T*skin), which are different from air temperatures (*T*air), as measured by an in situ instrument usually 1.5 to 2 m above the ground (Jin and Dickinson 2010; Shreve 2010). Remote sensing of *T*skin by sensors aboard satellites is the radiometric temperature derived from the inverse of Planck's function (Jin and Dickinson 2010). Jin and Dickinson (2010) show that *T*skin is a different physical parameter from *T*air, and *T*skin varies from *T*air. Surface temperatures (*T*skin) are determined by and responded to land surface-atmosphere interactions (Jin 2004; Jin and Dickinson 2002). *T*air and *T*skin especially vary depending on surface conditions (land cover) and cloud cover (Sun and Mahrt 1995). The sparser the vegetation cover the greater the temperature flux for *T*skin (Sun and Mahrt 1995). It is still uncertain in the scientific community how *T*skin will be used in climate studies, but it is believed that these data could be very beneficial for future climate studies (Shreve 2010). Errors in satellite-derived temperatures can come from a variety of sources such as instrument noise and drift, sun glint, residual cloud contamination, atmospheric attenuation, and various surface emissivity effects.

If there are differences between the data types and if we already have a long-term set of *T*air data, why do we need *T*skin data? One reason for the usefulness of *T*skin data is that *T*skin observations provide more coverage than *T*air. *T*air observations are not uniformly distributed over the globe and some places in the world have very limited *T*air stations and data, such as parts of northeastern North America. The high spatial resolution of satellite data allows us to analyze fine details over the globe. The *T*skin data also provides a different way to understand Earth's temperature. Jin and Dickinson (2010) found that despite the differences between *T*skin and *T*air, the major patterns of *T*air are consistent with those of *T*skin, although details differ.

Our study area includes the Canadian provinces of New Brunswick, Newfoundland & Labrador, Nova Scotia, Prince Edward Island, and Quebec, along with the American states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont (Figure 1).

Figure 1. Study area includes the Canadian provinces of New Brunswick, Newfoundland & Labrador, Nova Scotia, Prince Edward Island, and Quebec, along with the American states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

Data

Site Description

The surface temperature of northeastern North America was examined from 2001 to 2011 using 11 years of data from the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the NASA Earth Observing System (EOS) Terra platform. The data used are the *MODIS/Terra Land Surface Temperature/ Emissivity Monthly L3 Global 0.05 Des V005,* CMG product (Short name: MOD11C3). Both day (10:30 AM) and night (10:30 PM) images were downloaded. Data were downloaded at the global scale from the National Aeronautics and Space Administration (NASA) Land Processes Distributed Active Archive Center (Wan 2008).

The MODIS sensor provides high radiometric sensitivity (12 bit) in 36 different spectral bands ranging in wavelength from 0.4 µm to 14.4 µm. The MODIS temperature product that we used is from the Terra satellite and is based on a daily 1 km spatial resolution of land surface temperature with high accuracy of 1° K for materials with known emissivities (Wan et al. 2002, 2004; Wan 2008). The MOD11C3 data are composited at a 0.05° latitude/longitude grid. The *Tskin* data are only retrieved on clear days and nights. Details of the MOD11C3 product (version 5) skin temperature process and validation can be found in Wan (2008, 2006) and Wan and Li (2008). This study utilizes the MODIS/Terra (PM and AM satellite) MOD11C3 product to study surface temperature change in Northeast North America (Figure 1).

Methodology

Data Preparation

MOD11C3 data (day and night) were downloaded from NASA's Land Processes Distributed Active Archive Center at the global scale and imported into the *Idrisi* image processing software (Eastman 2009). The *MOD11C3* data were in monthly maximum value composites (MVC). The MVC is created on a pixel-by-pixel bases where each pixel's *Tskin* value is the highest value during the monthly time period being composited (Holben 1986). The quality control data for each month were examined one by one before using the temperature data. There were no extensive errors found in northeastern North America and the total error was less than 1 percent for each month. In addition to analyzing NASA's quality control data, we ran a principle component analysis (PCA) to examine the data again and we found some night images in 2007 with noise greater than 5% which affected the quality of both seasonal and annual images. Therefore, we decided to remove all the night images for the year 2007.

Using the *Idrisi* software we further processed the data into seasonal and annual composites. We created seasons by averaging 3 month periods: Spring (March, April, May); Summer (June, July, August); Fall (September, October, November); and Winter (December, January, February - January and February are from the next calendar year). The winter of 2011 would include December 2011 plus January 2012 and February 2012. For annual averages we added all 12 months of the calendar year and then divided by 12. Therefore the annual averages do not include the same months used in the winter season. We did not process the 2007 *MOD11C3* night data as noted above.

We processed the seasonal and annual average images at the global scale. Once the images were produced, we used a raster mask image to window out northeastern North America. The windowed-out data were then transformed from Kelvin to Celsius with the following equation: [(MPVK x 0.02) – 273] = MPVC, where MPVK = the MODIS Pixel Value in Kelvin and MPVC = MODIS Pixel Value in Celsius. The data were then reprojected from the MODIS Sinusoidal projection into a latitude – longitude projection in the Idrisi image processing software.

For our research we undertook two major analyses: 1) Anomaly and Mean Time Series Analysis of all pixels of the study area to determine how the entire area in Northeast North America changed in temperature throughout the time period, and 2) Simple Differencing (Univariate Differencing) of all pixels to determine which pixels were increasing and which were decreasing in surface temperature in Northeast North America during the time period.

Anomaly Analysis

For the anomaly analysis, we created 11-year average images for each season and for the annual averages. To calculate the 11-year average images we used the equation: [2001-2011AAday = (MPVC2001 + MPVC2002+ ... + MPVC2011) / 11] where AA = Annual Average, using the image calculator in *Idrisi*. We ran this equation for each season and for the annual averages for the day images. Because the 2007 night images were found to have noise (> 5%), the night eleven-year average images (seasonal and annual) were calculated as: 2001-2011AAnight = (MPVC2001+ MPVC2002+... +MPVC2006 + MPVC2008 +...+ MPVC2011) / 10. Then 2001-2011AA was subtracted by each year (annual averages and annual seasonal averages), for example: 2001AAA = 2001annual average – 2001-2011AA., where AAA = Annual Average Anomaly.

After finishing 11 years annual average and seasonal anomalies, we ran a Time Series Analysis (TSA) with these anomalies for the entire study area for the annual averages and each season (Spring, Summer, Fall, Winter) for each time period (day and night) to find the surface temperature change pattern during the time period. We also ran a TSA for the mean values of the annual averages and seasonal data.

Univariate Differencing

To determine change over the course of 11 years (2001 to 2011), a univariate differencing, or simple differencing, methodology was undertaken. Simple differencing is a basic method of expressing the difference between two dates which involves two spatially registered images of the same area taken at different times where one image is subtracted from the other. Mathematically:

$$Dx^k_{ij} = x^k_{ij}(t_2) - x^k_{ij}(t_1)$$

where x^k_{ij} = pixel value for band k, and i and j are line and pixel numbers in the image, t_1 = first date and t_2 = second date (Singh 1989). Simple differencing is a widely used change detection technique and has been used in a great variety of environments and with a wide assortment of satellite data (Singh 1989; Jensen 1996).

Because the annual average surface temperatures for northeastern North America have considerable inter-annual variation, we created a number of multiple year averages for our univariate differencing. The end points of our data set were averaged (in order to minimize the inter-annual variation) where: MPVC2001-02 = [(MPVC2001 + MPVC2002) / 2], and MPVC2010-11 = [(MPVC2010 + MPVC2011) / 2]. Using this method we created 2-year, 3-year and 4-year averages (MPVC2010-11, MPVC2009-10-11, MPVC2008-09-10-11, MPVC2001-02, MPVC2001-02-03, MPVC2001-02-03-04). Because the North Atlantic Oscillation in 2001 and 2010 had a strong influence on warm temperatures we also created a 4-year period without 2001 and 2010 (MPVC2002-03-04, MPVC2008-09-11). To determine changes in temperature over the time period we differenced the various end-point averages, for example: MPVC2010-11 - MPVC2001-02 = MPVC1011minus0102. Temperature change was evaluated in this manner for the annual data, both day and night at the 2-year, 3-year, 4-year and 4-year minus 2001 and 2010 levels. Results of the univariate differencing were then value sliced by temperature into 5 categories: 1) decrease > 2^0 C, 2) decrease from 1^0 C to 2^0 C, 3) slight change from decreasing 1^0 C to increasing 1^0 C, 4) increasing from 1^0 C to 2^0 C, and 5) increasing greater than 2^0 C.

Results and Discussion

Anomaly and Mean Analysis

The average annual surface temperature for the entire study area (Figure 1) was 1.23^0 C for the daytime (ranging from 0.11^0 C to 3.15^0 C) and -5.89^0 C for the nighttime (ranging from -7.34^0 C to -3.76^0 C). For both the day and night data sets there was an overall increase in surface temperature as expressed in the R2 of the linear regression line of the annual average data over the course of the time period (2001 – 2011). Surface temperature increased more in the night than in the day (day $R^2 = 0.056$ and night $R^2 = 0.1913$) (Figure 2). The day and night data showed a similar pattern of change with peak warming occurring in 2001, 2006 and 2010. These years are also the three distinct years of a negative phase of the North Atlantic Oscillation during the same time period of 2001 to 2011 (Figure 3) (Hurrell 2012). A negative phase brings about mild temperatures in Greenland and northern Canada (Hurrell et al. 2003), and with much of the study area at high latitudes there is a clear correlation with the negative phase of the North Atlantic Oscillation. The negative NAO index phase shows a weak subtropical high and a weak Icelandic low and the reduced pressure gradient produces fewer and weaker winter storms. Although the US east coast experiences more cold air outbreaks, Greenland and northern Canada have milder winter temperatures (Ghatak, Gong, and Frei 2010).

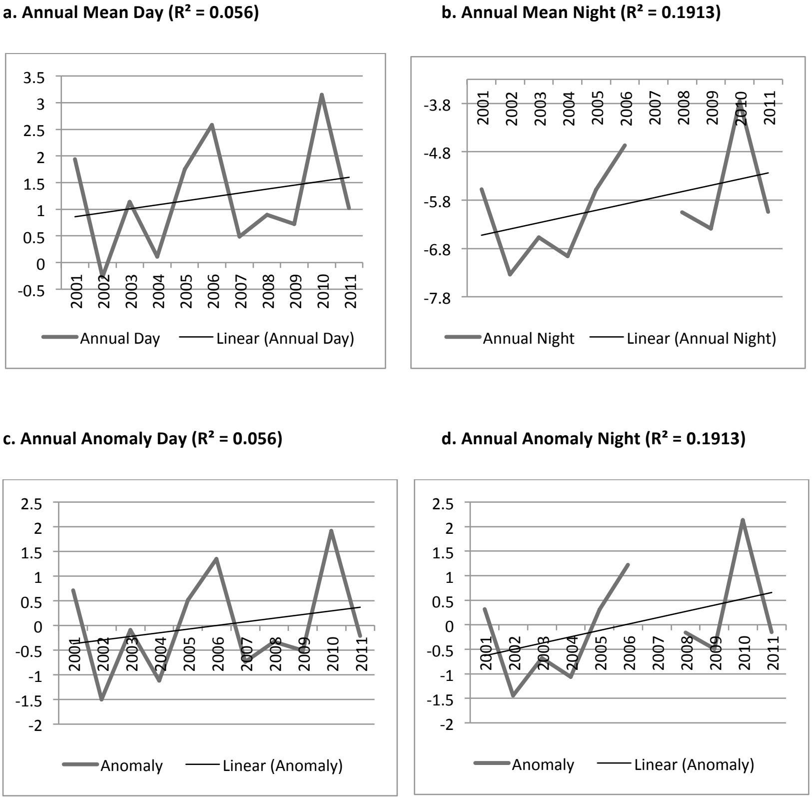


Figure 2. Annual Average Mean and Anomaly Analysis.

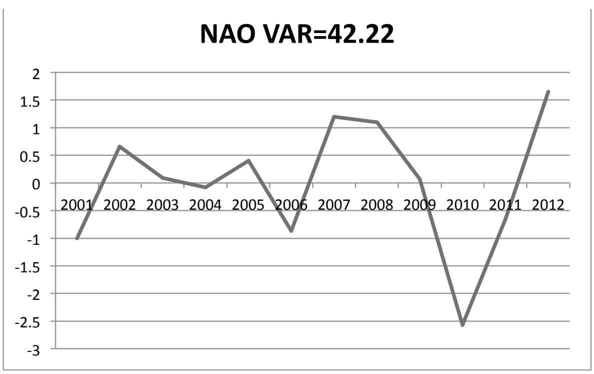
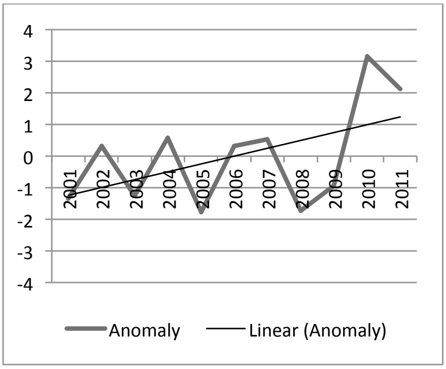


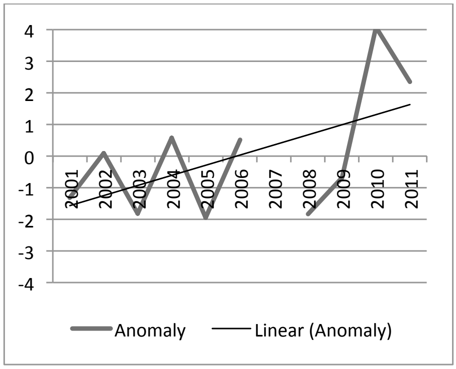
Figure 3. North Atlantic Oscillation for latitude: 42.22.

Concerning seasonal variation over the time period (Figure 4), all seasons showed an increase in temperature throughout the time period except for summer day (R2 = -0.034). In the winter, spring, and summer seasons there was a greater increase in temperature at night than in the day, with only the fall season showing a greater warming during the daytime. The greatest change occurred in the fall and winter seasons. Spring was the only season to show a strong correlation with the NAO negative phase, which was so prominent with the annual average anomaly analysis. The spring also had the greatest inter-annual variation due to the strong influence of the warming temperature in 2001, 2006 and 2010, during both day and night. The winter season, however, appears to have been strongly influenced by the 2010 NAO event. This coincided with an exceptionally negative phase of the NAO. Seager et al. (2010) suggests it was caused by a freak combination of an 'El Niño' event and the rare occurrence of an extremely negative NAO.

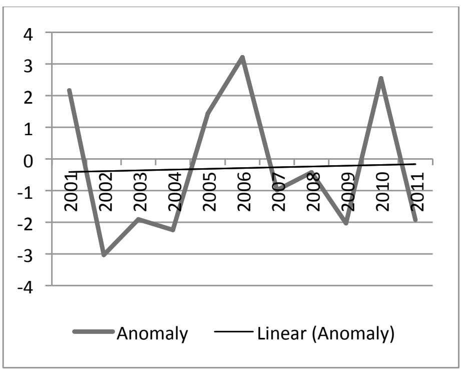
a. Winter Day ($R^2 = 0.2638$)



b. Winter Night ($R^2 = 0.3272$)



c. Spring Day ($R^2 = 0.0013$)



d. Spring Night ($R^2 = 0.0219$)

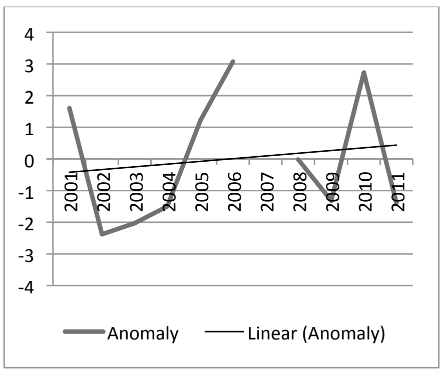


Figure 4. Seasonal Average Anomaly Analysis in Degrees Celsius (continued on next page).

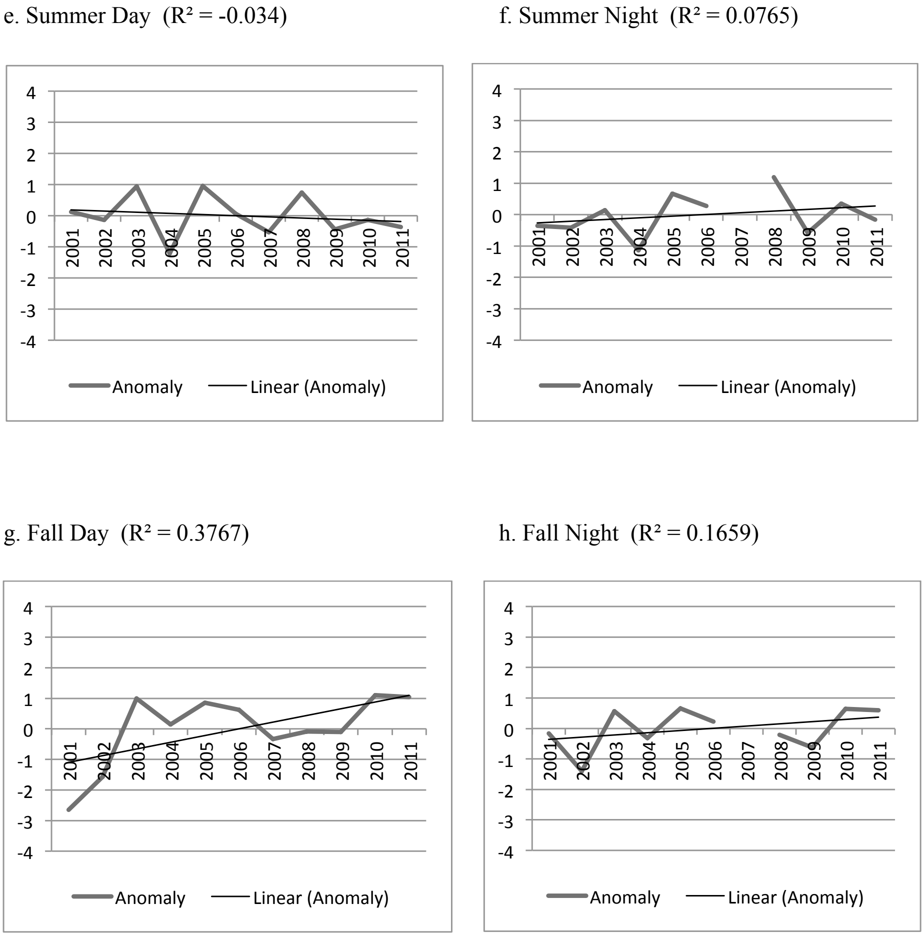


Figure 4 (continued). Seasonal Average Anomaly Analysis in Degrees Celsius

Univariate Differencing Analysis

Through the univariate differencing analysis the region showed extensive warming occurring through the time period (Table 1, Figures 5 and 6). As noted in the methods section above, because of the extensive inter-annual variation, we averaged the end points into 2-year averages (2001+2002 and 2010+2011), 3-year averages (2001+2002+2003 and 2009+2010+2011), and 4-year averages (2001+2002+2003+2004 and 2008+2009+2010+2011). Also because of the strong influence of the NAO's negative phase on years 2001, 2006 and 2010, we created a 4-year average minus 2001 at the beginning and 2010 at the end (2002+2003+2004 and 2008+2009+2011). The univariate differencing for all of these time periods showed extensive areas warming with very few pixels (<1% of study area) cooling (Table 1, Figures 5 and 6).

For every time period there was more warming at night than during the day (Table 1), with the most warming occurring with the 2-year averages. In the 2-year average univariate differencing 79% of the study area warmed by at least 1^0 C during the night and 69% warmed during the day. The least amount of warming occurred at the 4-year average, especially when 2001 and 2010 were removed from the data. However, even these long term averages showed 57% of pixels warming at night (33% when 2001 and 2010 are removed) and 25% during the day (14% when 2001 and 2010 are removed). Almost all of the warming has occurred in Canada with nearly all of New York and New England showing no change (between -1^0 C and + 1^0 C) at all. The warming of higher latitudes is consistent with the current pattern of global warming (IPCC 2007).

Conclusion

The results of analyzing the Earth's land surface temperature (*Tskin*) for northeastern North America shows patterns of change which are consistent with global warming patterns emerging throughout the world (Keim et al. 2003). Not all areas throughout the world are warming. Globally, high latitude regions tend to be warming more than lower latitudinal regions and this pattern emerged from the MODIS land surface temperature data analyzed here.

For the annual average temperature of the entire study area, the temporal pattern of change which emerged was one with warming temperatures both in the day and night, with greater warming at night. The temporal pattern of change also

a. Day

Temperature Change	2 years Pixels Percent	3 years Pixels Percent	4 years Pixels Percent	4 years (no 2001, 2010) Pixels Percent
>-2 ^{0}C	44 (<1%)	91 (<1%)	93 (<1%)	54 (<1%)
-2 to -1^{0}C	324 (<1%)	9 (<1%)	0 (0%)	5 (<1%)
-1 to 1^{0}C	37519 (31%)	91254 (74%)	92094 (75%)	106395 (86%)
1 to 2^{0}C	69635 (56%)	31075 (25%)	30033 (24%)	15966 (13%)
> 2^{0}C	15633 (13%)	726 (1%)	935 (1%)	580 (1%)
Total	123155 (100%)	123155 (100%)	123155 (100%)	123155 (100%)

Table 1. Surface Temperature Change Analysis (2001 to 2011) (continued on next page).

b. Night Temperature Change	2 years Pixels Percent	3 years Pixels Percent	4 years Pixels Percent	4 years (no 2001, 2010) Pixels Percent
>-2 ^{0}C	3 (<1%)	18 (<1%)	21 (<1%)	18 (<1%)
-2 to -1^{0}C	115 (<1%)	37 (<1%)	4 (<1%)	4 (<1%)
-1 to 1^{0}C	25888 (21%)	45607 (37%)	53401 (43%)	81577 (66%)
1 to 2^{0}C	60789 (49%)	75552 (61%)	68254 (56%)	40901 (33%)
> 2^{0}C	36360 (30%)	1941 (2%)	1475 (1%)	500 (<1%)
Total	123155 (100%)	123155 (100%)	123155 (100%)	123155 (100%)

Table 1 (continued). Surface Temperature Change Analysis (2001 to 2011).

showed extensive inter-annual variation with a strong correlation to NAO's negative phase years of 2001, 2006 and 2010. Seasonally the region showed the greatest warming occurring in the fall and winter, both during the day and during the night. The summer day analysis was the only season to show a cooling effect, though it was very slight (R^2 = -0.034). The spring season was the season with the greatest inter-annual variation and the only season to show a strong correlation with NAO's negative phases which were prominently seen in the annual average temporal analysis.

Determining which regions in the study area were warming and cooling through a univariate differencing analysis showed that there was almost no areas cooling, and most of the warming was happening at higher latitudes. There was extensive warming occurring with more than half of the land area warming greater than 1^0 C at night for all analysis (except when years 2001 and 2010 were removed, then one-third of the land area warmed), and more than a quarter of the land area warming greater than 1^0 C at night for all analysis (except when years 2001 and 2010 were removed, then 14% of the land area warmed).

Eleven years of data is a short time period to record long-term climate changes. In northeastern North America weather patterns vary considerably from year to year, so long-term data sets are needed to compensate for the annual fluctuations of weather. However, with eleven years of land surface temperature data, patterns of long-term change are beginning to emerge which can be compared with other data sets such as air temperature, phenological changes, and physical changes such as lake ice melt. The main patterns to emerge from this research are that extensive areas of high latitudes are warming more than areas of low latitudes, which has been discovered in many parts of the world. Warming is happening more broadly and faster at night and seasonally, the fall and winter are warming faster than the other seasons. In addition, the negative phase of the North Atlantic Oscillation appears to have a broad warming of much of northeastern North America, both during the day and at night. Climate models are predicting continued climatic changes for the northeast (Hayhoe et al. 2007) and the MODIS land surface temperature data can help verify these predicted changes in the future.

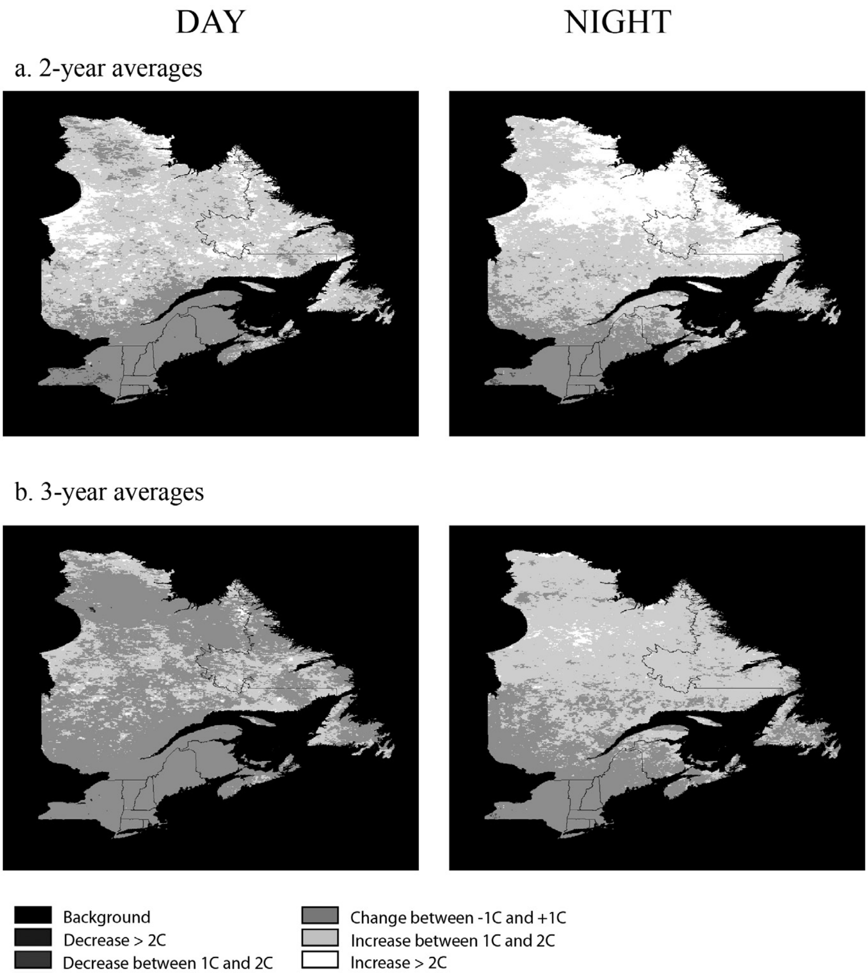


Figure 5. Regions of changing temperature for 2-year and 3-year averages. The daytime and nighttime results of univariate differencing for 2-year (2010 & 2011 minus 2001 & 2002) and 3-year (2009 & 2010 & 2011 minus 2001 & 2002 & 2003) composites.

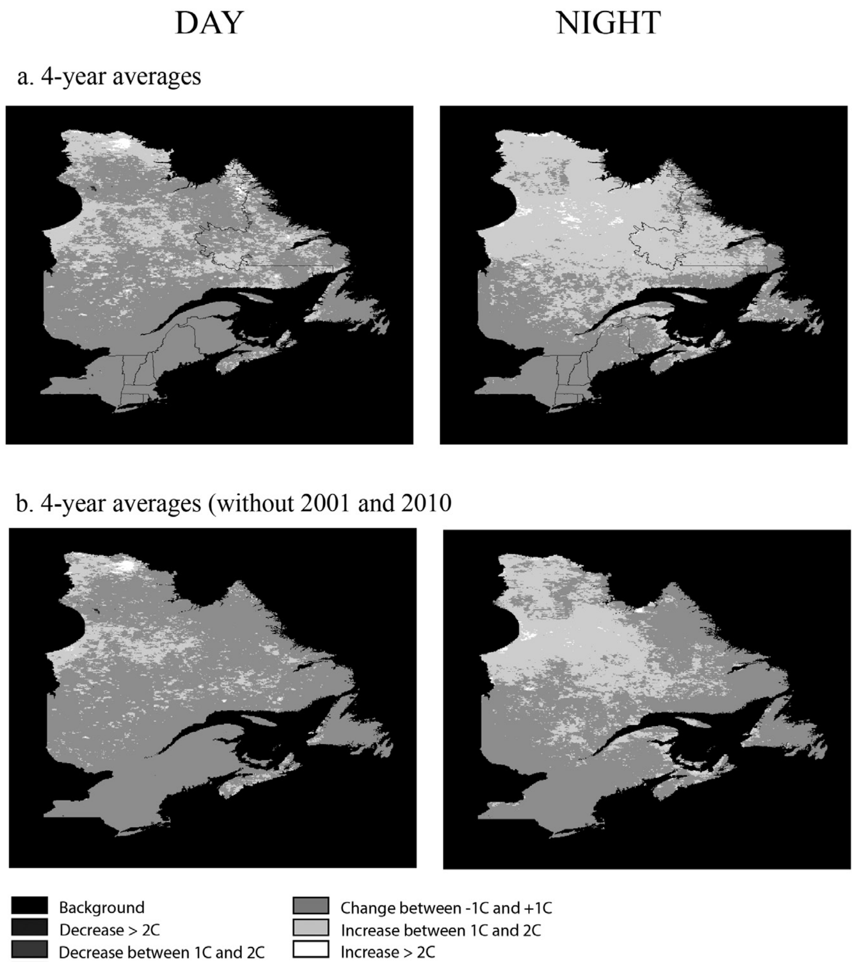


Figure 6. Regions of changing temperature for 4-year and 4-year (minus strong NOA negative phases) averages. The daytime and nighttime results of univariate differencing for 4-year (2008 & 2009 & 2010 & 2011 minus 2001 & 2002 & 2003 & 2004) and 4-year (minus strong NOA negative phases – 2001 and 2010 averages – 2008 & 2009 & 2011 minus 2002 & 2003 & 2004) composites.

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Acknowledgements

The authors would like to thank the National Aeronautics and Space Administration (NASA) Land Processes Distributed Active Archive Center for the MODIS data and the Digital Geography Lab (DGL) for the use of their computers and software. We also thank the anonymous reviewers for their helpful comments. NAO Index Data provided by the Climate Analysis Section, NCAR, Boulder, USA, Hurrell (2011). Updated regularly. Last accessed 01 January 2012. We also thank the anonymous reviewers for their helpful comments.

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NEW DEAL VS. YANKEE INDEPENDENCE:
The Failure of Comprehensive Development on the Connecticut River, and its Long-Term Consequences

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ABSTRACT
In the 1930s, comprehensive development of the Connecticut River basin – coordinated dam-building and operations from tributaries to tidewater – was advanced by multiple people and agencies. However, they fought for twenty years over the specifics. President Franklin Roosevelt and his New Deal supporters and heirs envisioned a federal valley authority that could provide regional economic development, resource conservation, pollution abatement, and, most important, cheap, widely available public electric power. The New England business establishment touted Yankee independence, but most of all, wanted hydropower allotted to states and private power companies. Upriver rural and farming advocates, led by Vermont's George Aiken, fought for a different kind of Yankee independence, endeavoring to prevent almost all flooding of upriver valleys. The Army Corps of Engineers and new interstate institutions tried with difficulty to develop compromise plans they could carry out themselves. In the end, the only compromise possible was non-comprehensive development. There would be only thirteen federal dams in the Connecticut River basin, they would be single-purpose flood control dams, and they would be built only in the tributaries. Hydroelectric power development and the mainstem river would be left to private companies. Connecticut River management would be divided spatially, functionally and institutionally. Ironically, in recent years, this has allowed some flexibility in terms of providing natural flows for fish and ecosystems, at least from the tributaries and federal storage dams. This article builds from secondary and primary historical documentary sources, plus interviews.
Keywords: Connecticut River, river basin development, New Deal, New England history, flood control, dams

Introduction

For a person familiar with federal dams on major rivers in the American West or South, a visit to an Army Corps of Engineers dam in New England's largest river basin, the Connecticut, can be a startling experience (Figure 1). The dam seems like a giant ridge separating two deep empty spaces on either side. Instead of an extended reservoir so common at dams on rivers like the Colorado, the Columbia, the Missouri, and the Tennessee, one is likely to find no reservoir at all, or only a low reservoir, filled to about two percent of its capacity. One looks down from the empty heights and on both sides sees only a small river far below. Nor is there the fanfare – the visitors center, the historical information, the celebratory propaganda – one finds often at federal dams in the West and the South, even at some other places in the Northeast. Simply finding one of the Connecticut River's federal dams can take some effort. None are on the mainstem. One must drive through the bucolic New England byways and forested hills to find a dam on a tributary (Figure 1).

For New Englanders, none of this may seem surprising. New England's history and identity, including the Connecticut Valley's, rests far more with the local and small-scale, mostly private, development of rivers for pre-industrial mills during the 17th and 18th centuries, and with the regional and medium-scale, also private, development of water-power dams during the launch of the American industrial revolution in the 19th century (e.g. Delaney 1983; Steinberg 1991; Judd 1997; Cumbler 2001). The old milldams, industrial dams, and the associated buildings and canals from these eras remain central landscapes of many New England villages, towns and cities. But large dams of the twentieth century, and major federal water agencies, seem to belong to far-away places mostly irrelevant to New England.

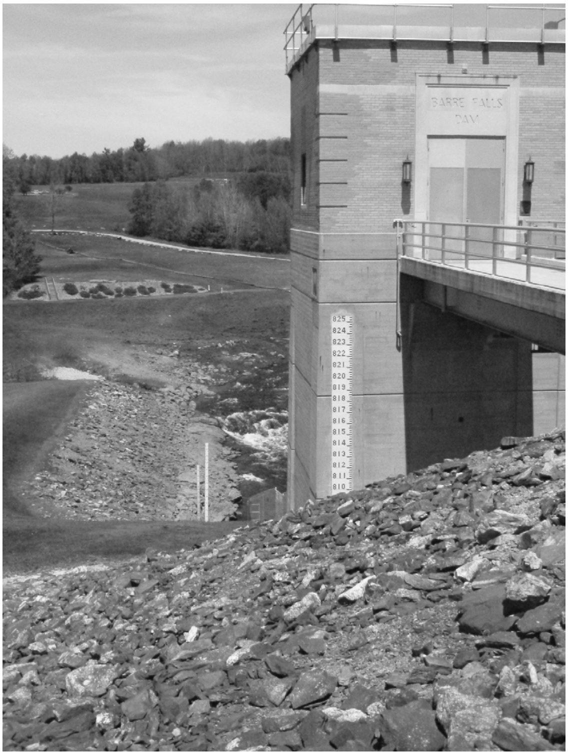

Figure 1. Barre Falls Dam, Hubbardston, MA, looking upstream. The gauge on the dam shows the dam can fill up to 825 feet; however, the water most of the time is far below (as the dam's website explains, it is a "drybed reservoir") and grass lines the sides of the empty reservoir. Much of the reservoir contains a Frisbee golf course. (See dam website at http://www.nae.usace.army.mil/recreati/bfd/bfdhome.htm.) Photograph by Alexandra Lacy, May 13, 2012.

The more startling realization for New Englanders might be that during the mid-twentieth century, the federal government did in fact build a series of very large dams that have profoundly affected rivers throughout the region. In the Connecticut River basin, there are thirteen large federal dams, all built and operated by the Army Corps of Engineers. Moreover, these thirteen dams are the legacy of a major push for large-scale comprehensive development on the Connecticut River that was quite similar to that in other river basins in the United States.

What was different in New England was that federal dam-building initiatives faced especially unified, vehement, and effective opposition. It was not that New Englanders were all opposed to large-scale river development; indeed, prominent groups developed their own plans. New England business and political leaders portrayed their resistance as a principled stand for Yankee independence and states' rights. But underneath, it was a fight over similar questions to those animating resistance in other regions: who would direct river development, where dams and reservoirs would be built, and who would control the most potentially profitable product of river development, hydroelectric power. The greater success of opposition in New England rested on three factors, which, if not unique to the region, were particularly prominent. First, privately owned electric companies and their investors and business allies were dominant players in the region's economic and political affairs. Second, the region had a relationship to the federal government during the New Deal that was distinct, and the opposite of the relationship of the South and the West: it saw itself as a region being *taken from* during the New Deal, for New England was an already industrialized region, indeed a region that was already starting to *de*-industrialize, whose taxes were now helping to fund investments in other regions to which its industries were moving. Third, the river valleys of the region had long been relatively densely settled, and in Vermont in particular, amenity tourism in those valleys was already playing an important economic and political role.

Yet New England's rivers continued their unpleasant habit of flooding every few years, which made even independent Yankees wish for some help. The result was a twenty-year back-and-forth fight over the fate of the Connecticut River, as well as the region's other major rivers.[1] What determined the Connecticut River's fate was that this fight resulted in stalemate. As a result of this stalemate, compromises carved up spaces and functions of the river, and set strict limits on what developments would take place. The lonely Corps dams in the Connecticut River basin and their usually empty reservoirs are among the results. They are also emblematic of broader consequences: Connecticut River development in the 20th century remained piecemeal, divided spatially, functionally and institutionally; and the role of the federal government on New England's greatest interstate river remained limited.

This article tells the story of the battle of the New Deal versus Yankee Independence over the Connecticut River, and outlines the results and legacies. The story was inspired by and draws deeply upon William Leuchtenburg's 1953 book *Flood Control Politics*. We have tremendous appreciation for the broad and inclusive thinking that supported New Deal river basin development ambitions on the Connecticut River, on which Leuchtenburg reported so well nearly sixty years ago, in what was to become the first among many seminal books in this historian's illustrious (and continuing!) career. But our story stretches beyond Leuchtenburg's volume to provide some of the broader historical context, widen the perspective from what were then Leuchtenberg's sometimes one-sided sympathies with New Deal aims and visions, fill out the story through to its political end in the late 1950s, and trace key legacies up to the present. In the first half of the paper, we describe the fights among four contending plans for comprehensive development of the Connecticut River. We show that the only solution to the fights among the plans was *un*-comprehensive river development, in which federal dams would be single-purpose flood control dams, limited in number, and located only on tributaries. In the second half of the paper, we describe what happened as the plans for un-comprehensive river development marched forward in time and northward in location, facing fierce resistance in upper New England, especially Vermont. The conclusion describes some of the long-term hydrological, institutional, and management legacies of these battles for Connecticut River development. In the end, we will argue that New England's river development, and its non-development, during the 20th century were and are just as central to the region and its rivers as development in the 17th, 18th and 19th centuries.

Battle over the Connecticut River, Part I: Irreconcilable Plans for Comprehensive River Development (1927-38)

Between 1930 and 1937, there were four distinct and largely irreconcilable plans issued for comprehensive development of the Connecticut River. The two most politically potent conflicts over the plans were ownership of electric power and the potential flooding of upriver valleys and farmland. Underlying these disputes was a fundamental question over whether government should be in the business of spatially distributing wealth.

By "comprehensive," different actors and agencies meant different things, but they all shared at least three ideas. There would be structures – dams mainly – built at sites throughout the basin (Figure 2); the construction program would be coordinated basin-wide; and once constructed, the operation of these dams and structures would be synchronized, so that upstream storage could reduce the risk of downstream flooding and provide flows when downriver dams needed to generate power.

Impetus for comprehensive development: "308 reports" and the 1927 flood

The impetuses for two of the plans came in 1927. First, Congress called upon the Army Corps of Engineers (Corps) to survey the country's river basins for possible improvements in navigation, water power, flood control and irrigation (White 1957). Among the nearly two hundred "308" reports – so named after the House document that had recommended the studies – that would eventually be published, seventeen would be surveys of New England's rivers (Parkman 1978).

Although the Connecticut River was large for New England, nationally other bigger rivers like the Tennessee and the Columbia took precedence (White 1957). In New England, in contrast, the Corps began with the smaller, easier rivers first (Parkman 1978). Between 1927, when the request was made for a Corps survey of the Connecticut River, and 1936, when the 308 report on the Connecticut River was finally released, there was plenty of time for other events and initiatives to spark heated contention over the river's future.

The second 1927 impetus for comprehensive development of the Connecticut River was a

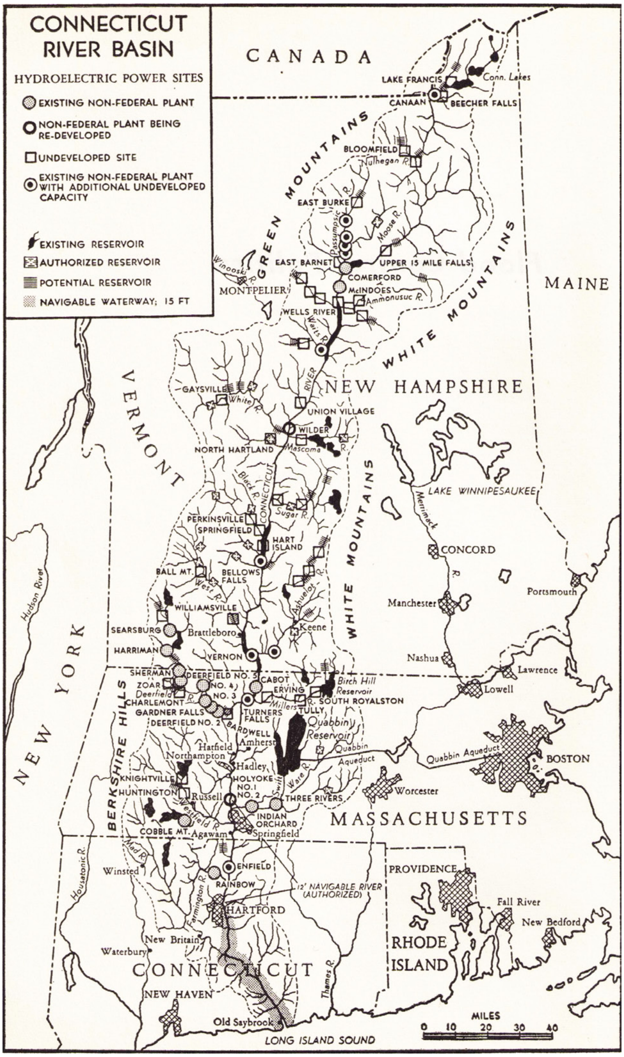

Figure 2. Connecticut River basin, planned developments, 1930s (Leuchtenburg 1953). No citation is given from the map but it appears to match reasonably well with data from the Corps' 308 plan, though with some sites missing on the map.

major flood. It was similar to that caused by Tropical Storm Irene in 2011, but even more devastating, particularly in Vermont (Figure 3). On a per capita basis, there was ten times as much property damage as in the Mississippi River flood that "changed America" earlier that same year (Patton 2005; Barry 1997). Though the Connecticut River basin had thousands of small and mid-size dams throughout the basin, they had done little to dampen the devastation. Only in the Deerfield River, where several large power dams had been built in the 1910s, had floodwaters been held back with "room to spare" (Clifford and Clifford 2007; Leuchtenburg 1953; Landry and Cruikshank 1996).

In the wake of the devastation, Congress approved legislation for unprecedented federal flood relief. Vermont received $2,654,000, mainly for repair of roads and other infrastructure (Clifford and Clifford 2007). Congress also considered authorizing storage dams to prevent future floods, but here Vermonters balked. An editorial in the *Burlington Free Press* warned that Vermont's plight would "be seized by interested parties as an excuse...to get their hands into Uncle Sam's strong box for the benefit of their own pockets" (Clifford and Clifford 2007, 120). For these Yankees, at least in the late 1920s, the commitment to independence was more important than the desire for river development. Vermonters

Figure 3. Flood at Springfield, VT. From: The Flood of 1927, Vermont History Explorer, Vermont Historical Society. http://www.vermonthistory.org/explorer/component/ content/ article/30/279-floodof1927homepage.html.

chose to wait for the Corps report, then still nine years off, before proceeding with discussions of federal river basin development, and showed no interest in hurrying the Corps' survey (Aiken 1938; Leuchtenburg 1953).

Plan 1: Barrows-Vermont Plan: Privately built and owned dams, maximum flood control and hydropower (1930)

Instead of seeking federal aid, Vermont's Public Service Board hired an engineering consultant from MIT to develop a flood control study. It got additional financial support from private utilities and the United States Geological Survey. The consultant, H.K. Barrows, in 1930 recommended 85 total dams in Vermont, many of these in the Connecticut Basin. In 1934 he recommended a similar number for New Hampshire (Barrows 1930; Leuchtenburg 1953; Clifford and Clifford 2007). What is immediately striking about Barrows' plans is the sheer number of dams and the enormity of the expected benefits he envisioned (Table 1, left side). Flood threats in the Connecticut basin would have been eliminated. Additionally, hydropower production in the basin would have surged, for storage dams would both generate power themselves, and also increase flows during low-flow seasons to improve power production downstream (Barrows 1930).

Barrows' approach was to have private power companies build storage dams. Production of hydropower would make flood control cost-effective, and could provide a net profit for the private companies. The Deerfield River dams were regarded as models. State legislation would

River	Barrows-Vermont Plan (1930, 1935)					Corps 308 Plan (1936)				
	Proposed dam site	Est. storage (below spillway, acre-ft)	Power at sites (river total, (million KW-hrs/yr)	Add'l power, down-stream sites (million KW-hrs/yr)	Total power (million KW-hrs/yr)	Proposed dam site	Est. storage (total reservoir capacity, acre-ft)	Power at site (million KW-hrs/yr)	Add'l power, down-stream sites (million KW-hrs/yr)	Total power (million KW-hrs/yr)
UPPER CONNECTICUT BASIN (Vermont and New Hampshire)										
Headwater tributaries (Perry Stream, Indian Stream, Hicks Brook/Mohawk)						Happy Corner	19.5	0	3.4	3.4
		rivers not	in plan			Perry Brook	37	0	5.5	5.5
						Kim Day	41	0	6.5	6.5
						Kidderville	10	0	3.6	3.6
Connecticut mainstem	Pittsburg	96.8	power	info not	available	Pittsburg	51.0	34.3	10.0	44.3
						Indian Stream	30	19.7	4.1	23.8
Nulhegan (VT)	Yellow Bogs	89.8	10	14	24	river not in plan				
Connecticut mainstem	Upper 15 Mile Falls	114.0	power	info not	available	Upper 15 Mile Falls	224.0	256.0	43.3	299.3
Upper Ammonoosuc (NH)	Bog Dam	10.1				Bog Dam	12.0	0.0	3.8	3.8
	Phillips Bog	17.5	power	info not	available	Phillips Bog	20.3	0.0	6.5	6.5
	Soule Dam	12.2								0.0
Passumpsic (VT)`	East Haven	12.7				East Haven	12.5	0.0	0.0	0.0
			31	80	111	Lyndonville	10.8	0.0	0.0	0.0
	Millers Run	23.4				Lyndon Ctr	31.7	0.0	6.1	6.1
	Victory	38.0				Victory	61.0	0.0	6.4	6.4
Ammonoosuc (NH)						Jefferson	26.0	0.0	10.3	10.3
	Bethlehem Jnct	24.2	power	info not	available	Bethlehem Jnct	24.2	0.0	0.0	0.0
						Alder Brook	14.0	0.0	0.0	0.0
	Mile 6.6 Gale River	18.7				Gale River	10.4	0.0	3.4	3.4
Wells (VT)	Groton Pond	18.4	0	34	34	Groton Pond	13.9	0.0	1.8	1.8
Waits (VT)	South Corinth	46.0	8	25	33	South Branch	38.0	0.0	4.7	4.7
Ompompanoosuc (VT)	Union Village	17.3	24	5	29	Union Village	22.0			0.0
Connecticut mainstem		site not	in plan			Piermont	49.0	85.6	0.0	85.6
White (VT)	Gaysville	120.0				Gaysville	129.8	51.3	20.0	71.3
	Ayers Brook	21.4				Ayers Brook	23.4	0.0	2.9	2.9
	South Randolph	15.0								
			64	84	148	Sharon	13.7	37.7	0.0	
	South Tunbridge	16.8				South Tunbridge	25.7	0.0	0.0	0.0
Mascoma (NH)	W. Canaan	41.4				river	not in plan			
Sugar (NH)	Claremont	49.0				river	not in plan			
Ottauquechee (VT)	Lower Sherburne	12.7								
	Bridgewater Cors	24.6	62	16	78	Bridgewater Corners	48.0	0.0	0.0	0.0
	North Hartland	22.1								
Black (VT)	Ludlow	27.6				Ludlow	19.8	0.0	0.0	0.0
			33	44	77	Amsden	22.3	0.0	2.5	2.5
	Mile 16.8	13.6								
	North Springfield	11.5								
Williams (VT)	Reedville	11.5	10	15	25	river	not in plan			
Connecticut mainstem		site not	in plan			Hart Island	17.3	114.8	0.0	114.8
West (VT)	North Landgrove	15.4	102	66	168	North Landgrove	13.8	0.0	1.5	1.5
	Londonderry	28.1								0.0
	Jamaica	24.4								0.0
	Newfane	94.5				Newfane	113.0	34.2	13.9	48.1
Ashuelot (NH)	Mile 4.9, Otter Brook	10.1								
	Bald Hill	18.2	power	info not	available	river	not in plan			
	Lower Stillwater	13.4								
	Russell Pd	15.2								
LOWER CONNECTICUT BASIN (Massachusetts and Connecticut)										
Millers	Moss Brook	12.7								
	West Tully	12.5								
	Tully	559.0	power	info not	available	river	not in plan			
	Priest	23.5								
	Sip Pond	11.3								
	Gardner	18.4								
Westfield		river not	in plan			Knightville	32	19.3	0.6	19.9
TOTALS		**1782.9**	**344**	**383**	**727**		**1217.1**	**652.9**	**160.8**	**774.5**

Notes on data: Only dams with over 10,000 acre feet total storage are shown. Barrows sometimes used only storage below spillway and sometimes that and total storage; for consistency we have used storage below spillway. Barrows' power information is by river, not site. Barrows' New Hampshire-only study was unavailable.

Table 1. Large-storage dams (over 10,000 acre-feet) proposed by Barrows-Vemont Plan (Barrows 1930; Barrows 1935) and Corps 308 plan (Secretary of War 1936). Besides the number of large-storage dams that were proposed and their estimated hydropower production, what is significant here is that both plans emphasized the valuable ability of upstream storage dams to provide increased flows during low-flow seasons, thereby augmenting downstream power production.

enable the state of Vermont to take land and water rights for the projects. Public river regulating districts would regulate the dams, and have the power to issue bonds to finance construction (Barrows 1930; Leuchtenburg 1953; Clifford and Clifford 2007).

But this seemingly homegrown Yankee solution was a non-starter. Vermont's House Speaker sponsored a bill modeled on Barrows' plan in the 1931 state legislature. However, freshman legislator George Aiken, who sat on the legislative committee to which the bill was assigned, got the committee to report the bill adversely, and the legislature declined to pass the bill (Leuchtenburg 1953; Hand 2003; Webb 1974; Aiken 1938).

The quick demise of the Barrows plan reflected the multifaceted suspicion of outsiders that marked Vermonters' sense of independence, as well as the state's changing politics in the early Depression. A wide mistrust of privately owned electric companies had been growing for two decades, and was suddenly politically potent. In the 1910s and 1920s, private power companies had expanded in Vermont. As in many states, they had been largely owned by out-of-state holding companies. Managers and investors in Boston, New York, and Chicago effectively controlled Vermont's electric power development, and most of the power produced from Vermont – at that time almost entirely hydropower – was exported to Massachusetts and Connecticut. The state's Public Service Commission regulated the electric companies weakly if at all, for its members were often appointed from the electric companies themselves, by the Republican business establishment, which controlled the governorship (Webb 1974; Judd 1979).

Adding to the growing resentment of private electric companies was their refusal to address an alarming decline in rural Vermont. Vermont's rural areas had been losing population for decades, and farmers throughout the country faced declines in the 1920s as prices dropped after World War I. The coming of the Great Depression was like a final blow, especially for Vermont's dairy farmers. New England residents were drinking less milk. To make matters worse, the spreading technology of electric refrigeration allowed Midwestern dairy farmers to sell milk in New England, creating new competition. Vermont farmers demanded rural electrification, to help them compete with the Midwesterners. The private companies, however, declined to build expensive transmission infrastructure to remote rural areas when they could sell instead to the more lucrative markets in southern New England (Webb 1974).

The main opposition to the dominant Republican establishment had long been a set of progressive Republicans. In 1930, progressive Republican George Aiken was elected to the state legislature. Aiken was a nursery owner from Putney, Vermont. When he argued against the Barrows plan in his legislative committee in 1931, he warned it would give power companies undue control over the destiny of the state. His arguments resonated. After all, the Barrows plan would not only let the private power companies take the lead on developing the state's rivers, but it would have this process regulated by the same kind of state public utility commission that had already proved to be ineffective in regulating the power companies (Webb 1974; Judd 1979; Aiken 1938).

The Barrows plan provoked alarm in rural Vermont for another reason as well. Perhaps its most horrifying aspect was that it proposed to flood vast areas of prime valley land throughout the state. Farmers and their allies wanted instead to revitalize farming and promote Vermont valleys as tourist destinations. Tourism was already a growing industry, offering recovery in the face of other economic decline. Fierce advocacy for farmers, farmlands, and the state's rural communities, and fierce attacks on outsiders' designs on Vermont's rivers, boosted George Aiken's political career, and doomed the Barrows plan (Webb 1974; Gregg 2010; Aiken 1938).

Plan 2: Connecticut River Valley Authority: Federal multiple-purpose river development and conservation, regional planning, and publicly owned power (1935)

Next came the outlines of a vision that was, if possible, even more ambitious – not in terms of greater transformations of the Connecticut valley's waters, but in terms of how these waters were to be linked to transformations of society, economy and environment. This plan came from the federal government, but not yet the Corps. In 1933, President Franklin Delano Roosevelt, familiarly known as FDR, became President. For FDR and his allies, federal dams were a means to a far broader social mission and political agenda. This was part of Roosevelt's New Deal, which aimed to promote economic recovery, social opportunity and resource conservation during the Great Depression (see e.g. Leuchtenburg 1963; Dick 1989; Reagan 1999; Phillips 2007).

The boldest New Deal river development visions were of integrated river valley authorities. In spring 1933, one of the first major pieces of legislation from the new Roosevelt administration was the creation of the Tennessee Valley Authority (TVA). This agency would carry out multiple-purpose river basin development including flood control, navigation, and production of hydropower, regional agricultural and industrial development, soil and forest conservation, and regional planning (*Tennessee Valley Authority* Act 1933; for a useful starting summary on the TVA see Miller and Reidinger 1998).

The TVA law included a "public preference" provision, that required that the TVA's hydropower be sold preferentially to "states, counties, municipalities, and cooperative organizations of citizens or farmers, not organized or doing business for profit, but primarily for the purpose of supplying electricity to its own citizens or members (*Tennessee Valley Authority Act* 1933 Section 10). For the New Dealers, public preference was a necessary criterion for any federally built dams. For the executives and investors of the private power companies, who wielded considerable influence in New England, it was anathema.[2]

Public preference was not new. Starting in 1906, federal hydropower from newly authorized reclamation projects had been sold preferentially and at low rates to municipalities, states and cooperative electric companies; this had been codified as general policy in the 1920 Federal Power Act (United States General Accounting Office 2001; Hirt 2012; but see Elkind 2011 on how and why an exception was made at Hoover Dam). What was new was that the question of electric power ownership had, by the early 1930s, become a central and hugely contested national political issue. Electricity had become a dominant source of lighting in American cities and was the fuel of choice for many industries. Yet high rates and limited transmission lines made electricity inaccessible not only to Vermont dairy farmers, but to many people in rural areas throughout the country, and it remained an expensive cost of production for industry. Criticism of private power companies rose across the country when it was revealed that speculative investments in electric power companies and pyramid-like consolidations had helped create the stock market bubbles of the 1920s and the crash of 1929, and when, in the late 1920s, a congressional inquiry exposed these companies' massive and distorting advertising campaigns (Dick 1989; Funigiello 1973; McCraw 1971).

Now, New Dealers – led by Roosevelt, Interior Secretary Harold Ickes, and Congressmen like Nebraska's George Norris (a progressive Republican like George Aiken, though nearing the end of his career as Aiken began his) – aimed to expand public preference into a general federal power policy. The one power source they could control for now was hydropower from federal dams. By making sure federal dams produced large volumes of hydropower, and that hydropower was sold with public preference, they aimed to provide cheap, widely available federal electricity to support fledgling municipal, cooperative and other publicly or consumer-owned power utilities, as well as industry. These local public and cooperative utilities would then sell cheap federal power to retail customers in urban and rural areas alike. To compete, privately owned electric companies would have to improve service out to rural areas and to lower rates – or risk being replaced entirely. Either way, electric power would become available to a broad public and to much-needed industrial development (Funigiello 1973; Dick 1989).

In January 1935, Connecticut Representative Citron introduced a Connecticut Valley Authority (CVA) bill. The CVA would not only build dams but also operate navigation locks, provide recreation, build transmission lines, reforest the hillslopes, and sell wholesale power. The federal government would control power sales. Ten percent of the power sales would go back to the states (Leuchtenburg 1953).

However, others attacked this proposal vehemently and hurried to advance alternatives. New England's private power companies came out against the bill (Leuchtenburg 1953). The Water Resources Committee of the New England Regional Planning Commission, an inter-state agency that was created as a regional arm of Roosevelt's Natural Resources Planning Board[3], rejected the valley authority idea (NERPC Water Resources Committee 1935b, cited in Leuchtenburg 1953, 40). It rested its argument on New England's characteristic independence. Despite its own dependence on federal funding and leadership, the regional planning commission would argue the next year that "New England is congenitally averse to the imposition of Federal authority" (Howard 1936, quoted in Leuchtenburg, 42).

The New England Regional Planning Commission represented all six New England states and claimed to represent a unified and inclusive commitment to the New England region (New England Regional Planning Commission 1935a). However, its origins and its stance on power development revealed its difference from at least the progressive Republicans in Vermont. The commission's Water Resources Committee was chaired by none other than MIT's H. K. Barrows. Moreover, the inter-state planning commission had grown out of the private New England Council, a business-oriented group created in 1925 as a regional Chamber of Commerce. In contrast to Vermont farmers' and New Dealers' position on rural electrification, the New England Council's power committee had averred in 1930 that, "It is not economically sound that the rural user should be permanently served at a loss with consequent burden to other customers, nor does the rural customer desire such a subsidy" (New England Council 1930). Their priority, in other words, was in maintaining profit and serving the most valuable loads first, not in providing rural electrification.

Understanding the New England Council's role behind the New England Regional Planning Commission sheds light on New England's supposedly congenital aversion to the imposition of federal authority. Here were the same business interests that were suspect to rural Vermonters, themselves fighting in the name of region-wide Yankee independence. Yankee independence in this case seems to have been at least partly a mask for private capital's aversion to public ownership.

But the New England Council's claims to be protecting regional interests cannot be dismissed entirely. The New England Council's self-defined primary function was, "To develop and maintain a sense of the importance of New England as an economic area in of the United States" (New England Council 1935, 6). In the 1930s, New England had been declining economically relative to the rest of the country for several decades. The textile and other industries were moving to the South, where labor and land costs were cheaper. The New England Council had a major publicity campaign, promoting New England as "a good place to live, work and play" (New England Council 1930, 5) (Figure 4). It also sponsored policies it saw as favorable to retaining and attracting New England business, including lowering taxation and restrictions on business. In this context, the New Deal's drive to regulate and restrict business, combined with

These four New England Council advertising cards appear in street cars throughout the six New England states, which carry five million riders daily, through the co-operation of the Eastern Advertising Company of Boston

Figure 4. New England Council advertising posters, in the Council's efforts to "develop and maintain a sense of the importance of New England as an economic area in of the United States." (New England Council 1930, 5)

its use of federal tax dollars to fund development in the South and West, seemed, as Leuchtenburg put it, "positively diabolical, in that they drained money out of New England to benefit the very regions that were already at a competitive advantage" (Leuchtenburg 1953, 15). Thus New England's opposition to federal interference could also be seen as a historically specific, self-interested protection of New England's initial advantages against a federal government eager to share some of the region's declining, but still comparatively large, wealth.

In 1936, the TVA itself faced a threatening lawsuit, and Roosevelt declined to come out in support of other valley authorities. The CVA bill died in committee (Leuchtenburg 1952, 1953; on the legal battles over the TVA, see McCraw 1971). The proposal would return later, however, and its shadow lay over the entire fight over New England comprehensive river management (Leuchtenburg 1953).

Plan 3: Corps 308 Plan (1936): Federal-state-private collaboration to construct dams for flood control, navigation, and privately owned power

In February 1936, the third major vision was unveiled: the Corps 308 report for the Connecticut River was finally released (Secretary of War 1936). In contrast to Professor Barrows' maximum-development proposal, the Corps was comparatively conservative, though still ambitious, envisioning thirty-three reservoirs (Table 1, right side). In contrast to the New Dealers' valley authority idea, the dams would fulfill a narrower range of purposes: flood control, power production, and navigation in the lower river. Storage would be primarily for flood control, but made economically justifiable by production and sale of hydropower. There would be some "indirect sanitary benefits" (Secretary of War 1936, 5), but broader stream pollution should be addressed by municipalities, through sewage plants, while erosion, reforestation and economic development should be handled by other agencies with relevant expertise (Leuchtenburg 1953).

The Corps recommended that local communities and states would provide rights-of-way, assume damages, and pay half the constructions costs. In return, they would take over and operate the dams once they were completed. Communities and states could sell hydropower to anyone they liked. The Corps reasoned that communities and states would sell to existing electric power companies, and thus the projects' cost-effectiveness would depend on meeting these companies' needs. This was a federal plan, but in contrast to the New Dealers' valley authority idea, it offered hydropower to state, local and private interests (Leuchtenburg 1953; Secretary of War 1936).

Ultimately, it was part of the Corps' plan, together with a part of the fourth plan, the interstate compact plan, which would go forward, shaping the river's future. But both would be severely reduced before their remnants could be cemented in physical and institutional form.

What was not clear in the Corps plan was what kind of coordination system would allocate and distribute the costs and benefits of Connecticut River dams. If not a valley authority, then what? Some Corps officials thought an interstate authority was needed, while others thought it would not be feasible (Secretary of War 1936).

Plan 4: Interstate Compact (1936-37): Federal-state-private collaboration to construct dams for flood control, navigation, and privately owned power

New Englanders who wanted river development faced the same question: what kind of institution should allocate and distribute the costs of Connecticut River flood control? In April 1936, the New England Regional Planning Commission voted to support an interstate compact for Connecticut River development as an alternative to a valley authority. Interstate compacts might be clumsy, but that was "the price that had to be paid for 'the safe-guarding of local privileges from inroads of Federal interference" (Howard 1936, quoted in Leuchtenburg 1953, 42).

Once again, the stance of the New England Regional Planning Commission can be seen as an outcome of its strong ties to the region's business leaders. In this case the links to the New England Council are less immediately evident, but the role of the private power companies in advancing the idea of interstate compacts could hardly have been more central. The Chairman of the New England Joint Commission on Interstate Compacts for Flood Control was none other than Henry I. Harriman, founder and former president of the New England Power Association, a privately owned electric company that in the previous ten years had been able to acquire a large proportion of the electrical generation, transmission systems and markets in New England (Leuchtenburg 1953; Landry and Cruikshank 1996; Webb 1974; Secretary of War 1936). Vermont's and New Hampshire's representatives on the Joint Commissions on Interstate Compacts for Flood Control were also closely tied to private electric companies and interests (Leuchtenburg 1953).

In August 1935, Representative Citron set aside his CVA proposal and introduced a bill to give advance Congressional consent for interstate compacts. Under this bill, when the Army Corps of Engineers constructed flood control dams, states would be responsible for "local costs" – the costs of acquiring lands, easements, and rights of way – and also maintenance. They would enter into an interstate compact in order to allocate these local costs. Thus a downstream state that benefited from a reservoir in an upstream state, for example, might pay a larger share of the related "local costs." Perhaps hoping to head off opposition in Congress or from the President, the bill did not clarify who would own the dams once built, or their hydropower, under these advance-approved interstate compacts (Leuchtenburg 1953).

If Mother Nature had not intervened, this bill probably would have gone nowhere. The FDR administration – outside the Army Corps of Engineers and the Secretary of War – hated the bill. It seemed to preempt the administration's own plans for comprehensive river basin development, instead handing leadership in river development to the Army Corps of Engineers – an agency the administration viewed with considerable suspicion. It suggested a disturbingly codified allocation of costs between the federal government and the states. And it failed to designate who would own the dams that would be built, the lands that would be acquired, and the hydropower that would be produced. Quite rightly, this was seen as an effort to obstruct New Deal visions of using comprehensive river basin development for broad regional planning and development, and to undercut the ability of federal dams to advance publicly owned power (Leuchtenburg 1953).

However, Mother Nature did intervene. Only a few weeks after the Corps issued its Connecticut River 308 report, from March 12-18,1936, another flood hit New England – and a huge swath of the American Northeast. Three successive storm fronts in a period of two weeks following a colder-than-average winter caused a torrent of rainfall, snowmelt and damaging ice flows. It was the worst flood in three centuries in the lower Connecticut River basin and devastated cities from Brattleboro, Vermont to Hartford, Connecticut. In many sites it remains by far the worst flood on record (Leuchtenburg 1953; National Weather Service Northeast River Forecast Center n.d.).

Less than two weeks after the flood, on March 25, the Senate Committee on Commerce began to debate the new flood control bill. Spurred by the horror of the March flood, Congress quickly passed the bill in June, the Omnibus Flood Control Act of 1936, and FDR reluctantly signed it (Leuchtenburg 1953).

Even with a federal bill to support interstate compacts, the Connecticut River states still had to find agreement and come up with their own specific compact, before they could ask for federal approval. Leuchtenburg suggests that only a renewed threat of a Connecticut Valley Authority was able to inspire interstate agreement. In early 1937, with the TVA lawsuit resolved favorably (McCraw 1971), Roosevelt and Congressional allies moved to authorize a whole set of "little TVAs," one of which would be an Atlantic Seaboard Authority, and would include New England. A month later, the governors from Vermont, New Hampshire, Massachusetts and Connecticut ratified their alternative, an interstate flood control compact, on July 6, 1937 (Leuchtenburg 1952, 1953).

The compact provided for the creation of the Connecticut Valley Flood Control Commission, which would have three representatives from each of the four basin states. The proposal had only eleven listed dam sites, eight of which were to be chosen. Three would be in Vermont, three in New Hampshire, and two in Massachusetts. The states would cover local costs, Massachusetts paying fifty percent, Connecticut forty percent, and New Hampshire and Vermont five percent each. The title to the lands would be taken in the name of the states, then leased to the interstate flood control commission. Indirectly, the compact also promised continued private sector dominance in New England's electric system. If there were any hydropower benefit to a dam, the state would receive the right to use it. Supporters acknowledged that this power would most likely be sold to private electric companies (Leuchtenburg 1953).

The governors hoped that the 1936 Flood Control Act meant their compact would win easy congressional approval. However, FDR and his Congressional allies took a firm stand against the New England states' asserted powers. They insisted that any dams to be funded or built by the federal government would be owned by the federal government. The lands acquired to build the dams would be acquired by the federal government and would remain under federal ownership. Any electricity the dams produced would be federal power, sold preferentially to public utilities in order to support a federal "yardstick" against which to measure other utilities' power rates. Congress, still dominated by New Deal Democrats, rejected the Connecticut River compact (Leuchtenburg 1953).

The demise of comprehensive development on the Connecticut River

By blocking the New England states' flood control compact, the Roosevelt administration and its supporters had prevented the states – and indirectly the private electric companies – from claiming the benefits of future federal dams on the Connecticut River. They thus closed off the state-led option for river basin development, and the private companies' bid to win control of federally produced hydropower on the Connecticut River.

The states and other New Deal opponents soon returned the favor, closing off the all-federal, publicly owned power, alternative. First, they killed the little TVAs bill. Not solely New Englanders, a broad national coalition that was growing increasingly critical of the New Deal overcame the initiative (Leuchtenburg 1952).[4]

Next came the death of multipurpose dams on the Connecticut River. The 1936 Flood Control Act had caused so much trouble that in early 1938, Congress resumed discussions, aiming to craft an alternative. A compromise 1938 Flood Control Act passed on June 14. It provided that federally built dams and reservoirs would be constructed entirely at federal cost, and would be owned and operated by the federal government. In the Connecticut basin, it authorized twenty reservoirs and seven local flood protection works. The reservoirs, however, would be strictly for flood control. Sites that were better for other purposes would not be selected for construction by the Corps (Parkman 1978, 177; Leuchtenburg 1953, 108).

As if to hammer home the futility of any further hopes for New Deal policy on the Connecticut, in September 1938 the river flooded again. The flood was caused when a hurricane followed two heavy rains. Much of the coast in southern New England – home to the region's population and economic centers – was even more devastated than the Connecticut Valley. Political challengers for the mid-term elections successfully blamed the flood on Roosevelt Democrats who had opposed the states' flood control compact. Every state in New England went Republican, and only one of the region's federal representatives who had supported Roosevelt held his seat (Leuchtenburg 1953). Now, an almost unified regional delegation in Congress could block any program of Connecticut River comprehensive river development that furthered the cause of publicly owned electric power. This sealed the stalemate.

The 1938 Flood Control Act spelled out the crucial compromise that would grow out of this stalemate, though the details would be the subject of ongoing fights for another twenty years. Twenty or fewer federal dams would be built in the Connecticut basin. Federal dams would be single-purpose flood control dams, with no hydropower, and would not be built with additional storage that would benefit downstream generation, nor would their operations coordinate closely with downstream dams. Federal dams would be built only in the tributaries. Privately owned power companies would retain all their existing ownerships of power generation sites, and almost total control of the mainstem river, as well as many tributaries like the Deerfield. The privately owned companies would have to provide any storage for themselves, without the benefit of reliable seasonal flows during the low-flow months from the large storage reservoirs the Corps would build in the tributaries. Thus the Connecticut River would be divided institutionally, functionally and spatially. While all this drastically reduced the potential economic benefits of federal dams in the Connecticut River basin, it circumvented the political impasse over ownership of electric power that kept stopping the construction of any dams at all.

Battle over the Connecticut River, Part II: The fight over Vermont's valleys (1927-38)

Even the more politically palatable single-purpose river basin development would not come easily. As general river basin development plans began to give way to surveys and construction of specific dams, a new set of fights faced off not the New Deal versus New England Yankees, but the Corps and the downriver states versus northern-valley Yankees in the upriver states, especially Vermont. This section outlines this fight, emphasizing a few of its highlights and the resulting step-by-step construction of thirteen federal dams in the Connecticut River basin.

In fall 1938, the September flood and the looming November mid-term elections helped push through funding and authority for the first four flood control dams in the basin. Three were completed by 1942: Surry Mountain on the New Hampshire's Ashuelot River, and Knightville and Birch Hill on Massachusetts' Westfield and Millers Rivers. Though locals in these places were not happy to surrender their lands, the states agreed to the federal government's terms when federal officials threatened to spend allotted money on flood control in other regions instead (Leuchtenburg 1953).

A fourth dam was supposed to be completed equally speedily, at Union Village, Vermont, on the Ompompanoosuc River. But George Aiken, since 1937 Governor of Vermont, was no more happy about having the Army Department flood fertile Vermont valleys for the benefit of the southern New England states, than about having the private power companies do so. Aiken insisted that the state acquire the lands for the federal government, and that the Corps sign an agreement that the dam would be only for flood control. At first, the Corps and the Secretary of War signaled their agreement, and the district engineer even wrote and signed a draft document. However, as the precedent-setting implications became more clear, the War Secretary – and President Roosevelt, who was brought into the discussion – balked at the notion that the federal government would have to submit to individual states' demands, and backed out of the agreement. Aiken then accused them, with considerable justification, of betraying a promise. Newspapers and politicians throughout Vermont cried out against federal intrusion and usurpation of state and local autonomy. Soon the press and Republican politicians across the country took up the cause, and hailed Governor Aiken as a national hero (Leuchtenburg 1953; Webb 1974).

The Second World War forced a two-year hiatus in domestic Army construction, but in 1944, the Corps began planning and surveying Connecticut River dam sites again. Multiple-purpose dams were, for a time, back on the table. The Corps began to survey Vermont's West River valley, the source of some of the greatest volumes of potential flood flows in the Connecticut River. The West River valley was also, as it happened, George Aiken's boyhood home. Valley residents protested the prospect of flooding their valley, especially because the Corps' proposed flood-control-and-power dam would need to be higher than a flood-control-only dam, and would therefore drown more of the valley. When the Corps suggested that the best location would be just below the village of West Dummerston, protesters began to organize. *The Brattleboro Reformer* came to their aid, announcing protests and calling for action in other river valleys as well. A group of valley residents calling themselves Freeman, Inc. organized to fight the dam. The state emergency board supported a defense fund to fight the dam. Writes Leuchtenburg, "The engineers, who continued their surveys in the West River Valley, were harassed by every means short of physical violence" (Leuchtenburg 1953, 162). The Corps surveyors were cited for trespassing, denied permits to buy explosives, and almost lost their access to preferred gas rations (Leuchtenburg 1953).

In 1944, Congress considered a new flood control bill that would appropriate $30 million for dams in the Connecticut River. In one of the early hearings, the Corps presented the West Dummerston dam as the most important flood control structure in the entire basin. The engineers contended that the villages that would be flooded had only a few hundred residents, and the increased height from building valuable power generation would cause only slightly more village flooding (Leuchtenburg 1953).

George Aiken, now a US Senator, arrived at this hearing with a cohort of dam opponents. He urged the Corps to use a series of smaller projects in the West River's tributary streams. As the House and then Senate hearings proceeded, Aiken became increasingly vociferous. He opposed the entire Connecticut River appropriation, because ten of the twenty planned dams would be in Vermont, flooding portions of almost every valley in the eastern half of the state. The reservoirs would stink when they were drawn down in the summer, fish would die, the generators would lie idle because there was little water in the summer and the fall, and communities would be devastated. Moreover, Aiken argued, "[I]t would be far better and in the long run cheaper to spend money in removing people from the danger areas, rebuilding their homes on higher ground" (Leuchtenburg 1953, 179).

In his seminal book on Connecticut River "flood control politics," William Leuchtenburg mocks this argument of Aiken's. Leuchtenburg notes that the factories and houses of flood-prone downstream cities were located along the river for a reason: because the rivers were used for industrial purposes. Aiken, says Leuchtenburg, "knew perfectly well that the relocation of factories and houses in cities like Springfield, Hartford, and Chicopee would have completely disrupted the lives of these industrial centers, and could only have been achieved at a staggering cost." What Leuchtenburg did seem to not recognize in 1953, however, was the legitimate hydrological and moral questions Aiken was raising, or, more pragmatically, their resounding political power. Today's decision makers, if faced with floods on the scale of those in the 1920s and 1930s, would almost certainly still choose to build flood control dams in the Connecticut River basin, but there might be more than a few who would be sympathetic to the logic of moving people out of floodplains in recognition of the recurring – and even ecologically important – cycle of river floods.[5] But more importantly for Aiken's supporters, building large flood control dams rested on a utilitarian logic in which upriver valleys with smaller populations and lower economic production should be sacrificed for the benefit of far-away larger cities. Needless to say, this did not sit well with Vermonters. Their version of Yankee independence meant the right to protect their homes, communities, scenic valleys, local economies, and self-direction against the reach of distant cities, governments, businesses, and industries.[6] Especially given Vermont's experience of development and exploitation by those from southern New England, Aiken's perspective does not seem as "cavalier" as Leuchtenburg suggests (Leuchtenburg 1953, 179, 180; see Aiken 1938, especially Chapter X, for Vermont conceptions of independence in relation to federal river development).

Cavalier or not, it was rhetorically powerful and politically influential. The upriver protests in Vermont, together with Aiken's efforts in Washington DC, were so successful they began to threaten effective Connecticut River flood control entirely.

As these implications became clearer, some politicians in the downstream states of Massachusetts and Connecticut became more sympathetic to the principle of federal preemption over state law. Representative Clason, representing Connecticut River cities Northampton and Springfield, Massachusetts, broke ranks publicly with his upstream neighbors, warmly favoring $20 million in funding to go toward Connecticut River flood control, including dams on the West River (Leuchtenburg 1953).

The 1944 Flood Control bill, passed a few days before Christmas, forged a compromise much like that in 1938, with more specifics. Any dam on the West River mainstem would be only for flood control. The Corps would have to consult with the Vermont governor before constructing dams at four other sites in the state. Additionally, the Corps would study Aiken's proposed system of smaller dams in the West River tributaries. If the smaller dams could provide at least 75% of the flood control of a Dummerston dam, and could be built for $11 million or less, the Corps would adopt this approach (Leuchtenburg 1953; Parkman 1978).

In this way, the upriver-downriver fracture of the New England states also catalyzed eventual compromise. Massachusetts and Connecticut governors and legislators became key intermediaries, forging compromises between Vermont, the Corps and the Presidential administration. The same basic approach would be used repeatedly. It was always in response either to some large-scale federal proposal or effort, or else a major flood. Legislators or businessmen from lower-river states would cajole their upper-river counterparts to support interstate or citizen agreements, in order to head off broader and far-reaching federal intervention. Then New England state representatives would go as a unified regional delegation to Congress, the President, and the Corps and show they had a constructive alternative, to persuade these federal leaders and agencies either to support them, or else simply to desist.

Their first successful compromise was reflected in the Corps' developing comprehensive plan, released in 1947. In 1945, the Corps had found that the eight-tributary-dam option in the West River valley was too expensive, and proposed three medium-sized dams. West Valley residents and the *Brattleboro Reformer* readied their protests. At the same time, the Corps faced growing protests in New Hampshire, where residents near the Surry Dam had experienced de-populated communities, a bad odor, and a rise in mosquitoes. But that same year, there was also a new federal regional authorities bill introduced to Congress. This was threatening to influential people in downstream New England state as well as to those in upstream states – and also to the Corps. The governors of Massachusetts and Connecticut convened a meeting of five New England governors (all but Maine) with the regional division of the Corps of Engineers. The governors agreed to get out more "yes" voices in local hearings about prospective dams, and the Corps removed the dams that were most offensive to Vermont legislators from its plans, including, once again, most dams with power potential. Even Vermont, to signal its good-faith support, finally approved the Union Village Dam, and agreed to two dams in the West River at

West Townshend and Ball Mountain. All three would be for flood control only, without reservoirs (Leuchtenburg 1953).

Next, as Congress considered a national pollution control bill, state leaders from Connecticut and Rhode Island persuaded those from Massachusetts to join a New England Interstate Water Pollution Control Compact. It would set pollution standards for pollution in interstate waters, but its decision-making structure gave each state veto power, and delegated all enforcement to the states. This time the New Englanders beat Congress's clock. A year before it could complete a national law, Congress approved the New England compact (Leuchtenburg 1953).

In 1948-9 it was both federal action *and* a flood that spurred state coordination. While the Corps was constructing Tully and finally Union Village Dams in the late 1940s, Massachusetts Governor Tobin gathered together the four Connecticut River state governors, to resume discussions on a flood control compact. They proposed the same cost-sharing approach as in the 1937 interstate compact, but did not attempt to assert state ownership. They specified twelve dam sites, several of which differed from the Corps' plan. They released a draft compact on December 31, 1948 (Leuchtenburg 1953). Then, repeating a theme, hours after they released their draft compact, starting on New Year's Eve 1948 and continuing to January 2, Day 1949, the Connecticut River flooded yet again. In the wake of the flood, in January, 1949, the states quickly signed their new flood control compact. The compact was not approved by Congress that year; Congress remained dominated by Democrats, and President Truman strongly supported federal power. However, the work done in 1948-9 would bear fruit in a few years: in 1953 a new Republican President Eisenhower and a new Republican Congress would eagerly approve the Connecticut River Valley Flood Control Compact (Leuchtenburg 1953; Richardson 1973).

In 1949, the idea of valley authorities and public power suddenly re-emerged, advanced enthusiastically by the Assistant Secretary of Interior C. Gerard Davidson of the Truman administration. This time, the stark decline of New England's economy lent political support to the idea of a Connecticut River Valley Authority, especially the idea of federal electric power, for some blamed high power rates for the exodus of New England industry to the South (Leuchtenburg 1953; Webb 1974). However, the threat of a valley authority again lit a fire amongst New England's political and business leaders. They attacked the idea mercilessly, arguing it was the fault of unions and their demands for high wages that drove industry away, not high power costs (Leuchtenburg 1953; see for example New England Council Power Survey Committee 1948). But they also buttressed their case that no federal intervention was needed. Vermont and New York joined the pollution control compact in 1949, and New Hampshire joined in 1951 (Gere 1968). And in 1952, a group of citizens and business leaders formed the non-profit Connecticut River Watershed Council as an alternative to a Connecticut Valley Authority (Miner et al. 2003).

Even all this interstate action did not produce rapid dam construction, however. In 1953, twenty-six years after the 1927 flood prompted serious planning for comprehensive river development in the Connecticut River basin, there were still only five completed flood control dams in the basin and one under construction. It took another major flood to finally drive the completion of the rest. That came in August, 1955, following Hurricane Diane. "Along with property and life," writes Parkman (1978), in a history of the New England district of the Army

Corps of Engineers, "Diane swept away complacent attitudes toward flood control." Politicians and business leaders from Connecticut, Massachusetts and Rhode Island began immediately to campaign for better flood control. In 1956, Congress instructed the Corps to expedite construction of the remaining New England flood control dams. The Corps proceeded apace, completing two Connecticut Basin dams in 1958 (Otter Brook, in New Hamshire and Barre Falls, in Massachusetts), one in 1960 (North Springfield, in Vermont), three in 1961 (Ball Mountain and Townshend Mountain, on Vermont's West River, and North Hartland, also in Vermont), one in 1965 (Littleville, in Massachusetts) and one in 1969 (Colebrook, in Connecticut

Conclusion: The un-comprehensive development of the Connecticut River: Results and legacies

Comprehensive river development, led by an over-arching federal effort, seems today like an idea for other rivers besides the Connecticut. However, as Leuchtenburg's fifty-nine-year-old book reminds us, this was a vision advanced and fought over very seriously on the Connecticut River for many years. Moreover, both the effort and its failures have left results and legacies that still shape the river and New England.

The most obvious physical results are thirteen Army Corps flood control dams that dot the basin (Table 2 and Figure 5). They sit on tributaries, often over hard-to-find and poorly marked roads. But in times of floods, they come into action, filling, holding back floodwaters. As drybed or almost drybed

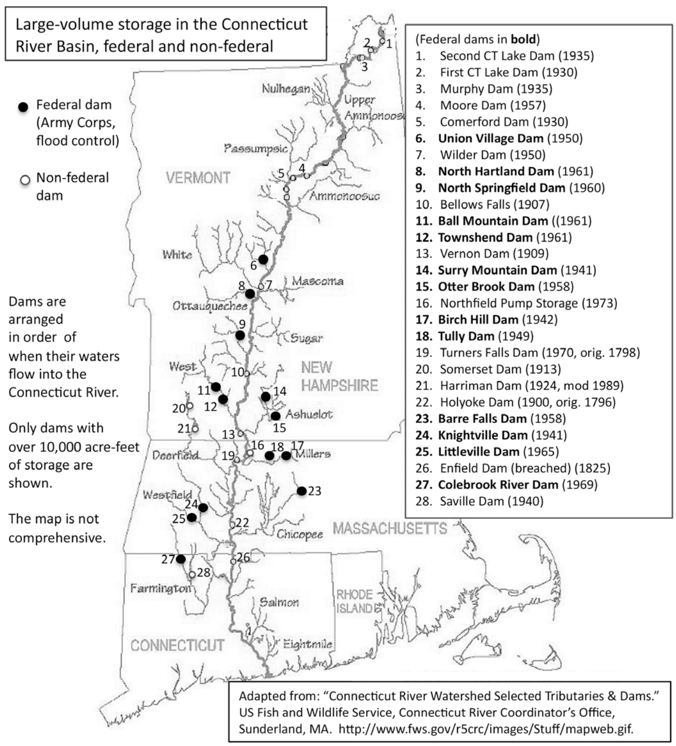

Figure 5. Large-volume storage in the Connecticut River basin today. Notice that federal dams are located only on tributaries.

River	# on map	Dam Name	Year Completed	Owner Type	Purposes	Storage (acre-ft)	Normal storage (acre-ft)
UPPER CONNECTICUT BASIN (Vermont and New Hampshire)							
Connecticut mainstem	1	Second Connecticut Lake	1935	Private	Hydroelectric	12,500	11,650
	2	First Connecticut Lake	1930	Private	Hydroelectric	114,000	91,000
	3	Murphy (Lake Francis)	1935	State	Recreation	132,000	99,500
	4	Moore (Upper 15 Mile Falls)	1957	Private	Hydroelectric, Recreation	223,722	223,722
	5	Comerford	1930	Private	Hydroelectric, Recreation	32,270	32,270
Ompompanoosuc (VT)	**6**	**Union Village**	**1950**	**Federal**	**Flood Control**	**49,640**	**1**
Connecticut mainstem	7	Wilder	1950	Private	Hydroelectric, Recreation	55,000	55,000
Ottauquechee (VT)	**8**	**North Hartland**	**1961**	**Federal**	**Flood Control, Recreation**	**94,600**	**2,350**
Black	**9**	**North Springfield**	**1960**	**Federal**	**Flood Control, Recreation**	**76,500**	**500**
Connecticut mainstem	10	Bellows Falls	1907	Private	Hydroelectric, Recreation	30,000	30,000
West	**11**	**Ball Mountain**	**1961**	**Federal**	**Flood Control**	**54,700**	**2,350**
	12	**Townshend**	**1961**	**Federal**	**Flood Control, Recreation**	**54,300**	**800**
Connecticut mainstem	13	Vernon	1909	Private	Hydroelectric, Recreation	54,000	18,300
Ashuelot	**14**	**Otter Brook**	**1958**	**Federal**	**Flood Control, Recreation**	**24,800**	**870**
	15	**Surry Mountain**	**1941**	**Federal**	**Flood Control, Recreation**	**44,000**	**1,320**
LOWER CONNECTICUT BASIN (Massachusetts and Connecticut)							
Connecticut mainstem	16	Northfield Mt. pump storage	1973	Private	Hydroelectric, Recreation	21,500	17,050
Millers	**17**	**Birch Hill**	**1942**	**Federal**	**Flood Control**	**76,000**	**1**
	18	**Tully**	**1949**	**Federal**	**Flood Control**	**35,800**	**1,500**
Connecticut mainstem	19	Turners Falls	1970 (1798,1869)	Private	Hydroelectric, Recreation	21,500	16,600
Deerfield	20	Somerset	1913	Private	Hydroelectric, Recreation	57,345	35,517
	21	Harriman	1924 (mod 1989)	Private	Hydroelectric, Recreation	116,075	103,375
Connecticut mainstem	22	Holyoke	1900 (1798,1850)	Local Govt	Hydroelectric, Recreation	26,000	26,000
Chicopee	**23**	**Barre Falls**	**1958**	**Federal**	**Flood Control**	**63,000**	**1**
Westfield	**24**	**Knightville**	**1941**	**Federal**	**Flood Control**	**64,000**	**1**
	25	**Littleville**	**1965**	**Federal**	**Flood Control, Water Supply**	**40,600**	**9,400**
Connecticut mainstem	26	Enfield	1825	Private	Recreation	10,744	10,744
Farmington	**27**	**Colebrook River**	**1969**	**Federal**	**Flood Control, Water Supply, Recreation**	**137,000**	**47,500**
	28	Saville (Barkhamsted Res.)	1940	Local Govt	Water Supply	113,000	113,000

Table 2. Large-storage dams (over 10,000 acre-feet) in the Connecticut River basin today, as shown in Figure 5. Not only are there fewer dams than envisioned in the 1930s (see Table 1 and Figure 2), flood control and power production were separated institutionally and spatially, the Corps providing flood control in the tributaries with mostly drybed reservoirs, and the privately owned power companies generating power on the mainstem and some tributaries. Thus, the coordination between upstream storage and downstream power production envisioned by Barrows and the Corps was largely lost. Data from the National Inventory of Dams.

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reservoirs (see Table 2 column, "Normal Storage"), virtually their full storage capacity is available at any time, so they provide as much flood control as possible for their size. All told, they control about twenty-five percent of the waters of the basin, the minimum the Corps said was necessary for flood control. They are able to make an enormous difference during flood events; for example, they reduced greatly the flooding during 2011's Tropical Storm Irene, which hit Vermont much like the 1927 flood. Most now also provide some kind of recreation in a small lake or in their grassy reservoir (New England District well prepared for Hurricane Irene 2011; Upper Connecticut River Basin 2009; Lower Connecticut River Basin 2009; Curran 2011).

However, there are other physical results that are less apparent because they are results of what did *not* happen. Connecticut River hydropower was developed largely separately from flood control, because of the deep and intractable divide between federal government proponents of public power and New England business interests' defense of private power, and because of the fierce protection of upriver communities from large reservoirs – in other words, because of the politics of the two faces of Yankee independence. Private companies developed most of the hydropower in the basin. Among the series of large hydropower dams on the mainstem river, all were privately owned until 2001, when the City of Holyoke, Massachusetts purchased the Holyoke Dam (Moore 2002). The operations of the basin's dams remain largely uncoordinated across ownerships, though three non-federal generation stations were built at Corps Connecticut basin dams (U.S. Army Corps of Engineers 2009); private companies have managed to build some large storage for themselves, most notably at Moore Dam, at Upper Fifteen Mile Falls; and some hydropower operators pay a small headwaters storage fee to the Corps for the storage that is provided by flood control (Ragonese 2012).

Because of this un-comprehensive, uncoordinated development of the Connecticut River, hydropower production in New England remained lower than it might have been, and so the region has been that much more dependent on fossil fuel-burning and nuclear power plants, and electric imports from Canada.[7]

On the other hand, the lack of coordination between different dam owners and purposes has also meant that the river never became as fully regulated in terms of flows as did many other American rivers. This is not to say that the Connecticut River's flows have not been disrupted by dams. It is one of the most fragmented rivers in the country if not the world, because of its high density of dams, a legacy of the small and mid-size dams of earlier centuries. Flood peaks are significantly diminished thanks to the success of the Corps' flood control dams. Large power generation facilities like the Moore Reservoir, Wilder Dam, and the Northfield Mountain pump-storage facility cause major daily fluctuations; and a host of dams, including sometimes

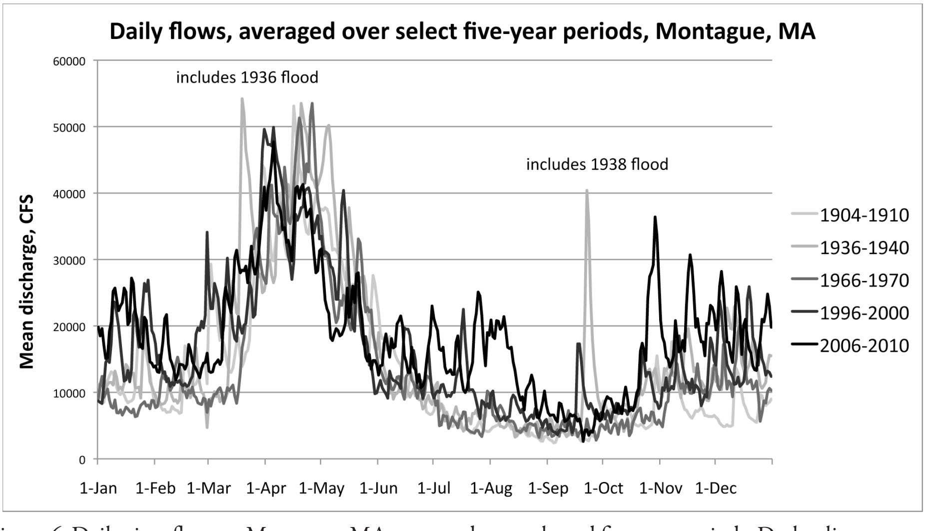

Figure 6. Daily river flows at Montague, MA, averaged over selected five-year periods. Darker lines are more recent five-year periods. The gauge is located below the Turners Falls Dam. Over 110 years, the over-all shape of the graph – the annual hydrograph – has not changed dramatically. However, daily and weekly-scale variations are strong, and seem to be increasing. These are heavily influenced by power operations from the Turners Falls dam, and from the Northfield pump-storage facility directly above the Turners Falls Dam. It is impressive to note that even after averaging with four other years' data, the 1936 and 1938 floods are evident. Data from USGS; graph prepared with help by Ryan O'Donnell.

the federal flood control dams, contribute to significant subdaily fluctuations (Zimmerman et al. 2008; 2009). What has not occurred, however, is for large storage dams in the upper river and high tributaries to store water seasonally to provide flows in low-water seasons for power generation below. Thus the river's annual hydrograph, and its seasonal flows, were not evened out across the year or reversed, in order to provide for peak power demand seasons, as they were in rivers like the Columbia (Bonneville Power Administration et al. 2001; Volkman 1997). The river's hydrography shows marked short-term fluctuations, but the shape of the year's flow variations has remained fairly consistent for the past 100 years (Figure 6). Another way to put this is that both flood control storage dams (outside of flood times and seasons) and many smaller power generation dams operate most of the time as run-of-the-river dams that let most water flow through.

This difference from rivers where development was comprehensive and more integrated has allowed the New England Corps of Engineers to work relatively easily with fish conservation efforts in recent years. The Corps simply made its generally run-of-the-river management into a more deliberate policy (Curran 2011). It did not have to justify the high costs of foregone power production, as is done in the Columbia River system (see e.g. Northwest Power and Conservation Council 2011). Now, the Corps is working closely with The Nature Conservancy to improve natural flows in the river (Curran 2011; Lutz and Hatfield 2009).

Besides the physical results and legacies from this era of battling over development of the Connecticut River, there are political and institutional legacies. Resentments linger in some parts of the northern basin, especially in Vermont, against the federal government, the power companies, and southern New Englanders. In the 1990s, this helped support an anti-government, anti-environmentalist politics that occasionally exploded in violence (Tripp 2006). The more regional, pro-business version of Yankee independence that fought off federal authorities and large-scale public power seems today to have little to say about the Connecticut River, but the New England Council has continued to thrive as an institution that promotes New England's interests in development and trade in its interactions with federal government policy (New England Council 2012).

In terms of river management, the basin has remained fragmented among multiple states, institutions, jurisdictions and purposes. No agency or institution came to coordinate Connecticut River management. Trying to craft basin-wide improvements is for this reason a major challenge. In a four-state basin, the most straightforward route to coordination might have been a strong centralized federal agency. There have been a number of basin-wide federal efforts in recent years. The federal government has added water quality standards, a Connecticut River Atlantic Salmon Commission, and a river-wide Conte National Wildlife Refuge. Still, these remain relatively piecemeal, limited, and often hamstrung by limited funding.[8]

Perhaps because of the fragmented and limited role of the federal government, however, the Connecticut River has had a fairly strong and lasting array of interstate and independent agencies. From the mid-1950s until 1981, there was a series of interstate rivers commissions, the most long-lived of which was the New England River Basins Commission (Foster 1984). Three interstate institutions that grew specifically out of the independent Yankees' efforts to head off the New Deal continue to function today. First, the Connecticut River Valley Flood Control

Commission has worked reasonably peaceably for over 50 years to balance out the cost arrangements for flood control between upriver and downriver states.[9] Second, the pollution control compact that was originally inspired by the threat of federal pollution control, the New England Interstate Water Pollution Commission, continues to work to protect the river's environmental quality and has become a close partner with the Environmental Protection Agency – even if it remains subject to individual states' vetoes. Finally, the nonprofit Connecticut River Watershed Council – which some accused at the time of being a front organization for private utilities – became one of the country's first watershed councils, and today, alongside more recently involved organizations like The Nature Conservancy and the Trust for Public Land, is one of the leading voices for river-wide thinking and conservation.

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Acknowledgements

Alexandra Lacy, a recent UMass alumna, did much initial research and drafting. Brandon Taylor helped research and draft sections on Vermont history. Andy Fisk, Kim Lutz, Mike Curran, Bruce Williams and Chris Hatfield provided background information. Andy Fisk, David Deen, and Kim Lutz read and commented on the submitted draft, as did one very thoughtful anonymous reviewer. Finally, thanks to William Leuchtenburg, for telling an important story 60 years ago, and working for so long since then to teach us about how people have worked to use government to make the world a better place, and how and why the consequences have been mixed – but the efforts and debates never insignificant.

Notes

1. The most contentious fight of all was not over a river, but Maine's Passamaquoddy Bay, where the Corps proposed to build a major tidal power generating plant. See Parkmann (1978), Ch. 9.

2. In other places, unions also were beginning to play a role in opposing publicly owned power, as private power companies had unionized labor, while municipal and other public and cooperative utilities did not. As Armstrong and Nelles (1986) explain in their history of utility organization and regulation in Canada, ownership of utilities by the public sometimes undercut public support for workers' fights against utility managers (see also Elkind 2011).

3. This agency had four names in its ten-year existence: National Planning Board (1933-4), National Resources Board (1934-5), National Resources Committee (1935-9), and National Resources Planning Board (1939-43). (See Reagan 1991.) I have used the agency's final name to refer to the agency even in its early years, to ease confusion.

4. For a very illuminating narrative of the fight over the "little TVAs" bill see Leuchtenburg 1952. Leuchtenburg shows that the tensions within the FDR administration were insurmountable – and in doing so, he highlights fundamental challenges to any kind of redistribution of authority along geographical lines. Within the administration itself, both the Secretary of War and the Secretary of Agriculture bitterly opposed the creation of any little TVAs. The bill threatened to take away major portions of both departments' responsibilities, after all, and hand them over to new regional agencies which would be within the Department of Interior.

5. There were some, even in the 1940s, who advised that one of the best ways to avoid flood damage would be to move people out of floodplains (White 1986).

6. This echoes closely recent seminal work that shows that early fights to protect land and waters in the United States were often rooted in Northern New England and other remote, rural areas; and were not always driven by a pro-regulation, urban-driven recreation sensibil- ity, but often the opposite (Judd 1997; Cumbler 2001; Brooks 2006). It also hints at an ironic legacy: these past environmental fights helped build toward an anti-government populism which often dominates these same regions' politics today, and commonly rejects government-led environmental protections (Tripp 2006; cf. Vogel 2008 on lessons from Brooks 2006). It also suggests these past environmental fights helped build toward an anti-government populism which often dominates these same regions' politics today, and commonly rejects government-led environmental protections (Tripp 2006 provides a lyrical reflection on some of these legacies in Northern New England and their sometimes counterproductive, even violent consequences; cf. also Vogel (2008) on lessons from Brooks' 2006 book about the Hells Canyon fight in Idaho).

7. Certainly, full power development of the Connecticut River basin never offered the power potential of rivers like the Columbia or the Tennessee, and would not have forestalled the need for other power sources in New England. The New England Council (1948) and the Corps' New England district's historian (Parkman 1978) argued that New England could not have produced much more hydropower than it did, because its already-settled valleys were not available for reservoirs in a way that valleys in other regions were. This seems to us to accept the Vermonters' hard-won limits on upper valley development as an inherent regional characteristic. It also ignores the sacrifices made of settled towns and residents in other river valleys in other regions (see e.g. McDonald and Muldowny 1981, Wilson 1973). Leuchtenburg (1953) suggests this argument was in many ways a political strategy not to re-open the possibility that the federal government might construct power facilities.

8. In summer 2012, for example, the US Fish and Wildlife Service announced the end of its effort to restock Atlantic salmon in the Connecticut River. Tropical Storm Irene had destroyed the main hatchery in White River Junction in 2011 (Daley 2012). Now there are concerns about how much funding will be forthcoming for recovery of other Connecticut River fish.

9. David Deen, Vermont Steward for the Connecticut River Watershed Council and state representative in Vermont, notes that the flood control compact is not entirely peaceable: while there have been "no shooting wars yet," Massachusetts and Connecticut have often not appropriated sufficient funds from their general funds to cover the full cost of lost real estate in the upriver states, and this has caused ongoing complaint, at least from Vermont (Deen 2012).

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Reviews

CLIMATE CHANGE: THE SCIENCE, IMPACT and Solutions 2nd edition

A. Barrie Pittock
Melbourne, Australia: CSIRO Publishing, 2009. 350 pp. paper, *ISBN: 978-0-643-09484-0*

Reviewed by Dr. Matthew Peros,
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In this textbook, written by Dr. Barrie Pittock and published in 2009 (2nd edition), one will find a review of climate change science (especially as it relates to recent global warming), its impacts on natural and human systems, and a review of strategies for mitigation against climate change. The author, now retired, is the former head of the Climate Impact Group at Australia's national government body for scientific research, the Commonwealth Scientific and Industrial Research Organisation (CSIRO). His academic training was in physics, and he has been the author of other climate change textbooks as well as a broad range of peer-reviewed journal articles dealing with topics ranging from the effects of solar variability on earth's climate to the influence of climate change on coral reefs. His long and productive career in climate change science and in government has certainly qualified him to write a textbook of such wide scope.

The textbook, a paperback, consists of twelve chapters which are divided into three broad themes. The first theme (chapters 1 – 4) focuses on the science behind climate change. In the first chapter, Dr. Pittock provides a range of evidence for recent climate changes worldwide, such as information on glacier retreat and sea level rise. Chapter 2 ("Learning from the Past") is a review of past climate changes inferred from the geological record over a variety of timescales. This is a good chapter and he does well in summarizing a huge and complex set of knowledge in a short space. Chapters 3 and 4 focus on future projections and the uncertainties with them—both important topics given the attention these areas receive from the public and media.

The second theme, climate impacts, is discussed in chapters 6 and 7. Here, Dr. Pittock discusses concepts such as climate thresholds—the idea that large-scale impacts can occur once a certain temperature or level of carbon dioxide is exceeded—and the risks faced from extreme climate events such as floods and ENSO. A short section is devoted to adaptation, including its costs, benefits, and implementation.

The third theme of the book (chapters 8 – 12) discusses climate change mitigation and delves into the politics behind these issues. Chapter 8 reviews a range of alternative energy options, such as solar, wind, and nuclear power, and briefly discusses geoengineering possibilities. Chapter 9 places ongoing climate change into a broader context, examining issues such as the relationship between climate and pollution, increasing population, and freshwater availability. Finally, chapters 10 and 11 discuss the political and policy issues associated with climate change, such as the roles that governments and NGOs should have in helping to enact mitigation efforts. The Kyoto Protocol is also discussed, along with how climate change will affect different regions around the world.

The textbook is well written and contains numerous examples. The level of the book is appropriate for an introductory course (perhaps 2nd or 3rd year undergraduate) in climate change and will also be of interest to members of the general public who have an interest in the topic. As someone who instructs a 3rd year undergraduate course in climate change science, I would probably choose another textbook for my course, as the chapters that focus on the science behind climate change are somewhat basic, but this would be a good text for a course that deals more with climate change from the social science point of view (i.e., impacts on humans, mitigation, and governance). Another positive aspect of the book is that it is very well referenced, with detailed annotations, links to websites, and a wide range of recent scientific articles provided. In fact, this may be the strongest aspect of the book: it serves as an excellent starting point to guide the reader to more detailed material.

Despite the breadth of information available, the textbook is unfortunately poorly illustrated. There are a number of black and white photos, but these have not been reproduced as large as they should be, making it difficult to see important details (e.g., the glacier in Figure 2, page 6; and the ice core in Figure 9, page 30). The tables are well done (although this is not a difficult task), but a number of figures are poorly rendered and are therefore difficult to read (e.g., projected precipitation values in Figure 17, page 83). I assume the book was printed in black and white in order to keep the cost down, although it could be improved by enlarging and sharpening many of the existing figures. In addition, figures, photos, and tables are rare in the last half of the text, especially in the mitigation chapter. A future edition, if one is produced, should add more visual information, even if it means replacing some of the text. Finally, the glossary at the end of the book is useful, although it could probably be expanded.

In summary, this is a good contribution to the existing body of literature, and a few small improvements would turn it into a very good textbook.

CLIMATE CHANGE:

From Science to Sustainability

Stephen Peake and Joe Smith
Oxford; New York: Oxford University Press, Second Edition, 2009, 291 pp. paper, ISBN: 978-0-19-956832-1

Reviewed by Norman K. Jones
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This book is written partly to support the Open University course *The environmental web,* however it could be used as a text for any related environmental change course. Given its stated purpose is the education of undergraduates, the language used is fairly general; advanced concepts and terminology are supported by numerous Figures, Text boxes, Activities and Tables. Each of the seven Chapters is followed by a series of Questions to reinforce the preceding concepts, and a list of References for further reading.

The seven book chapters are arranged in a logical sequence beginning with two chapters providing overviews of the science behind climate change. A general definition of climate change is provided and then Chapter 1 focuses on the role played by the greenhouse effect, particularly what the authors refer to as the enhanced greenhouse effect. A reasonably thorough, straightforward explanation of the greenhouse effect and especially the roles played by water vapour and carbon dioxide is provided. The human role in 'enhancing' the greenhouse effect through the emission of greenhouse gases is made clear. In fact, throughout the chapter the underlying theme is one of how important an environmental issue climate change is, and what a threat it is to humanity. There is also a relatively constant theme of human blame. The authors carefully select quotes from scientists, politicians and media representatives to support this theme. In other words, underlying the scientific message is an even stronger political one. This is not to say that the scientific basis for climate change is not explained well, it is. However, the authors clearly want to emphasize the relationship between the science and the politics of change.

Chapter 2 is thematically similar to Chapter 1. A basic explanation of how the Earth's climate operates and how it is changing is presented in simple, straightforward language. Basic concepts, such as the energy balance and global patterns of air movement, are discussed and displayed in clear, easy to understand Figures. Similarly, Earth's evolution from its origins to the present and the progression of past climate change are discussed in basic terms. The slow cooling that took place during the Cenozoic Era is covered and the cyclical pattern of Earth's climate over the past 800,000 years, with long glacial periods alternating with short interglacial periods, is well described. Like in Chapter 1, the carbon cycle and the importance of carbon dioxide as a greenhouse gas play a key role in this Chapter. And, once again, the role of humans in enhancing this effect, principally through the release of increasing amounts of CO2, is emphasized. The political message in text, Boxes and Activities is made clear: humans are responsible for climate change, at least in very recent times. The title of one chapter sub-section “Is climate changing and are humans the cause?” could easily be re-written as “The climate is changing and we are the cause”. The authors make it clear in the rest of the Chapter that they are not really interested in climate change in the geologic past, the focus here is on very recent climate change and the important role people are having in creating it. Various examples of the projected impacts of human-induced climate change, ranging from increased storm intensity to ecosystem damage to food insecurity are used to illustrate the detrimental role people are having on their changing environment.

Chapter 3 provides an overview of how people are responding to climate change. The creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 is outlined and is regarded as a centerpiece of the global political response to climate change. Even with the establishment of this Convention it is made clear that political uncertainty will greatly limit its effectiveness. The same point is made of the adoption of the Kyoto Protocol in 1997. The authors recognize the limited impact this Protocol will have. Both the Convention and the Protocol are seen as having more political significance than potential for reducing the human impact on climate change.

The title of Chapter 4, *Future climate scenarios*, is based on the scenario analysis used by the Intergovernmental Panel on Climate Change (IPCC). The focus here is on how people may respond to the economic and environmental impacts of climate change. The four families of scenarios used by the IPCC are well explained, with cartoon-like Figures used to further illustrate the similarities and differences between them. An integrated approach to understanding climate change would involve taking into account the costs of either business as usual, adaptation or mitigation. It is noted that all three options have costs and benefits. Simple quantitative models are used to illustrate the uncertainties surrounding projections of future change and the role played by people in any change. Population, income and technological change are seen as the driving forces in the human involvement in environmental change. Finally, the Chapter outlines how co-operation between developing and developed countries will be critical for any substantive action on the human influence on future climate change.

In Chapter 5 the authors concentrate on the role that ethics plays in the climate change issue. They state that questions of equity, vulnerability and responsibility, across both time and space, are key to understanding how humans will respond to changes in their environment. They point the finger of blame squarely at the expensive lifestyles and high consumption patterns present in developed nations as the main culprits in global world problems, and suggest the Gaia hypothesis conceived by James Lovelock is a possible alternative viewpoint, helping to lead the world on a more sustainable path. The cooperative political approach suggested by political philosopher Mary Midgley and based on the Gaia hypothesis is seen as one possible solution. In the end, a balancing of economic and Gaian approaches is deemed appropriate, indeed necessary.

The concept of sustainable development, a key concept in the book, is introduced in Chapter 6. Climate change affects the entire physical global environment, rather than causing geographically distinct environmental damage, and is therefore seen as a more complex problem than people have previously faced. The concept of sustainable development may serve as a political compromise between development and environmental concerns. The authors suggest that well-known indicators of socioeconomic health, such as Gross Domestic Product (GDP), be replaced by an indicator that includes 'ecological footprinting', the inclusion of the state of the physical environment in any analysis of political, economic and environmental life. However, it is acknowledged that any attempt to make such a change is not likely to happen anytime soon.

In the final chapter the authors attempt to bring together two major concepts previously covered in the book, sustainability and climate change, and join them with a new one, globalisation. Globalisation can be identified as economic: the flow of goods and services; political: the flow of ideas and ideologies; social/cultural: the flow of social practices and cultural products; and ecological: the movement of species. In their opinion, a key issue is our global dependence on fossil fuels. This dependence must end and people must learn to adapt to a new future where societies are environmentally adaptable and sustainable. In order to achieve this goal, and many others associated with future climate change, new forms of governance are necessary. They argue for better linkages between the social and economic systems and the natural world. Societies must find ways to be more environmentally sustainable and develop what the authors term 'ecological citizenship'. Increased communication and debate on future climate change is of extreme importance, and the media must play a central role.

Climate Change: from science to sustainability has one central message: climate change may be a natural process but recent change has been principally caused by human action. The authors are concerned with how people are causing dramatic, perhaps unstoppable, changes to our climate system and our world as a whole. Embracing the concept of sustainable development is seen as a way to, if not stop, at least reduce the impact people are having on future change. The book would be suitable for an upper-level secondary school or introductory-level college course.

ADAPTION TO CLIMATE CHANGE:

From Resilience to Transformation

Mark Pelling
London; New York: Routledge, 2011, 203 pp.
paper, ISBN: 978-0-415-47751-2

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The book's back cover claims: "The impacts of climate change are already being felt. Learning how to live with these impacts is a priority for human development". These sentences accurately betray the central purpose of the book, which is to present a comprehensive analysis of the social dimensions to climate change adaptation.

The book is divided into four parts. Part I *Framework and theory* contains two chapters that present theory surrounding the social aspects of adaption research. Chapter 1: *The adaptation age*, introduces adaptation as a process rather than a status. One cannot arrive at being adapted to climate change. Rather, one can move toward adaptation. This perspective explains the choice of subtitle: from resilience to transformation (explained later) which demonstrates that adaptation is something that not only adjusts to change, but is, itself, a process of change. The bulk of the opening chapter sets out a conceptual framework which claims that adaptation is driven by four questions: *1) what to adapt to?; 2) Who or what adapts?; 3) How does adaptation occur?;* and *4) What are the limits of adaptation?* These are surprisingly simple questions with very complex answers. The book responds to these four questions from a perspective of wishing to understand, rather than measure adaptation. The central emphasis, then, is one of critical assessment, and of interpretative analysis of contested discourse, rather than of presenting discrete facts and procedures to be "nailed down" for adaptation to be said to have taken place.

Chapter 2: *Understanding adaptation* begins with a provocative quote by Paulo Friere that warms us that without a critical awareness, adaptation is hostage to being limited to efforts that promote action to survive with, rather than seek change to, the social and political structures that shape life chances. Pelling wants the reader to really *understand* adaptation not just jump to fixing problems, by recognizing it is fundamentally about transforming our choices, and building capacity to make those changes. I think that if the reader cannot find the time to read the whole book, he or she should at least read this chapter. While relying on well-documented sources, this chapter explores antecedents to adaptation, as well as what is meant by resilience and thresholds to transformational change. This chapter contains the healthy appetizer for the substantial meat of the book that follows.

Part II The resilience-transition-transformation framework, contains three chapters. Chapter 3: *Adaptation as resilience* sets out a vision of adaptation as resilience by describing it in terms of social learning and self-organization, and by outlining pathways of adaptation. I found Figure 3.1 and Table 3.1, which presents five adaptive pathways, to be particularly useful is grasping Pelling's robust theoretical, analytical and heuristic contributions. Chapter 4: *Adaptation as transition* is about incremental social change. It explores vital questions of risk, governance regimes and socio-technological transition required for adaptation. Governments at all levels and society at large grapple with how to adapt to climate change. Pelling warms that planned innovations, and adaptation in society may exacerbate existing inequalities or generate new ones. Again the point is made; there are no easy solutions to the complex problems associated with climate change. Chapter 5: *Adaptation as transformation* is about new rights claims and changes in political regimes. The socio-contract and human security issues are discussed. Drawing on Jean-Jacques Rousseau, Ulrich Beck, Jürgen Habermas and a host of others, the heart of the theoretical discussion on risk, modernity and society are found in this chapter. Pelling manages to neatly tie these together to give support to his framework and ends the chapter discussing how disasters are conceived as catalysts and tipping point for this vision of adaptation-as-transformation. Good reading indeed.

Part III Living with climate change contains three detailed case studies that support the resilience-transition-transformation framework in three separate chapters. Chapter 6: *Adaptation within organisations* looks at the local-scale institution and organizational levels by exploring the Environment Agency and a farmers' support group in the UK. The quote at the beginning of the chapter says it all - relationships and not structures are what counts for adaptation. Anyone reading this chapter will be able to make the connections – at the ground level – with any number of organizational situations. Chapter 7: *Adaptation as urban risk discourse and governance* uses urban cases in Mexico to examine how the discourses of adaptation in four communities of various sizes (populations range from 1.3 million to 1,000) can either challenge or further entrench development inequalities and failures. Some empirical evidence in this chapter provides substance to the earlier theoretical discussions. Chapter 8: *Adaptation as national political response to disaster* examines national-level policies and methods through three case studies (Bangladesh, Nicaragua , and USA). Each case shows the technical, but also political, nature of adaptation. Disasters brought by cyclones and hurricanes tell the story of adaptation politics. Political ramifications following the 1970 Bhola Cyclone in East Pakistan (now Bangladesh) and missed opportunities for transformation are analyzed following the wake of the 1998 Hurricane Mitch storm in Nicaragua and the 2005 Hurricane Katrina storm in New Orleans.

Part IV Adapting with climate change concludes the book by discuss how to adapt with climate change (does this imply it may be possible to adapt without climate change?) explains too often adaptation is too narrowly framed. Chapter 9 outlines the research and policy development needs that arise from the central argument that adaptation is a social, cultural and political as well as a technological process. Moving from theory to action will not be easy.

In short, *Adaptation to Climate Change*: from resilience to transformation is a well-researched, well-written analysis of the social dimension of climate change adaptation. Carefully blending theoretical explanations and empirical evidence is probably the most comprehensive treatment of the subject to date. It is a timely book which will be helpful for the foreseeable future. I wish for all involved in climate change research and policy-makers to read this book. It should be used as required reading in university-based courses at the upper undergraduate and graduate level in climate change, geography and development studies.

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A typical manuscript should be between 12 and 20 double-spaced pages of text. The journal will consider both shorter and longer pieces depending on their appropriateness. Articles submitted for consideration must be typewritten using Times New Roman 12-point font, double-spaced, 1-inch margins and with a minimum of special formatting. Electronic submission is preferred as a Word document. Do not place any identifying information in your manuscript or your file names to ensure a blind review. This includes names of authors, their affiliations or acknowledgments.

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